INTEGRATED CIRCUITS FOR STORAGE PRODUCTS

1991 Data Book

silicon systems®

Table of Contents

Advanced and Preliminary Information
In this data book the following conventions are used in designating a data sheet "Advanced" or "Preliminary."

Advance Information–
Indicates a product still in the design cycle, and any specifications are based on design goals only. Do not use for final design.

Preliminary Data–
Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Product Index

* Data Sheet available upon request.

Product Index (Continued)

Section 4. HDD DATA RECOVERY

Section 5. HDD HEAD POSITIONING

Section 6. HDD SPINDLE MOTOR CONTROL

Section 7. HDD CONTROLLER/INTERFACE

* Data Sheet available upon request.

Product Index (Continued)

Discontinued Parts List

The following parts are no longer supplied or supported by Silicon Systems. Please note alternate sources.

Part #	Description	Alternate Source
SSI 32B450A	SCSI Controller	SSI 32B451
SSI 32D452A	Storage Controller	SSI 32D452
SSI 32D536	Data Separator/1, 7 RLL Encoding	SSI 32D5362
SSI 32D537	Data Synchronizer/1,7 RLL ENDEC	SSI 32D5371/5372
SSI 32P542	Read Data Processor	None

Numerical Index

* Data Sheet available upon request

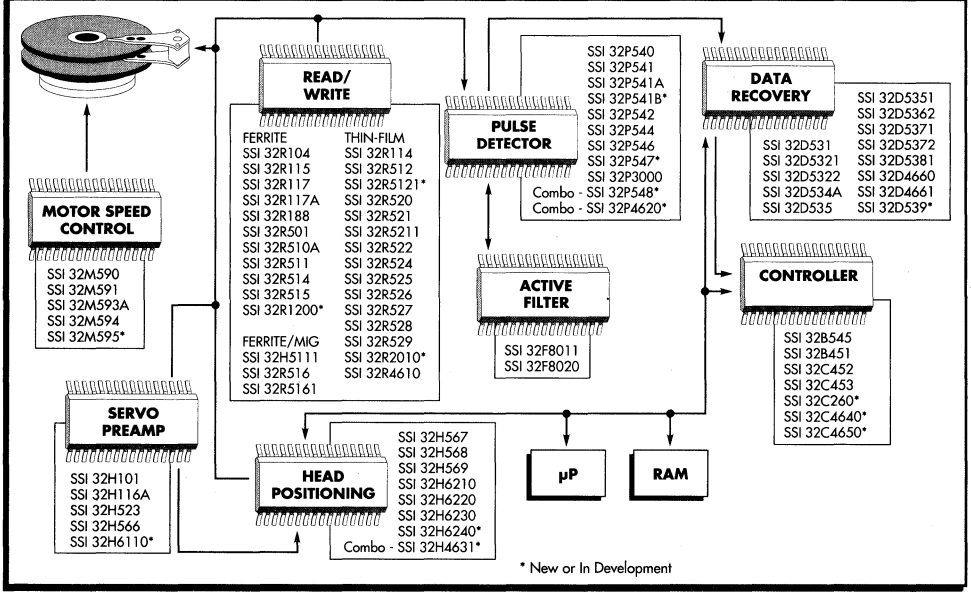
Storage IC Selector Guide

Device Numbers	Head Type	Number of Channels	Max Input Noise (nV/√Hz)	Max Input Capacitance (pF)	Read Gain (typ)	Write Current Range (mA)	Power Supply (V)	Read/Write Data Ports
HDD Read/Write Amplifiers								
SSI 32R104C	Ferrite	4	2.4	23	35	15 - 45	+6, -4	Differential, Bi-directional
SSI 32R104CLN	Ferrite	4	1.7	23	35	15 - 45	+6, -4	Differential, Bi-directional
SSI 32R115	Ferrite	2, 4, 5	1.8	20	40	30 - 50	+5, -5	Differential, Bi-directional
SSI 32R117	Ferrite	2, 4, 6	2.1	23	100	10 - 50	+5, +12	Differential / TTL
SSI 32R117A	Ferrite	2, 4, 6	1.7	20	100	10 - 50	+5, +12	Differential / TTL
SSI 32R188	Ferrite	4	2.4	18	43	35 - 70	+6, -5	Differential, Bi-directional
SSI 32R501	Ferrite	4, 6, 8	1.5	23	100	10 - 50	+5, +12	Differential / TTL
SSI 32R510A	Ferrite	2, 4, 6	1.5	20	100	10 - 40	+5, +12	Differential / TTL
SSI 32R511	Ferrite	4, 6, 8	1.5	20	100	10 - 40	+5, +12	Differential / TTL
SSI 32R5111	Ferrite/MIG	4, 6, 8	1.5	20	150	10 - 40	+5, +12	Differential / TTL
SSI 32R512	Thin Film	8, 9	0.85	35	150	10 - 40	+5, +12	Differential / TTL
SSI 32R5121	Thin Film	14	0.85	35	250	10 - 40	+5, +12	Differential / TTL
SSI 32R514	Ferrite	2, 4, 6	1.5	20	150	10 - 40	+5, +12	Differential / TTL
SSI 32R515	Ferrite	9, 10	1.5	20	100	10 - 50	+5, +12	Differential / TTL
SSI 32R516	Ferrite/MIG	4, 6, 8	1.3	18	120	20 - 60	+5, +12	Differential / TTL
SSI 32R5161	Ferrite/MIG	10	1.3	18	150	20 - 60	+5, +12	Differential / TTL
SSI 32R520	Thin Film	4	0.9	65	123	30 - 75	+5, -5	Differential / Differential
SSI 32R521	Thin Film	6	0.9	65	100	20 - 70	+5, +12	Differential / TTL
SSI 32R5211	Thin Film	6	0.9	65	150	20 - 70	+5, +12	Differential / TTL
SSI 32R522	Thin Film	4, 6	1.0	32	100	6 - 35	+5, +12	Differential / TTL
SSI 32R524R	Thin Film	7.5	0.8	60	100	20 - 60	+5, +12	Differential / TTL
SSI 32R525	Thin Film	4	0.8	35	150	25 - 40	+5, -5	Differential / Differential
SSI 32R526R	Thin Film	4	0.6	65	100	17 - 50	+5, -5	Differential / Differential
SSI 32R527	Thin Film	8, 9	0.85	35	120	10 - 40	+5, +12	Differential / Differential
SSI 32R528	Thin Film	8, 9	0.85	35	150	10 - 40	+5, +12	Differential / Differential
SSI 32R529	Thin Film	8	0.8	38	100	17 - 50	+5, -5	Differential / Differential
SSI 32R1200	Ferrite	2, 4	1.2	17	200	15 - 45	+5	Differential / TTL
SSI 32R2010	Thin Film	10	0.8	25	150	17 - 50	+5, +12	Differential / Differential
SSI 32R4610	Thin Film	2, 4	0.85	35	200	10 - 35	+5	Differential / TTL

Device Numbers	Circuit Function	Features
HDD Pulse Detection		
SSI 32P540	Read Data Processor	Time Domain Filter
SSI 32P541	Read Data Processor	AGC, Amplitude & Time Pulse Qualification, RLL Compatible
SSI 32P541A	Read Data Processor	32P541 pin Comp.– Enhanced Write to Read Recovery & Voltage Fault Detection
SSI 32P541B	Read Data Processor	32P541 pin Comp.– 32P541A with Increased Data Rate to 24 Mbit/s
SSI 32P542	Read Data Processor	32P544-type PD with Data Channel, Clock Channel for Access
SSI 32P544	Pulse Detector	32P541-type PD with Embedded Servo Electronics
SSI 32P546	Pulse Detector	32P541-type PD with Pulse Slimming Compatibility
SSI 32P547	Pulse Detector	32P544-type PD with a Filter Multiplexer, Pulse Slimming Support
SSI 32P549	Read Data Processor	32P541 pin Comp., +5V only, Enhanced Write-to-Read Recovery
HDD Read Channel Combination Devices		
SSI 32P548	Pulse Detector / Data Sync.	32P544-type PD with 2, 7 Synchronizer, +5V only Low Power <700 mW
SSI 32P4620	Pulse Detector / Data Sep.	32P541-type PD & 537-type Data Sep. –Pulse Slimming & Constant Density Rec.
HDD Data Recovery		
SSI 32D531	Data Synchronizer	Data Synchronizer / Write Precompensation
SSI 32D5321	Data Separator	Data Synchronizer / 2, 7 RLL ENDEC
SSI 32D534A	Data Separator	Data Synchronizer / MFM ENDEC / Write Precompensation
SSI 32D535	Data Separator	Data Synchronizer / 2, 7 RLL ENDEC / Write Precompensation
SSI 32D5351	Data Separator	Data Synchronizer / 2, 7 RLL ENDEC / Write Precompensation 8-18 Mbit/s
SSI 32D5362	Data Separator	Data Synchronizer / 1, 7 RLL ENDEC / Write Precompensation 10-20 Mbit/s
SSI 32D5371/2	Data Separator	Data Synchronizer / 1, 7 RLL ENDEC / Write Precompensation 12-24 Mbit/s
SSI 32D4660/1	Time Base Generator	24 Mbit/s Reference Frequency PLL for constant density recording
HDD Active Filters		
SSI 32F8011	Programmable Active Channel Filter	7-pole Bessel Active Filter, Programmable Cutoff Frequency, Programmable Pulse Slimming
SSI 32F8020	Programmable Channel Filter	7-pole Equiripple Active Filter, Programmable Cutoff Frequency, Programmable Pulse Slimming

Device Numbers	Circuit Function	Features
HDD Head Positioning		
SSI 32H101A	Preamplifier - Ferrite head	AV=93, BW=10 MHz, e_n=7.0 nV/$\sqrt{Hz}$
SSI 32H116	Preamplifier - Thin Film head	AV=250, BW=20 MHz, e_n=0.94 nV/$\sqrt{Hz}$
SSI 32H523R	Servo Read/Write	Single-Channel Thin-Film Read/Write Device
SSI 32H566	Servo Read/Write	Single-Channel Ferrite Read/Write Device
SSI 32H567	Servo Demodulator	Di-bit Quadrature Servo Pattern; PLL Synchronization
SSI 32H568	Servo Controller	Track & Seek Mode Operation; Microprocessor Interface
SSI 32H569	Servo Motor Driver	Head Parking, Spindle Motor Braking
SSI 32H4630	Combo Servo & MSC	Embedded & Hybrid Servo, Hall Sensor-less Motor Speed Control, +5V only
SSI 32H6110	Preamplifier - Thin Film head	AV=250 or 300, BW=20 MHz, e_n=0.85 nV/$\sqrt{Hz}$
SSI 32H6210	Servo Demodulator	Di-bit Quadrature Servo Pattern, PLL Synchronization AGC adjustment
SSI 32H6220	Servo Controller	Track & Seek Mode Operation; Microprocessor Interface
SSI 32H6230	Servo Motor Driver	Head Parking; Spindle Motor Braking, Voltage Clamp
SSI 32H6240	Servo Motor Driver	Head Parking; Spindle Motor Braking, Voltage Clamp, Drives Bipolar Devices
HDD Spindle Motor Control		
SSI 32M590	2-Phase Motor Speed Control	±0.035% Speed Accuracy; Unipolar Operation
SSI 32M591	3-Phase Motor Speed Control	±0.05% Speed Accuracy; Unipolar Operation
SSI 32M593	3-Phase Motor Speed Control	±0.037% Speed Accuracy; Bipolar Operation, 5 1/4" Drives
SSI 32M594	3-Phase Motor Speed Control	±0.037% Speed Accuracy; Bipolar Operation, 3 1/2", 5 1/4" Drives
SSI 32M595	3-Phase Sensor-less MSC	Hall Sensor-less; 5V only Motor Speed Control
HDD Controller/Interface		
SSI 32C260	Combo Controller	20 Mbit/s; AT/XT Combo Controller; Cirrus Logic SH-260 Compatible
SSI 32B451	SCSI Controller	Async Transfer to 1.5 Mbyte/s; Internal Drivers; AIC 500L Compatible
SSI 32C452	Storage Controller	20 Mbit/s; CMOS; Programmable; AIC 010 Compatible
SSI 32C453	Buffer Controller	Non-mux Addressing to 16K; CMOS; AIC 300 Compatible
SSI 32B545	Support Logic	Includes ST506 Bus Drivers/Receivers
SSI 32C4640	Combo SCSI Controller	High Performance DRAM Buffer Manager, 32 Mbit/s disk, 10 Mbyte/s SCSI
SSI 32C4650	Combo AT Controller	High Performance SRAM Buffer Manager, 32 Mbit/s disk, 10 Mbyte/s AT

Winchester Disk Drive IC Product Family



Section 1

HDD READ/WRITE AMPLIFIERS

SSI 32R117/117R, 32R117A/117AR
2, 4, 6 Channel Read/Write Device

1

July, 1990

DESCRIPTION

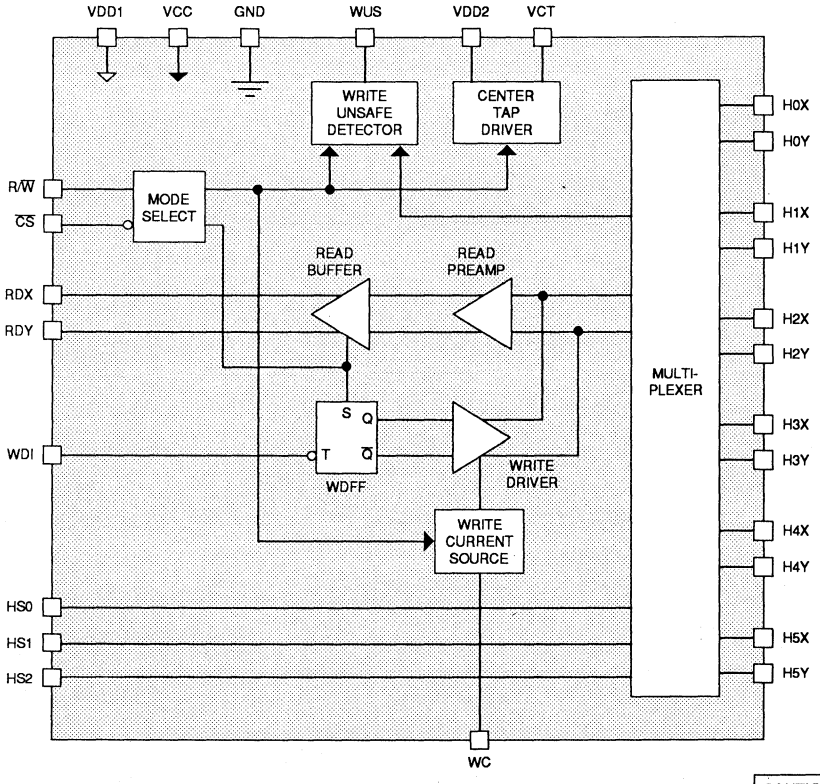
The SSI 32R117/117A devices are bipolar monolithic integrated circuits designed for use with center-tapped ferrite recording heads. They provide a low noise read path, write current control, and data protection circuitry for as many as six channels. The SSI 32R117/117A requires +5V and +12V power supplies and is available in 2, 4 or 6 channel versions with a variety of packages.

The SSI 32R117R/117AR differs from the SSI 32R117/117A by having internal damping resistors.

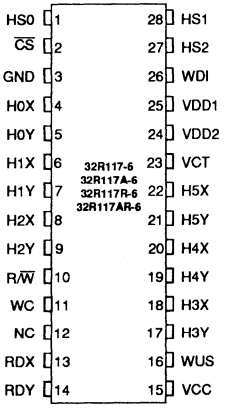
FEATURES

- **+5V, +12V power supplies**
- **Single or multi-platter Winchester drives**
- **Designed for center-tapped ferrite heads**
- **Programmable write current source**
- **Available in 2, 4 or 6 channels**
- **Easily multiplexed for larger systems**
- **Includes write unsafe detection**

BLOCK DIAGRAM



PIN DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

CIRCUIT OPERATION

The SSI 32R117/117A functions as a write driver or as a read amplifier for the selected head. Head selection and mode control are described in Tables 1 & 2. Both R/$\overline{W}$ and $\overline{CS}$ have internal pull-up resistors to prevent an accidental write condition.

WRITE MODE

The Write mode configures the SSI 32R117/117A as a current switch and activates the Write Unsafe Detector. Head current is toggled between the X- and Y-side of the recording head on the falling edges of WDI, Write Data Input. Note that a preceding read operation initializes the Write Data Flip-Flop, WDFF, to pass current through the X-side of the head. The magnitude of the write current, given by

Iw = K/Rwc, where K = Write Current Constant

is set by the external resistor, Rwc, connected from pin WC to GND.

Any of the following conditions will be indicated as a high level on the Write Unsafe, WUS, open collector output.

- Head open
- Head center tap open
- WDI frequency too low
- Device in Read mode
- Device not selected
- No write current

After the fault condition is removed, two negative transitions on WDI are required to clear WUS.

Power dissipation in write mode may be reduced by placing a resistor (RCT) between VDD1 & VDD2. The optimum resistor value is 130Ω x 50/Iw (Iw in mA). At low write currents (<15 mA) read mode dissipation is higher than write mode and RCT, though recommended, may not be considered necessary. In this case VDD2 is connected directly to VDD1.

READ MODE

In the Read mode the SSI 32R117/117A is configured as a low noise differential amplifier, the write current source and the write unsafe detector are deactivated, and the write data flip-flop is set. The RDX and RDY outputs are driven by emitter followers and are in phase with the "X" and "Y" head ports. They should be AC coupled to the load.

Note that the internal write current source is deactivated for both the Read and the Chip Deselect mode. This eliminates the need for external gating of the write current source.

IDLE MODE

Taking $\overline{CS}$ high selects the idle mode which switches the RDX, RDY outputs into a high impedance state and deactivates the internal write current source. This facilitates multi-device installations by allowing the read outputs to be wire OR'ed.

TABLE 1: Mode Select

$\overline{CS}$	R/$\overline{W}$	MODE
0	0	Write
0	1	Read
1	x	Idle

TABLE 2: Head Select

HS2	HS1	HS0	HEAD
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	x	None

0 = Low level 1 = High level x = Don't care

PIN DESCRIPTIONS

NAME	I/O	DESCRIPTION
HS0-HS2	I	Head Select: selects up to six heads
$\overline{CS}$	I	Chip Select: a low level enables device
R/$\overline{W}$	I	Read/Write: a high level selects read mode
WUS	O*	Write Unsafe: a high level indicates an unsafe writing condition (open collector)
WDI	I	Write Data In: negative transition toggles the direction of the head current
H0X-H5X H0Y-H5Y	I/O	X,Y head connections
RDX, RDY	O*	X, Y Read Data: differential read signal out
WC	-	Write Current: used to set the magnitude of the write current
VCT	-	Voltage Center Tap: voltage source for head center tap
VCC	-	+5V
VDD1	-	+12V
VDD2	-	Positive power supply for the center tap voltage source
GND	-	Ground

*When more than one R/W device is used, these signals can be wire OR'ed.

ABSOLUTE MAXIMUM RATINGS (Operation above absolute maximum ratings may permanently damage the device. All voltages referenced to GND.)

PARAMETER		VALUE	UNITS
VDD1	DC Supply Voltage	-0.3 to +14	VDC
VDD2	DC Supply Voltage	-0.3 to +14	VDC
VCC	DC Supply Voltage	-0.3 to +6	VDC
VIN	Digital Input Voltage Range	-0.3 to VCC + 0.3	VDC
VH	Head Port Voltage Range	-0.3 to VDD + 0.3	VDC
Vwus	WUS Port Voltage Range	-0.3 to +14	VDC
Iw	Write Current	60	mA
Io	RDX, RDY Output Current	-10	mA
IVCT	VCT Output Current	-60	mA
Iwus	WUS Output Current	+12	mA
Tstg	Storage Temperature Range	-65 to +150	°C
Lead Temperature, PDIP, Flatpack (10 sec soldering)		260	°C
Package Temperature, PLCC, SOL (20 sec reflow)		215	°C

RECOMMENDED OPERATION CONDITIONS

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
DC Supply Voltage	VDD1		10.8	12.0	13.2	VDC
DC Supply Voltage	VCC		4.5	5.0	5.5	VDC
Head Inductance	Lh		5		15	µH
Damping Resistor	RD	32R117 only	500		2000	Ω
RCT Resistor	RCT		125.0	130	135.0	Ω
Write Current	Iw		25		50	mA
Junction Temperature Range	Tj		25		125	°C

DC CHARACTERISTICS
(Unless otherwise specified, recommended operating conditions apply.)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
VCC Supply Current		Read/Idle Mode			25	mA
		Write Mode			30	mA
VDD Supply Current		Idle Mode			25	mA
		Read Mode			50	mA
		Write Mode			30+Iw	mA
Power Dissipation (Tj = +125°C)		Idle Mode			400	mW
		Read Mode			600	mW
		Write Mode, Iw = 50 mA, RCT = 130Ω			700	mW
		Write Mode, Iw = 50 mA, RCT = 0Ω			1050	mW
Digital Inputs						
Input Low Voltage	VIL		-0.3		0.8	VDC
Input High Voltage	VIH		2.0		VCC+0.3	VDC
Input Low Current	IIL	VIL = 0.8V	-0.4			mA
Input High Current	IIH	VIH = 2.0V			100	µA
WUS Output	VOL	IOL = 8 mA			0.5	VDC
WUS Output	IOH	VOH = 5.0V			100	µA
Center Tap Voltage	VCT	Write Mode		6.0		VDC
		Read Mode		4.0		VDC

WRITE CHARACTERISTICS (Unless otherwise specified: recommended operating conditions apply, IW = 45 mA, Lh = 10 µH, Rd = 750Ω (32R117/A only), f(Data) = 5 MHz, CL(RDX, RDY) ≤ 20 pF)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Write Current Range		10		50	mA
Write Current Constant "K"		133		147	V
Differential Head Voltage Swing		8.0			V(pk)
Unselected Head Transient Current				2	mA(pk)
Differential Output Capacitance				15	pF
Differential Output Resistance	32R117/A	10K			Ω
	32R117R	562		938	Ω
	32R117/AR	638		863	Ω
WDI Transition Frequency	WUS = low	250			KHz
Iwc to Head Current Gain	Iw/Iwc		20		mA/mA
Unselected Head Leakage Current	Sum of X & Y side leakage current			85	µA

READ CHARACTERISTICS
(Unless otherwise specified: recommended operating conditions apply, IW = 45 mA, Lh = 10 µH, Rd = 750Ω (32R117/117A only), f(Data) = 5 MHz, CL(RDX, RDY) ≤ 20 pF, Vin is referenced to VCT)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Differential Voltage Gain	Vin = 1 mVpp @ 300 KHz RL(RDX), RL(RDY) = 1 KΩ 32R117/117R	80		120	V/V
	32R117/117AR	90		110	V/V
Dynamic Range	DC Input Voltage, Vi, Where Gain Falls by 10%, Vin = Vi + 0.5 mVpp @ 300 KHz	-3		+3	mV
Bandwidth (-3dB)	|Zs| < 5Ω, Vin = 1 mVpp	30			MHz
Input Noise Voltage	BW = 15 MHz, Lh = 0, Rh = 0 32R117/R			2.1	nV/√Hz
	32R117A/AR			1.7	nV/√Hz
Differential Input Capacitance	f = 5 MHz			20	pF
Differential Input Resistance	32R117/117A, f = 5 MHz	2K			Ω
	32R117R, f = 5 MHz	390		810	Ω
	32R117/117AR	450		750	Ω

READ CHARACTERISTICS (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Input Bias Current (per side)				45	µA
Common Mode Rejection Ratio	Vcm = VCT + 100 mVpp @ 5 MHz	50			dB
Power Supply Rejection Ratio	100 mVpp @ 5 MHz on VDD1, VDD2 or VCC	45			dB
Channel Separation	Unselected Channels: Vin=100 mVpp @ 5 MHz; Selected Channel: Vin = 0 mVpp	45			dB
Output Offset Voltage	32R117/117R	-480		+480	mV
	32R117/117AR	-440		+440	mV
Common Mode Output Voltage	Read Mode	5		7	V
	Write/Idle Mode		4.3		V
Single Ended Output Resistance	f = 5 MHz			30	Ω
Leakage Current, RDX, RDY	RDX, RDY = 6V Write/Idle Mode	-100		+100	µA
Output Current	AC Coupled Load, RDX to RDY	2			mA

SWITCHING CHARACTERISTICS (Unless otherwise specified: recommended operating conditions apply, IW = 45 mA, Lh = 10 µH, Rd = 750Ω (32R117/A) only, f(Data) = 5 MHz)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
R/$\overline{W}$ To Write	Delay to 90% of write current			1.0	µs
R/$\overline{W}$ to Read	Delay to 90% of 100 mV 10 MHz read signal envelope or to 90 % decay of write current			1.0	µs
$\overline{CS}$ to Select	Delay to 90% of write current or to 90% of 100mV 10MHz read signal envelope			1.0	µs
$\overline{CS}$ to Unselect	Delay to 90% decay of write current			1.0	µs

SWITCHING CHARACTERISTICS (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
HS0 - HS2 to any head	Delay to 90% of 100 mV 10 MHz read signal envelope			1.0	µs
WUS - Safe to Unsafe - TD1	Iw = 50 mA	1.6		8.0	µs
WUS - Unsafe to Safe - TD2	Iw = 20 mA			1.0	µs
Head Current (Lh = 0 µH, Rh = 0Ω)					
Prop. Delay - TD3	From 50% points			25	ns
Asymmetry	WDI has 50% duty cycle and 1ns rise/fall time			2	ns
Rise/Fall Time	10% - 90% points			20	ns

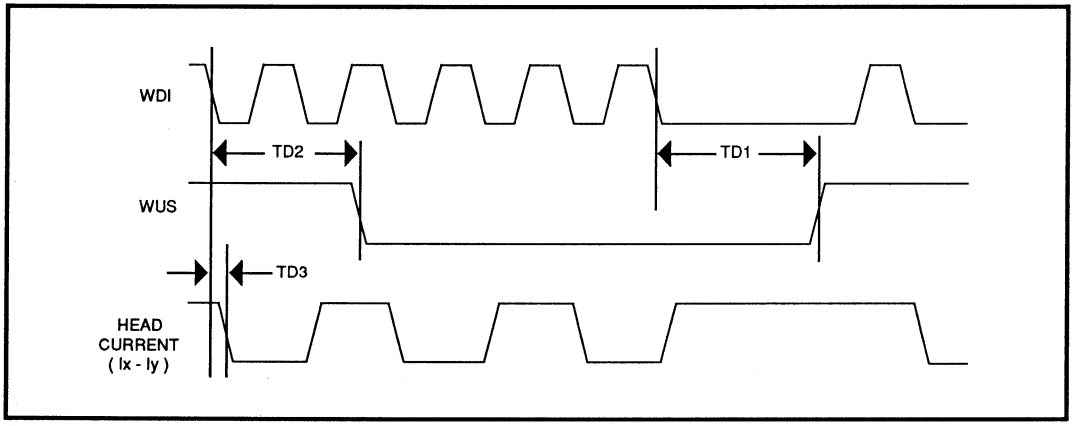
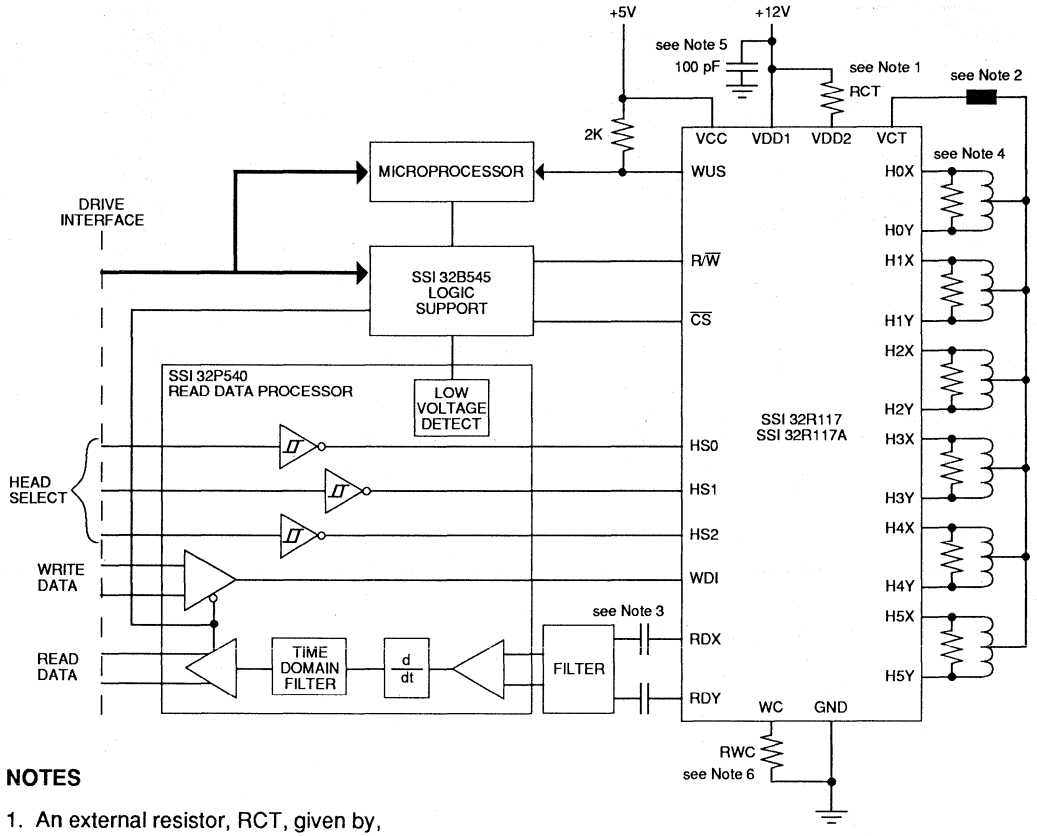


FIGURE 1: Write Mode Timing Diagram



NOTES

1. An external resistor, RCT, given by,

   117/117R RCT = 130(55/Iw)Ω, where Iw is in mA,

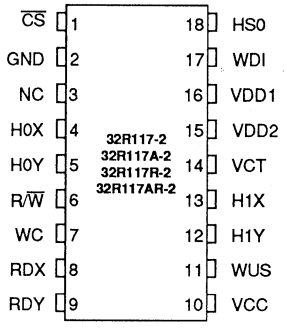
   117/117AR = 130(50/Iw)Ω

   can be used to limit internal power dissipation. Otherwise connect VDD2 to VDD1.
2. A ferrite bead (Ferroxcube 5659065/4A6) can be used to suppress write current overshoot and ringing induced by flex cable parasitics.
3. Limit DC current from RDX and RDY to 100 µA and load capacitance to 20 pF.
4. Damping resistors not required on 32R117R/117AR version.
5. The power bypassing capacitor must be located close to the 32R117/117A with its ground returned directly to device ground with as short a path as possible.
6. To reduce ringing due to stray capacitance this resistor should be located close to the 32R117/117A. Where this is not desirable a series resistor can be used to buffer a long WC line.

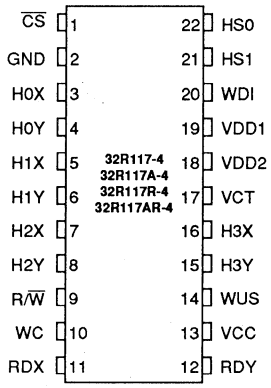
FIGURE 2: Applications Information

PACKAGE PIN DESIGNATIONS

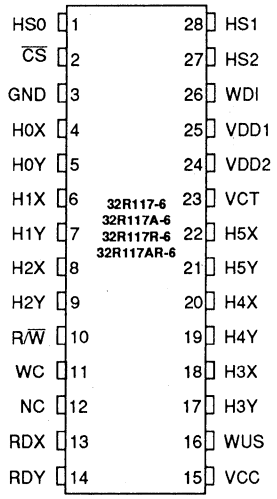
(TOP VIEW)



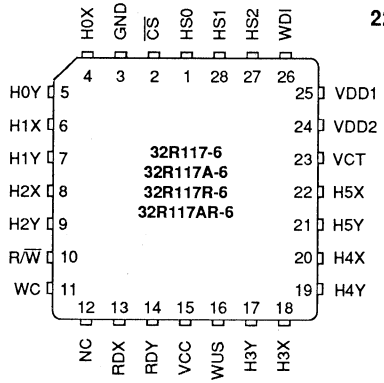
18-lead PDIP



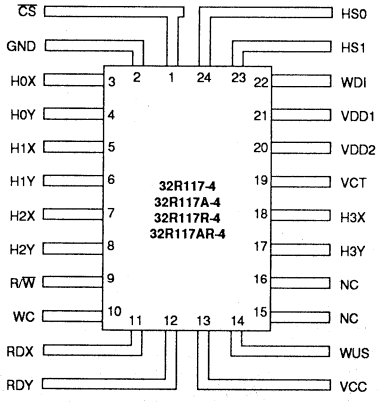
22-lead PDIP



28-lead PDIP,
Flatpack, SOL



28-lead PLCC



24-lead Flatpack, SOL

THERMAL CHARACTERISTICS

PACKAGE	Øja
18-lead PDIP	140°C/W
22-lead PDIP	65°C/W
24-lead Flatpack	110°C/W
SOL	80°C/W
28-lead PDIP	55°C/W
Flatpack	100°C/W
PLCC	65°C/W
SOL	70°C/W

SSI 32R117/117R
32R117A/117AR
2, 4, 6-Channel
Read/Write Device

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32R117		
2-Channel PDIP	SSI 32R117-2P	32R117-2P
4-Channel PDIP	SSI 32R117-4CP	32R117-4CP
4-Channel SOL	SSI 32R117-4CL	32R117-4CL
4-Channel Flatpack	SSI 32R117-4F	32R117-4F
6-Channel PDIP	SSI 32R117-6CP	32R117-6CP
6-Channel SOL	SSI 32R117-6CL	32R117-6CL
6-Channel Flatpack	SSI 32R117-6F	32R117-6F
6-Channel PLCC	SSI 32R117-6CH	32R117-6CH
SSI 32R117R with Internal Damping Resistor		
2-Channel PDIP	SSI 32R117R-2P	32R117R-2P
4-Channel PDIP	SSI 32R117R-4CP	32R117R-4CP
4-Channel SOL	SSI 32R117R-4CL	32R117R-4CL
4-Channel Flatpack	SSI 32R117R-4F	32R117R-4F
6-Channel PDIP	SSI 32R117R-6CP	32R117R-6CP
6-Channel SOL	SSI 32R117R-6CL	32R117R-6CL
6-Channel Flatpack	SSI 32R117R-6F	32R117R-6F
6-Channel PLCC	SSI 32R117R-6CH	32R117R-6CH
SSI 32R117A		
2-Channel PDIP	SSI 32R117A-2P	32R117A-2P
4-Channel PDIP	SSI 32R117A-4CP	32R117A-4CP
4-Channel SOL	SSI 32R117A-4CL	32R117A-4CL
4-Channel Flatpack	SSI 32R117A-4F	32R117A-4F
6-Channel PDIP	SSI 32R117A-6CP	32R117A-6CP
6-Channel SOL	SSI 32R117A-6CL	32R117A-6CL
6-Channel Flatpack	SSI 32R117A-6F	32R117A-6F
6-Channel PLCC	SSI 32R117A-6CH	32R117A-6CH
SSI 32R117AR with Internal Damping Resistor		
2-Channel PDIP	SSI 32R117AR-2P	32R117AR-2P
4-Channel PDIP	SSI 32R117AR-4CP	32R117AR-4CP
4-Channel SOL	SSI 32R117AR-4CL	32R117AR-4CL
4-Channel Flatpack	SSI 32R117AR-4F	32R117AR-4F
6-Channel PDIP	SSI 32R117AR-6CP	32R117AR-6CP
6-Channel SOL	SSI 32R117AR-6CL	32R117AR-6CL
6-Channel Flatpack	SSI 32R117AR-6F	32R117AR-6F
6-Channel PLCC	SSI 32R117AR-6CH	32R117AR-6CH

SSI 32R501/501R
4, 6, 8-Channel Ferrite Read/Write Device

1

July, 1990

DESCRIPTION

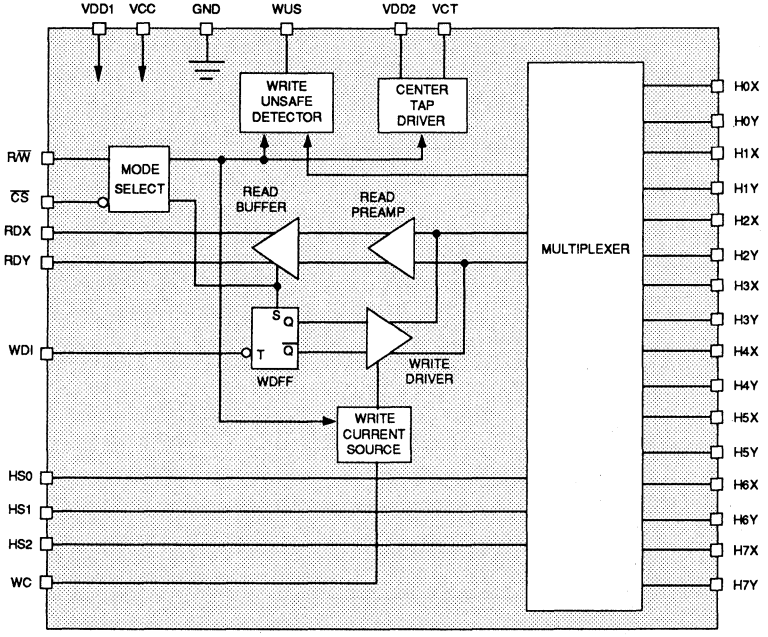
The SSI 32R501 is a bipolar monolithic integrated circuit designed for use with a center-tapped ferrite recording head. It provides a low noise read path, write current control, and data protection circuitry for as many as 8 channels. The SSI 32R501 requires +5V and +12V power supplies and is available in a variety of packages.

The SSI 32R501R performs the same function as the SSI 32R501 with the addition of internal damping resistors.

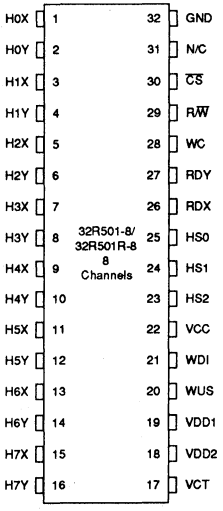
FEATURES

- **Single or multi-platter Winchester drives**
- **Designed for center-tapped ferrite heads**
- **Programmable write current source**
- **Easily multiplexed for larger systems**
- **Includes write unsafe detection**
- **TTL compatible control signals**
- **1.5 nV/√Hz maximum input noise voltage**
- **+5V, +12V power supplies**
- **Mirror image package option**

BLOCK DIAGRAM



PIN DIAGRAM



32-LEAD SOW

CAUTION: Use handling procedures necessary for a static sensitive component.

CIRCUIT OPERATION

The SSI 32R501 gives the user the ability to address up to eight center-tapped ferrite heads and provide write drive or read amplification. Head selection and mode control is accomplished using the HSn, $\overline{CS}$ and R/$\overline{W}$ inputs as shown in Tables 1 & 2. Internal pullups are provided for the $\overline{CS}$ & R/$\overline{W}$ inputs to force the device into a non-writing condition if either control line is opened accidentally.

TABLE 1: Mode Select

$\overline{CS}$	R/$\overline{W}$	MODE
0	0	Write
0	1	Read
1	X	Idle

TABLE 2: Head Select

HS2	HS1	HS0	HEAD
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

0 = Low level 1 = High level

WRITE MODE

Taking both $\overline{CS}$ and R/$\overline{W}$ low selects write mode which configures the SSI 32R501 as a current switch and activates the Write Unsafe (WUS) detector circuitry. Write current is toggled between the X and Y side of the selected head on each high to low transition of the Write Data Input (WDI). Note that a preceding read mode selection initializes the Write Data Flip-Flop, WDFF, to pass write current through the "X" side of the head. The zero-peak write current magnitude is programmed by an external resistor Rwc from pin WC to GND and is given by:

Iw = K/Rwc, where K = Write Current Constant

The Write Unsafe detection circuitry monitors voltage transitions at the selected head connections and flags any of the following conditions as a high level on the Write Unsafe open collector output:

- Head open
- WDI frequency too low
- Device not selected
- Head center tap open
- Device in read mode
- No write current

Two negative transitions on WDI, after the fault is corrected, will clear the WUS flag.

Power dissipation in write mode may be reduced by placing a resistor (RCT) between VDD1 & VDD2. The optimum resistor value is 120Ω x 50/Iw (Iw in mA). At low write currents (<15 mA) read mode dissipation is higher than write mode and RCT, though recommended, may not be considered necessary. In this case VDD2 is connected directly to VDD1.

READ MODE

Taking $\overline{CS}$ low and R/$\overline{W}$ high selects read mode which configures the SSI 32R501 as a low noise differential amplifier for the selected head. The RDX and RDY outputs are driven by emitter followers and are in phase with the "X" and "Y" head ports. These outputs should be AC coupled to the load. The internal write current source is gated off in read mode eliminating the need for any external gating.

Read mode selection also initializes the Write Data Flip-Flop (WDFF) to pass write current through the "X" side of the head at a subsequent write mode selection.

IDLE MODE

Taking $\overline{CS}$ high selects the idle mode which switches the RDX, RDY outputs into a high impedance state and deactivates the internal write current source. This facilitates multi-device installations by allowing the read outputs to be wire OR'ed.

PIN DESCRIPTIONS

NAME	I/O	DESCRIPTION
HS0-HS2	I	Head Select
$\overline{CS}$	I	Chip Select: a low level enables device
R/$\overline{W}$	I	Read/Write: a high level selects read mode
WUS	O*	Write Unsafe: a high level indicates an unsafe writing condition
WDI	I	Write Data In: negative transition toggles direction of head current
H0X-H7X H0Y-H7Y	I/O	X,Y head connections
RDX, RDY	O*	X, Y Read Data: differential read signal out
WC		Write Current: used to set the magnitude of the write current
VCT		Voltage Center Tap: voltage source for head center tap
VCC		+5V
VDD1		+12V
VDD2		Positive power supply for the center tap voltage source
GND		Ground
* When more than one R/$\overline{W}$ device is used these signals can be wire OR'ed.		

ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS (All voltages referenced to GND. Currents into device are positive.)

PARAMETER		VALUE	UNITS
DC Supply Voltage	VDD1	-0.3 to +14	VDC
DC Supply Voltage	VDD2	-0.3 to +14	VDC
DC Supply Voltage	VCC	-0.3 to +6	VDC
Digital Input Voltage Range	VIN	-0.3 to VCC + 0.3	VDC
Head Port Voltage Range	VH	-0.3 to VDD1 + 0.3	VDC
WUS Pin Voltage Range	Vwus	-0.3 to +14	VDC
Write Current Zero Peak	Iw	60	mA
Output Current	RDX, RDY Io	-10	mA
Output Current	IVCT	-60	mA
Output Current	Iwus	+12	mA
Storage Temperature Range	Tstg	-65 to 150	°C
Lead Temp. PDIP, Flatpack (10 sec Soldering)		260	°C
Package Temperature PLCC, SO (20 sec Reflow)		215	°C

RECOMMENDED OPERATION CONDITIONS

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
DC Supply Voltage	VDD1		10.8	12.0	13.2	VDC
DC Supply Voltage	VCC		4.5	5.0	5.5	VDC
Head Inductance	Lh		5		15	µH
Damping Resistor	RD	32R501 only	500		2000	Ω
RCT Resistor	RCT*	Iw = 50 mA	114	120	126	Ω
Write Current	Iw		22		50	mA
Junction Temperature Range	Tj		+25		+135	°C
*For Iw = 50 mA. At other Iw levels refer to Applications Information that follows this specification.						

DC CHARACTERISTICS

Unless otherwise specified, recommended operating conditions apply.

POWER SUPPLY

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
VCC Supply Current	Read/Idle Mode			25	mA
	Write Mode			30	mA
VDD Supply Current (sum of VDD1 and VDD2)	Idle Mode			25	mA
	Read Mode			50	mA
	Write Mode			30 + Iw	mA
Power Dissipation (Tj = +135°C)	Idle Mode			400	mW
	Read Mode			600	mW
	Write Mode, Iw = 50 mA, RCT = 0Ω			1050	mW
	Write Mode, Iw = 50 mA RCT = 120Ω			750	mW

DC CHARACTERISTICS (Continued)

DIGITAL I/O

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
VIL	Input Low Voltage		-0.3		0.8	VDC
VIH	Input High Voltage		2.0		VCC + 0.3	VDC
IIL	Input Low Current	VIL = 0.8V	-0.4			mA
IIH	Input High Current	VIH = 2.0V			85	µA
VOL	WUS Output Low Voltage	IOL = 8 mA			0.5	VDC
IOH	WUS Output High Current	VOH = 5.0V			100	µA

WRITE MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Center Tap Voltage VCT	Write Mode		6.0		VDC
Write Current Range		10		50	mA
Write Current Constant "K"		129		151	
Iwc to Head Current Gain			20		mA/mA
Unselected Head Leakage Current				85	µA
RDX, RDY Common Mode Output Voltage	Write/Idle Mode		4.3		VDC
RDX, RDY Leakage	3.0 < RDX, RDY < 8.0V Write/Idle Mode	-50		+50	µA

READ MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Center Tap Voltage	Read Mode		4.0		VDC
Input Bias Current (differential)				100	µA
Output Offset Voltage	Read Mode	-480		+480	mV
Common Mode Output Voltage	Read Mode	5		7	VDC

DYNAMIC CHARACTERISTICS AND TIMING

Unless otherwise specified, recommended operating conditions apply and Iw = 45 mA, Lh = 10 µH, Rd = 750Ω 32R501 only, f(WDI) = 5 MHz, CL(RDX, RDY) ≤ 20 pF.)

WRITE MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Differential Head Voltage Swing		7.5			V(pk)
Unselected Head Transient Current	5 µH ≤ Lh ≤ 9.5 µH			2	mA(pk)
Differential Output Capacitance				15	pF
Differential Output Resistance	32R501	10K			Ω
	32R501R	600		960	Ω
WDI Transition Frequency	WUS = low	250			KHz

READ MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Differential Voltage Gain	Vin = 1 mVpp @ 300 kHz, RL(RDX), RL(RDY) = 1 kΩ	80		120	V/V
Dynamic Range	DC Input Voltage, Vi, Where Gain Falls by 10%. Vin = Vi + 0.5 mVpp @ 300 KHz	-3		+3	mV
Bandwidth (-3dB)	|Zs| < 5Ω, Vin = 1 mVpp	30			MHz
Input Noise Voltage	BW = 15 MHz, Lh = 0, Rh = 0			1.5	$nV/\sqrt{Hz}$
Differential Input Capacitance	f = 5 MHz			23	pF
Differential Input Resistance	32R501, f = 5 MHz	2K			Ω
Differential Input Resistance	32R501R, f = 5 MHz	460		860	Ω
Common Mode Rejection Ratio	Vcm = VCT + 100 mVpp @ 5 MHz	50			dB
Power Supply Rejection Ratio	100 mVpp @ 5 MHz on VDD1, VDD2 or VCC	45			dB
Channel Separation	Unselected Channels: Vin=100 mVpp @ 5 MHz; Selected Channel: Vin = 0 mVpp	45			dB
Single Ended Output Resistance	f = 5 MHz			30	Ω

READ MODE (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Output Current	AC Coupled Load, RDX to RDY	2.0			mA
External Resistance Load	AC coupled to output per side to GND	100			Ω
Center tap output impedance	$0 \leq f \leq 5$ MHz			150	Ω

SWITCHING CHARACTERISTICS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
R/$\overline{W}$ To Write	Delay to 90% of Write Current			600	ns
R/$\overline{W}$ to Read	Delay to 90% of 100 mV, 10 MHz Read Signal Envelope or to 90% decay of Write Current			600	ns
$\overline{CS}$ to Select	Delay to 90% of Write Current or to 90% of 100 mV, 10 MHz Read Signal Envelope			600	ns
$\overline{CS}$ to Unselect	Delay to 90% Decay of Write Current			600	ns
HS0 - HS2 to any head	Delay to 90% of 100 mV, 10 MHz Read Signal Envelope			600	ns
WUS-Safe to Unsafe - TD1	Iw = 50 mA	1.6		8.0	µs
WUS-Unsafe to Safe - TD2	Iw = 20 mA			1.0	µs
Head Current (Lh = 0 µH, Rh = 0Ω)					
Prop. Delay - TD3	From 50% Points			30	ns
Asymmetry	WDI has 50% Duty Cycle and 1ns Rise/Fall Time			2	ns
Rise/Fall Time	10% - 90% Points			20	ns

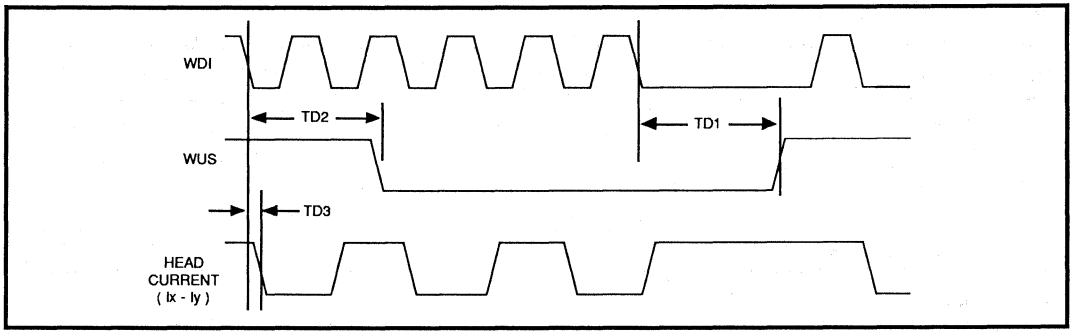
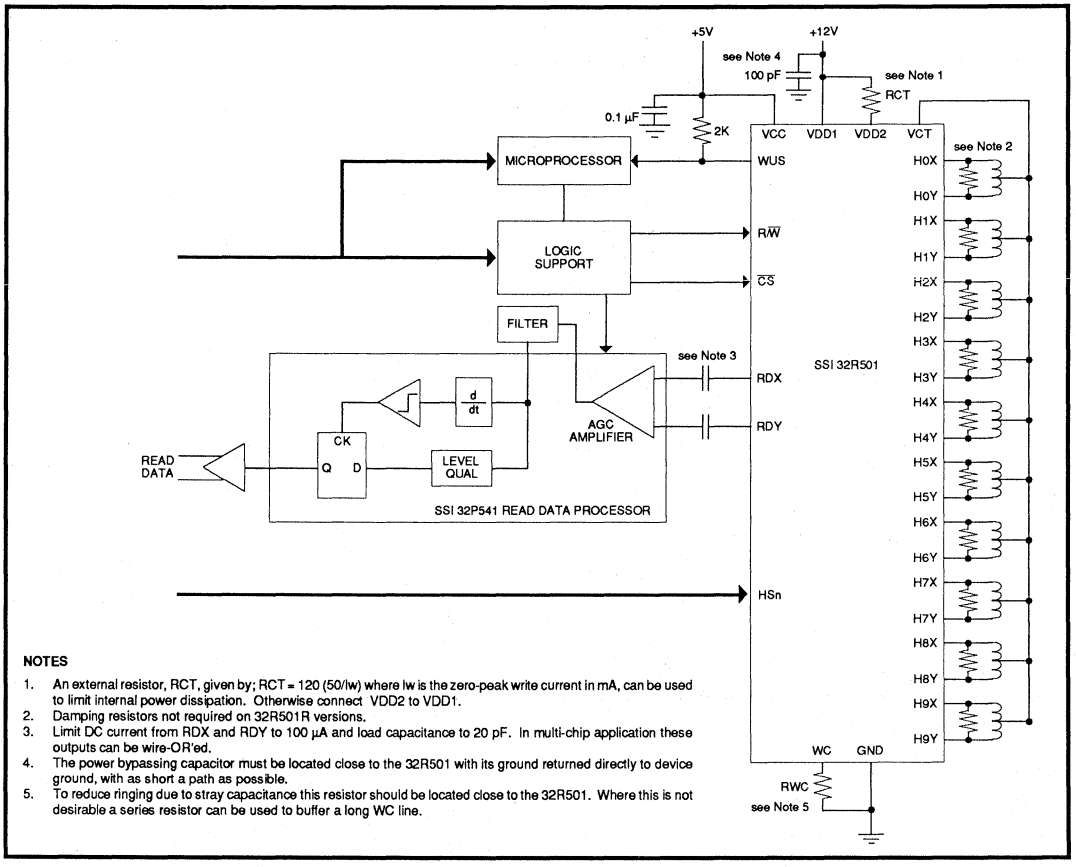


FIGURE 1: Write Mode Timing Diagram



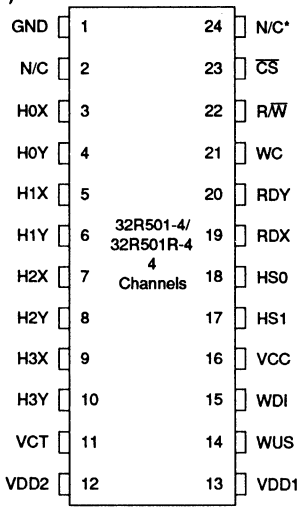
NOTES

1. An external resistor, RCT, given by; RCT = 120 (50/Iw) where Iw is the zero-peak write current in mA, can be used to limit internal power dissipation. Otherwise connect VDD2 to VDD1.
2. Damping resistors not required on 32R501R versions.
3. Limit DC current from RDX and RDY to 100 µA and load capacitance to 20 pF. In multi-chip application these outputs can be wire-OR'ed.
4. The power bypassing capacitor must be located close to the 32R501 with its ground returned directly to device ground, with as short a path as possible.
5. To reduce ringing due to stray capacitance this resistor should be located close to the 32R501. Where this is not desirable a series resistor can be used to buffer a long WC line.

FIGURE 2: Applications Information

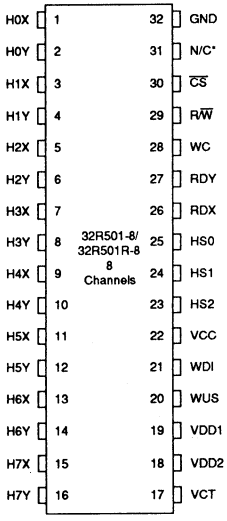
PACKAGE PIN DESIGNATIONS

(TOP VIEW)



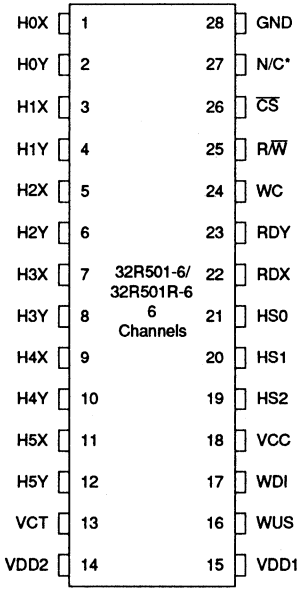
* Must remain open

24-Lead SOL



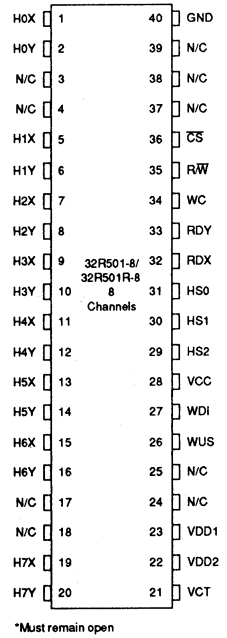
*Must remain open

32-Lead Flatpack, SOW



*Must remain open

28-Lead PDIP, SOL, Flatpack

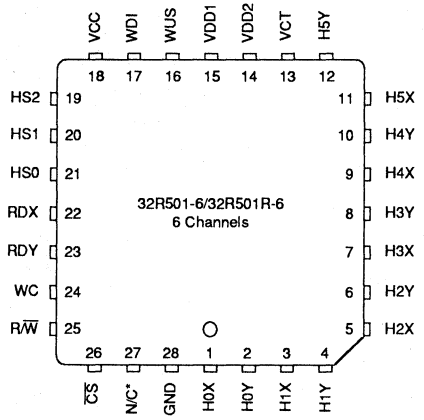


*Must remain open

40-Lead PDIP

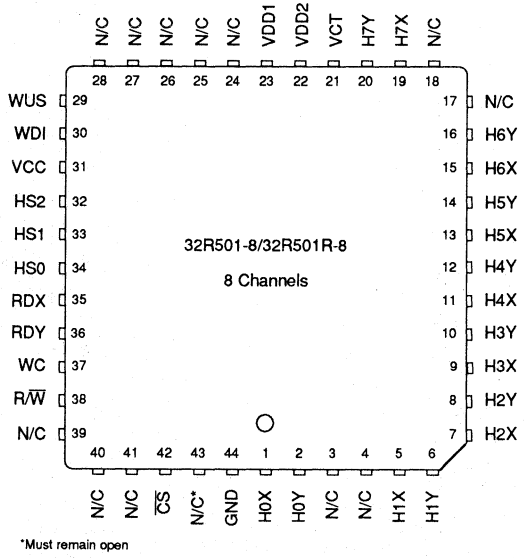
SSI 32R501/501R
4, 6, 8-Channel Ferrite Read/Write Device

PACKAGE PIN DESIGNATIONS
(TOP VIEW)



*Must remain open

28-Lead PLCC



*Must remain open

44-Lead PLCC

THERMAL CHARACTERISTICS: θja

24-lead	SOL	80°C/W	32-lead	FLATPACK	60°C/W
28-lead	PDIP	55°C/W		SOW	55°C/W
	PLCC	65°C/W	40-lead	PDIP	45°C/W
	SOL	70°C/W	44-lead	PLCC	60°C/W
	Flatpack	65°C/W			

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32R501		
4-Channel SOL	SSI 32R501-4CL	32R501-4CL
6-Channel Flatpack	SSI 32R501-6F	32R501-6F
6-Channel PLCC	SSI 32R501-6CH	32R5O1-6CH
6-Channel SOL	SSI 32R501-6CL	32R501-6CL
6-Channel PDIP	SSI 32R501-6CP	32R501-6CP
8-Channel Flatpack	SSI 32R501-8F	32R501-8F
8-Channel SOW	SSI 32R501-8CW	32R501-8CW
8-Channel PDIP	SSI 32R501-8CP	32R501-8CP
8-Channel PLCC	SSI 32R501-8CH	32R501-8CH
SSI 32R501R		
4-Channel SOL	SSI 32R501R-4CL	32R501R-4CL
6-Channel Flatpack	SSI 32R501R-6F	32R501R-6F
6-Channel PLCC	SSI 32R501R-6CH	32R501R-6CH
6-Channel SOL	SSI 32R501R-6CL	32R501R-6CL
6-Channel PDIP	SSI 32R501R-6CP	32R501R-6CP
8-Channel Flatpack	SSI 32R501R-8F	32R501R-8F
8-Channel SOW	SSI 32R501R-8CW	32R501R-8CW
8-Channel PDIP	SSI 32R501R-8CP	32R501R-8CP
8-Channel PLCC	SSI 32R501R-8CH	32R501R-8CH

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32R502R

6, 7, 8-Channel Center-Tapped Thin Film Read/Write Device

Advance Information

1

July, 1990

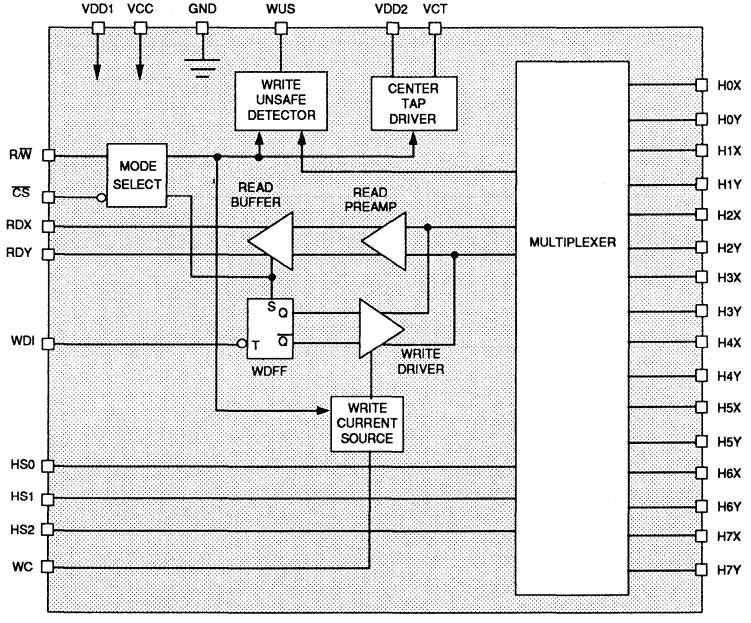
DESCRIPTION

The SSI 32R502R Read/Write devices are bipolar monolithic integrated circuits designed for use with center-tapped, three-terminal, thin-film or ferrite recording heads. They provide a low-noise read amplifier, write current control and data protection circuitry for as many as eight channels. They require +5 and +12V power supplies and are available in a variety of package configurations. The SSI 32R502R provides internal 750Ω damping resistors. Please refer to ordering information for different packaging options.

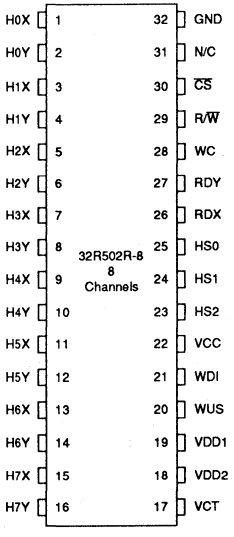
FEATURES

- **High performance**
  - **Read mode gain = 120 V/V**
  - **Input noise = 1.5 nV/√Hz maximum**
  - **Input capacitance = 23 pF**
  - **Write current range = 10 mA to 50 mA**
- **Power supply fault protection**
- **Pin compatible with the SSI 32R501R**
- **Designed for center-tapped thin film and ferrite heads**
- **Programmable write current source**
- **Easily multiplexed for larger systems**
- **Includes write unsafe detection**
- **TTL compatible control signals**
- **+5V, +12V power supplies**

BLOCK DIAGRAM



PIN DIAGRAM



32-LEAD SOW

CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 32R502R
6, 7, 8-Channel Center-Tapped Thin Film Read/Write Device

CIRCUIT OPERATION

The SSI 32R502R gives the user the ability to address up to 8 center-tapped thin film or ferrite heads and provide write drive or read amplification. Head selection and mode control is accomplished using the HSn, $\overline{CS}$ and R/$\overline{W}$ inputs as shown in tables 1 & 2. Internal pullups are provided for the $\overline{CS}$ & R/$\overline{W}$ inputs to force the device into a non-writing condition if either control line is opened accidentally.

TABLE 1: MODE SELECT

$\overline{CS}$	R/$\overline{W}$	MODE
0	0	Write
0	1	Read
1	X	Idle

TABLE 2: HEAD SELECT

HS2	HS1	HS0	HEAD
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

0 = Low level 1 = High level

WRITE MODE

Taking both $\overline{CS}$ and R/$\overline{W}$ low selects write mode which configures the SSI 32R502R as a current switch and activates the Write Unsafe (WUS) detector circuitry. Write current is toggled between the X and Y side of the selected head on each high to low transition of the Write Data Input (WDI). Note that a preceding read mode selection initializes the Write Data Flip-Flop, WDFF, to pass write current through the "X" side of the head. The zero-peak write current magnitude is programmed by an external resistor Rwc from pin WC to GND and is given by:

Iw = K/Rwc, where K = Write Current Constant

The Write Unsafe detection circuitry monitors voltage transitions at the selected head connections and flags any of the following conditions as a high level on the Write Unsafe open collector output:

- Head open
- WDI frequency too low
- Device not selected
- Head center tap open
- Device in read mode
- No write current

Two negative transitions on WDI, after the fault is corrected, will clear the WUS flag.

To further assure data security a voltage fault detection circuit prevents application of write current during power loss or power sequencing.

To enhance write-to-read recovery time the change in RDX, RDY common mode voltage is minimized by biasing these outputs to a level within the read mode range when in write mode.

Power dissipation in write mode may be reduced by placing a resistor (RCT) between VDD1 & VDD2. The optimum resistor value is 120Ω x 50 /Iw (Iw in mA). At low write currents (<15 mA) read mode dissipation is higher than write mode and RCT, though recommended, may not be considered necessary. In this case VDD2 is connected directly to VDD1.

READ MODE

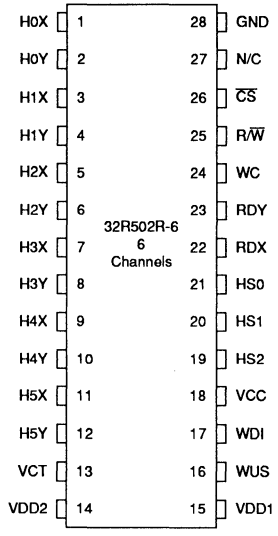
Taking $\overline{CS}$ low and R/$\overline{W}$ high selects read mode which configures the SSI 32R502R as a low noise differential amplifier for the selected head. The RDX and RDY outputs are driven by emitter followers and are in phase with the "X" and "Y" head ports. These outputs should be AC coupled to the load. The internal write current source is gated off in read mode eliminating the need for any external gating.

Read mode selection also initializes the Write Data Flip-Flop (WDFF) to pass write current through the "X" side of the head at a subsequent write mode selection.

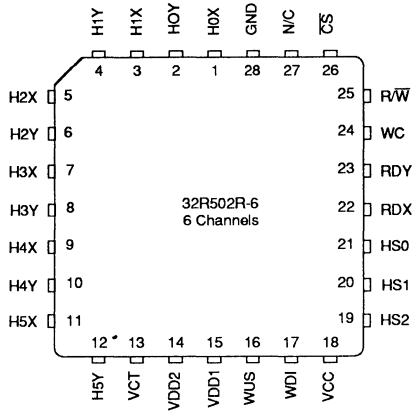
IDLE MODE

Taking $\overline{CS}$ high selects the idle mode which switches the RDX, RDY outputs into a high impedance state and deactivates the internal write current source. This facilitates multi-device installations by allowing the read outputs to be wire OR'ed.

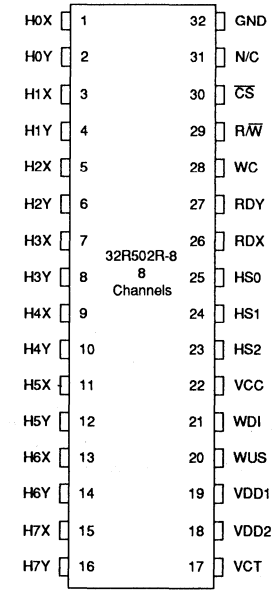
PACKAGE PIN DESIGNATIONS (Top View)



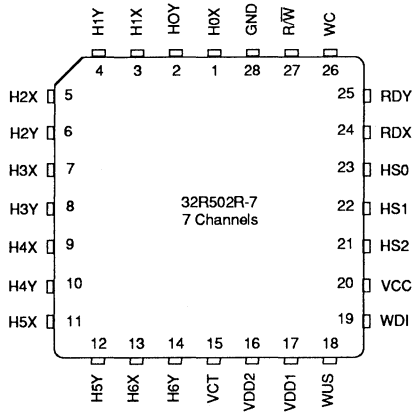
28-Lead SOL



28-Lead PLCC



32-Lead SOW



7-Channel 28-Lead PLCC

THERMAL CHARACTERISTICS: Øja

28-lead	PLCC	65°C/W
	SOL	70°C/W
32-lead	SOW	55°C/W

SSI 32R502R
6, 7, 8-Channel Center-Tapped Thin Film Read/Write Device

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32R510/510AR
32R514/514R
2, 4, 6 Channel Read/Write Devices

1

June, 1990

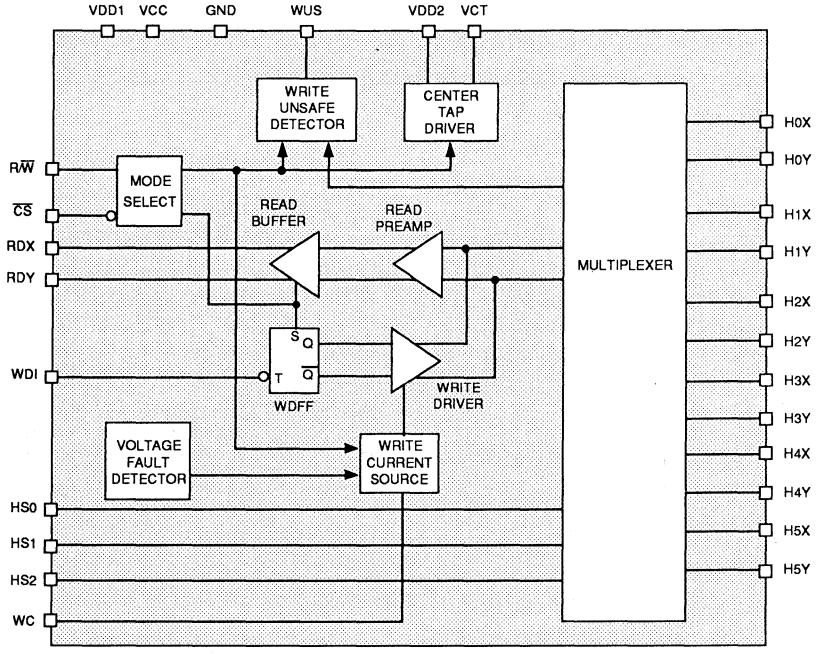
DESCRIPTION

The SSI 32R510/510AR, 32R514/514R Read/Write devices are bipolar monolithic integrated circuits designed for use with center-tapped ferrite recording heads. They provide a low noise read amplifier, write current control and data protection circuitry for as many as six channels. The R option provides internal 750Ω damping resistors. Power supply fault protection is provided by disabling the write current generator during power sequencing. System write to read recovery time is significantly improved by controlling the read channel common mode output voltage shift in the write mode. They are available in a variety of package and channel configurations.

FEATURES

- **High performance:**
  - **Read mode gain = 100 V/V (32R510A)**
    = 150 V/V (32R514)
  - **Input noise = 1.5 nV/$\sqrt{Hz}$ max.**
  - **Input capacitance = 20 pF max.**
  - **Write current range = 10 mA to 40 mA**
- **Enhanced system write to read recovery time**
- **Power supply fault protection**
- **Plug compatible to the SSI 32R117**
- **Designed for center-tapped ferrite heads**
- **Programmable write current source**
- **Write unsafe detection**
- **TTL compatible control signals**
- **+5V, +12V power supplies**

BLOCK DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

CIRCUIT OPERATION

These devices address up to six center-tapped ferrite heads providing write drive or read amplification. Head selection and mode control is accomplished with pins HSn, $\overline{CS}$, and R/$\overline{W}$, as shown in Tables 1 & 2. Internal resistor pullups, provided on pins $\overline{CS}$ and R/$\overline{W}$, will force the device into a non-writing condition if either control line is opened accidentally.

TABLE 1: Mode Select

$\overline{CS}$	R/$\overline{W}$	MODE
0	0	Write
0	1	Read
1	X	Idle

TABLE 2: Head Select

HS2	HS1	HS0	HEAD
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	X	None

0 = Low level 1 = High level X=Don't care

WRITE MODE

The write mode configures the device as a current switch and activates the Write Unsafe (WUS) detection circuitry. Write current is toggled between the X and Y side of the selected head on each high to low transition of the Write Data Input (WDI).

The magnitude of the write current (0-pk) is programmed by an external resistor RWC, connected from pin WC to ground and is given by:

$$Iw = \frac{K}{RWC}$$

where K is the Write Current Constant. In multiple device applications, a single RWC resistor may be made common to all devices.

Power supply fault protection improves data security by disabling the write current generator during a voltage fault or power supply sequencing. Additionally, the write unsafe detection circuitry monitors voltage transitions at the selected head connections and flags any of the conditions listed below as a high level on the open collector output pin, WUS. Two negative transitions on pin WDI, after the fault is corrected, are required to clear the WUS flag.

- Head open
- WDI frequency too low
- Device not selected
- Head center tap open
- Device in read mode
- No write current

To reduce internal power dissipation, an optional external resistor, RCT, given by RCT ≤ 130Ω x 40/Iw (Iw in mA), is connected between pins VDD1 and VDD2. Otherwise connect pin VDD1 to VDD2.

To initialize the Write Data Flip Flop (WDFF) to pass current through the X-side of the head, pin WDI must be low when the previous read mode was commanded.

READ MODE

The read mode configures the device as a low noise differential amplifier and deactivates the write current generator and write unsafe circuitry. The RDX and RDY outputs are emitter followers and are in phase with the "X" and "Y" head ports. These outputs should be AC coupled to the load. The RDX, RDY common mode voltage is maintained in the write mode, minimizing the transient between write mode and read mode, substantially reducing the write to read recovery time in the subsequent pulse detection circuitry.

IDLE MODE

The idle mode deactivates the internal write current generator, the write unsafe detector, and switches the RDX, RDY outputs into a high impedance state. This facilitates multiple device applications by enabling the read outputs to be wire OR'ed and the write current programming resistor to be common to all devices.

PIN DESCRIPTIONS

NAME	I/O	DESCRIPTION
HS0-HS2	I	Head Select
$\overline{CS}$	I	Chip Select: a low level enables device
R/$\overline{W}$	I	Read/Write: a high level selects Read mode
WUS	O*	Write Unsafe: a high level indicates an unsafe writing condition
WDI	I	Write Data In: negative transition toggles direction of head current
H0X-H5X H0Y-H5Y	I/O	X,Y head connections
RDX, RDY	O*	X, Y Read Data: differential read signal output
WC	*	Write Current: used to set the magnitude of the write current
VCT	-	Voltage Center Tap: voltage source for head center tap
VCC	-	+5V
VDD1	-	+12V
VDD2	-	Positive power supply for the center-tap voltage source
GND	-	Ground

*When more than one R/W device is used, these signals can be wire OR'ed.

ABSOLUTE MAXIMUM RATINGS

(All voltages referenced to GND. Currents into device are positive.)

PARAMETER		VALUE	UNITS
DC Supply Voltage	VDD1	-0.3 to +14	VDC
DC Supply Voltage	VDD2	-0.3 to +14	VDC
DC Supply Voltage	VCC	-0.3 to +6	VDC
Digital Input Voltage Range	VIN	-0.3 to VCC + 0.3	VDC
Head Port Voltage Range	VH	-0.3 to VDD1 + 0.3	VDC
WUS Pin Voltage Range	Vwus	-0.3 to +14	VDC
Write Current (0-pk)	Iw	60	mA
RDX, RDY Output Current	Io	-10	mA
VCT Output Current	Ivct	-60	mA
WUS Output Current	Iwus	+12	mA
Storage Temperature Range	Tstg	-65 to 150	°C
Lead Temperature PDIP, (10 sec Soldering)		260	°C
Package Temperature PLCC, SO (20 sec Reflow)		215	°C

RECOMMENDED OPERATING CONDITIONS

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
VDD1	DC Supply Voltage		10.8	12.0	13.2	VDC
VCC	DC Supply Voltage		4.5	5.0	5.5	VDC
Lh	Head Inductance		5		15	µH
RD	Damping Resistor	32R510A and 32R514 only	500		2000	Ω
RCT*	RCT Resistor	Iw = 40 mA	123	130	137	Ω
Iw	Write Current (0-pk)		10		40	mA
Tj	Junction Temperature Range		+25		+135	°C

*For Iw = 40 mA. At other Iw levels refer to Applications Information that follows this specification.

DC CHARACTERISTICS

(Recommended operating conditions apply unless otherwise specified.)

POWER SUPPLY

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
VCC Supply Current	Read/Idle Mode			35	mA
	Write Mode			30	mA
VDD Supply Current	Idle Mode			20	mA
(sum of VDD1 and VDD2)	Read Mode			35	mA
	Write Mode			20 + Iw	mA
Power Dissipation (Tj = +135°C)	Idle Mode			400	mW
	Read Mode			600	mW
	Write Mode, Iw = 40 mA, RCT = 0Ω			800	mW
	Write Mode, Iw = 40 mA, RCT = 130Ω			600	mW

DC CHARACTERISTICS (continued)

DIGITAL I/O

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
VIL	Input Low Voltage				0.8	VDC
VIH	Input High Voltage		2.0			VDC
IIL	Input Low Current	VIL = 0.8V	-0.4			mA
IIH	Input High Current	VIH = 2.0V			100	µA
VOL	WUS Output Low Voltage	IOL = 8 mA			0.5	VDC
IOH	WUS Output High Current	VOH = 5.0V			100	µA

WRITE MODE

VCT Center Tap Voltage	Write Mode 32R510A		6.0		
	Write Mode 32R514		6.7		VDC
Head Current (per side)	Write Mode, 0 ≤ VCC ≤ 3.7V, 0 ≤ VDD1 ≤ 8.7V	-200		200	µA
Write Current Range		10		40	mA
Write Current Constant "K"		2.375		2.625	
Iwc to Head Current Gain			0.99		mA/mA
Unselected Head Leakage Current				85	µA
RDX, RDY Output Offset Voltage	Write/Idle Mode	-20		+20	mV
RDX, RDY Common Mode Output Voltage	Write/Idle Mode		5.3		VDC
RDX, RDY Leakage	RDX, RDY = 6V Write/Idle Mode	-100		100	µA

READ MODE

VCT Center Tap Voltage	Read Mode		4.0		VDC
Head Current (per side)	Read or Idle Mode 0 ≤ VCC ≤ 5.5V 0 ≤ VDD1 ≤ 13.2V	-200		200	µA
Input Bias Current (per side)				45	µA
Output Offset Voltage	Read Mode 32R510A	-440		+440	mV
	Read Mode 32R514	-615		+615	mV
Common Mode Output Voltage	Read Mode	4.5		6.5	VDC

DYNAMIC CHARACTERISTICS AND TIMING

Iw = 35 mA, Lh = 10 µH, Rd = 750 Ω 32R514 only, f(WDI) = 5 MHz, CL(RDX, RDY) ≤ 20 pF. Recommended operating conditions apply unless otherwise specified.

WRITE MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Differential Head Voltage Swing		7.0			V(pk)
Unselected Head Transient Current				2	mA(pk)
Differential Output Capacitance				15	pF
Differential Output Resistance	32R510A and 32R514	10K			Ω
	32R510AR and 32R514R	600		960	Ω
WDI Transition Frequency	WUS = low	250			KHz

READ MODE

Differential Voltage Gain	32R510A	Vin = 1 mVpp @ 300 kHz ZL(RDX), ZL(RDY) = 1 kΩ	85		115	V/V
	32R514	Vin = 1 mVpp @ 300 kHz ZL(RDX), ZL(RDY) = 1 kΩ	125		175	V/V
Dynamic Range		DC Input Voltage, Vi, Where Gain Falls by 10% Vin = Vi + 0.5 mVpp @ 300 kHz	-2		+2	mV
Bandwidth (-3dB)		|Zs| < 5Ω, Vin = 1 mVpp	30			MHz
Input Noise Voltage		BW = 15 MHz, Lh = 0, Rh = 0			1.5	nV/√Hz
Differential Input Capacitance		f = 5 MHz			20	pF
Differential Input Resistance		32R514, f = 5 MHz	3.2K			Ω
		32R514R, f = 5 MHz	500		1000	Ω
		32R510A, f = 5 MHz	2K			Ω
		32R510AR, f = 5 MHz	460		860	Ω
Common Mode Rejection Ratio		Vcm = VCT + 100 mVpp @ 5 MHz	50			dB
Power Supply Rejection Ratio		100 mVpp @ 5 MHz on VDD1, VDD2 or VCC	45			dB
Channel Separation		Unselected Channels: Vin=100 mVpp @ 5 MHz; Selected Channel: Vin = 0 mVpp	45			dB
Single Ended Output Resistance		f = 5 MHz			30	Ω
Output Current		AC Coupled Load, RDX to RDY	±2.1			mA

DYNAMIC CHARACTERISTICS AND TIMING (continued)

SWITCHING CHARACTERISTICS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
R/$\overline{W}$ To Write Mode	Delay to 90% of Write Current			1.0	µs
R/$\overline{W}$ to Read Mode	Delay to 90% of 100 mV, 10 MHz Read Signal Envelope or to 90% decay of Write Current			1.0	µs
$\overline{CS}$ to Select	Delay to 90% of Write Current or to 90% of 100 mV, 10 MHz Read Signal Envelope			1.0	µs
$\overline{CS}$ to Unselect	Delay to 90% Decay of Write Current			1.0	µs
HS0 - HS2 to any head	Delay to 90% of 100mV 10 MHz Read Signal Envelope			1.0	µs
WUS, Safe to Unsafe - TD1	Iw = 35 mA, see Figure 1	1.6		8.0	µs
WUS, Unsafe to Safe - TD2	Iw = 35 mA, see Figure 1			1.0	µs
Head Current (Lh = 0 µH, Rh = 0Ω, see Figure 1)					
Prop. Delay - TD3	From 50% Points			25	ns
Asymmetry	WDI has 50% Duty Cycle and 1ns Rise/Fall Time			2	ns
Rise/Fall Time	10% - 90% Points			20	ns

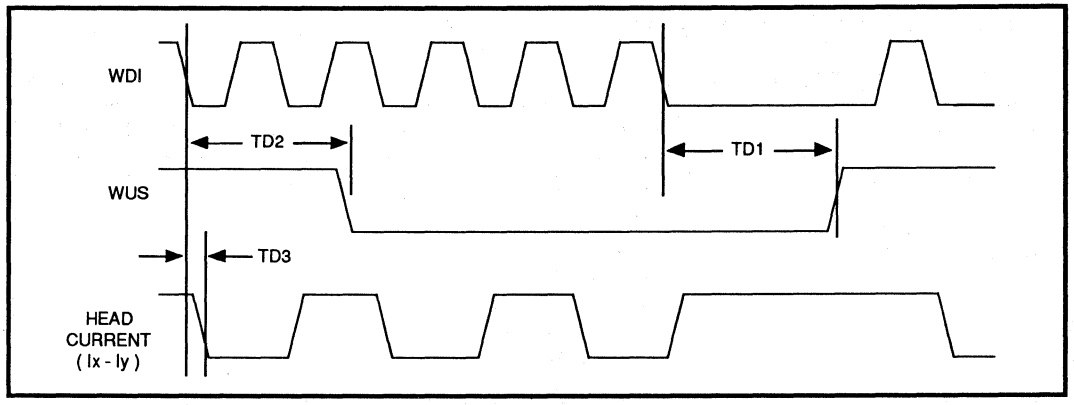


FIGURE 1: Write Mode Timing Diagram

APPLICATIONS INFORMATION

The specifications, provided in the data section, account for the worst case values of each parameter taken individually. In actual operation, the effects of worst case conditions on many parameters correlate. Tables 3 & 4 demonstrate this for several key parameters. Notice that under the conditions of worst case input noise, the higher read back signal resulting from the higher input impedance can compensate for the higher input noise. Accounting for this correlation in your analysis will be more representative of actual performance.

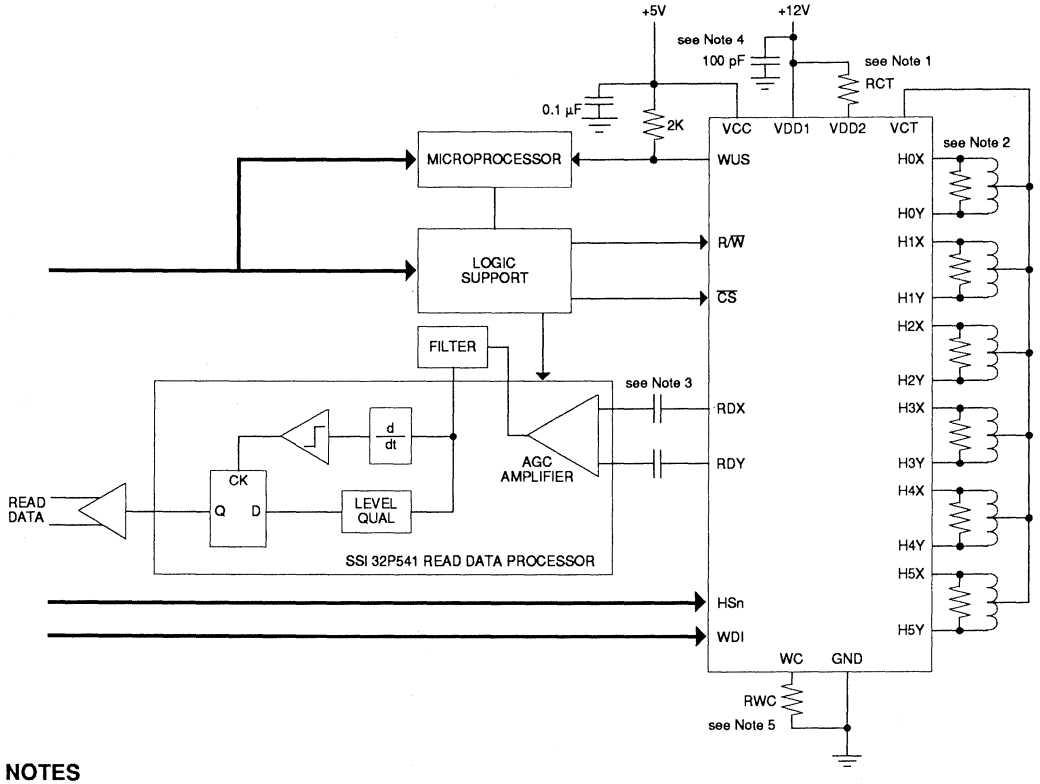
TABLE 3: Key Parameters Under Worst Case Input Noise Conditions

PARAMETER		Tj=25°C	Tj=135°C	UNITS
Inputs Noise Voltage (max.)		1.1	1.5	nV/√Hz
Differential Input Resistance (min.)	32R514R	850	1000	Ω
	32R514	15.4	29.4	KΩ
Differential Input Capacitance (max.)		11.6	10.8	pF

TABLE 4: Key Parameters Under Worst Case Input Impedance Conditions

PARAMETER		Tj=25°C	Tj=135°C	UNITS
Inputs Noise Voltage (max.)		0.92	1.2	nV/√Hz
Differential Input Resistance (min.)	32R514R	500	620	Ω
	32R514	3.2	6.1	KΩ
Differential Input Capacitance (max.)		10.1	10.3	pF

APPLICATIONS INFORMATION (continued)



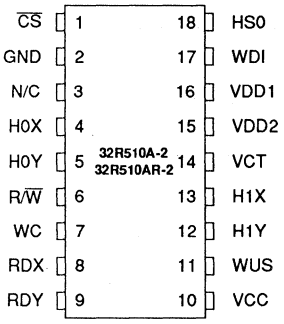
NOTES

1. An external resistor, RCT, given by; RCT ≤ 130 (40/Iw) where Iw is the zero-peak write current in mA, can be used to limit internal power dissipation. Otherwise connect VDD2 to VDD1.
2. Damping resistors not required on R versions.
3. Limit DC current from RDX and RDY to 100 µA and load capacitance to 20 pF. In multi-chip application these outputs can be wire OR'ed.
4. The power bypassing capacitor must be located close to the device with its ground returned directly to device ground, with as short a path as possible.
5. To reduce ringing due to stray capacitance this resistor should be located close to the device. Where this is not desirable a series resistor can be used to buffer a long WC line. In multi-chip applications a single resistor common to all chips may be used.

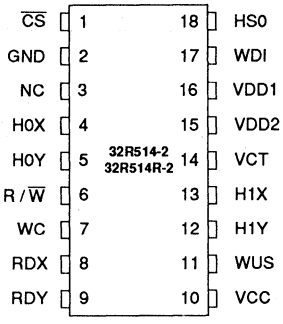
FIGURE 2: Typical Application Diagram

SSI 32R510A/510AR
32R514/514R
2, 4, 6-Channel
Read/Write Devices

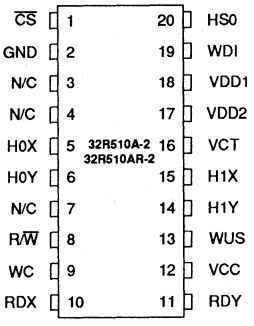
PACKAGE PIN DESIGNATIONS (TOP VIEW)



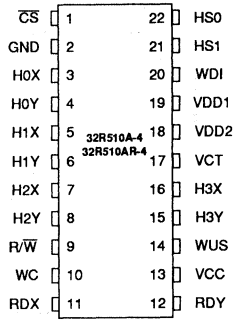
18-LEAD PDIP



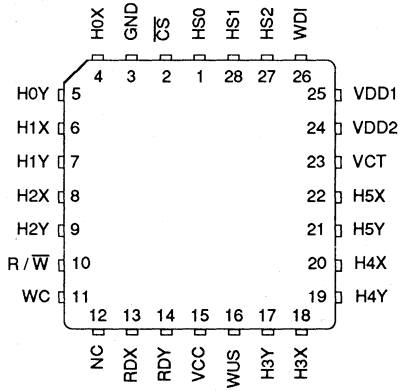
18-LEAD SOL



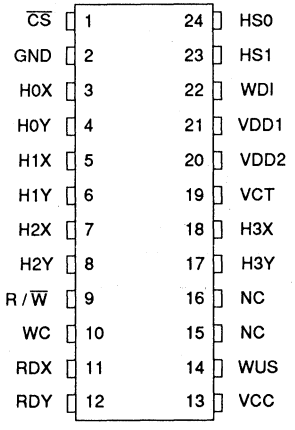
20-LEAD SOL



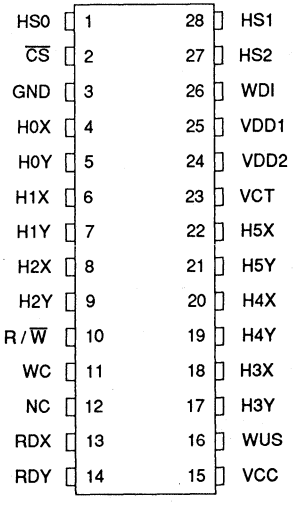
22-LEAD PDIP



6-CHANNEL
28-LEAD PLCC



4-CHANNEL
24-LEAD SOL,FLATPACK



6-CHANNEL
28-LEAD PDIP,
FLATPACK, SOL

THERMAL CHARACTERISTICS

PACKAGE		θja
18-Lead	PDIP	140°C/W
18-Lead	SOL	100°C/W
20-Lead	SOL	95°C/W
22-Lead	PDIP	65°C/W
24-Lead	Flatpack	105°C/W
24-Lead	SOL	80°C/W
28-Lead	PLCC	65°C/W
28-Lead	Flatpack	100°C/W
28-Lead	PDIP	55°C/W
28-Lead	SOL	70°C/W

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32R510A		
2-Channel PDIP	SSI 32R510A-2P	32R510A-2P
2-Channel SOL	SSI 32R510A-2L	32R510A-2L
4-Channel SOL	SSI 32R510A-4CL	32R510A-4CL
4-Channel Flatpack	SSI 32R510A-4F	32R510A-4F
4-Channel PDIP	SSI 32R510A-4CP	32R510A-4CP
6-Channel PDIP	SSI 32R510A-6CP	32R510A-6CP
6-Channel SOL	SSI 32R510A-6CL	32R510A-6CL
6-Channel Flatpack	SSI 32R510A-6F	32R510A-6F
6-Channel PLCC,	SSI 32R510A-6CH	32R510A-6CH
SSI 32R510AR with Internal Damping Resistor		
2-Channel PDIP	SSI 32R510AR-2P	32R510AR-2P
2-Channel SOL	SSI 32R510AR-2L	32R510AR-2L
4-Channel SOL	SSI 32R510AR-4CL	32R510AR-4CL
4-Channel Flatpack	SSI 32R510AR-4F	32R510AR-4F
4-Channel PDIP	SSI 32R510AR-4CP	32R510AR-4CP
6-Channel PDIP	SSI 32R510AR-6CP	32R510AR-6CP
6-Channel SOL	SSI 32R510AR-6CL	32R510AR-6CL
6-Channel Flatpack	SSI 32R510AR-6F	32R510AR-6F
6-Channel PLCC	SSI 32R510AR-6CH	32R510AR-6CH
SSI 32R514 Read/Write IC		
2-Channel SOL	SSI 32R514-2CL	32R514-2CL
4-Channel SOL	SSI 32R514-4CL	32R514-4CL
6-Channel SOL	SSI 32R514-6CL	32R514-6CL
6-Channel PLCC	SSI 32R514-6CH	32R514-6CH
SSI 32R514R Read/Write IC-with internal damping resistors		
2-Channel SOL	SSI 32R514R-2CL	32R514R-2CL
4-Channel SOL	SSI 32R514R-4CL	32R514R-4CL
6-Channel SOL	SSI 32R514R-6CL	32R514R-6CL
6-Channel PLCC	SSI 32R514R-6CH	32R514R-6CH

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32R511/511R
SSI 32R5111/5111R
4, 6, 8-Channel Ferrite/MIG Read/Write Devices

1

July, 1990

DESCRIPTION

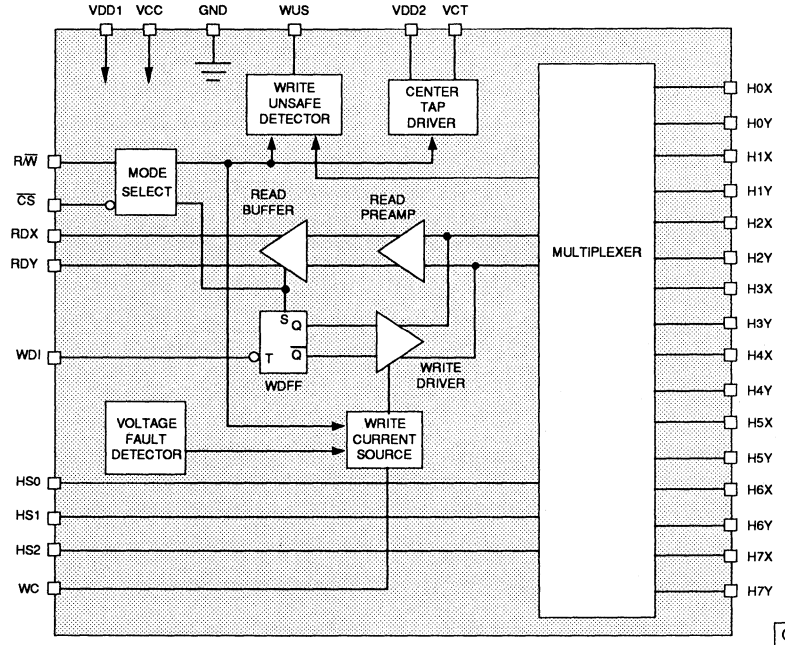
The SSI 32R511 and 32R5111 are bipolar monolithic integrated circuits designed for use with center-tapped ferrite or MIG recording heads. They offer the performance upgrades of the SSI 32R510A, along with the improved pin arrangement of the SSI 32R501. Both provide a low noise read path, write current control, and data protection circuitry for as many as 8 channels. They require +5V and +12V power supplies and are available in a variety of packages.

The R option adds internal 750Ω damping resistors. The M versions have a mirror image pin arrangement to simplify layout when using multiple devices.

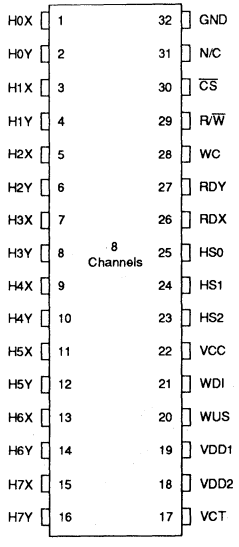
FEATURES

- **High performance**
  - **Read mode gain = 100 V/V (32R511)**
  - **= 150V/V (32R5111)**
  - **Input noise = 1.5 nV/√Hz maximum**
  - **Input capacitance = 20 pF**
  - **Write current range = 10 mA to 40 mA**
- **Enhanced system write to read recovery time**
- **Power supply fault protection**
- **Pin compatible with the SSI 32R501/501R**
- **Designed for center-tapped ferrite or MIG heads**
- **Programmable write current source**
- **Easily multiplexed for larger systems**
- **Includes write unsafe detection**
- **TTL compatible control signals**
- **+5V, +12V power supplies**
- **Mirror image pin arrangements**

BLOCK DIAGRAM



PIN DIAGRAM



32-LEAD SOW

CAUTION: Use handling procedures necessary for a static sensitive component.

CIRCUIT OPERATION

These devices give the user the ability to address up to 8 center-tapped ferrite heads and provide write drive or read amplification. Head selection and mode control is accomplished using the HSn, $\overline{CS}$ and R/$\overline{W}$ inputs as shown in tables 1 & 2. Internal pullups are provided for the $\overline{CS}$ & R/$\overline{W}$ inputs to force the device into a non-writing condition if either control line is opened accidentally.

TABLE 1: Mode Select

$\overline{CS}$	R/$\overline{W}$	MODE
0	0	Write
0	1	Read
1	X	Idle

TABLE 2: Head Select

HS2	HS1	HS0	HEAD
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

0 = Low level 1 = High level

WRITE MODE

Taking both $\overline{CS}$ and R/$\overline{W}$ low selects write mode which configures the SSI 32R511/5111 as a current switch and activates the Write Unsafe (WUS) detector circuitry. Write current is toggled between the X and Y side of the selected head on each high to low transition of the Write Data Input (WDI). Note that a preceding read mode selection initializes the Write Data Flip-Flop, WDFF, to pass write current through the "X" side of the head. The zero-peak write current magnitude is programmed by an external resistor Rwc from pin WC to GND and is given by:

Iw = K/Rwc, where K = Write Current Constant

The Write Unsafe detection circuitry monitors voltage transitions at the selected head connections and flags any of the following conditions as a high level on the Write Unsafe open collector output:

- Head open
- WDI frequency too low
- Device not selected
- Head center tap open
- Device in read mode
- No write current

Two negative transitions on WDI, after the fault is corrected, will clear the WUS flag.

To further assure data security a voltage fault detection circuit prevents application of write current during power loss or power sequencing.

To enhance write to read recovery time the change in RDX, RDY common mode voltage is minimized by biasing these outputs to a level within the read mode range when in write mode.

Power dissipation in write mode may be reduced by placing a resistor (RCT) between VDD1 & VDD2. The optimum resistor value is 120Ω x 40 /Iw (Iw in mA). At low write currents (<15 mA) read mode dissipation is higher than write mode and RCT, though recommended, may not be considered necessary. In this case VDD2 is connected directly to VDD1.

READ MODE

Taking $\overline{CS}$ low and R/$\overline{W}$ high selects read mode which configures the SSI 32R511/5111 as a low noise differential amplifier for the selected head. The RDX and RDY outputs are driven by emitter followers and are in phase with the "X" and "Y" head ports. These outputs should be AC coupled to the load. The internal write current source is gated off in read mode eliminating the need for any external gating.

Read mode selection also initializes the Write Data Flip-Flop (WDFF) to pass write current through the "X" side of the head at a subsequent write mode selection.

IDLE MODE

Taking $\overline{CS}$ high selects the idle mode which switches the RDX, RDY outputs into a high impedance state and deactivates the internal write current source. This facilitates multi-device installations by allowing the read outputs to be wire OR'ed and the write current programming resistor to be common to all devices.

PIN DESCRIPTIONS

NAME	I/O	DESCRIPTION
HS0-HS2	I	Head Select
$\overline{CS}$	I	Chip Select: a low level enables device
R/$\overline{W}$	I	Read/Write: a high level selects read mode
WUS	O*	Write Unsafe: a high level indicates an unsafe writing condition
WDI	I	Write Data In: negative transition toggles direction of head current
H0X-H7X H0Y-H7Y	I/O	X,Y head connections
RDX, RDY	O*	X, Y Read Data: differential read signal out
WC	*	Write Current: used to set the magnitude of the write current
VCT	-	Voltage Center Tap: voltage source for head center tap
VCC	-	+5V
VDD1	-	+12V
VDD2	-	Positive power supply for the center tap voltage source
GND	-	Ground

*When more than one R/W device is used, these signals can be wire OR'ed.

ELECTRICAL CHARACTERISTICS

RECOMMENDED OPERATING CONDITIONS

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
DC Supply Voltage	VDD1		10.8	12.0	13.2	VDC
DC Supply Voltage	VCC		4.5	5.0	5.5	VDC
Head Inductance	Lh		5		15	µH
Damping Resistor	RD	32R511/5111 only	500		2000	Ω
RCT Resistor	RCT*	Iw = 40 mA	114	120	126	Ω
Write Current	IW		10		40	mA
Junction Temperature Range	Tj		+25		+135	°C

*For Iw = 40 mA. At other Iw levels refer to Applications Information that follows this specification.

ABSOLUTE MAXIMUM RATINGS (All voltages referenced to GND. Currents into device are positive. Operation above maximum ratings may permanently damage the device.)

PARAMETER		VALUE	UNITS
DC Supply Voltage	VDD1	-0.3 to +14	VDC
DC Supply Voltage	VDD2	-0.3 to +14	VDC
DC Supply Voltage	VCC	-0.3 to +6	VDC
Digital Input Voltage Range	VIN	-0.3 to VCC + 0.3	VDC
Head Port Voltage Range	VH	-0.3 to VDD1 + 0.3	VDC
WUS Pin Voltage Range	Vwus	-0.3 to +14	VDC
Write Current Zero Peak	IW	60	mA
RDX, RDy Output Current	Io	-10	mA
VCT Output Current	IVCT	-60	mA
WUS Output Current	Iwus	+12	mA
Storage Temperature Range	Tstg	-65 to 150	°C
Lead Temperature PDIP, Flat Pack (10 sec Soldering)		260	°C
Package Temperature PLCC, SO (20 sec Reflow)		215	°C

DC CHARACTERISTICS

(Unless otherwise specified, recommended operating conditions apply.)

POWER SUPPLY

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
VCC Supply Current	Read/Idle Mode			35	mA
	Write Mode			30	mA
VDD Supply Current (sum of VDD1 and VDD2)	Idle Mode			20	mA
	Read Mode			35	mA
	Write Mode			20 + Iw	mA
Power Dissipation (Tj = +125°C)	Idle Mode			400	mW
	Read Mode			600	mW
	Write Mode, IW = 40 mA, RCT = 0Ω			800	mW
	Write Mode, IW = 40 mA, RCT = 120Ω			610	mW

DC CHARACTERISTICS (continued)

DIGITAL I/O

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
VIL	Input Low Voltage				0.8	VDC
VIH	Input High Voltage		2.0		VCC + 0.3	VDC
IIL	Input Low Current	VIL = 0.8V	-0.4			mA
IIH	Input High Current	VIH = 2.0V			100	µA
VOL	WUS Output Low Voltage	IOL = 8 mA			0.5	VDC
IOH	WUS Output High Current	VOH = 5.0V			100	µA

WRITE MODE

Center Tap Voltage VCT	Write Mode		6.0		VDC
Head Current (per side)	Write Mode, 0 ≤ VCC ≤ 3.7V, 0 ≤ VDD1 ≤ 8.7V	-200		200	µA
Write Current Range		10		40	mA
Write Current Constant "K"		2.375		2.625	
Iwc to Head Current Gain			0.99		mA/mA
Unselected Head Leakage Current				85	µA
RDX, RDY Output Offset Voltage	Write/Idle Mode	-20		+20	mV
RDX, RDY Common Mode Output Voltage	Write/Idle Mode		5.3		VDC
RDX, RDY Leakage	RDX, RDY = 6V Write/Idle Mode	-100		100	µA

READ MODE

Center Tap Voltage	Read Mode		4.0		VDC
Head Current (per side)	Read or Idle Mode 0 ≤ VCC ≤ 5.5V 0 ≤ VDD1 ≤ 13.2V	-200		200	µA
Input Bias Current (per side)				45	µA
Input Offset Voltage	Read Mode	-4		+4	mV
Common Mode Output Voltage	Read Mode	4.5		6.5	VDC

DYNAMIC CHARACTERISTICS AND TIMING

(Unless otherwise specified, recommended operating conditions apply and IW = 35 mA, Lh = 10 µH, Rd = 750Ω 32R511 only, f(WDI) = 5 MHz, CL(RDX, RDY) ≤ 20 pF.)

WRITE MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Differential Head Voltage Swing		7.0			V(pk)
Unselected Head Transient Current				2	mA(pk)
Differential Output Capacitance				15	pF
Differential Output Resistance	32R511, 32R5111	10K			Ω
	32R511R, 32R5111R	600		960	Ω
WDI Transition Frequency	WUS = low	250			KHz

READ MODE

Differential Voltage Gain	32R511	Vin = 1 mVpp @ 300 kHz, RL(RDX), RL(RDY)= 1kΩ	85		115	V/V
	32R5111		125		175	V/V
Dynamic Range		DC Input Voltage, Vi, Where Gain Falls by 10%. Vin = Vi + 0.5 mVpp @ 300 kHz	-3		+3	mV
Bandwidth (-3dB)		|Zs| < 5Ω, Vin = 1 mVpp	30			MHz
Input Noise Voltage		BW = 15 MHz, Lh = 0, Rh = 0			1.5	nV/√Hz
Differential Input Capacitance		f = 5 MHz			20	pF
Differential Input Resistance		32R511, f = 5 MHz	2K			Ω
Differential Input Resistance		32R511R, f = 5 MHz	460		860	Ω
Common Mode Rejection Ratio		Vcm = VCT + 100 mVpp @ 5 MHz	50			dB
Power Supply Rejection Ratio		100 mVpp @ 5 MHz on VDD1, VDD2 or VCC	45			dB
Channel Separation		Unselected Channels: Vin=100 mVpp @ 5 MHz; Selected Channel: Vin = 0 mVpp	45			dB
Single Ended Output Resistance		f = 5 MHz			30	Ω
Output Current		AC Coupled Load, RDX to RDY	±2.1			mA

DYNAMIC CHARACTERISTICS AND TIMING (continued)

SWITCHING CHARACTERISTICS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
R/$\overline{W}$ To Write	Delay to 90% of Write Current			1.0	µs
R/$\overline{W}$ to Read	Delay to 90% of 100 mV, 10 MHz Read Signal Envelope or to 90% decay of Write Current			1.0	µs
$\overline{CS}$ to Select	Delay to 90% of Write Current or to 90% of 100 mV, 10 MHz Read Signal Envelope			1.0	µs
$\overline{CS}$ to Unselect	Delay to 90% Decay of Write Current			1.0	µs
HS0 - HS2 to any head	Delay to 90% of 100 mV, 10 MHz Read Signal Envelope			1.0	µs
WUS, Safe to Unsafe - TD1	Iw = 35 mA	1.6		8.0	µs
WUS, Unsafe to Safe - TD2	Iw = 35 mA			1.0	µs
Head Current (Lh = 0 µH, Rh = 0Ω)					
Prop. Delay - TD3	From 50% Points			25	ns
Asymmetry	WDI has 50% Duty Cycle and 1ns Rise/Fall Time			2	ns
Rise/Fall Time	10% - 90% Points			20	ns

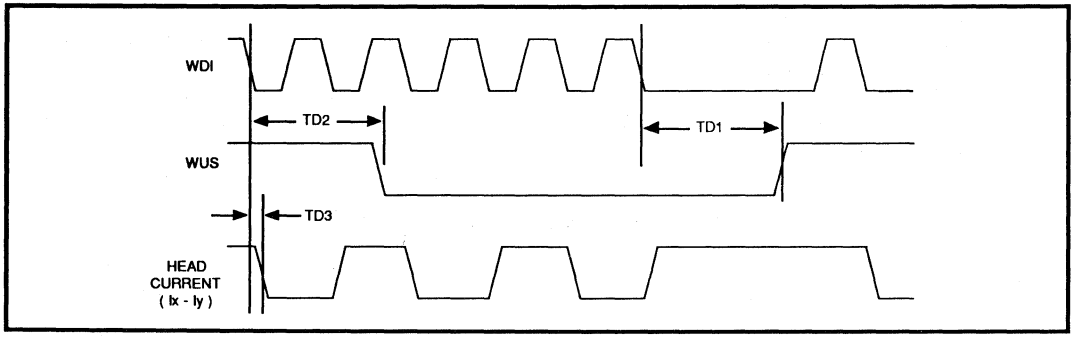
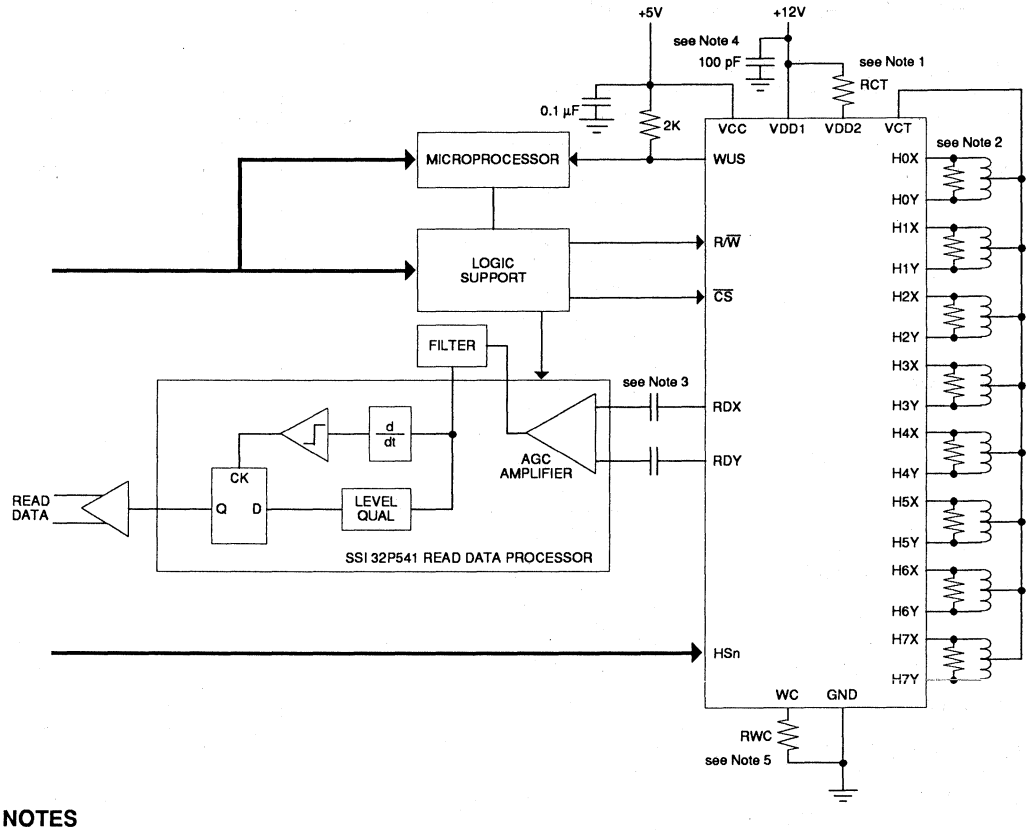


FIGURE 1: Write Mode Timing Diagram

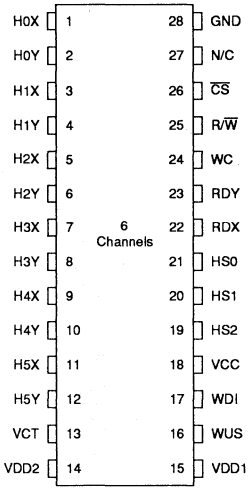


NOTES

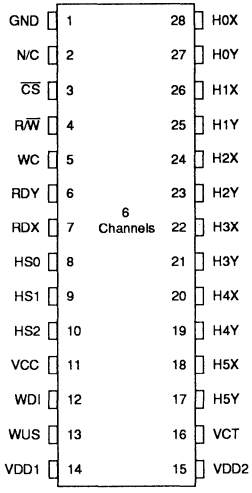
1. An external resistor, RCT, given by; RCT = 120 (40/Iw) where Iw is the zero-peak write current in mA, can be used to limit internal power dissipation. Otherwise connect VDD2 to VDD1.
2. Damping resistors not required on R versions.
3. Limit DC current from RDX and RDY to 100 µA and load capacitance to 20 pF. In multi-chip application these outputs can be wire-OR'ed.
4. The power bypassing capacitor must be located close to the device with its ground returned directly to device ground, with as short a path as possible.
5. To reduce ringing due to stray capacitance this resistor should be located close to the device. Where this is not desirable a series resistor can be used to buffer a long WC line. In multi-chip applications a single resistor common to all chips may be used.

FIGURE 2: Applications Information

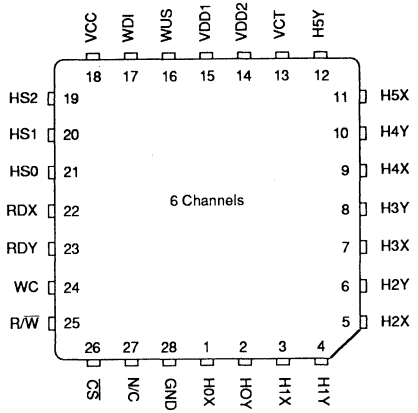
PACKAGE PIN DESIGNATIONS (Top View)



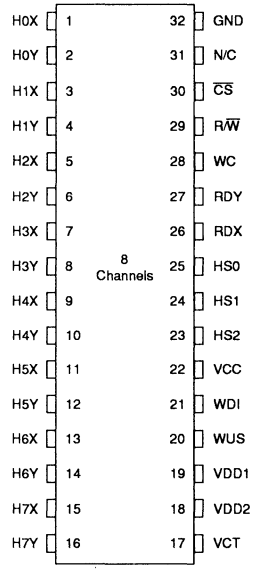
28-Lead SOL



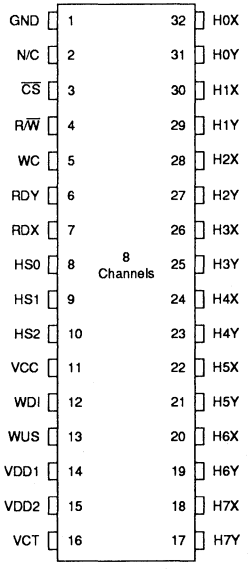
28-Lead SOL Mirror Image



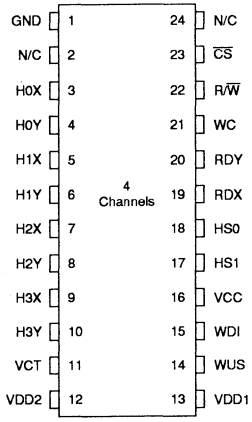
28-Lead PLCC



32-Lead Flatpack, SOW

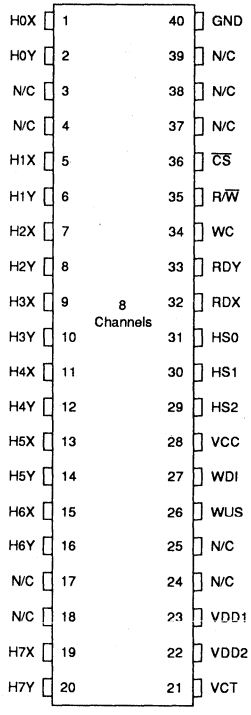


32-Lead SOW Mirror Image

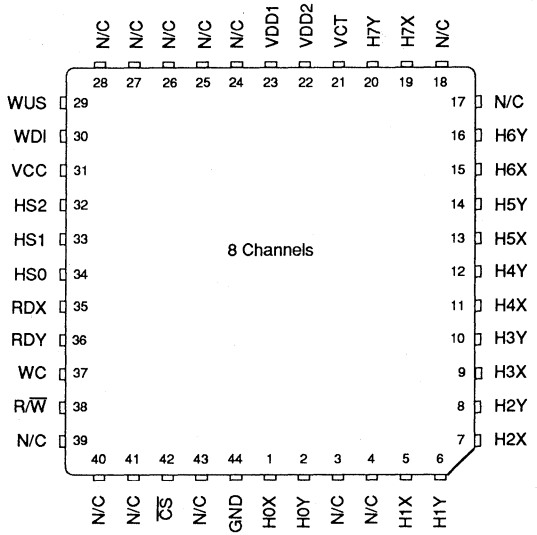


24-Lead SOL

PACKAGE PIN DESIGNATIONS (Continued)



40-Lead PDIP



44-Lead PLCC

THERMAL CHARACTERISTICS: Øja

24-lead	SOL	80°C/W
28-lead	PLCC	65°C/W
	SOL	70°C/W
32-lead	FLATPACK	60°C/W
	SOW	55°C/W
40-lead	PDIP	45°C/W
44-lead	PLCC	60°C/W

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32R511		
4-Channel SOL	SSI 32R511-4CL	32R511-4CL
6-Channel PLCC	SSI 32R511-6CH	32R511-6CH
6-Channel SOL	SSI 32R511-6CL	32R511-6CL
8-Channel Flat Pack	SSI 32R511-8F	32R511-8F
8-Channel SOW	SSI 32R511-8CW	32R511-8CW
8-Channel PDIP	SSI 32R511-8CP	32R511-8CP
8-Channel PLCC	SSI 32R511-8CH	32R511-8CH
SSI 32R511R		
4-Channel SOL	SSI 32R511R-4CL	32R511R-4CL
6-Channel PLCC	SSI 32R511R-6CH	32R511R-6CH
6-Channel SOL	SSI 32R511R-6CL	32R511R-6CL
8-Channel Flat Pack	SSI 32R511R-8F	32R511R-8F
8-Channel SOW	SSI 32R511R-8CW	32R511R-8CW
8-Channel PDIP	SSI 32R511R-8CP	32R511R-8CP
8-Channel PLCC	SSI 32R511R-8CH	32R511R-8CH
SSI 32R511M		
6-Channel SOL	SSI 32R511M-6CL	32R511M-6CL
8-Channel SOW	SSI 32R511M-8CW	32R511M-8CW
SSI 32R511RM		
6-Channel SOL	SSI 32R511RM-6CL	32R511RM6CL
8-Channel SOW	SSI 32R511RM-8CW	32R511RM-8CW

ORDERING INFORMATION (Continued)

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32R5111		
4-Channel SOL	SSI 32R5111-4CL	32R5111-4CL
6-Channel PLCC	SSI 32R5111-6CH	32R5111-6CH
6-Channel SOL	SSI 32R5111-6CL	32R5111-6CL
8-Channel SOW	SSI 32R5111-8CW	32R5111-8CW
8-Channel PLCC	SSI 32R5111-8CH	32R5111-8CH
8-Channel SOL	SSI 32R5111-8CL	32R5111-8CL
SSI 32R5111R		
4-Channel SOL	SSI 32R5111R-4CL	32R5111R-4CL
6-Channel PLCC	SSI 32R5111R-6CH	32R5111R-6CH
6-Channel SOL	SSI 32R5111R-6CL	32R5111R-6CL
8-Channel SOW	SSI 32R5111R-8CW	32R5111R-8CW
8-Channel PLCC	SSI 32R5111R-8CH	32R5111R-8CH
8-Channel SOL	SSI 32R5111R-8CL	32R5111R-8CL
SSI 32R5111M		
6-Channel SOL	SSI 32R5111M-6CL	32R5111M-6CL
8-Channel SOW	SSI 32R5111M-8CW	32R5111M-8CW
8-Channel SOL	SSI 32R5111M-8CL	32R5111M-8CL
SSI 32R5111RM		
6-Channel SOL	SSI 32R5111RM-6CL	32R5111RM-6CL
8-Channel SOW	SSI 32R5111RM-8CW	32R5111RM-8CW
8-Channel SOL	SSI 32R5111RM-8CL	32R5111RM-8CL

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32R512/512R
8 & 9-Channel Thin Film Read/Write Device

1

July, 1990

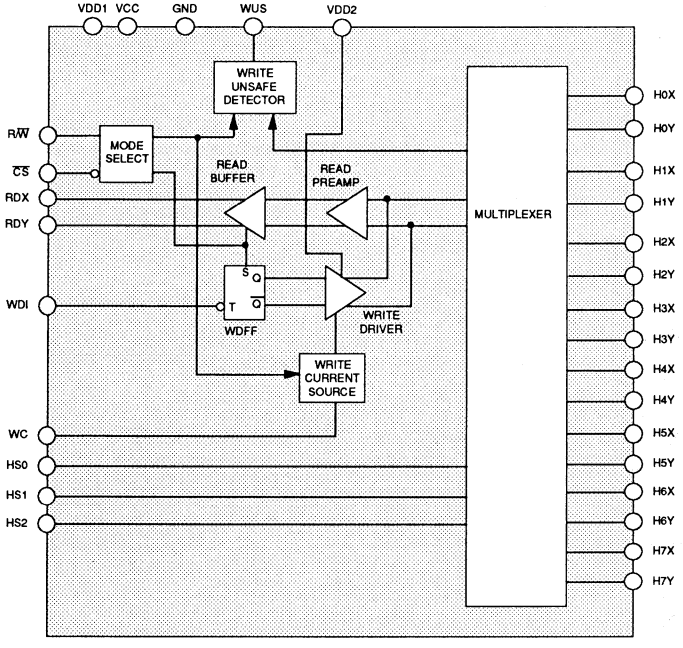
DESCRIPTION

The SSI 32R512/512R Read/Write devices are bipolar monolithic integrated circuits designed for use with two terminal thin film recording heads. They provide a low noise read amplifier, write current control and data protection circuitry for eight or nine channels. Power supply fault protection is provided by disabling the write current generator during power sequencing. System write to read recovery time is significantly improved by controlling the read channel common mode output voltage shift in the write mode. They require +5V and +12V power supplies and are available in a variety of package configurations. A mirror image pinout option is available to simplify flex circuit layout in multiple R/W device applications. The SSI 32R512R option provides internal 1000Ω damping resistors.

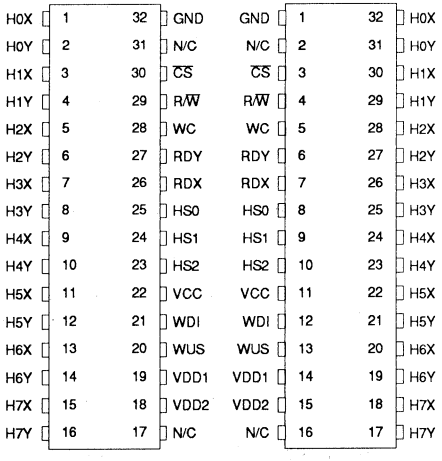
FEATURES

- **High performance:**
  - **Read mode gain = 150 V/V**
  - **Input noise = 0.85 nV/√Hz max.**
  - **Input capacitance = 35 pF max.**
  - **Write current range = 10 mA to 40 mA**
  - **Head voltage swing = 7 Vpp**
  - **Write current rise time = 9 ns**
- **Enhanced system write to read recovery time**
- **Power supply fault protection**
- **Plug compatible to the SSI 32R501 & SSI 32R511**
- **Compatible with two & three terminal thin film heads**
- **Write unsafe detection**
- **+5V, +12V power supplies**
- **Mirror image pinout option**

BLOCK DIAGRAM



PIN DIAGRAM



32-LEAD SOW, FLATPACK

32-LEAD SOW MIRROR

CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 32R512/512R
8 & 9-Channel Thin Film Read/Write Device

CIRCUIT OPERATION

The SSI 32R512 addresses up to nine two-terminal thin film heads providing write drive or read amplification. Head selection and mode control is accomplished with pins HSn, $\overline{CS}$ and R/$\overline{W}$, as shown in Tables 1 & 2. Internal resistor pullups, provided on pins $\overline{CS}$ and R/$\overline{W}$ will force the device into a non-writing condition if either control line is opened accidentally.

WRITE MODE

The write mode configures the SSI 32R512 as a current switch and activates the Write Unsafe (WUS) detection circuitry. Write current is toggled between the X and Y direction of the selected head on each high to low transition on pin WDI, Write Data Input.

A preceding read operation initializes the Write Data Flip Flop (WDFF) to pass write current in the X-direction of the head.

The magnitude of the write current (0-pk) given by:

$$Iw = \frac{Vwc}{RWC}$$

where Vwc (WC pin voltage) = 1.65V ± 5%, is programmed by an external resistor RWC, connected from pin WC to ground. In multiple device applications, a single RWC resistor may be made common to all devices. The actual head current Ix, y is given by:

$$Ix,y = \frac{Iw}{1 + Rh/Rd}$$

where:
Rh = head resistance + external wire resistance, and
Rd = damping resistance.

Power supply fault protection improves data security by disabling the write current generator during a voltage fault or power supply sequencing. Additionally, the write unsafe detection circuitry will flag any of the conditions listed below as a high level on the open collector output pin, WUS. Two negative transitions on pin WDI, after the fault is corrected, are required to clear the WUS flag.

- WDI frequency too low
- Device not selected
- Device in read mode
- No write current

Power dissipation in Write Mode may be reduced by placing a resistor, Rw, between VDD1 and VDD2. The resistor value should be chosen such that Iw Rw ≤ 3.0V for an accompanying reduction of $(Iw)^2$ Rw in power dissipation. If a resistor is not used, VDD2 should be connected to VDD1. Note that Rw will also provide current limiting in the event of a head short.

READ MODE

The read mode configures the SSI 32R512 as a low noise differential amplifier and deactivates the write current generator and write unsafe detection circuitry. The RDX and RDY outputs are emitter followers and are in phase with the "X" and "Y" head ports. These outputs should be AC coupled to the load. The RDX, RDY common mode voltage is maintained in the write mode, minimizing the transient between write mode and read mode, substantially reducing the write to read recovery time in the subsequent Pulse Detection circuitry.

IDLE MODE

The idle mode deactivates the internal write current generator, the write unsafe detector and switches the RDX, RDY outputs into a high impedance state. This facilitates multiple device applications by enabling the read outputs to be wire OR'ed and the write current programming resistor to be common to all devices.

TABLE 1: Mode Select

$\overline{CS}$	R/$\overline{W}$	MODE
0	0	Write
0	1	Read
1	0	Idle
1	1	Idle

TABLE 2: Head Select

HS3	HS2	HS1	HS0	HEAD
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8

0 = Low level 1 = High level

PIN DESCRIPTIONS

NAME	TYPE	DESCRIPTION
HS0 - HS3	I	Head Select
$\overline{CS}$	I	Chip Select: a low level enables the device
R/$\overline{W}$	I	Read/Write: a high level selects Read mode
WUS	O*	Write Unsafe: Open collector output, a high level indicates an unsafe writing condition
WDI	I	Write Data In: a negative transition toggles the direction of the head current
H0X - H8X H0Y - H8Y	I/O	X, Y Head Connections: Current in the X-direction flows into the X-port
RDX, RDY	O*	X, Y Read Data: differential read data output
WC	*	Write Current: used to set the magnitude of the write current
VCC	-	+5V Logic Circuit Supply
VDD1	-	+12V
VDD2	-	Positive Power Supply for Write current drivers
GND	-	Ground

*When more than one R/W device is used, these signals can be wire OR'ed.

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

PARAMETER		SYMBOL	VALUE	UNITS
DC Supply Voltage		VDD1, 2	-0.3 to +14	VDC
		VCC	-0.3 to +7	VDC
Write Current		Iw	100	mA
Digital Input Voltage		Vin	-0.3 to VCC +0.3	VDC
Head Port Voltage		VH	-0.3 to VDD2 +0.3	VDC
WUS Pin Voltage Range		Vwus	-0.3 to +14	VDC
Output Current	RDX, RDY	Io	-10	mA
	WUS	Iwus	+12	mA
Storage Temperature		Tstg	-65 to +150	°C

RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	VALUE	UNITS
DC Supply Voltage	VDD1	12 ± 10%	VDC
	VDD2	VDD1 - 3.0 to VDD1	VDC
	VCC	5 ± 10%	VDC
Operating Temperature	Tj	+25 to +135	°C

DC CHARACTERISTICS

Unless otherwise specified, recommended operating conditions apply.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
VDD1 Supply Current	Read Mode	-	-	34	mA
	Write Mode	-	-	38	mA
	Idle Mode	-	-	14	mA
VDD2 Supply Current	Read Mode	-	-	200	µA
	Write Mode	-	-	IW+0.4	mA
	Idle Mode	-	-	200	µA
VCC Supply Current	Read Mode	-	-	75	mA
	Write Mode	-	-	56	mA
	Idle Mode	-	-	60	mA
Power Dissipation (Tj = +135°C)	Read Mode	-	-	800	mW
	Write Mode: Iw = 20 mA, VDD2 = VDD1	-	-	1000	mW
	Write Mode: Iw = 40 mA, VDD1 - VDD2 = 3.0V	-	-	1140	mW
	Idle Mode	-	-	500	mW
Input Low Voltage (VIL)		-	-	0.8	VDC
Input High Voltage (VIH)		2.0	-	-	VDC
Input Low Current (IIL)	VIL = 0.8V	-0.4	-	-	mA
Input High Current (IHL)	VIH = 2.0V	-	-	100	µA
WUS Output Low Voltage (VOL)	Iol = 8 mA	-	-	0.5	VDC
VDD Fault Voltage		8.5	-	10.0	VDC
VCC Fault Voltage		3.5	-	4.2	VDC
Head Current (HnX, HnY)	Write Mode, 0≤ VCC ≤3.5V 0 ≤ VDD1 ≤ 8.5V	-200	-	+200	µA
	Read/Idle Mode 0 ≤ VCC ≤ 5.5V 0 ≤ VDD1 ≤ 13.2V	-200	-	+200	µA

WRITE CHARACTERISTICS
Unless otherwise specified, recommended operating conditions apply, Iw = 20 mA, Lh = 1.0 µH, Rh = 30Ω and f(WDI) = 5 MHz.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
WC Pin Voltage (Vwc)		-	1.65 ±5%	-	V
Differential Head Voltage Swing		7	-	-	Vpp
Unselected Head Current		-	-	1	mA(pk)
Differential Output Capacitance		-	-	25	pF
Differential Output Resistance	32R512R	800	1000	1350	Ω
	32R512	4	-	-	kΩ
WDI Transition Frequency	WUS = low	1.7	-	-	MHz
Write Current Range		10	-	40	mA

READ CHARACTERISTICS
Unless otherwise specified, recommended operating conditions apply CL (RDX, RDY) < 20pF and RL (RDX,RDY) = 1 kΩ.

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
Differential Voltage Gain		Vin=1mVpp @ 300 kHz	125	-	175	V/V
Bandwidth	-1dB	|Zs|<5Ω, Vin=1 mVpp @ 300 kHz	25	-	-	MHz
	-3dB	|Zs|<5Ω, Vin=1 mVpp @ 300 kHz	45	-	-	MHz
Input Noise Voltage		BW = 15 MHz, Lh = 0, Rh = 0	-	0.62	0.85	nV/√Hz
Differential Input Capacitance		Vin = 1 mVpp, *f* = 5 MHz	-	-	35	pF
Differential Input Resistance	32R512R	Vin = 1 mVpp, *f* = 5 MHz	390	-	-	Ω
	32R512	Vin = 1 mVpp, *f* = 5 MHz	640	-	-	Ω
Dynamic Range		DC input voltage where gain falls to 90% of its 0 VDC value, Vin = VDC +0.5 mVpp, *f* = 5 MHz	-3	-	3	mV
Common Mode Rejection Ratio		Vin = 0 VDC+100 mVpp @ 5 MHz	54	-	-	dB
Power Supply Rejection Ratio		100 mVpp @ 5 MHz on VDD1 100 mVpp @ 5 MHz on VCC	54	-	-	dB
Channel Separation		Unselected channels driven with 100 mVpp @ 5 MHz, Vin = 0 mVpp	45	-	-	dB
Output Offset Voltage			-360	-	+360	mV
RDX, RDY Common Mode Output Voltage		Read Mode	2.2	2.9	3.6	VDC
		Write Mode	-	2.9	-	VDC
Single Ended Output Resistance		*f* = 5 MHz	-	-	30	Ω
Output Current		AC Coupled Load, RDX to RDY	3.2	-	-	mA

5SWITCHING CHARACTERISTICS (See Figure 1)
Unless otherwise specified, recommended operating conditions apply, Iw = 20 mA, Lh = 1.0 µH, Rh = 30Ω and f (WDI) = 5 MHz.

PARAMETER	CONDITIONS	MIN	MAX	UNITS
R/$\overline{W}$				
R/$\overline{W}$ to Write Mode	Delay to 90% of write current	-	0.6	µs
R/$\overline{W}$ to Read Mode	Delay to 90% of 100 mV 10 MHz Read signal envelope or to 90% decay of write current	-	0.6	µs
$\overline{CS}$				
$\overline{CS}$ to Select	Delay to 90% of write current or to 90% of 100mV 10MHz Read signal envelope	-	0.6	µs
$\overline{CS}$ to Unselect	Delay to 90% of write current	-	0.6	µs
HSn				
HS0, 1, 2 to any Head	Delay to 90% of 100 mV 10 MHz Read signal envelope	-	0.4	µs
WUS				
Safe to Unsafe - TD1		0.6	3.6	µs
Unsafe to Safe - TD2		-	1	µs
Head Current				
Prop. Delay - TD3	From 50% points, Lh=0µh, Rh=0Ω	-	32	ns
Asymmetry	WDI has 50% duty cycle and 1ns rise/fall time, Lh=0µh, Rh=0Ω	-	1	ns
Rise/Fall Time	10% - 90% points, Lh=0µh, Rh=0Ω	-	9	ns

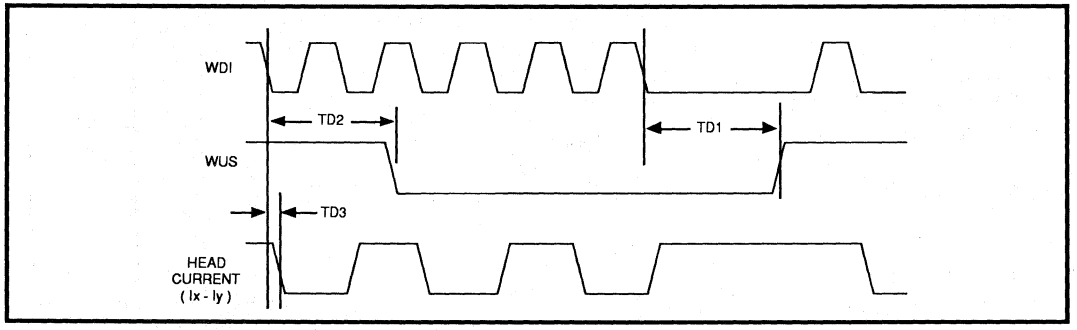


FIGURE 1: Write Mode Timing Diagram

APPLICATIONS INFORMATION

The specifications, provided in the data section, account for the worst case values of each parameter taken individually. In actual operation, the effects of worst case conditions on many parameters correlate. Tables 3 & 4 demonstrate this for several key parameters. Notice that under the conditions of worst case input noise, the higher read back signal resulting from the higher input impedance can compensate for the higher input noise. Accounting for this correlation in your analysis will be more representative of actual performance.

TABLE 3: Key Parameters Under Worst Case Input Noise Conditions

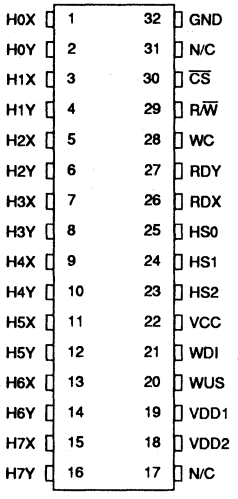
PARAMETER		Tj = 25°C	Tj = 135°C	UNITS
Input Noise Voltage (Max.)		0.70	0.85	$nV/\sqrt{Hz}$
Differential Input Resistance (Min.)	32R512R	539	595	Ω
	32R512	1200	1500	Ω
Differential Input Capacitance (Max.)		32	34	pF

TABLE 4: Key Parameters Under Worst Case Input Impedance Conditions

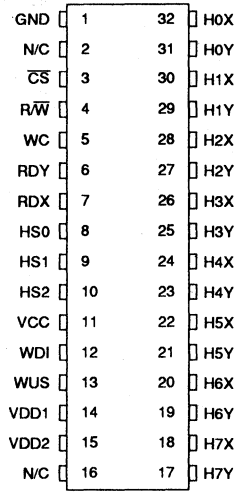
PARAMETER		Tj = 25°C	Tj = 135°C	UNITS
Input Noise Voltage (Max.)		0.58	0.71	$nV/\sqrt{Hz}$
Differential Input Resistance (Min.)	32R512R	391	458	Ω
	32R512	643	846	Ω
Differential Input Capacitance (Max.)		33	35	pF

SSI 32R512/512R
8 & 9-Channel Thin Film Read/Write Device

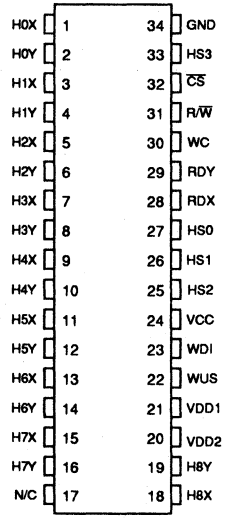
PACKAGE PIN DESIGNATIONS (Top View)



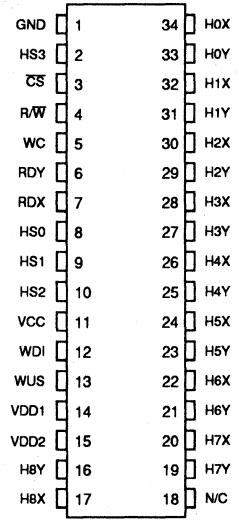
8-Channel 32-Lead SOW



8-Channel 32-Lead SOW Mirror



9-Channel 34-Lead SOL



9-Channel 34-Lead SOL Mirror

THERMAL CHARACTERISTICS: Øja

32-Lead SOW	55°C/W
34-Lead SOL	60°C/W

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32R512 Read/Write IC		
8-Channel SOW	SSI 32R512-8CW	32R512-8CW
9-Channel SOL	SSI 32R512-9CL	32R512-9CL
SSI 32R512R with Internal Damping Resistor		
8-Channel SOW	SSI 32R512R-8CW	32R512R-8CW
9-Channel SOL	SSI 32R512R-9CL	32R512R-9CL
SSI 32R512M Mirror Image		
8-Channel SOW	SSI 32R512M-8CW	32R512M-8CW
9-Channel SOL	SSI 32R512M-9CL	32R512M-9CL
SSI 32R512RM Mirror Image with Damping Resistor		
8-Channel SOW	SSI 32R512RM-8CW	32R512RM-8CW
9-Channel SOL	SSI 32R512RM-9CL	32R512RM-9CL

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32R5121/5121R
14-Channel Thin Film Read/Write Device

Advance Information

1

July, 1990

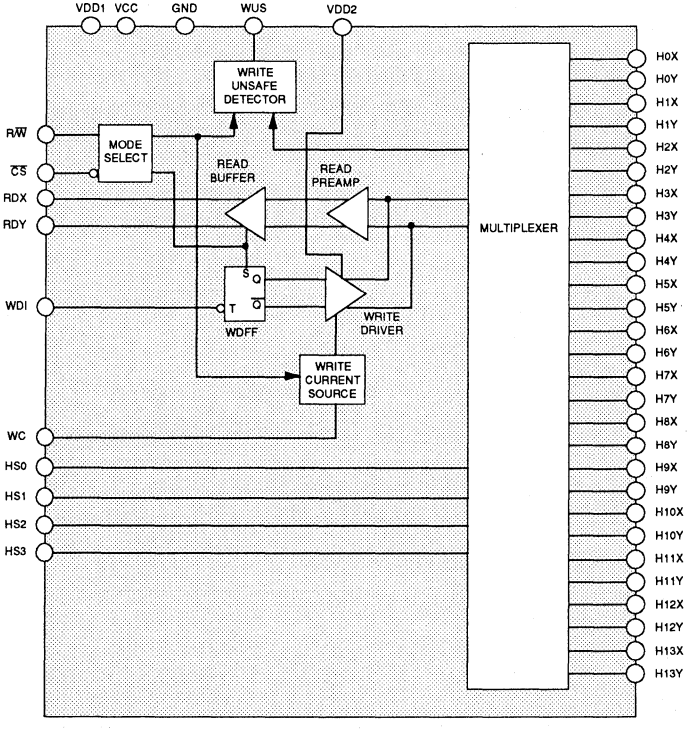
DESCRIPTION

The SSI 32R5121/5121R Read/Write devices are bipolar monolithic integrated circuits designed for use with two terminal thin film recording heads. They provide a low noise read amplifier, write current control and data protection circuitry for up to 14 channels. Power supply fault protection is provided by disabling the write current generator during power sequencing. System write to read recovery time is significantly improved by controlling the read channel common mode output voltage shift in the write mode. They require +5V and +12V power supplies and are available in a variety of package configurations. The SSI 32R512R option provides internal 180Ω damping resistors.

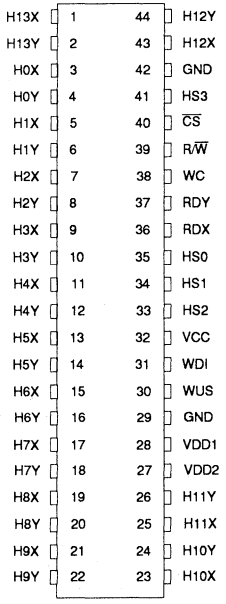
FEATURES

- **High performance:**
  - **Read mode gain = 250 V/V**
  - **Input noise = 0.85 nV/√Hz max.**
  - **Input capacitance = 35 pF max.**
  - **Write current range = 10 mA to 40 mA**
  - **Head voltage swing = 7 Vpp**
  - **Write current rise time = 9 ns**
- **Enhanced system write to read recovery time**
- **Power supply fault protection**
- **Compatible with two & three terminal thin film heads**
- **Write unsafe detection**
- **+5V, +12V power supplies**

BLOCK DIAGRAM



PIN DIAGRAM



44-LEAD SOL, FLATPACK

CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 32R5121/5121R
14-Channel Thin Film
Read/Write Device

CIRCUIT OPERATION

The SSI 32R5121 addresses up to 14 two-terminal thin film heads providing write drive or read amplification. Head selection and mode control is accomplished with pins HSn, $\overline{CS}$ and R/$\overline{W}$, as shown in Tables 1 & 2. Internal resistor pullups, provided on pins $\overline{CS}$ and R/$\overline{W}$ will force the device into a non-writing condition if either control line is opened accidentally.

WRITE MODE

The write mode configures the SSI 32R5121 as a current switch and activates the Write Unsafe (WUS) detection circuitry. Write current is toggled between the X and Y direction of the selected head on each high to low transition on pin WDI, Write Data Input.

A preceding read operation initializes the Write Data Flip Flop (WDFF) to pass write current in the X-direction of the head, i.e., into the X-port.

The magnitude of the write current (0-pk) given by:

$$Iw = \frac{Vwc}{RWC}$$

where Vwc (WC pin voltage) = 1.65V ± 5%, is programmed by an external resistor RWC, connected from pin WC to ground. In multiple device applications, a single RWC resistor may be made common to all devices. The actual head current Ix, y is given by:

$$Ix,y = \frac{Iw}{1 + Rh/Rd}$$

where:
Rh = head resistance + external wire resistance, and
Rd = damping resistance.

Power supply fault protection improves data security by disabling the write current generator during a voltage fault or power supply sequencing. Additionally, the write unsafe detection circuitry will flag any of the conditions listed below as a high level on the open collector output pin, WUS. Two negative transitions on pin WDI, after the fault is corrected, are required to clear the WUS flag.

- WDI frequency too low
- Device not selected
- Open head
- Device in read mode
- No write current

Power dissipation in Write Mode may be reduced by placing a resistor, Rw, between VDD1 and VDD2. The resistor value should be chosen such that Iw Rw ≤ 3.0V for an accompanying reduction of $(Iw)^2$ Rw in power dissipation. If a resistor is not used, VDD2 should be connected to VDD1. Note that Rw will also provide current limiting in the event of a head short.

READ MODE

The read mode configures the SSI 32R5121 as a low noise differential amplifier and deactivates the write current generator and write unsafe detection circuitry. The RDX and RDY outputs are emitter followers and are in phase with the "X" and "Y" head ports. These outputs should be AC coupled to the load. The RDX, RDY common mode voltage is maintained at the write mode valve, minimizing the transient between write mode and read mode, substantially reducing the write to read recovery time in the subsequent Pulse Detection circuitry.

IDLE MODE

The idle mode deactivates the internal write current generator, the write unsafe detector and switches the RDX, RDY outputs into a high impedance state. This facilitates multiple device applications by enabling the read outputs to be wire OR'ed and the write current programming resistor to be common to all devices.

TABLE 1: Mode Select

$\overline{CS}$	R/$\overline{W}$	MODE
0	0	Write
0	1	Read
1	0	Idle
1	1	Idle

TABLE 2: Head Select

HS3	HS2	HS1	HS0	HEAD
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9
1	0	1	0	10
1	0	1	1	11
1	1	0	0	12
1	1	0	1	13

PIN DESCRIPTIONS

NAME	TYPE	DESCRIPTION
HSO - HS3	I	Head Select
$\overline{CS}$	I	Chip Select: a low level enables the device
R/$\overline{W}$	I	Read/Write: a high level selects Read mode
WUS	O*	Write Unsafe: Open collector output, a high level indicates an unsafe writing condition
WDI	I	Write Data In: a negative transition toggles the direction of the head current
H0X - H13X H0Y - H13Y	I/O	X, Y Head Connections: Current in the X-direction flows into the X-port
RDX, RDY	O*	X, Y Read Data: differential read data output
WC	*	Write Current: used to set the magnitude of the write current
VCC	-	+5V Logic Circuit Supply
VDD1	-	+12V
VDD2	-	Positive Power Supply for Write current drivers
GND	-	Ground

*When more than one R/W device is used, these signals can be wire OR'ed.

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

PARAMETER		SYMBOL	VALUE	UNITS
DC Supply Voltage		VDD1, 2	-0.3 to +14	VDC
		VCC	-0.3 to +7	VDC
Write Current		Iw	100	mA
Digital Input Voltage		Vin	-0.3 to VCC +0.3	VDC
Head Port Voltage		VH	-0.3 to VDD2 +0.3	VDC
WUS Pin Voltage Range		Vwus	-0.3 to +14	VDC
Output Current	RDX, RDY	Io	-10	mA
	WUS	Iwus	+12	mA
Storage Temperature		Tstg	-65 to +150	°C

RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	VALUE	UNITS
DC Supply Voltage	VDD1	12 ± 10%	VDC
	VDD2	VDD1 - 3.0 to VDD1	VDC
	VCC	5 ± 10%	VDC
Operating Temperature	Tj	+25 to +135	°C

DC CHARACTERISTICS

Unless otherwise specified, recommended operating conditions apply.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
VDD1 Supply Current	Read Mode	-	24	36	mA
	Write Mode	-	34	46	mA
	Idle Mode	-	11	16	mA
VDD2 Supply Current	Read Mode	-	0	200	µA
	Write Mode	-	Iw	Iw + 0.4	mA
	Idle Mode	-	0	200	µA
VCC Supply Current	Read Mode	-	52	73	mA
	Write Mode	-	35	54	mA
	Idle Mode	-	43	58	mA
Power Dissipation ($\overline{Tj}$ = +135°C)	Read Mode	-	-	800	mW
	Write Mode: Iw = 20 mA, VDD2 = VDD1	-	-	1000	mW
	Write Mode: Iw = 40 mA, VDD1 - VDD2 = 3.0V	-	-	1150	mW
	Idle Mode	-	-	500	mW
Input Low Voltage (VIL)		-	-	0.8	VDC
Input High Voltage (VIH)		2.0	-	-	VDC
Input Low Current (IIL)	VIL = 0.8V	-0.4	-	-	mA
Input High Current (IHL)	VIH = 2.0V	-	-	100	µA
WUS Output Low Voltage (VOL)	Iol = 8 mA	-	-	0.5	VDC
VDD Fault Voltage		8.5	-	10.0	VDC
VCC Fault Voltage		3.5	-	4.2	VDC
Head Current (HnX, HnY)	Write Mode, 0 ≤ VCC ≤ 3.5V 0 ≤ VDD1 ≤ 8.5V	-200	-	+200	µA
	Read/Idle Mode, 0 ≤ VCC ≤ 5.5V 0 ≤ VDD1 ≤13.2V	-200	-	+200	µA

WRITE CHARACTERISTICS
Unless otherwise specified, recommended operating conditions apply, Iw = 20 mA, Lh = 500 nH, Rh = 30Ω and f(WDI) = 5 MHz.

PARAMETER	CONDITIONS	MIN.	NOM	MAX	UNITS
WC Pin Voltage (Vwc)		-	1.65 ±5%	-	V
Differential Head Voltage Swing	Iw = 40 mA	7	-	-	Vpp
Unselected Head Current		-	-	1	mA(pk)
Differential Output Capacitance		-	-	25	pF
Differential Output Resistance	32R5121R	140	180	220	Ω
	32R5121	4K	-	-	Ω
WDI Transition Frequency	WUS = low	1.7	-	-	MHz
Write Current Range		10	-	40	mA

READ CHARACTERISTICS
Unless otherwise specified, recommended operating conditions apply CL (RDX, RDY) < 20pF and RL (RDX,RDY) = 1 kΩ.

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
Differential Voltage Gain		Vin=1mVpp @ 300 kHz	210	250	290	V/V
Bandwidth	-1dB	|Zs|<5Ω, Vin=1 mVpp @ 300 kHz	-	30	-	MHz
	-3dB	|Zs|<5Ω, Vin=1 mVpp @ 300 kHz	27	45	-	MHz
Input Noise Voltage		BW = 15 MHz, Lh = 0, Rh = 0	-	0.62	0.85	nV/√Hz
Differential Input Capacitance		Vin = 1 mVpp, f = 5 MHz	-	-	35	pF
Differential Input Resistance	32R5121R	Vin = 1 mVpp, f = 5 MHz	115	-	-	Ω
	32R5121	Vin = 1 mVpp, f =5 MHz	640	-	-	Ω
Dynamic Range		Peak-to-peak AC input voltage where gain falls to 90% of its small signal value, f = 5 MHz	2.0	-	-	mVpp
Common Mode Rejection Ratio		Vin = 0 VDC+100 mVpp @ 5 MHz	54	-	-	dB
Power Supply Rejection Ratio		100 mVpp @ 5 MHz on VDD1 100 mVpp @ 5 MHz on VCC	54	-	-	dB
Channel Separation		Unselected channels driven with 100 mVpp @ 5 MHz, Vin = 0 mVpp	45	-	-	dB
Output Offset Voltage			-600	-	+600	mV
RDX, RDY Common Mode Output Voltage		Read Mode	2.2	2.9	3.6	VDC
		Write Mode	-	2.9	-	VDC
Single Ended Output Resistance		f = 5 MHz	-	-	30	Ω
Output Current		AC Coupled Load, RDX to RDY	3.2	-	-	mA

SWITCHING CHARACTERISTICS (See Figure 1)
Unless otherwise specified, recommended operating conditions apply, Iw = 20 mA, Lh = 500 nH, Rh = 30Ω and f(WDI) = 5 MHz.

PARAMETER	CONDITIONS	MIN	MAX	UNITS
R/$\overline{W}$				
R/$\overline{W}$ to Write Mode	Delay to 90% of write current	-	0.6	µs
R/$\overline{W}$ to Read Mode	Delay to 90% of 100mV 10MHz Read signal envelope or to 90% decay of write current	-	0.6	µs
$\overline{CS}$				
$\overline{CS}$ to Select	Delay to 90% of write current or to 90% of 100mV 10MHz Read signal envelope	-	0.6	µs
$\overline{CS}$ to Unselect	Delay to 90% of write current	-	0.6	µs
HSn				
HS0, 1, 2 to any Head	Delay to 90 % of 100mV 10MHz Read signal envelope	-	0.4	µs
WUS				
Safe to Unsafe - TD1		0.6	3.6	µs
Unsafe to Safe - TD2		-	1	µs
Head Current				
Prop. Delay - TD3	From 50 % points, Lh=0µh, Rh=0Ω	-	32	ns
Asymmetry	WDI has 50 % duty cycle and 1ns rise/fall time, Lh=0µh, Rh=0Ω	-	1	ns
Rise/Fall Time	10% - 90% points, Lh=0µh, Rh=0Ω	-	9	ns

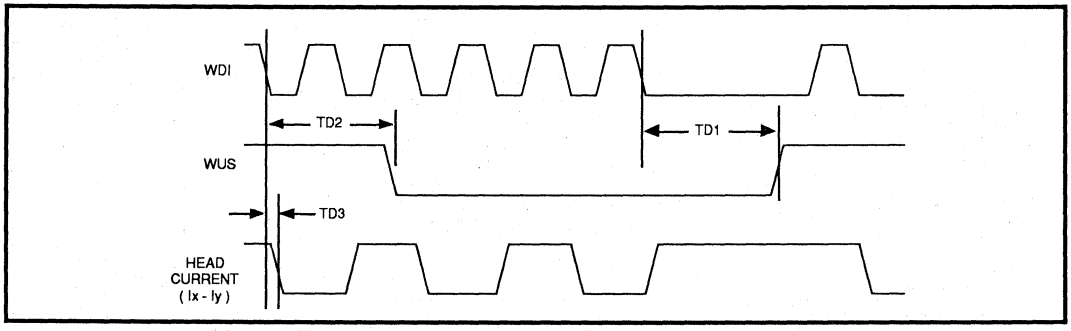


FIGURE 1: Write Mode Timing Diagram

APPLICATIONS INFORMATION

The specifications, provided in the data section, account for the worst case values of each parameter taken individually. In actual operation, the effects of worst case conditions on many parameters correlate. Tables 3 & 4 demonstrate this for several key parameters. Notice that under the conditions of worst case input noise, the higher read back signal resulting from the higher input impedance can compensate for the higher input noise. Accounting for this correlation in your analysis will be more representative of actual performance.

TABLE 3: Key Parameters Under Worst Case Input Noise Conditions

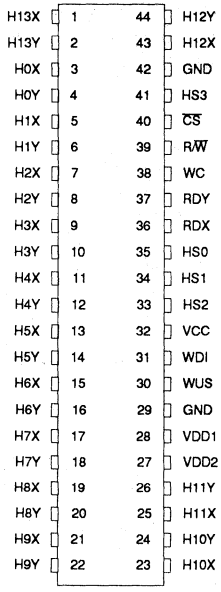
PARAMETER		Tj = 25°C	Tj = 135°C	UNITS
Input Noise Voltage (Max.)		0.70	0.85	nV/√Hz
Differential Input Resistance (Min.)	32R5121R	165	185	Ω
	32R5121	1200	1500	Ω
Differential Input Capacitance (Max.)		32	34	pF

TABLE 4: Key Parameters Under Worst Case Input Impedance Conditions

PARAMETER		Tj = 25°C	Tj = 135°C	UNITS
Input Noise Voltage (Max.)		0.58	0.71	nV/√Hz
Differential Input Resistance (Min.)	32R5121R	115	125	Ω
	32R5121	640	850	Ω
Differential Input Capacitance (Max.)		33	35	pF

SSI 32R5121/5121R
14-Channel Thin Film Read/Write Device

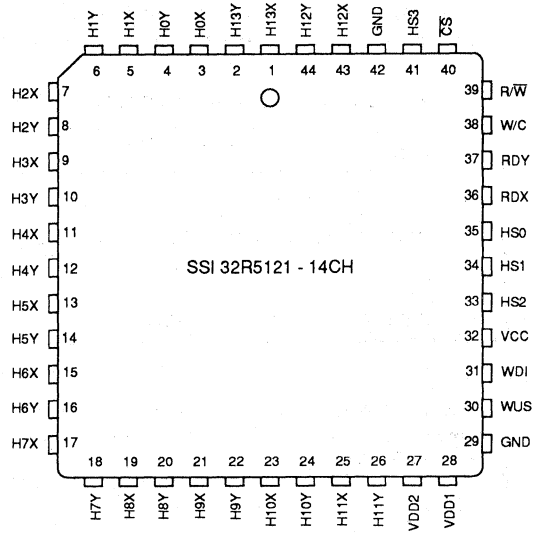
PACKAGE PIN DESIGNATIONS
(Top View)



44-Pin SOL

THERMAL CHARACTERISTICS: Øja

44-Lead SOL	50°C/W
44-PLCC	60°C/W



44-Pin PLCC

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only. Do not use for final design.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32R515R
9, 10-Channel Ferrite/MIG Read/Write Device

Preliminary Data

1

July, 1990

DESCRIPTION

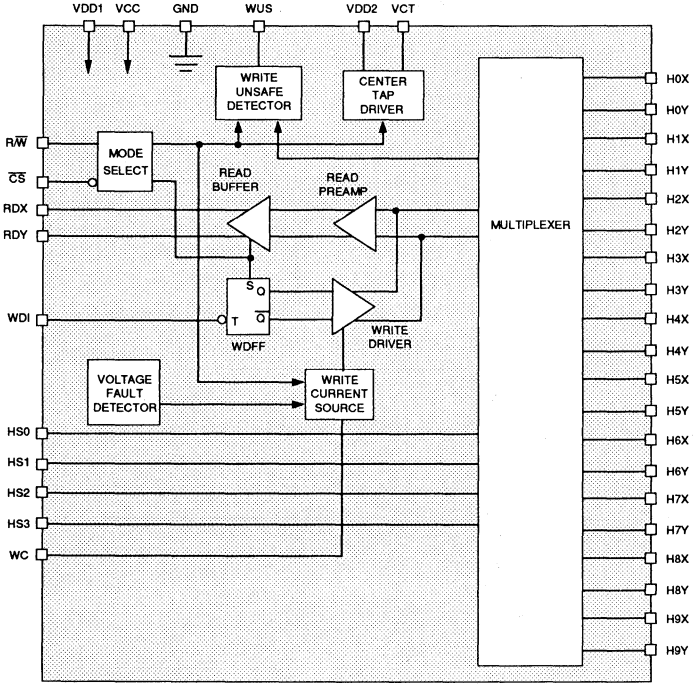
The SSI 32R515R is a bipolar monolithic integrated circuit designed for use with center-tapped ferrite or MIG recording heads. It provides a low noise read path, write current control, and data protection circuitry for as many as 10 channels. The SSI 32R515R requires +5V and +12V power supplies and is available in a variety of packages.

The SSI 32R515R includes internal damping resistors. The SSI 32R515RM is functionally equivalent to the SSI 32R515R however, it has the mirror image pin arrangement to simplify layout when using multiple devices.

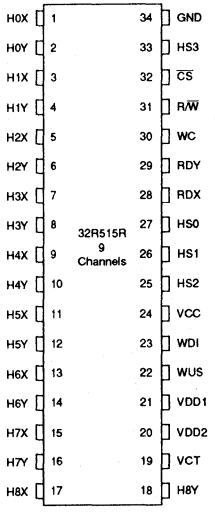
FEATURES

- **High Performance**
  - **Read Mode Gain = 100V/V**
  - **Input Noise = 1.5 nV/$\sqrt{Hz}$ max.**
  - **Input Capacitance = 20 pF**
  - **Write Current Range = 10 mA to 50 mA**
- **Enhanced system write to read recovery time**
- **Power supply fault protection**
- **Designed for center-tapped ferrite or MIG heads**
- **Programmable write current source**
- **Includes write unsafe detection**
- **TTL compatible control signals**
- **+5V, +12V power supplies**
- **Mirror image package option**

BLOCK DIAGRAM



PIN DIAGRAM



34-LEAD SOL

CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 32R515R
9, 10-Channel Ferrite/MIG Read/Write Device

CIRCUIT OPERATION

The SSI 32R515 gives the user the ability to address up to 10 center-tapped ferrite heads and provide write drive or read amplification. Head selection and mode control is accomplished using the HSn, $\overline{CS}$ and R/$\overline{W}$ inputs as shown in tables 1 & 2. Internal pullups are provided for the $\overline{CS}$ & R/$\overline{W}$ inputs to force the device into a non-writing condition if either control line is opened accidentally.

TABLE 1: Mode Select

$\overline{CS}$	R/$\overline{W}$	MODE
0	0	Write
0	1	Read
1	X	Idle

TABLE 2: Head Select

HS3	HS2	HS1	HS0	HEAD
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9

0 = Low level 1 = High level

WRITE MODE

Taking both $\overline{CS}$ and R/$\overline{W}$ low selects write mode which configures the SSI 32R515 as a current switch and activates the Write Unsafe (WUS) detector circuitry. Write current is toggled between the X and Y side of the selected head on each high to low transition of the Write Data Input (WDI). Note that a preceding read mode selection initializes the Write Data Flip-Flop, WDFF, to pass write current through the "X" side of the head. The zero-peak write current magnitude is programmed by an external resistor Rwc from pin WC to GND and is given by:

Iw = K/Rwc, where K = Write Current Constant

The Write Unsafe detection circuitry monitors voltage transitions at the selected head connections and flags any of the following conditions as a high level on the Write Unsafe open collector output:

- Head open
- WDI frequency too low
- Device not selected
- Head center tap open
- Device in read mode
- No write current

Two negative transitions on WDI, after the fault is corrected, will clear the WUS flag.

To further assure data security a voltage fault detection circuit prevents application of write current during power loss or power sequencing.

To enhance write to read recovery time the change in RDX, RDY common mode voltage is minimized by biasing these outputs to a level within the read mode range when in write mode.

Power dissipation in write mode may be reduced by placing a resistor (RCT) between VDD1 & VDD2. The optimum resistor value is 96Ω x 50/Iw (Iw in mA). At low write currents (<15 mA) read mode dissipation is higher than write mode and RCT, though recommended, may not be considered necessary. In this case VDD2 is connected directly to VDD1.

READ MODE

Taking $\overline{CS}$ low and R/$\overline{W}$ high selects read mode which configures the SSI 32R515 as a low noise differential amplifier for the selected head. The RDX and RDY outputs are driven by emitter followers and are in phase with the "X" and "Y" head ports. These outputs should be AC coupled to the load. The internal write current source is gated off in read mode eliminating the need for any external gating.

Read mode selection also initializes the Write Data Flip-Flop (WDFF) to pass write current through the "X" side of the head at a subsequent write mode selection.

IDLE MODE

Taking $\overline{CS}$ high selects the idle mode which switches the RDX, RDY outputs into a high impedance state and deactivates the internal write current source. This facilitates multi-device installations by allowing the read outputs to be wire OR'ed and the write current programming resistor to be common to all devices.

PIN DESCRIPTIONS

NAME	I/O	DESCRIPTION
HS0-HS3	I	Head Select
$\overline{CS}$	I	Chip Select: a low level enables device
R/$\overline{W}$	I	Read/Write: a high level selects read mode
WUS	O*	Write Unsafe: a high level indicates an unsafe writing condition
WDI	I	Write Data In: negative transition toggles direction of head current
H0X-H9X H0Y-H9Y	I/O	X,Y head connections
RDX, RDY	O*	X, Y Read Data: differential read signal out
WC	*	Write Current: used to set the magnitude of the write current
VCT	-	Voltage Center Tap: voltage source for head center tap
VCC	-	+5V
VDD1	-	+12V
VDD2	-	Positive power supply for the center tap voltage source
GND	-	Ground
* When more than one Read/Write device is used, these signals can be wire OR'ed.		

ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS (All voltages referenced to GND. Currents into device are positive.)

PARAMETER		VALUE	UNITS
DC Supply Voltage	VDD1	-0.3 to +14	VDC
DC Supply Voltage	VDD2	-0.3 to +14	VDC
DC Supply Voltage	VCC	-0.3 to +6	VDC
Digital Input Voltage Range	VIN	-0.3 to VCC + 0.3	VDC
Head Port Voltage Range	VH	-0.3 to VDD1 + 0.3	VDC
WUS Pin Voltage Range	Vwus	-0.3 to +14	VDC
Write Current Zero Peak	Iw	60	mA
Output Current	RDX, RD Io	-10	mA
Output Current	IVCT	-60	mA
Output Current	Iwus	+12	mA
Storage Temperature Range	Tstg	-65 to 150	°C
Package Temperature PLCC, SO (20 sec Reflow)		215	°C

RECOMMENDED OPERATION CONDITIONS

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
DC Supply Voltage	VDD1		10.8	12.0	13.2	VDC
DC Supply Voltage	VCC		4.5	5.0	5.5	VDC
Head Inductance	Lh		3		15	µH
RCT Resistor	RCT*	Iw = 50 mA	91	96	101	Ω
Write Current	IW		10		80	mA
Junction Temperature Range	Tj		+25		+135	°C
*For Iw = 50 mA. At other Iw levels refer to Applications Information that follows this specification.						

DC CHARACTERISTICS

Unless otherwise specified, recommended operating conditions apply.

POWER SUPPLY

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
VCC Supply Current	Read/Idle Mode			35	mA
	Write Mode			30	mA
VDD Supply Current (sum of VDD1 and VDD2)	Idle Mode			20	mA
	Read Mode			35	mA
	Write Mode			20 + Iw	mA
Power Dissipation (Tj = +125°C)	Idle Mode			400	mW
	Read Mode			600	mW
	Write Mode, Iw = 50 mA, RCT = 0Ω			900	mW
	Write Mode, IW = 50 mA RCT = 96Ω			660	mW

DC CHARACTERISTICS (Continued)

DIGITAL I/O

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
VIL	Input Low Voltage				0.8	VDC
VIH	Input High Voltage		2.0		VCC + 0.3	VDC
IIL	Input Low Current	VIL = 0.8V	-0.4			mA
IIH	Input High Current	VIH = 2.0V			100	µA
VOL	WUS Output Low Voltage	IOL = 8 mA			0.5	VDC
IOH	WUS Output High Current	VOH = 5.0V			100	µA

WRITE MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Center Tap Voltage VCT	Write Mode		6.0		VDC
Head Current (per side)	Write Mode, 0 ≤ VCC ≤ 3.7V, 0 ≤ VDD1 ≤ 8.7V	-200		200	µA
Write Current Range		10		50	mA
Write Current Constant "K"		2.375		2.625	
Iwc to Head Current Gain			0.99		mA/mA
Unselected Head Leakage Current				100	µA
RDX, RDY Output Offset Voltage	Write/Idle Mode	-20		+20	mV
RDX, RDY Common Mode Output Voltage	Write/Idle Mode		5.3		VDC
RDX, RDY Leakage	RDX, RDY = 6V Write/Idle Mode	-100		100	µA

READ MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Center Tap Voltage	Read Mode	3.0	4.0	5.0	VDC
Head Current (per side)	Read or Idle Mode 0 ≤ VCC ≤ 5.5V 0 ≤ VDD1 ≤ 13.2V	-200		200	µA
Input Bias Current (differential)				100	µA
Input Offset Voltage	Read Mode	-4		+4	mV
Common Mode Output Voltage	Read Mode	4.5		6.5	VDC

DYNAMIC CHARACTERISTICS AND TIMING

Unless otherwise specified, recommended operating conditions apply and Iw = 35 mA, Lh = 10 µH, Rd = 750Ω 32R515 only, f(WDI) = 5 MHz, CL(RDX, RDY) ≤ 20 pF.)

WRITE MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Differential Head Voltage Swing		7.0			V(pk)
Unselected Head Transient Current				.5	mA(pk)
Differential Output Capacitance				15	pF
Differential Output Resistance		458	610	763	Ω
WDI Transition Frequency	WUS = low Iw = 35 mA LH = 4-10 µH	250			kHz
	WUS = low Iw = 20 mA LH = 4 µH	400			kHz

READ MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Differential Voltage Gain	Vin = 1 mVpp @ 300 kHz, RL(RDX), RL(RDY) = 1 kΩ	85		115	V/V
Dynamic Range	DC Input Voltage, Vi, Where Gain Falls by 10%. Vin = Vi + 0.5 mVpp @ 300 kHz	-3		+3	mV
Bandwidth (-3dB)	|Zs| < 5Ω, Vin = 1 mVpp	30			MHz
Input Noise Voltage	BW = 15 MHz, Lh = 0, Rh = 0			1.5	nV/√Hz
Differential Input Capacitance	f = 5 MHz			20	pF
Differential Input Resistance	f = 5 MHz	373		735	Ω
Common Mode Rejection Ratio	Vcm = VCT + 100 mVpp @ 5 MHz	50			dB
Power Supply Rejection Ratio	100 mVpp @ 5 MHz on VDD1, VDD2 or VCC	45			dB
Channel Separation	Unselected Channels: Vin=100 mVpp @ 5 MHz; Selected Channel: Vin = 0 mVpp	45			dB
Single Ended Output Resistance	f = 5 MHz			30	Ω
Output Current	AC Coupled Load, RDX to RDY	±2.1			mA

DYNAMIC CHARACTERISTICS AND TIMING (Continued)

SWITCHING CHARACTERISTICS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
R/$\overline{W}$ To Write	Delay to 90% of Write Current			1.0	µs
R/$\overline{W}$ to Read	Delay to 90% of 100 mV, 10 MHz Read Signal Envelope or to 90% decay of Write Current			1.0	µs
$\overline{CS}$ to Select	Delay to 90% of Write Current or to 90% of 100 mV, 10 MHz Read Signal Envelope			1.0	µs
$\overline{CS}$ to Unselect	Delay to 90% Decay of Write Current			1.0	µs
HS0 - HS3 to any head	Delay to 90% of 100 mV, 10 MHz Read Signal Envelope			600	ns
WUS-Safe to Unsafe - TD1	Iw = 35 mA, LH = 4-10 µH	1.6		8	µs
	Iw = 20 mA, LH = 4 µH	1.0		5.0	µs
WUS-Unsafe to Safe - TD2	Iw = 35 mA			1.0	µs
Head Current (Lh = 0 µH, Rh = 0Ω)					
Prop. Delay - TD3	From 50% Points			25	ns
Asymmetry	WDI has 50% Duty Cycle and 1ns Rise/Fall Time			2	ns
Rise/Fall Time	10% - 90% Points			20	ns

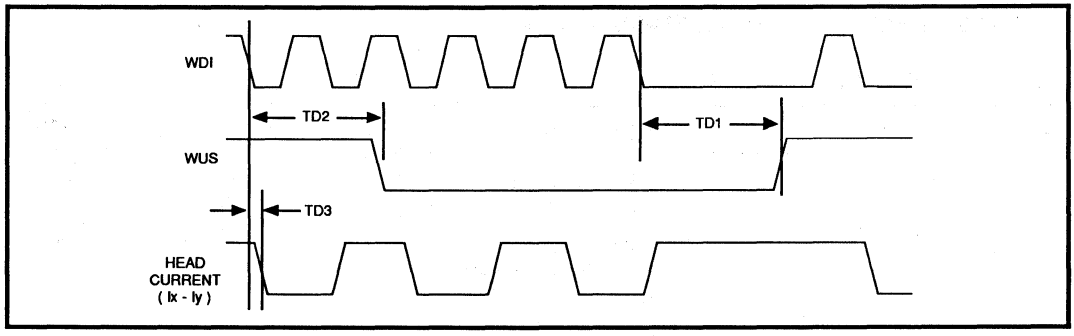
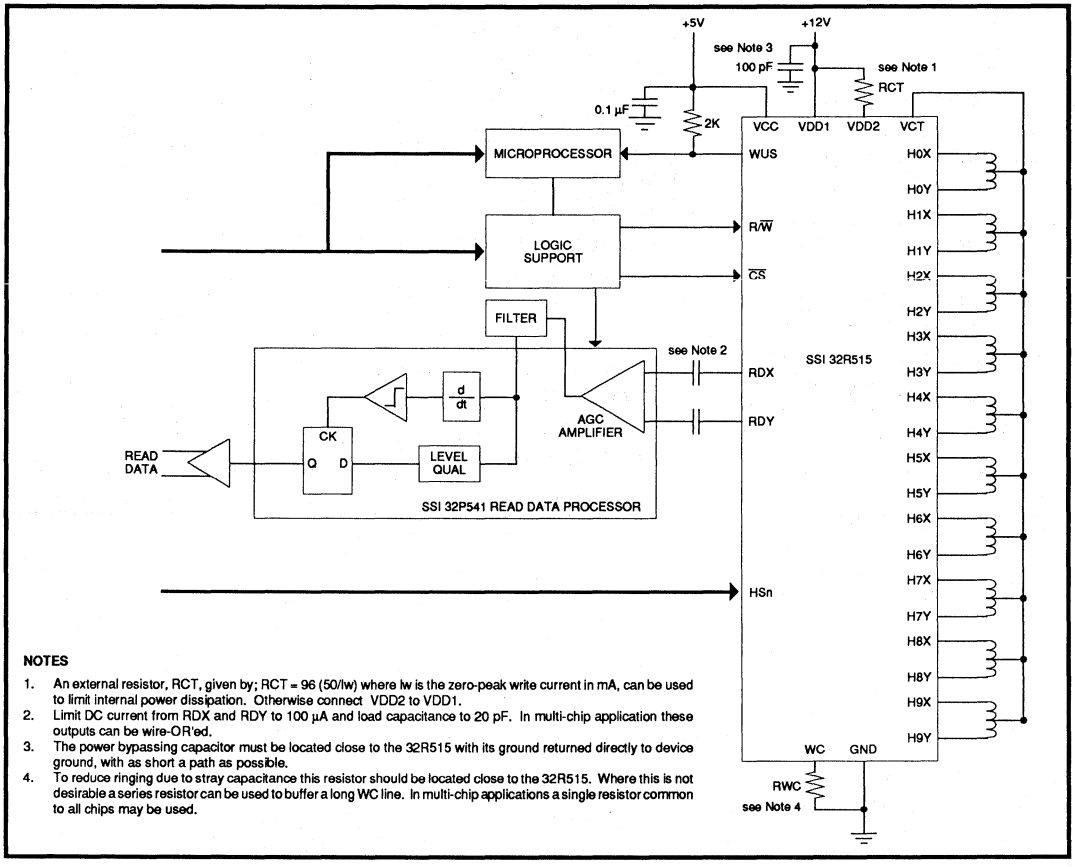


FIGURE 1: Write Mode Timing Diagram



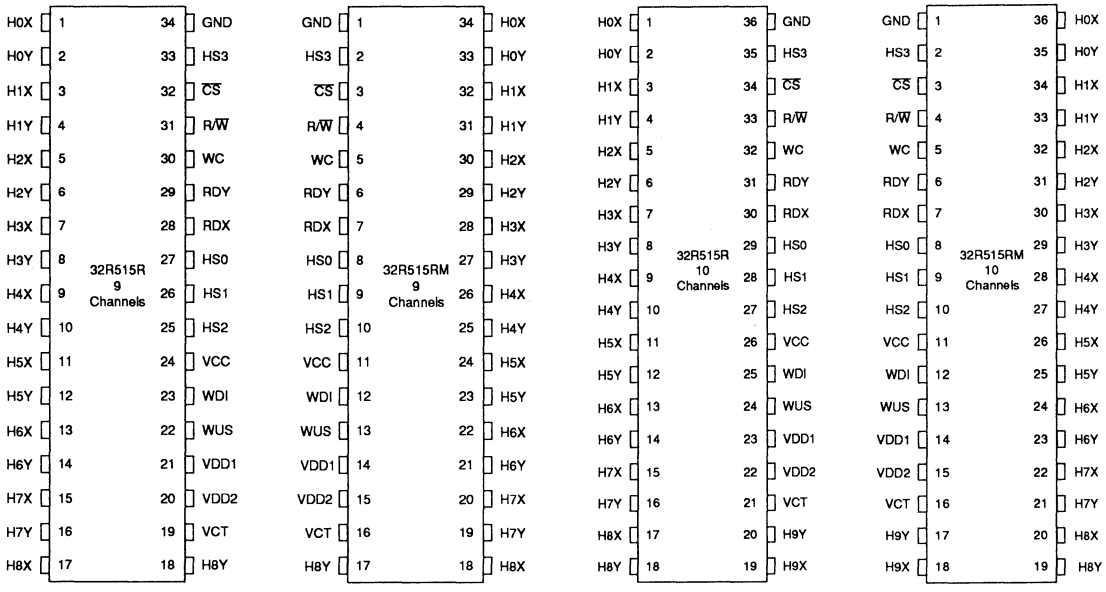
NOTES

1. An external resistor, RCT, given by; RCT = 96 (50/Iw) where Iw is the zero-peak write current in mA, can be used to limit internal power dissipation. Otherwise connect VDD2 to VDD1.
2. Limit DC current from RDX and RDY to 100 µA and load capacitance to 20 pF. In multi-chip application these outputs can be wire-OR'ed.
3. The power bypassing capacitor must be located close to the 32R515 with its ground returned directly to device ground, with as short a path as possible.
4. To reduce ringing due to stray capacitance this resistor should be located close to the 32R515. Where this is not desirable a series resistor can be used to buffer a long WC line. In multi-chip applications a single resistor common to all chips may be used.

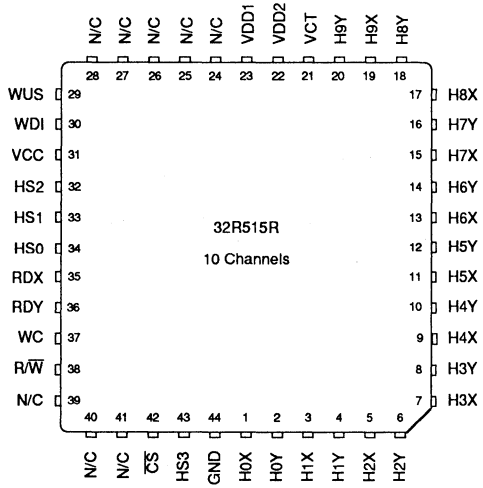
FIGURE 2: Applications Information

PACKAGE PIN DESIGNATIONS

(TOP VIEW)



34-Lead SOL | **34-Lead SOL Mirror Image** | **36-Lead SOM** | **36-Lead SOM Mirror Image**



44-Lead PLCC

THERMAL CHARACTERISTICS: Ø ja

34-Lead	SOL	50°C/W
36-Lead	SOM	50°C/W
44-Lead	PLCC	60°C/W

SSI 32R515R
9, 10-Channel Ferrite/MIG Read/Write Device

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32R515R		
9-Channel SOL	SSI 32R515R-9CL	32R515R-9CL
10-Channel PLCC	SSI 32R515R-10CH	32R515R-10CH
10-Channel SOM	SSI 32R515R-10CM	32R515R-10CM
SSI 32R515RM		
9-Channel SOL	SSI 32R515RM-9CL	32R515RM-10CL
10-Channel SOM	SSI 32R515RM-10CM	32R515RM-10CM

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX: (714) 731-5457

SSI 32R516/516R
4, 6, 8-Channel Ferrite/MIG Read/Write Device
Preliminary Data

1

July, 1990

DESCRIPTION

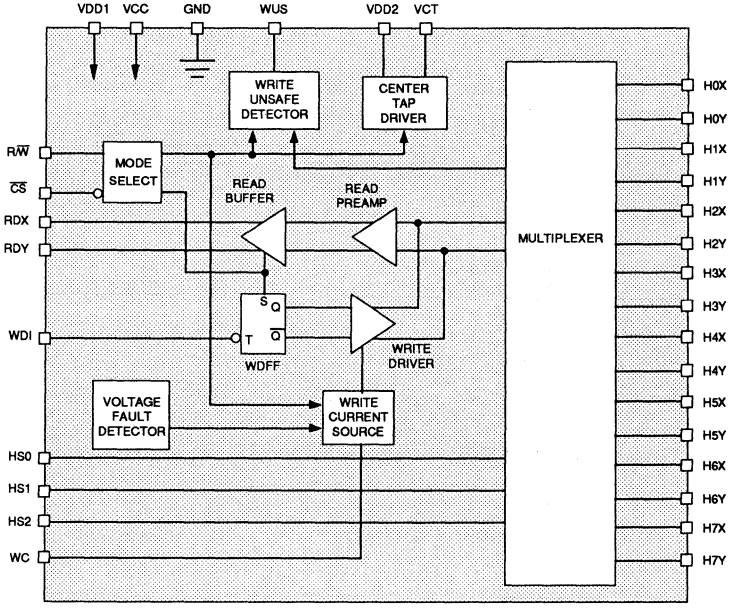
The SSI 32R516 is a bipolar monolithic integrated circuit designed for use with a center-tapped ferrite or MIG recording heads. The SSI 32R516 offers the performance upgrades of the SSI 32R511 along with improved head port characteristics and increased read gain. It provides a low noise read path, write current control, and data protection circuitry for as many as 8 channels. The SSI 32R516 requires +5V and +12V power supplies and is available in a variety of packages.

The SSI 32R516R performs the same function as the SSI 32R516 with the addition of internal 650Ω damping resistors. The SSI 32R516M and SSI 32R516RM are functionally equivalent to the SSI 32R516 and SSI 32R516R however, they have the mirror image pin arrangement to simplify layout when using multiple devices.

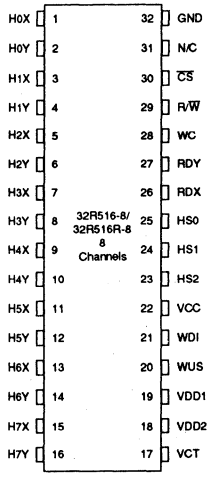
FEATURES

- **High performance**
  - **Read mode gain = 120 V/V**
  - **Input noise = 1.3 nV/√Hz maximum**
  - **Input capacitance = 18 pF**
  - **Write current range = 10 mA to 60 mA**
- **Enhanced system write to read recovery time**
- **Power supply fault protection**
- **Pin compatible with the SSI 32R501 & SSI 32R511**
- **Designed for center-tapped ferrite or MIG heads**
- **Programmable write current source**
- **Easily multiplexed for larger systems**
- **Includes write unsafe detection**
- **TTL compatible control signals**
- **+5V, +12V power supplies**
- **Mirror image pin arrangements**

BLOCK DIAGRAM



PIN DIAGRAM



32-LEAD SOW

CAUTION: Use handling procedures necessary for a static sensitive component.

CIRCUIT OPERATION

The SSI 32R516 gives the user the ability to address up to 8 center-tapped ferrite heads and provide write drive or read amplification. Head selection and mode control is accomplished using the HSn, $\overline{CS}$ and R/$\overline{W}$ inputs as shown in tables 1 & 2. Internal pullups are provided for the $\overline{CS}$ & R/$\overline{W}$ inputs to force the device into a non-writing condition if either control line is opened accidentally.

TABLE 1: Mode Select

$\overline{CS}$	R/$\overline{W}$	MODE
0	0	Write
0	1	Read
1	X	Idle

TABLE 2: Head Select

HS2	HS1	HS0	HEAD
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

0 = Low level 1 = High level

WRITE MODE

Taking both $\overline{CS}$ and R/$\overline{W}$ low selects write mode which configures the SSI 32R516 as a current switch and activates the Write Unsafe (WUS) detector circuitry. Write current is toggled between the X and Y side of the selected head on each high to low transition of the Write Data Input (WDI). Note that a preceding read mode selection initializes the Write Data Flip-Flop, WDFF, to pass write current through the "X" side of the head. The zero-peak write current magnitude is programmed by an external resistor Rwc from pin WC to GND and is given by:

Iw = K/Rwc, where K = Write Current Constant

The Write Unsafe detection circuitry monitors voltage transitions at the selected head connections and flags any of the following conditions as a high level on the Write Unsafe open collector output:

- Head open
- WDI frequency too low
- Device not selected
- Head center tap open
- Device in read mode
- No write current

Two negative transitions on WDI, after the fault is corrected, will clear the WUS flag.

To further assure data security a voltage fault detection circuit prevents application of write current during power loss or power sequencing.

To enhance write to read recovery time the change in RDX, RDY common mode voltage is minimized by biasing these outputs to a level within the read mode range when in write mode.

Power dissipation in write mode may be reduced by placing a resistor (RCT) between VDD1 & VDD2. The optimum resistor value is 82Ω x 60/Iw (Iw in mA). At low write currents (<15 mA) read mode dissipation is higher than write mode and RCT, though recommended, may not be considered necessary. In this case VDD2 is connected directly to VDD1.

READ MODE

Taking $\overline{CS}$ low and R/$\overline{W}$ high selects read mode which configures the SSI 32R516 as a low noise differential amplifier for the selected head. The RDX and RDY outputs are driven by emitter followers and are in phase with the "X" and "Y" head ports. These outputs should be AC coupled to the load. The internal write current source is gated off in read mode eliminating the need for any external gating.

Read mode selection also initializes the Write Data Flip-Flop (WDFF) to pass write current through the "X" side of the head at a subsequent write mode selection.

IDLE MODE

Taking $\overline{CS}$ high selects the idle mode which switches the RDX, RDY outputs into a high impedance state and deactivates the internal write current source. This facilitates multi-device installations by allowing the read outputs to be wire OR'ed and the write current programming resistor to be common to all devices.

PIN DESCRIPTIONS

NAME	I/O	DESCRIPTION
HS0-HS2	I	Head Select
$\overline{CS}$	I	Chip Select: a low level enables device
R/$\overline{W}$	I	Read/Write: a high level selects read mode
WUS	O*	Write Unsafe: a high level indicates an unsafe writing condition
WDI	I	Write Data In: negative transition toggles direction of head current
H0X-H7X H0Y-H7Y	I/O	X,Y head connections
RDX, RDY	O*	X, Y Read Data: differential read signal out
WC	*	Write Current: used to set the magnitude of the write current
VCT	-	Voltage Center Tap: voltage source for head center tap
VCC	-	+5V
VDD1	-	+12V
VDD2	-	Positive power supply for the center tap voltage source
GND	-	Ground

*When more than one R/W device is used, these signals can be wire OR'ed.

ABSOLUTE MAXIMUM RATINGS (All voltages referenced to GND. Currents into device are positive.)

PARAMETER		VALUE	UNITS
DC Supply Voltage	VDD1	-0.3 to +14	VDC
DC Supply Voltage	VDD2	-0.3 to +14	VDC
DC Supply Voltage	VCC	-0.3 to +6	VDC
Digital Input Voltage Range	VIN	-0.3 to VCC + 0.3	VDC
Head Port Voltage Range	VH	-0.3 to VDD1 + 0.3	VDC
WUS Pin Voltage Range	Vwus	-0.3 to +14	VDC
Write Current Zero Peak	IW	90	mA
RDX, RDy Output Current	Io	-10	mA
VCT Output Current	IVCT	-90	mA
WUS Output Current	Iwus	+12	mA
Storage Temperature Range	Tstg	-65 to 150	°C
Lead Temperature PDIP, Flat Pack (10 sec Soldering)		260	°C
Package Temperature PLCC, SO (20 sec Reflow)		215	°C

RECOMMENDED OPERATION CONDITIONS

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
DC Supply Voltage	VDD1		10.8	12.0	13.2	VDC
DC Supply Voltage	VCC		4.5	5.0	5.5	VDC
Head Inductance	Lh		5		10	µH
Damping Resistor	RD	32R516 only	500		2000	Ω
RCT Resistor	RCT*	Iw = 60 mA		82		Ω
Write Current	IW		10		60	mA
Junction Temperature Range	Tj		+25		+135	°C

*For Iw = 60 mA. At other Iw levels refer to Applications Information that follows this specification.

DC CHARACTERISTICS

(Unless otherwise specified, recommended operating conditions apply.)

POWER SUPPLY

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
VCC Supply Current	Read/Idle Mode			30	mA
	Write Mode			30	mA
VDD Supply Current	Idle Mode			20	mA
(sum of VDD1 and VDD2)	Read Mode			40	mA
	Write Mode			20 + Iw	mA
Power Dissipation (Tj = +125°C)	Idle Mode			400	mW
	Read Mode			620	mW
	Write Mode, IW = 45 mA, RCT = 0Ω			800	mW
	Write Mode, IW = 45 mA, RCT = 110Ω			610	mW
	Write Mode, IW = 60 mA RCT = 82Ω			680	mW

DC CHARACTERISTICS (continued)

DIGITAL I/O

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
VIL	Input Low Voltage				0.8	VDC
VIH	Input High Voltage		2.0		VCC + 0.3	VDC
IIL	Input Low Current	VIL = 0.8V	-0.4			mA
IIH	Input High Current	VIH = 2.0V			100	µA
VOL	WUS Output Low Voltage	IOL = 8 mA			0.5	VDC
IOH	WUS Output High Current	VOH = 5.0V			100	µA

WRITE MODE

Center Tap Voltage	VCT	Write Mode		6.9		VDC
Head Current (per side)		Write Mode, 0 ≤ VCC ≤ 3.7V, 0 ≤ VDD1 ≤ 8.7V	-200		200	µA
Write Current Range			10		60	mA
Write Current Constant "K"		IW = 10 - 45 mA	2.375		2.625	
Write Current Constant "K"		IW = 45 - 60 mA	2.3		2.625	
Iwc to Head Current Gain				0.99		mA/mA
Unselected Head Leakage Current					85	µA
RDX, RDY Output Offset Voltage		Write/Idle Mode	-20		+20	mV
RDX, RDY Common Mode Output Voltage		Write/Idle Mode		5.5		VDC
RDX, RDY Leakage		RDX, RDY = 6V Write/Idle Mode	-100		100	µA

READ MODE

Center Tap Voltage	Read Mode		4.2		VDC
Head Current (per side)	Read or Idle Mode 0 ≤ VCC ≤ 5.5V 0 ≤ VDD1 ≤ 13.2V	-200		200	µA
Input Bias Current (per side)				45	µA
Input Offset Voltage	Read Mode	-4		+4	mV
Common Mode Output Voltage	Read Mode	4.5	5.5	6.5	VDC

DYNAMIC CHARACTERISTICS AND TIMING

(Unless otherwise specified, recommended operating conditions apply and IW = 35 mA, Lh = 5 µH, Rd = 750Ω (32R516) only, f(WDI) = 5 MHz, CL(RDX, RDY) ≤ 35 pF.)

WRITE MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Differential Head Voltage Swing		7.0			V(pk)
Unselected Head Transient Current				2	mA(pk)
Differential Output Capacitance				15	pF
Differential Output Resistance	32R516	10K			Ω
	32R516R	430	650	870	Ω
WDI Transition Frequency	WUS = low	125			KHz

READ MODE

Differential Voltage Gain	Vin = 1 mVpp @ 300 kHz, RL(RDX), RL(RDY) = 1 KΩ	100	120	140	V/V
Dynamic Range	AC Input Voltage, Vi, Where Gain Falls by 10%. V + f = 300 KHz	-3			mVpp
Bandwidth (-3dB)	|Zs| < 5Ω, Vin = 1 mVpp	30			MHz
Input Noise Voltage	BW = 15 MHz, Lh = 0, Rh = 0		1.0	1.3	nV/√Hz
Differential Input Capacitance	f = 5 MHz		14	18	pF
Differential Input Resistance	32R516, f = 5 MHz	2K			Ω
Differential Input Resistance	32R516R, f = 5 MHz	350		800	Ω
Common Mode Rejection Ratio	Vcm = VCT + 100 mVpp @ 5 MHz	50			dB
Power Supply Rejection Ratio	100 mVpp @ 5 MHz on VDD1, VDD2 or VCC	45			dB
Channel Separation	Unselected Channels: Vin=100 mVpp @ 5 MHz; Selected Channel: Vin = 0 mVpp	45			dB
Single Ended Output Resistance	f = 5 MHz			30	Ω
Output Current	AC Coupled Load, RDX to RDY	±2.1			mA

DYNAMIC CHARACTERISTICS AND TIMING (continued)

SWITCHING CHARACTERISTICS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
R/$\overline{W}$ To Write	Delay to 90% of Write Current		.15	.7	µs
R/$\overline{W}$ to Read	Delay to 90% of 100 mV, 10 MHz Read Signal Envelope or to 90% decay of Write Current		.25	.7	µs
$\overline{CS}$ to Select	Delay to 90% of Write Current or to 90% of 100 mV, 10 MHz Read Signal Envelope		.2	1.0	µs
$\overline{CS}$ to Unselect	Delay to 90% Decay of Write Current		.1	1.0	µs
HS0 - HS2 to any head	Delay to 90% of 100 mV, 10 MHz Read Signal Envelope		.25	1.0	µs
WUS, Safe to Unsafe - TD1	Iw = 35 mA	1.6		8.0	µs
WUS, Unsafe to Safe - TD2	Iw = 35 mA			1.0	µs
Head Current (Lh = 0 µH, Rh = 0Ω)					
Prop. Delay - TD3	From 50% Points			25	ns
Asymmetry	WDI has 50% Duty Cycle and 1ns Rise/Fall Time			1	ns

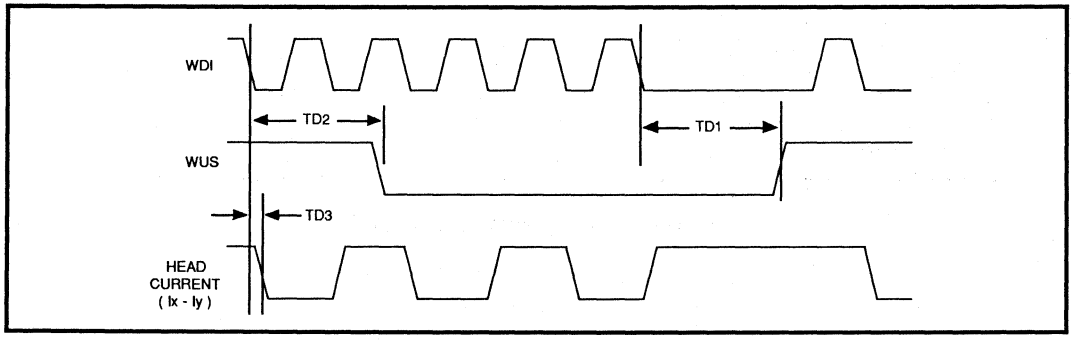
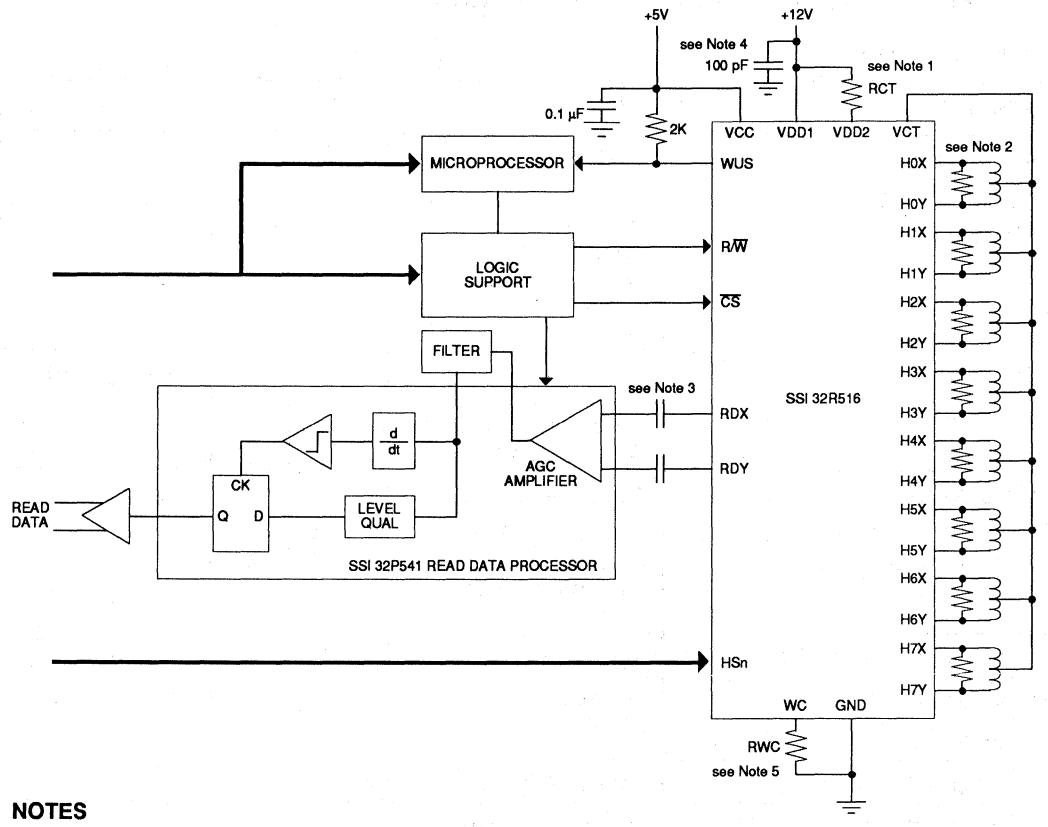


FIGURE 1: Write Mode Timing Diagram

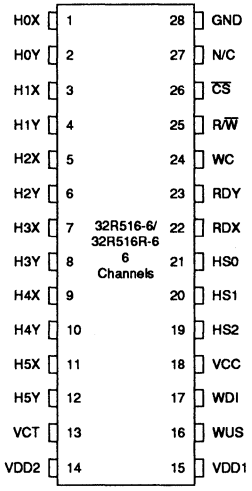


NOTES

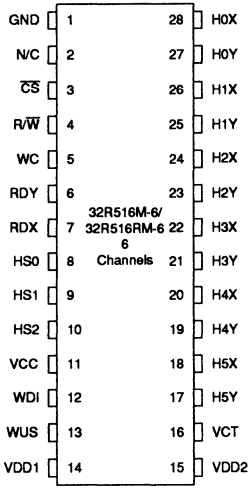
1. An external resistor, RCT, given by; RCT = 82 (60/Iw) where Iw is the zero-peak write current in mA, can be used to limit internal power dissipation. Otherwise connect VDD2 to VDD1.
2. Damping resistors not required on 32R516R versions.
3. Limit DC current from RDX and RDY to 100 µA and load capacitance to 20 pF. In multi-chip application these outputs can be wire-OR'ed.
4. The power bypassing capacitor must be located close to the 32R516 with its ground returned directly to device ground, with as short a path as possible.
5. To reduce ringing due to stray capacitance this resistor should be located close to the 32R516. Where this is not desirable a series resistor can be used to buffer a long WC line. In multi-chip applications a single resistor common to all chips may be used.

FIGURE 2: Applications Information

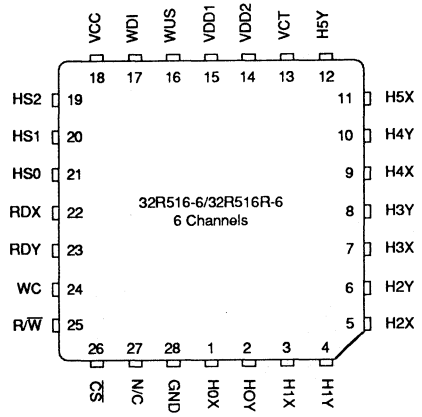
PACKAGE PIN DESIGNATIONS (Top View)



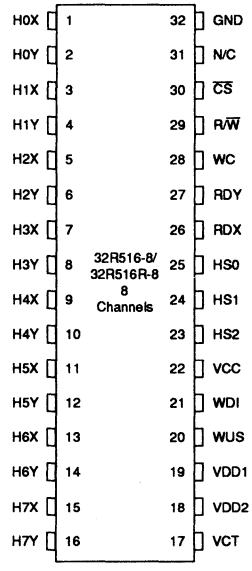
28-Lead SOL



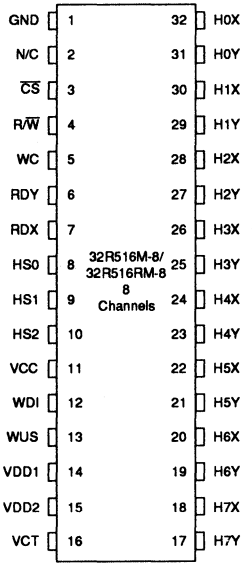
28-Lead SOL
Mirror Image



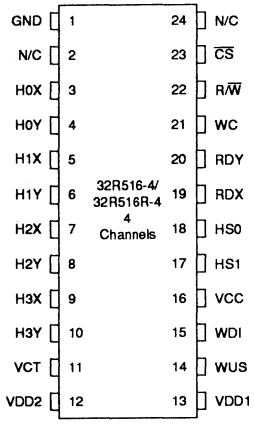
28-Lead PLCC



32-Lead SOW

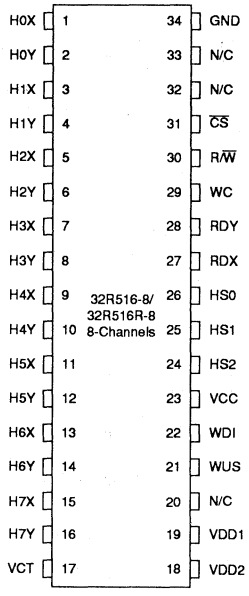


32-Lead SOW
Mirror Image

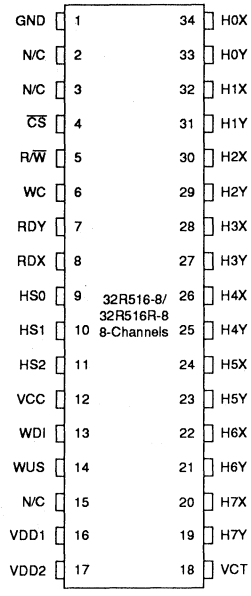


24-Lead SOL

PACKAGE PIN DESIGNATIONS (Continued)



34-Lead SOL



34-Lead SOL
Mirror Image

THERMAL CHARACTERISTICS: Øja

24-lead	SOL	80°C/W
28-lead	PLCC	65°C/W
	SOL	70°C/W
32-lead	SOW	55°C/W
34-lead	SOL	50°C/W
44-lead	PLCC	60°C/W

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32R516		
4-Channel SOL	SSI 32R516-4CL	32R516-4CL
6-Channel PLCC	SSI 32R516-6CH	32R516-6CH
6-Channel SOL	SSI 32R516-6CL	32R516-6CL
8-Channel SOW	SSI 32R516-8CW	32R516-8CW
8-Channel SOL	SSI 32R516-8CL	32R516-8CL
SSI 32R516R		
4-Channel SOL	SSI 32R516R-4CL	32R516R-4CL
6-Channel PLCC	SSI 32R516R-6CH	32R516R-6CH
6-Channel SOL	SSI 32R516R-6CL	32R516R-6CL
8-Channel SOW	SSI 32R516R-8CW	32R516R-8CW
8-Channel SOL	SSI 32R516R-8CL	32R516R-8CL
SSI 32R516M		
6-Channel SOL	SSI 32R516M-6CL	32R516M-6CL
8-Channel SOW	SSI 32R516M-8CW	32R516M-8CW
8-Channel SOL	SSI 32R516M-8CL	32R516M-8CL
SSI 32R516RM		
6-Channel SOL	SSI 32R516RM-6CL	32R516RM-6CL
8-Channel SOW	SSI 32R516RM-8CW	32R516RM-8CW
8-Channel SOL	SSI 32R516RM-8CL	32R516RM-8CL

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32R5161R
10-Channel Ferrite/MIG Read/Write Device
Advance Information

1

July, 1990

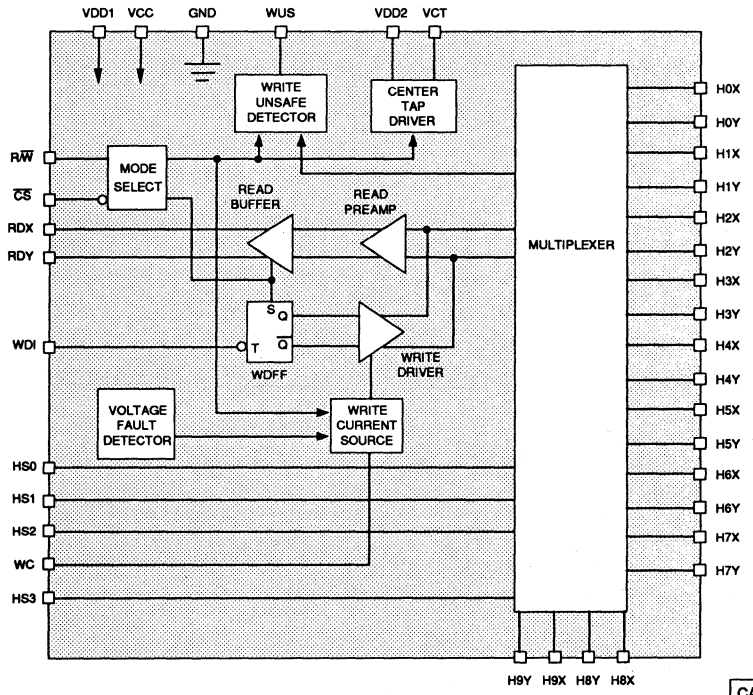
DESCRIPTION

The SSI 32R5161R is a bipolar monolithic integrated circuit designed for use with a center-tapped ferrite or MIG recording heads. The SSI 32R5161R offers the performance upgrades of the SSI 32R511 along with improved head port characteristics and increased read gain. It provides a low noise read path, write current control, and data protection circuitry for as many as 10 channels. The SSI 32R5161R requires +5V and +12V power supplies and is available in a variety of packages.

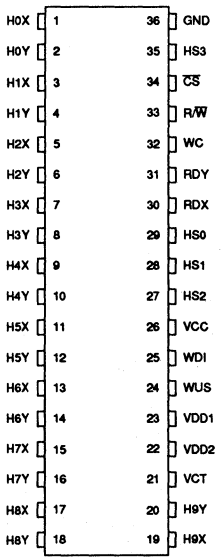
FEATURES

- **High performance**
  - **Read mode gain = 150 V/V**
  - **Input noise = 1.3 nV/$\sqrt{Hz}$ maximum**
  - **Input capacitance = 18 pF**
  - **Write current range = 10 mA to 60 mA**
- **Enhanced system write to read recovery time**
- **Power supply fault protection**
- **Designed for center-tapped ferrite or MIG heads**
- **Programmable write current source**
- **Easily multiplexed for larger systems**
- **Includes write unsafe detection**
- **TTL compatible control signals**
- **+5V, +12V power supplies**

BLOCK DIAGRAM



PIN DIAGRAM



36-LEAD SOM

CAUTION: Use handling procedures necessary for a static sensitive component.

CIRCUIT OPERATION

The SSI 32R5161R gives the user the ability to address up to 10 center-tapped ferrite heads and provide write drive or read amplification. Head selection and mode control is accomplished using the HSn, $\overline{CS}$ and R/$\overline{W}$ inputs as shown in tables 1 & 2. Internal pullups are provided for the $\overline{CS}$ & R/$\overline{W}$ inputs to force the device into a non-writing condition if either control line is opened accidentally.

TABLE 1: Mode Select

$\overline{CS}$	R/$\overline{W}$	MODE
0	0	Write
0	1	Read
1	X	Idle

TABLE 2: Head Select

HS3	HS2	HS1	HS0	HEAD
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9

0 = Low level 1 = High level

WRITE MODE

Taking both $\overline{CS}$ and R/$\overline{W}$ low selects write mode which configures the SSI 32R5161R as a current switch and activates the Write Unsafe (WUS) detector circuitry. Write current is toggled between the X and Y side of the selected head on each high to low transition of the Write Data Input (WDI). Note that a preceding read mode selection initializes the Write Data Flip-Flop, WDFF, to pass write current through the "X" side of the head. The zero-peak write current magnitude is programmed by an external resistor Rwc from pin WC to GND and is given by:

Iw = K/Rwc, where K = Write Current Constant

The Write Unsafe detection circuitry monitors voltage transitions at the selected head connections and flags any of the following conditions as a high level on the Write Unsafe open collector output:

- Head open
- WDI frequency too low
- Device not selected
- Head center tap open
- Device in read mode
- No write current

Two negative transitions on WDI, after the fault is corrected, will clear the WUS flag.

To further assure data security a voltage fault detection circuit prevents application of write current during power loss or power sequencing.

To enhance write to read recovery time the change in RDX, RDY common mode voltage is minimized by biasing these outputs to a level within the read mode range when in write mode.

Power dissipation in write mode may be reduced by placing a resistor (RCT) between VDD1 & VDD2. The optimum resistor value is 82Ω x 60/Iw (Iw in mA). At low write currents (<15 mA) read mode dissipation is higher than write mode and RCT, though recommended, may not be considered necessary. In this case VDD2 is connected directly to VDD1.

READ MODE

Taking $\overline{CS}$ low and R/$\overline{W}$ high selects read mode which configures the SSI 32R5161R as a low noise differential amplifier for the selected head. The RDX and RDY outputs are driven by emitter followers and are in phase with the "X" and "Y" head ports. These outputs should be AC coupled to the load. The internal write current source is gated off in read mode eliminating the need for any external gating.

Read mode selection also initializes the Write Data Flip-Flop (WDFF) to pass write current through the "X" side of the head at a subsequent write mode selection.

IDLE MODE

Taking $\overline{CS}$ high selects the idle mode which switches the RDX, RDY outputs into a high impedance state and deactivates the internal write current source. This facilitates multi-device installations by allowing the read outputs to be wire OR'ed and the write current programming resistor to be common to all devices.

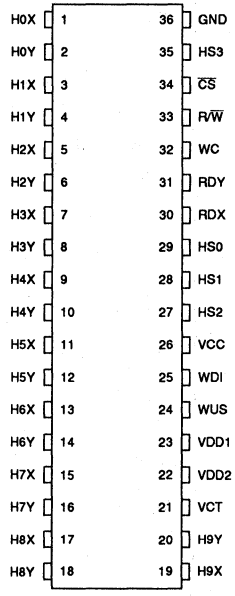
PIN DESCRIPTIONS

NAME	I/O	DESCRIPTION
HS0-HS2	I	Head Select
$\overline{CS}$	I	Chip Select: a low level enables device
R/$\overline{W}$	I	Read/Write: a high level selects read mode
WUS	O*	Write Unsafe: a high level indicates an unsafe writing condition
WDI	I	Write Data In: negative transition toggles direction of head current
H0X-H7X H0Y-H7Y	I/O	X,Y head connections
RDX, RDY	O*	X, Y Read Data: differential read signal out
WC	*	Write Current: used to set the magnitude of the write current
VCT	-	Voltage Center Tap: voltage source for head center tap
VCC	-	+5V
VDD1	-	+12V
VDD2	-	Positive power supply for the center tap voltage source
GND	-	Ground

*When more than one R/W device is used, these signals can be wire OR'ed.

SSI 32R5161R
10-Channel Ferrite/MIG
Read/Write Device

PACKAGE PIN DESIGNATIONS
(TOP VIEW)



36-Lead SOM

THERMAL CHARACTERISTICS: Øja

36-lead	SOM	50°C/W

ORDERING INFORMATION

PART DESCRIPTION	ORDERING NO.	PKG. MARK
SSI 32R5161R Read/Write Device		
10-Channel SOM	SSI 32R5161R-10CM	32R5161R-10CM

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32R521/521R
SSI 32R5211
Thin Film-6-Channel Read/Write Devices

1

July, 1990

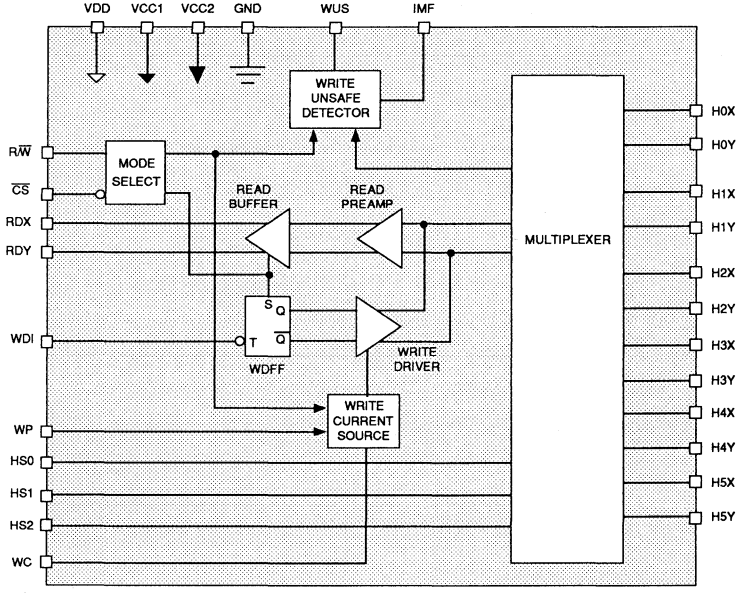
DESCRIPTION

The SSI 32R521 and 32R5211 are bipolar monolithic integrated circuits designed for use with non-center tapped thin film recording heads. They provide a low noise read path, write current control, and data protection circuitry for up to six channels. They require +5V and +12V power supplies and are available in a variety of packages. The SSI 32R521R differs from the SSI 32R521 by having 200Ω internal damping resistors.

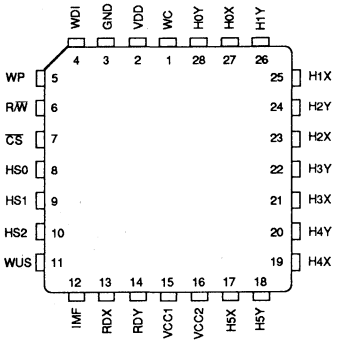
FEATURES

- **High performance**
  - **Read mode gain = 100V/V (32R521)**
  - **= 150V/V (32R5211)**
  - **Input noise = 0.9nV/√Hz maximum**
  - **Input capacitance = 65 pF**
  - **Write current range = 20 mA to 70 mA**
  - **Head voltage swing = 3.4 Vpp**
  - **Write current rise time = 13 nsec**
- **+5V, +12V power supplies**
- **Includes write unsafe detection**

BLOCK DIAGRAM



PIN DIAGRAM



28-LEAD PLCC

CAUTION: Use handling procedures necessary for a static sensitive component.

CIRCUIT OPERATION

The SSI 32R521 functions as a write driver or as a read amplifier for the selected head. Head selection and mode control are described in Tables 1& 2. The inputs R/$\overline{W}$, $\overline{CS}$ and WP have internal pull-up resistors to prevent an accidental write condition.

WRITE MODE

The Write mode configures the SSI 32R521 as a current switch and activates the Write Unsafe Detector. Head current is toggled between the X- and Y-directions of the recording head on the falling edges of WDI, Write Data Input. The magnitude of the write current, given by:

$$Iw = \frac{Vwc}{Rwc}$$

is controlled by an external resistor, Rwc, connected from pin WC to GND.

$$\text{Head Current Ix, y} = \frac{Iw}{1 + Rh/Rd}$$

Any of the following conditions will be indicated as a high level on the Write Unsafe, WUS, open collector output.

- WDI frequency too low
- Device in Read mode
- Chip disabled
- No write current

After fault condition is removed, two negative transitions on WDI are required to clear WUS. The Current monitor output (IMF) sinks one unit of current when the device is selected. This allows a multichip enable fault to be detected.

NOTE: If it is desirable to initialize the Write Data flip-flop to pass current in the Y-direction of the head when entering Write Mode, the WDI input must go low in Read mode for 20 ns minimum.

READ MODE

In the Read mode, the SSI 32R521 is configured as a low noise differential amplifier, the write current source and the write unsafe detector are deactivated, and the write data flip-flop can be set. The RDX and RDY outputs are driven by emitter followers. They should be AC coupled to load. Note that the internal write current source is deactivated for both the Read and chip deselected modes.

IDLE MODE

The idle mode deactivates the internal write current generator, the write unsafe detector and switches the RDX, RDY outputs into a high impedance state. This facilitates multiple device applications by enabling the read outputs to be wire OR'ed and the write current programming resistor to be common to all devices.

TABLE 1: Mode Select

$\overline{CS}$	R/$\overline{W}$	MODE
0	0	Write
0	1	Read
1	0	Idle
1	1	Idle

TABLE 2: Head Select

HS2	HS1	HS0	HEAD
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	none
1	1	1	none

PIN DESCRIPTIONS

NAME	I/O	DESCRIPTION
HSO - HS2	I	Head Select: selects one of six heads
$\overline{CS}$	I	Chip Select: a high inhibits chip
R/$\overline{W}$	I	Read/Write: a high selects Read mode
WP	I	Write Protect: a low enables the write current source
WUS	O*	Write Unsafe: a high indicates an unsafe writing condition
IMF	O*	Current Monitor Function: allows multichip enable fault detection
WDI	I	Write Data In: changes the direction of the current in the recording head
HOX - H5X HOY - H5Y	I/O	X, Y Head Connections: Current in the X-direction flows into the X-port
RDX, RDY	O*	X, Y Read Data: differential read data output
WC	*	Write Current: used to set the magnitude of the write current
VCC1	-	+5V Logic Circuit Supply
VCC2	-	+5V Write Current Supply
VDD	-	+12V
GND	-	Ground

*When more than one device is used, these signals can be wire OR'ed.

ABSOLUTE MAXIMUM RATINGS

PARAMETER		SYMBOL	VALUE	UNITS
DC Supply Voltage		VDD	-0.3 to +14	VDC
		VCC	-0.3 to +7	VDC
Write Current		IW	100	mA
Digital Input Voltage		Vin	-0.3 to VCC +0.3	VDC
Head Port Voltage		VH	-0.3 to VDD +0.3	VDC
Output Current:	RDX, RDY	Io	-10	mA
	WUS	Iwus	+12	mA
Storage Temperature		Tstg	-65 to +150	°C

RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	VALUE	UNITS
DC Supply Voltage	VDD	12 ± 5%	VDC
	VCC1	5 ± 5%	VDC
	VCC2	5 ± 5%	VDC
Operating Temperature	Tj	+25 to +135	°C

DC CHARACTERISTICS

Unless otherwise specified, recommended operating conditions apply.

PARAMETER	CONDITIONS	MIN	MAX	UNITS
VDD Supply Current	Read Mode		34	mA
	Write Mode		38	mA
	Idle Mode		9	mA
VCC Supply Current	Idle Mode		49	mA
	Read Mode		62	mA
	Write Mode		49 + IW	mA
Power Dissipation (Tj = +135°C)	Idle Mode		400	mW
	Read Mode		800	mW
	Write Mode, IW = 70 mA		990	mW

DC CHARACTERISTICS (Continued)

PARAMETER		CONDITIONS	MIN	MAX	UNITS
Digital Inputs					
Input Low Voltage (VIL)			-0.3	0.8	VDC
Input High Voltage (VIH)			2.0	VCC+0.3	VDC
Input Low Current		VIL = 0.8V	-0.4		mA
Input High Current		VIH = 2.0V		100	µA
RDX, RDY Common Mode Output Voltage			3	5	VDC
WUS Output	VOL	Iol = 8 mA		0.5	VDC
IMF Output		$\overline{CS}$ = 0	0.73	1.23	mA
		$\overline{CS}$ = 1		0.02	mA

WRITE CHARACTERISTICS
Unless otherwise specified, recommended operating conditions apply, and IW = 40 mA, Lh = 200 nH, Rh = 16Ω, f(Data) = 5 MHz, CL(RDX, RDY) < 20 pF, RL(RDX,RDY) = 1 kΩ.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Write Current Voltage Vwc			1.65±5%		V
Differential Head Voltage Swing		3.4			V(pp)
Unselected Head Current				2	mA(pk)
Differential Output Capacitance				30	pF
Differential Output Resistance	32R521R	160	200	240	Ω
	32R521, 32R5211	2K			Ω
WDI Transition Frequency	WUS=low	1.7			MHz
Write Current Range		20		70	mA

READ CHARACTERISTICS
Unless otherwise specified, recommended operating conditions apply.

PARAMETER			CONDITIONS	MIN	MAX	UNITS
Differential Voltage Gain		32R521	Vin = 1 mVpp @ 300 kHz RL(RDX), RL(RDY) = 1 kΩ	75	125	V/V
		32R5211	Same as above	120	180	V/V
Voltage Bandwidth	-1dB	32R521	|Zs| < 5Ω, Vin = 1 mVpp @ 300 kHz	25		MHz
		32R5211	Same as above	10		MHz
	-3dB	32R521	Same as above	45		MHz
		32R5211	Same as above	30		MHz

READ CHARACTERISTICS (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Input Noise Voltage	BW = 15 MHz, Lh = 0, Rh = 0			0.9	nV/√Hz
Differential Input Capacitance	f = 5 MHz			65	pF
Differential Input Resistance	521R, f = 5 MHz		200		Ω
	521 and 5211, f = 5 MHz	600			Ω
Input Bias Current				170	mA
Dynamic Range	DC input voltage where gain falls to 90% of its 0 VDC value Vin=VDC+0.5mVpp, f=5MHz	-3		3	mV
Common Mode Rejection Ratio	Vin=0VDC+100mVpp@5MHz	54			dB
Power Supply Rejection Ratio	100 mVpp @ 5 MHz on VDD	54	90		dB
	100 mVpp @ 5 MHz on VCC		49		
Channel Separation	Unselected channels driven with 100 mVpp @ 5 MHz Vin = 0 mVpp	45			dB
Output Offset Voltage		-360		360	mV
Single Ended Output Resistance	f = 5 MHz			30	Ω
Output Current	AC Coupled Load, RDX to RDY	3.2			mA

SWITCHING CHARACTERISTICS
Unless otherwise specified, recommended operating conditions apply, and IW = 40 mA, Lh = 200 nH, Rh = 16Ω, f(Data) = 5 MHz.

PARAMETER		CONDITIONS	MIN	MAX	UNITS
R/$\overline{W}$	R/$\overline{W}$ to Write	To 90% of write current		0.6	µs
	R/$\overline{W}$ to Read	To 90% of 100 mV, 10 MHz Read signal envelope		0.6	µs
$\overline{CS}$	$\overline{CS}$ to Select	To 90% of write current		1	µs
	$\overline{CS}$ to Unselect	To 90% of 100 mV, 10 MHz Read signal envelope		1	µs
HS0, 1, 2 to any Head		To 90% of 100 mV, 10 MHz Read signal envelope		0.4	µs
WUS	Safe to Unsafe TD1		0.6	3.6	µs
	Unsafe to Safe TD2			1	µs
IMF	Transition Time	Delay from 50% point of CS to 90%of IMF current		0.6	µs
Head Current		Lh = 0, Rh = 0			
	WDI to (Ix-Iy) TD3	From 50% points		32	ns
	Asymmetry	WDI has 50% duty cycle and 1ns rise/fall time		1.0	ns
	Rise/Fall Time	10% - 90% points		13	ns

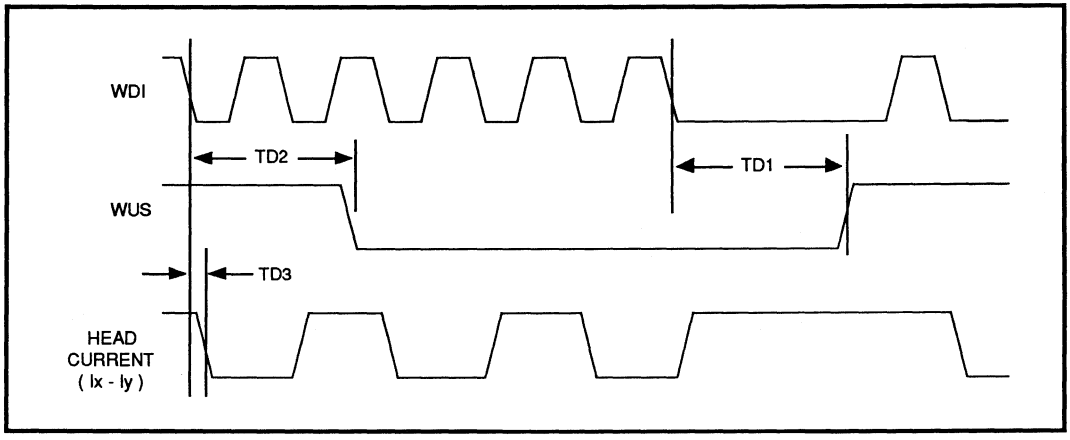


FIGURE 1: Write Mode Timing Diagram

APPLICATIONS INFORMATION

Read mode input port parameter limits, as given in the specifications, are over extremes of temperature, voltage and process. The tabulation below shows parameter correlation as a function of base sheet resistance, a processing parameter. Use of these limits, for worst case analysis, will be more representative of actual performance.

EXAMPLE 1: Base Sheet Resistance = Maximum

PARAMETER		Tj = 25°C	Tj = 135°C	UNITS
Input Noise Voltage (Maximum)		0.69	0.9	nV/√Hz
Differential Input Resistance (Minimum)	521R	146	150	Ω
	521, 5211	1025	1240	Ω
Differential Input Capacitance (Maximum)		43	47	pF

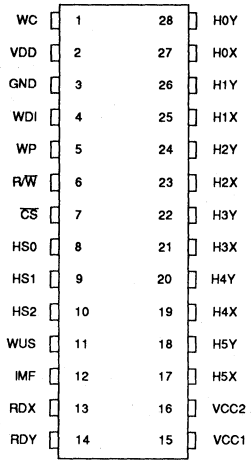
EXAMPLE 2: Base Sheet Resistance = Minimum

PARAMETER		Tj = 25°C	Tj = 135°C	UNITS
Input Noise Voltage (Maximum)		0.58	0.75	nV/√Hz
Differential Input Resistance (Minimum)	521R	133	140	Ω
	521, 5211	600	760	Ω
Differential Input Capacitance (Maximum)		51	56	pF

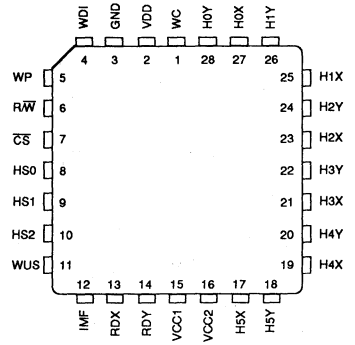
SSI 32R521/521R
SSI 32R5211
Thin Film-6-Channel Read/Write Devices

PACKAGE PIN DESIGNATIONS

(Top View)



28-Lead SOL, Flatpack



28-Lead PLCC

THERMAL CHARACTERISTICS: Øja

28-Lead	SOL	75°C/W
	PLCC	65°C/W
	Flatpack	100°C/W

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32R521 - Read/Write IC		
6 - Channel SOL	SSI 32R521-6L	32R521-6L
6 - Channel PLCC	SSI 32R521-6CH	32R521-6CH
6 - Channel Flatpack	SSI 32R521-6F	32R521-6F
SSI 32R521R - with Internal Damping Resistors		
6 - Channel SOL	SSI 32R521R-6L	32R521R-6L
6 - Channel PLCC	SSI 32R521R-6CH	32R521R-6CH
6 - Channel Flatpack	SSI 32R521R-6F	32R521R-6F
SSI 32R5211 - Read/Write IC		
6 - Channel SOL	SSI 32R5211-6L	32R5211-6L
6 - Channel PLCC	SSI 32R5211-6CH	32R5211-6CH

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32R522/522R
4, 6-Channel Thin Film Read/Write Device

1

July, 1990

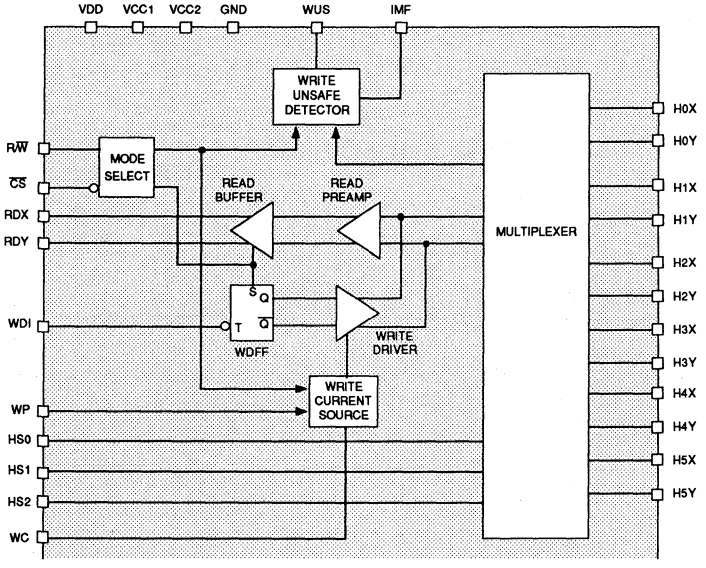
DESCRIPTION

The SSI 32R522/522R Read/Write devices are bipolar monolithic integrated circuits designed for use with two terminal thin film recording heads. They provide a low noise read amplifier, write current control and data protection circuitry for as many as six channels. They require +5V and +12V power supplies and are available in a variety of package and channel configurations. The 32R522R option provides internal 1000Ω damping resistors.

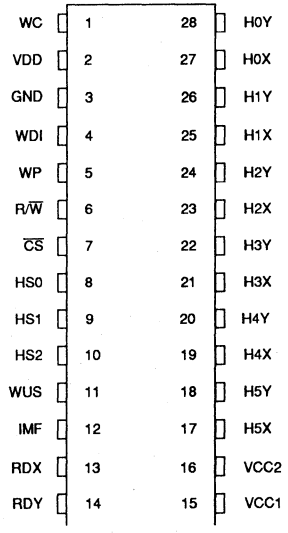
FEATURES

- **High performance:**
  - **Read mode**
  - **Input noise = 1.0nV/√Hz max.**
  - **Input capacitance = 32 pF**
  - **Write current range = 6 mA to 35 mA**
  - **Head voltage swing = 3.4 Vpp**
- **Compatible with two & three terminal thin film heads**
- **Programmable write current source**
- **Write unsafe detection**
- **TTL compatible control signals**
- **+5 & +12V power supplies**

BLOCK DIAGRAM



PIN DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 32R522/522R
4, 6-Channel Thin Film Read/Write Device

CIRCUIT OPERATION

The SSI 32R522 addresses up to six two-terminal thin film heads providing write current drive or read amplification. Head selection and mode control is accomplished with pins HSn, $\overline{CS}$ and R/$\overline{W}$, as shown in Tables 1 & 2. Internal resistor pullups, provided on pins $\overline{CS}$, R/$\overline{W}$ and WP will force the device into a non-writing condition if either control line is opened accidentally.

WRITE MODE

The write mode configures the SSI 32R522 as a current switch and activates the Write Unsafe (WUS) detection circuitry. Write current is toggled between the X and Y direction of the selected head on each high to low transition on pin WDI, Write Data Input.

The magnitude of the write current (0-pk) given by:

$$Iw = \frac{Vwc}{RWC}$$

where Vwc (WC pin voltage) = 1.7V ± 5%, is programmed by an external resistor RWC, connected from pin WC to ground. In multiple device applications, a single RWC resistor may be made common to all devices. The actual head current Ix, y is given by:

$$Ix, y = \frac{Iw}{1 + Rh/Rd}$$

where:
Rh = Head resistance + external wire resistance, and
Rd = Damping resistance.

The write unsafe detection circuitry will flag any of the conditions listed below as a high level on the open collector output pin, WUS. Two negative transitions on pin WDI, after the fault is corrected, are required to clear the WUS flag.

- WDI frequency too low
- Device in read mode
- Device not selected
- No write current

A multiple device enable condition can be detected by monitoring the voltage across a resistor connected from VCC to the wire OR'ed IMF (Current Monitor Function) pins. Pin IMF sinks one unit of current when the device is enabled.

To initialize the Write Data Flip Flop (WDFF) to pass current through the Y-direction of the head, pin WDI must be low when the previous read mode was commanded.

READ MODE

The read mode configures the SSI 32R522 as a low noise differential amplifier and deactivates the write current generator and write unsafe circuitry. The RDX and RDY outputs are emitter followers and are in phase with the "X" and "Y" head ports. These outputs should be AC coupled to the load.

IDLE MODE

The idle mode deactivates the internal write current generator, the write unsafe detector and switches the RDX, RDY outputs into a high impedance state. This facilitates multiple device applications by enabling the read outputs to be wire OR'ed and the write current programming resistor to be common to all devices.

TABLE 1: Mode Select

$\overline{CS}$	R/$\overline{W}$	MODE
0	0	Write
0	1	Read
1	0	Idle
1	1	Idle

TABLE 2: Head Select

HS2	HS1	HS0	HEAD
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	X	none

0 = Low level, 1 = High level, X = Don't care

PIN DESCRIPTIONS

NAME	I/O	DESCRIPTION
HS0 - HS2	I	Head Select: selects one of six heads
$\overline{CS}$	I	Chip Select: a low level enables the device
R/$\overline{W}$	I	Read/Write: a high level selects read mode
WP	I	Write Protect: a low level enables the write current source
WUS	O*	Write Unsafe: a high level indicates an unsafe writing condition
IMF	O*	Current Monitor Function: allows multichip enable fault detection
WDI	I	Write Data In: a negative transition toggles the direction of the head current
H0X - H5X H0Y - H5Y	I/O	X, Y Head Connections: Current in the X-direction flows into the X-port
RDX, RDY	O*	X, Y Read Data: differential read data output
WC	*	Write Current: used to set the magnitude of the write current
VCC1	-	+5V Logic Circuit Supply
VCC2	-	+5V Write Current Supply
VDD	-	+12V
GND	-	Ground

*When more than one device is used, these signals can be wire OR'ed.

SSI 32R522/522R
4, 6-Channel Thin Film
Read/Write Device

ABSOLUTE MAXIMUM RATINGS

PARAMETER		SYMBOL	VALUE	UNITS
DC Supply Voltage		VDD	-0.3 to +14	VDC
		VCC1, 2	-0.3 to +7	VDC
Write Current		Iw	100	mA
Digital Input Voltage		Vin	-0.3 to VCC +0.3	VDC
Head Port Voltage		VH	-0.3 to VDD +0.3	VDC
Output Current	RDX, RDY	Io	-10	mA
	WUS	Iwus	+12	mA
Storage Temperature		Tstg	-65 to +150	°C

RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	VALUE	UNITS
DC Supply Voltage	VDD	12 ± 5%	VDC
	VCC1	5 ± 5%	VDC
	VCC2	5 ± 5%	VDC
Operating Temperature	Tj	+25 to +135	°C

DC CHARACTERISTICS

Unless otherwise specified: recommended operating conditions apply.

PARAMETER	CONDITIONS	MIN	MAX	UNITS
VDD Supply Current	Read Mode	-	34	mA
	Write Mode	-	38	mA
	Idle Mode	-	9	mA
VCC Supply Current	Read Mode	-	62	mA
	Write Mode	-	49+IW	mA
	Idle Mode	-	49	mA
Power Dissipation (Tj=+135°C)	Read Mode	-	800	mW
	Write Mode, Iw = 35 mA	-	950	mW
	Idle Mode	-	400	mW
Input Low Voltage (VIL)		-	0.8	VDC
Input High Voltage (VIH)		2.0	-	VDC
Input Low Current (IIL)	VIL = 0.8V	-0.4	-	mA
Input High Current (IIH)	VIH = 2.0V	-	100	µA

DC CHARACTERISTICS (Continued)

PARAMETER	CONDITIONS	MIN	MAX	UNITS
RDX, RDY Common Mode Output Voltage	Read Mode	3	5	VDC
WUS Output Low Voltage (VOL)	Iol = 8 mA	-	0.5	VDC
IMF Output Current	$\overline{CS}$ = 0	0.73	1.23	mA
	$\overline{CS}$ = 1	-	0.02	mA

WRITE CHARACTERISTICS
Unless otherwise specified: recommended operating conditions apply, Iw = 10 mA, Lh = 1.5 µH, Rh = 30Ω and f(Data) = 5 MHz.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
WC Pin Voltage (Vwc)		1.61	1.7	1.79	V
Differential Head Voltage Swing		3.4	-	-	Vpp
Unselected Head Current	Iw = 50 mA	-	-	1	mA(pk)
Differential Output Capacitance		-	-	30	pF
Differential Output Resistance	32R522R	800	1000	1350	Ω
	32R522	2400	-	-	Ω
WDI Transition Frequency	WUS=low	1.7	-	-	MHz
Write Current Range		6	-	35	mA

READ CHARACTERISTICS
Unless otherwise specified: recommended operating conditions apply, CL(RDX, RDY) < 20 pF and RL(RDX, RDY) = 1 KΩ.

PARAMETER		CONDITIONS	MIN	MAX	UNITS
Differential Voltage Gain		Vin = 1 mVpp @ 300 KHz	75	125	V/V
Bandwidth	-1dB	|Zs|<5Ω, Vin = 1 mVpp @ 300 KHz	25	-	MHz
	-3dB	|Zs|<5Ω, Vin = 1 mVpp @ 300 KHz	45	-	MHz
Input Noise Voltage		BW = 15 MHz, Lh = 0, Rh = 0	-	1.0	$nV/\sqrt{Hz}$
Differential Input Capacitance		Vin = 1 mVpp, f = 5 MHz	-	32	pF
Differential Input Resistance	32R522R	Vin = 1 mVpp, f = 5 MHz	460	-	Ω
	32R522	Vin = 1 mVpp, f = 5 MHz	770	-	Ω
Dynamic Range		DC input voltage where gain falls to 90% of its 0 VDC value, Vin = VDC + 0.5 mVpp, f = 5 MHz	-3	3	mV
Common Mode Rejection Ratio		Vin = 0 VDC + 100 mVpp @ 5 MHz	54	-	dB
Power Supply Rejection Ratio		100 mVpp @ 5 MHz on VDD 100 mVpp @ 5 MHz on VCC	54	-	dB

READ CHARACTERISTICS (Continued)

PARAMETER	TEST CONDITIONS	MIN.	MAX.	UNITS
Channel Separation	Unselected channels driven with 100 mVpp @ 5 MHz, Vin = 0 mVpp	45	-	dB
Output Offset Voltage		-300	+300	mV
Single Ended Output Resistance	f = 5 MHz	-	30	Ω
Output Current	AC Coupled Load, RDX to RDY	3.2	-	mA

SWITCHING CHARACTERISTICS
Unless otherwise specified: recommended operating conditions apply, IW = 10 mA, Lh = 1.5 µH, Rh = 30Ω and f(Data) = 5 MHz. Reference Figure 1.

PARAMETER	CONDITIONS	MIN	MAX	UNITS
R/$\overline{W}$				
R/$\overline{W}$ to Write Mode	Delay to 90% of write current	-	0.6	µs
R/$\overline{W}$ to Read Mode	Delay to 90% of 100 mV, 10 MHz Read signal envelope or to 90% decay of write current	-	0.6	µs
$\overline{CS}$				
$\overline{CS}$ to Select	Delay to 90% of write current or to 90% of 100 mV, 10 MHz Read signal envelope	-	1	µs
$\overline{CS}$ to Unselect	Delay to 90% of write current	-	1	µs
HSn				
HS0, 1, 2 to any Head	Delay to 90% of 100 mV, 10 MHz Read signal envelope	-	0.4	µs
WUS				
Safe to Unsafe-TD1		0.6	3.6	µs
Unsafe to Safe-TD2		-	1	µs
IMF				
Propagation Delay	Delay from 50% point of $\overline{CS}$ to 90% of IMF current	-	0.6	µs
Head Current				
Prop. Delay-TD3	From 50% points, Lh=0µh, Rh=0Ω	-	32	ns
Asymmetry	WDI has 50% duty cycle and 1ns rise/fall time, Lh=0µh, Rh=0Ω	-	0.5	ns
Rise/Fall Time	10% - 90% points, Lh=0µh, Rh=0Ω	-	10	ns

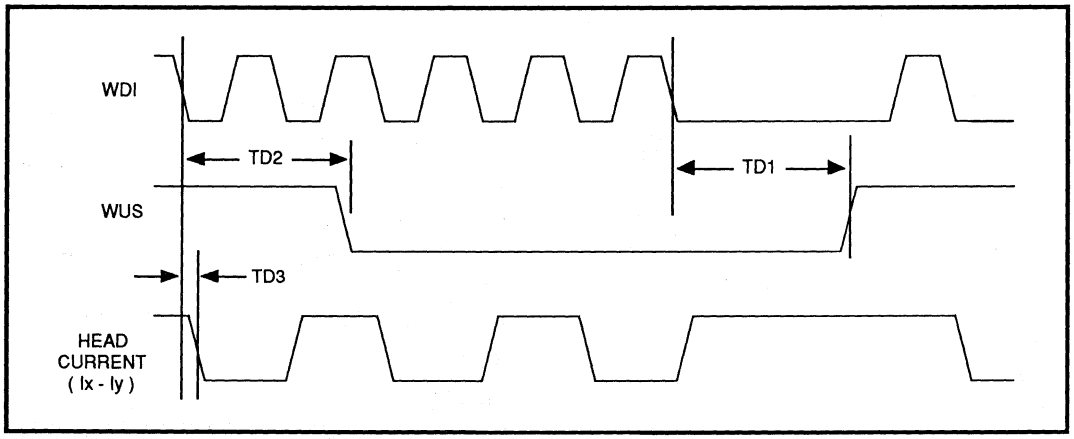


FIGURE 1: Write Mode Timing Diagram

APPLICATIONS INFORMATION

The specifications, provided in the data section, account for the worst case values of each parameter taken individually. In actual operation, the effects of worst case conditions on many parameters correlate. Tables 3 & 4 demonstrate this for several key parameters. Notice that under the conditions of worst case input noise, the higher read back signal resulting from the higher input impedance can compensate for the higher input noise. Accounting for this correlation in your analysis will be more representative of actual performance.

TABLE 3: Key Parameters Under Worst Case Input Noise Conditions

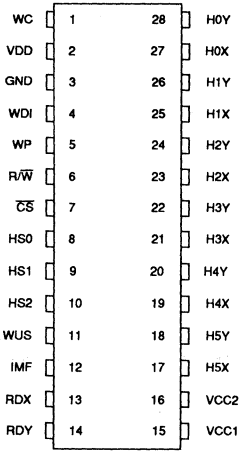
PARAMETER		Tj = 25°C	Tj = 135°C	UNITS
Input Noise Voltage (Max.)		0.76	1.0	nV/√Hz
Differential Input Resistance (Min.)	32R522R	602	645	Ω
	32R522	1245	1455	Ω
Differential Input Capacitance (Max.)		25	28	pF

TABLE 4: Key Parameters Under Worst Case Input Impedance Conditions

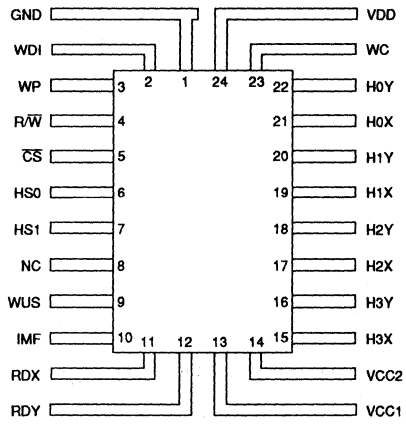
PARAMETER		Tj = 25°C	Tj = 135°C	UNITS
Input Noise Voltage (Max.)		0.63	0.82	nV/√Hz
Differential Input Resistance (Min.)	32R522R	460	526	Ω
	32R522	770	960	Ω
Differential Input Capacitance (Max.)		30	32	pF

SSI 32R522/522R
4, 6-Channel Thin Film Read/Write Device

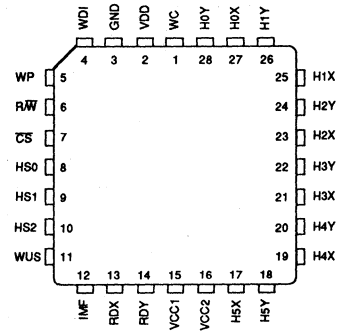
PACKAGE PIN DESIGNATIONS
(TOP VIEW)



28 - LEAD SOL



24 - LEAD FLATPACK



28 - LEAD PLCC

THERMAL CHARACTERISTICS: θja	
24 - Lead FLAT PACK	105°C/W
28 - Lead SOL	70°C/W
28 - Lead PLCC	65°C/W

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32R522 - Read/Write IC		
4 - Channel Flat Pack	SSI 32R522 - 4F	32R522 - 4F
6 - Channel SOL	SSI 32R522 - 6L	32R522 - 6L
6 - Channel PLCC	SSI 32R522 - 6CH	32R522 - 6CH
SSI 32R522R- w/Internal Damping Resistors		
4 - Channel Flat Pack	SSI 32R522R - 4F	32R522R - 4F
6 - Channel SOL	SSI 32R522R - 6L	32R522R - 6L
6 - Channel PLCC	SSI 32R522R - 6CH	32R522R - 6CH

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32R524R
8-Channel Thin Film Read/Write Device

1

July, 1990

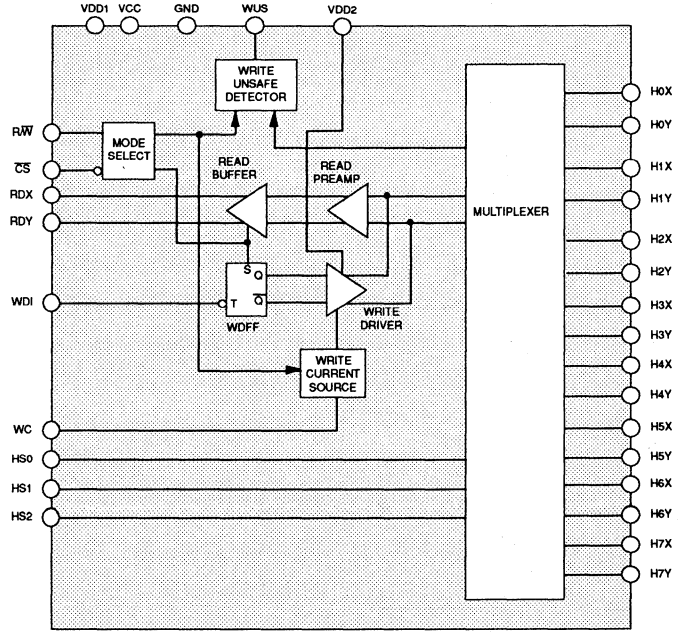
DESCRIPTION

The SSI 32R524R Read/Write device is a bipolar monolithic integrated circuit designed for use with two terminal thin film recording heads. It provides a low noise read amplifier, write current control and data protection circuitry for eight channels. Power supply fault protection is provided by disabling the write current generator during power sequencing. System write to read recovery time is significantly improved by controlling the read channel common mode output voltage shift in the write mode. It requires +5V and +12V power supplies and is available in a variety of package configurations. A mirror image pinout option is available to simplify flex circuit layout in multiple R/W device applications. The SSI 32R524R provides internal 740Ω damping resistors.

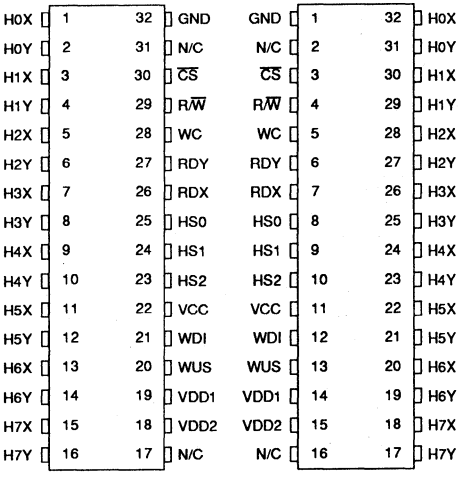
FEATURES

- **High performance:**
  - **Read mode gain = 100V/V**
  - **Input noise = 0.75 nV/√Hz max.**
  - **Input capacitance = 60 pF max.**
  - **Write current range = 20 to 60 mA**
  - **Head voltage swing = 7 Vpp**
  - **Write current rise time = 9 nsec**
- **Enhanced system write to read recovery time**
- **Power supply fault protection**
- **Plug compatible to the SSI 32R501, SSI 32R511 & SSI 32R512**
- **Compatible with two & three terminal thin film heads**
- **Write unsafe detection**
- **+5V, +12V power supplies**
- **Mirror image pinout option**

BLOCK DIAGRAM



PIN DIAGRAM



32-LEAD SOW, FLATPACK

32-LEAD SOW MIRROR

CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 32R524R
8-Channel Thin Film
Read/Write Device

CIRCUIT OPERATION

The SSI 32R524R addresses eight two-terminal thin film heads providing write drive or read amplification. Head selection and mode control is accomplished with pins HSn, $\overline{CS}$ and R/$\overline{W}$, as shown in Tables 1 & 2. Internal resistor pullups, provided on pins $\overline{CS}$ and R/$\overline{W}$ will force the device into a non-writing condition if either control line is opened accidentally.

WRITE MODE

The write mode configures the SSI 32R524R as a differential current switch and activates the Write Unsafe (WUS) detection circuitry. Write current is toggled between the X and Y directions of the selected head on each high to low transition on pin WDI, Write Data Input.

A preceding read operation initializes the Write Data Flip Flop (WDFF) to pass write current in the X-direction of the head, which is defined as entering from the Y-side and flowing to the X-side.
The magnitude of the write current (0-pk) given by:

$$Iw = \frac{K}{RWC}$$

where K (Write Current Constant) = 70 ± 5%, is programmed by an external resistor RWC, connected from pin WC to ground. The actual head current Ix, y is given by:

$$Iw,y = \frac{Iw}{1 + Rh/Rd}$$

where:
Rh = head resistance + external wire resistance, and
Rd = damping resistance.

Power supply fault protection improves data security by disabling the write current generator during a voltage fault or power supply sequencing. Additionally, the write unsafe detection circuitry will flag any of the conditions listed below as a high level on the open collector output pin, WUS. Two negative transitions on pin WDI, after the fault is corrected, are required to clear the WUS flag.

- Open head
- WDI frequency too low
- Device not selected
- Device in read mode
- No write current

Power dissipation in Write Mode may be reduced by placing a resistor, Rw, between VDD1 and VDD2. The resistor value should be chosen such that Iw Rw ≤ 3.0V for an accompanying power dissipation reduction of $(Iw)^2$ Rw. If a resistor is not used, VDD2 should be connected to VDD1. Note that Rw will also provide current limiting in the event of a head short.

READ MODE

The read mode configures the SSI 32R524R as a low noise differential amplifier and deactivates the write current generator and write unsafe detection circuitry. The RDX and RDY outputs are emitter followers and are in phase with the "X" and "Y" head ports. These outputs should be AC coupled to the load. The RDX, RDY common mode voltage is maintained in the write mode, minimizing the transient between write mode and read mode, substantially reducing the write to read recovery time in the subsequent Pulse Detection circuitry.

IDLE MODE

The idle mode deactivates the internal write current generator, the write unsafe detector, and switches the RDX, RDY outputs into a high impedance state. This facilitates multiple device applications by enabling the read outputs to be wire OR'ed.

TABLE 1: Mode Select

$\overline{CS}$	R/$\overline{W}$	MODE
0	0	Write
0	1	Read
1	0	Idle
1	1	Idle

TABLE 2: Head Select

HS2	HS1	HS0	HEAD
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

0 = Low level, 1 = High level

PIN DESCRIPTIONS

NAME	TYPE	DESCRIPTION
HSO - HS2	I	Head Select: selects one of eight heads
$\overline{CS}$	I	Chip Select: a low level enables the device
R/$\overline{W}$	I	Read/Write: a high level selects Read Mode
WUS	O*	Write Unsafe: Open collector output, a high level indicates an unsafe writing condition
WDI	I	Write Data In: a negative transition toggles the direction of the head current
H0X - H7X H0Y - H7Y	I/O	X, Y Head Connections: Current in the X-direction flows into the X-port
RDX, RDY	O*	X, Y Read Data: differential read data output
WC	-	Write Current: used to set the magnitude of the write current
VCC	-	+5V Logic Circuit Supply
VDD1	-	+12V
VDD2	-	Positive Power Supply for Write current drivers
GND	-	Ground

* When more than one R/W device is used, these signals can be wire OR'ed.

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

PARAMETER		SYMBOL	VALUE	UNITS
DC Supply Voltage		VDD1, 2	-0.3 to +14	VDC
		VCC	-0.3 to +7	VDC
Write Current		Iw	100	mA
Digital Input Voltage		Vin	-0.3 to VCC +0.3	VDC
Head Port Voltage		VH	-0.3 to VDD2 +0.3	VDC
WUS Pin Voltage Range		Vwus	-0.3 to +14	VDC
Output Current	RDX, RDY	Io	-10	mA
	WUS	Iwus	+12	mA
Storage Temperature		Tstg	-65 to +150	°C

RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	VALUE	UNITS
DC Supply Voltage	VDD1	12 ± 10%	VDC
	VDD2	≥VDD1 - 3.0V	VDC
	VCC	5 ± 10%	VDC
Junction Temperature	Tj	+25 to +135	°C

DC CHARACTERISTICS

Unless otherwise specified, recommended operating conditions apply.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
VDD1 Supply Current	Read Mode	-	-	50	mA
	Write Mode	-	-	45	mA
	Idle Mode	-	-	25	mA
VDD2 Supply Current	Read Mode	-	-	200	µA
	Write Mode	-	-	Iw+0.4	mA
	Idle Mode	-	-	200	µA
VCC Supply Current	Read Mode	-	-	60	mA
	Write Mode	-	-	50	mA
	Idle Mode	-	-	45	mA
Power Dissipation (Tj = +135°C)	Read Mode	-	-	900	mW
	Write Mode Iw = 40mA, VDD2 = VDD1	-	-	1300	mW
	Write Mode Iw = 60mA, VDD1 - VDD2 = 3.0V	-	-	1425	mW
	Idle Mode	-	-	500	mW
Input Low Voltage (VIL)		-	-	0.8	VDC
Input High Voltage (VIH)		2.0	-	-	VDC
Input Low Current (IIL)	VIL = 0.8v	-0.8	-	-	mA
Input High Current (IHL)	VIH = 2.0v	-	-	100	µA
WUS Output Low Voltage (VOL)	Iol = 8mA	-	-	0.5	VDC
VDD Fault Voltage		8.5	-	10.0	VDC
VCC Fault Voltage		3.5	-	4.2	VDC
Head Current (HnX, HnY)	Write Mode, 0≤VCC ≤3.5V 0≤VDD1 ≤8.5V	-200	-	+200	µA
	Read/Idle Mode 0≤VCC ≤5.5V 0≤VDD1 ≤13.2V	-200	-	+200	µA

WRITE CHARACTERISTICS
Unless otherwise specified, recommended operating conditions apply, Iw = 40mA, Lh = 500nH, Rh = 30Ω and f(WDI) = 5MHz.

PARAMETER	CONDITIONS	MIN.	NOM	MAX	UNITS
Write Current Constant "K"		66.5	-	73.5	V
Differential Head Voltage Swing		7	-	-	Vpp
Unselected Head Current		-	-	1	mA(pk)
Differential Output Capacitance		-	-	35	pF
Differential Output Resistance		400	740	1000	Ω
WDI Transition Frequency	WUS = low	1.0	-	-	MHz
Write Current Range		20	-	60	mA

READ CHARACTERISTICS
Unless otherwise specified, recommended operating conditions apply, CL (RDX, RDY) < 20 pF and RL (RDX,RDY) = 1 kΩ.

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
Differential Voltage Gain		Vin=1 mVpp @ 300 kHz	80	100	120	V/V
Bandwidth	-1dB	|Zs|<5Ω, Vin=1 mVpp @ 300 kHz	25	-	-	MHz
	-3dB	|Zs|<5Ω, Vin=1 mVpp @ 300 kHz	45	-	-	MHz
Input Noise Voltage		BW = 15 MHz, Lh = 0, Rh = 0	-	0.55	0.75	nV/√Hz
Differential Input Capacitance		Vin = 1 mVpp, f = 5 MHz	-	-	60	pF
Differential Input Resistance		Vin = 1 mVpp, f = 5 MHz	220	-	-	Ω
Dynamic Range		DC input voltage where gain falls to 90% of its 0 VDC value, Vin = VDC +0.5 mVpp, f = 5 MHz	-3	-	3	mV
Common Mode Rejection Ratio		Vin = 0 VDC+100 mVpp @ 5 MHz	54	-	-	dB
Power Supply Rejection Ratio		100 mVpp @ 5 MHz on VDD1 100 mVpp @ 5 MHz on VCC	54	-	-	dB
Channel Separation		Unselected channels driven with 100 mVpp @ 5 MHz, Vin = 0 mVpp	45	-	-	dB
Output Offset Voltage			-360	-	+360	mV
RDX, RDY Common Mode Output Voltage		Read Mode	Vcc-2.2V	Vcc-1.9V	Vcc-1.6V	VDC
		Write Mode	-	2.9	-	VDC
Single Ended Output Resistance		f = 5 MHz	-	-	30	Ω
Output Current		AC Coupled Load, RDX to RDY	3.2	-	-	mA

SWITCHING CHARACTERISTICS (See Figure 1)
Unless otherwise specified, recommended operating conditions apply, Iw = 40mA, Lh = 500nH, Rh = 30Ω and f(WDI) = 5MHz.

PARAMETER	CONDITIONS	MIN	MAX	UNITS
R/$\overline{W}$				
R/$\overline{W}$ to Write Mode	Delay to 90% of write current	-	0.6	µs
R/$\overline{W}$ to Read Mode	Delay to 90% of 100mV 10MHz Read signal envelope or to 90% decay of write current	-	0.6	µs
$\overline{CS}$				
$\overline{CS}$ to Select	Delay to 90% of write current or to 90% of 100mV 10MHz Read signal envelope	-	0.6	µs
$\overline{CS}$ to Unselect	Delay to 10% of write current	-	0.6	µs
HSn				
HS0, 1, 2 to any Head	Delay to 90% of 100mV 10MHz Read signal envelope	-	0.4	µs
WUS				
Safe to Unsafe - TD1		0.6	5.0	µs
Unsafe to Safe - TD2		-	1	µs
Head Current				
Prop. Delay - TD3	From 50% points, Lh=0µh, Rh=0Ω	-	32	ns
Asymmetry	WDI has 50% duty cycle and 1ns rise/fall time, Lh=0µh, Rh=0Ω	-	1	ns
Rise/Fall Time	10%-90% points, Lh=0µh, Rh=0Ω	-	9	ns
Rise/Fall Time	10%-90% points, R(HnX, HnY)=10Ω	-	10	ns

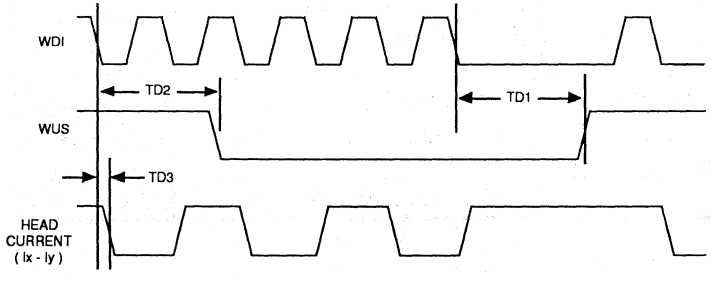


FIGURE 1: Write Mode Timing Diagram

APPLICATIONS INFORMATION

The specifications, provided in the data section, account for the worst case values of each parameter taken individually. In actual operation, the effects of worst case conditions on many parameters correlate. Tables 3 & 4 demonstrate this for several key parameters. Notice that under the conditions of worst case input noise, the higher read back signal resulting from the higher input impedance can compensate for the higher input noise. Accounting for this correlation in your analysis will be more representative of actual performance.

TABLE 3: Key Parameters Under Worst Case Input Noise Conditions

PARAMETER	Tj = 25°C	Tj = 135°C	UNITS
Input Noise Voltage (Max.)	0.5	0.75	$nV/\sqrt{Hz}$
Differential Input Resistance (Min.)	292	318	Ω
Differential Input Capacitance (Max.)	43	48	pF

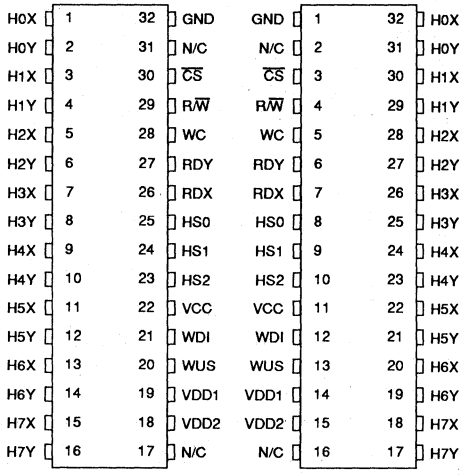
TABLE 4: Key Parameters Under Worst Case Input Impedance Conditions

PARAMETER	Tj = 25°C	Tj = 135°C	UNITS
Input Noise Voltage (Max.)	0.45	0.6	$nV/\sqrt{Hz}$
Differential Input Resistance (Min.)	220	260	Ω
Differential Input Capacitance (Max.)	55	60	pF

SSI 32R524R
8-Channel Thin Film
Read/Write Device

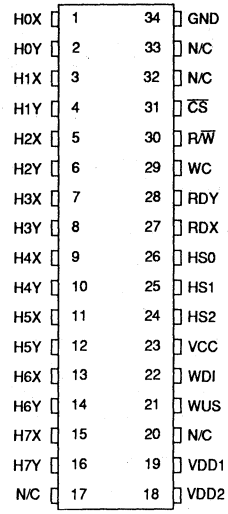
PACKAGE PIN DESIGNATIONS

(TOP VIEW)

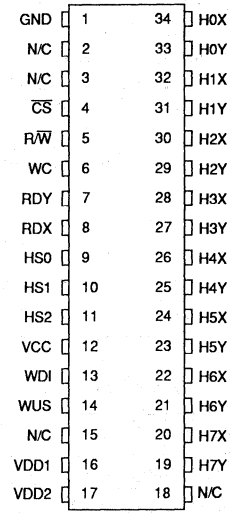


32-LEAD SOW

32-LEAD SOW MIRROR



34-LEAD SOL



34-LEAD SOL MIRROR

THERMAL CHARACTERISTICS: θja

32-Lead SOW	55°C/W
34-Lead SOL	50°C/W

ORDERING INFORMATION

PART DESCRIPTION		ORDER NO.	PKG. MARK
SSI 32R524R	8-Channel SOW	SSI 32R524R-8W	32R524R-8W
	8-Channel SOL	SSI 32R524R-8L	32R524R-8L
SSI 32R524RM	8-Channel SOW	SSI 32R524RM-8W	32R524RM-8W
	8-Channel SOL	SSI 32R524RM-8L	32R524RM-8L

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SSI 32R525R

4-Channel Thin Film Read/Write Device

Preliminary Data

1

July, 1990

DESCRIPTION

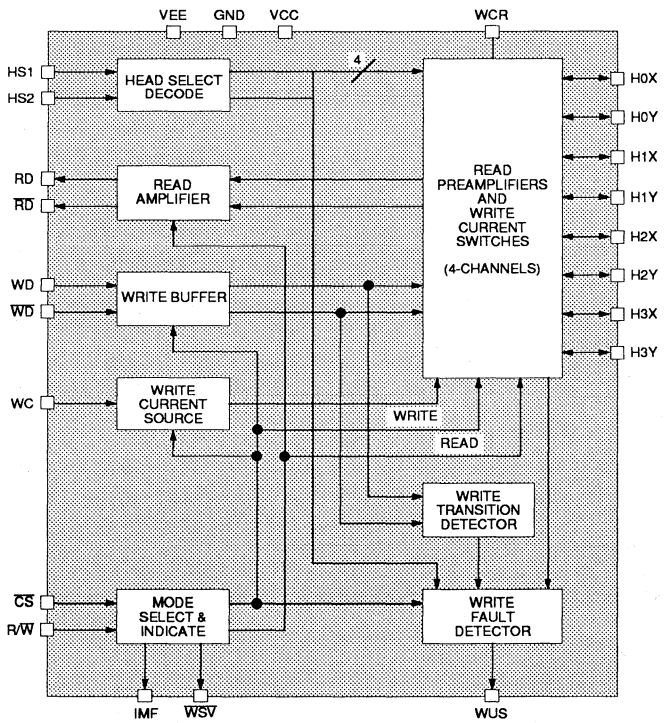
The SSI 32R525R is an integrated read/write circuit designed for use with non-center tapped thin film heads in disk drive systems. Each chip controls four heads and has three modes of operation: read, write, and idle. The circuit contains four channels of read amplifiers and write drivers and also has an internal write current source.

A current monitor (IMF) output is provided that allows a multichip enable fault to be detected. An enabled chip's output will produce one unit of current. An open collector output, write select verify (WSV), will go low if the write current source transistor is forward biased. The circuit operates on +5 volt, and -5 volt power and is available in 24-pin Flatpack and SOL packages.

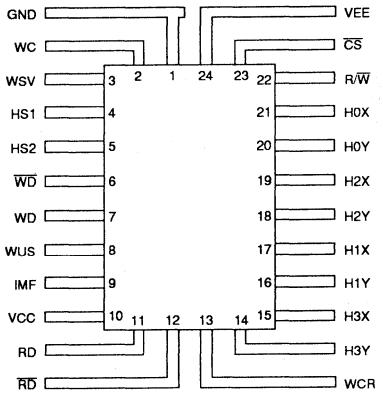
FEATURES

- **High performance**
  - **Read Mode Gain = 125 V/V nominal**
  - **Input Noise = 0.8 nV/$\sqrt{Hz}$ max**
  - **Input Capacitance = 35 pF max**
  - **Write Current Range = 25 mA to 40 mA**
  - **Write Current Rise Time = 10 nsec max**
  - **Head Voltage Swing = 3.8 Vpp min**
- **Write unsafe detection**
- **-5V, +5V power supplies**

BLOCK DIAGRAM



PIN DIAGRAM



24-Pin Flatpack

CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 32R525R
4-Channel Thin Film
Read/Write Device

FUNCTIONAL DESCRIPTION

WRITE MODE

In Write Mode (R/$\overline{W}$ and $\overline{CS}$ low) the circuit functions as a differential current switch. The Head Select Inputs (HS1 and HS2) determine the selected head. The write current magnitude is adjusted by an external resistor Rex from WC to Vcc.

$$Iw = \frac{80}{Rex} Adc$$

WRITE MODE FAULT DETECT CIRCUIT

Several circuits are dedicated to detecting fault conditions associated with the write mode. A logical high (off) level will be present at the Write Unsafe (WUS) terminal if any of the following write fault conditions are present:

- Open head circuit
- Head shorted to ground
- No write current
- Write current transition frequency too low
- Head select input(s) open circuit
- Write mode not logically selected

The Write Unsafe output is open-collector and is usually terminated by an external resistor connected to Vcc.

READ MODE

In Read Mode, (R/$\overline{W}$ high and $\overline{CS}$ low), the circuit functions as a low noise differential amplifier. The read amplifier input terminals are determined by the Head Select inputs. The read amplifier outputs (RD, $\overline{RD}$) are open collector, requiring external load resistors connected to Vcc. The amplifier gain polarity is non–inverting between HX, Y inputs and RD outputs.

IDLE MODE

Taking $\overline{CS}$ high selects the idle mode which switches the RD and $\overline{RD}$ outputs into a high impedance state and deactivates the internal write current source. This facilitates multi-device installations by allowing the read outputs to be wired OR'ed.

MODE SELECTION AND INDICATION CIRCUIT

Logical control inputs which select mode and head channel are TTL compatible. Their functions are described in Tables 1 and 2.

Selection of the write mode is indicated by a low (on) state of the Write Select Verify ($\overline{WSV}$) terminal. The open collector output is usually terminated by an external resistor connected to Vcc.

The selection of either the write or read mode is indicated by the flow of a unit of current into the Current Monitor (IMF) terminal. By summing the currents from multiple circuits, the user can determine that one, and only one, circuit is active.

The mode select inputs have internal pull up circuits so that if an input is open it will rise to the upper logic level.

Table 1: Head Select Table

Head Selected	HS2	HS1
0	0	0
1	0	1
2	1	0
3	1	1

Table 2: Mode Select Table

Mode Select			Indicating & Fault Outputs		
$\overline{CS}$	R/$\overline{W}$	Selected Mode	IMF	WSV	WUS
1	X	Idle	off	off	off
0	1	Read	on	off	off
0	0	Write	on	on	on*

*Provided that no fault is detected.

PIN DESCRIPTIONS

NAME	TYPE	DESCRIPTION
CONTROL INPUT PINS		
$\overline{CS}$	I	Chip Select input. A logical low level enables the circuit for a read or write operation. Has internal pull up.
R/$\overline{W}$	I	Read/Write select. A logical low level enables the write mode (when $\overline{CS}$ is low). Has internal pull up.
HS1,HS2	I	Head Select inputs. Logical combinations (Table 1) select one of four heads.
HEAD TERMINAL PINS		
H0X - H3X H0Y - H3Y	I/O	Connection to read/write magnetic head terminals
DATA INPUT/OUTPUT PINS		
WD, $\overline{WD}$	I	Differential Write Data inputs used to write data patterns on the disk
RD, $\overline{RD}$	I	Differential Read Data pattern output amplified playback from the disk. These outputs are normally terminated in 100Ω resistors to Vcc.
EXTERNAL COMPONENT CONNECTION PINS		
WC	I	Resistor connected to VEE to provide desired value of write current
CURRENT MONITOR PINS		
$\overline{WSV}$	O	Write Select Verify is an open collector output with the on state indicating that the circuit has been selected for a write operation. It is normally terminated to +Vcc through a resistor.
WUS	O	Write Unsafe is an open collector output with the off state indicating that conditions are not proper for a write operation.
IMF	O	High impedance output sinks a unit of monitor current when the chip is enabled.
POWER, GROUND PINS		
Vcc	I	Positive power supply voltage for circuit functions
VEE	I	Negative power supply voltage
GND	I/O	Power supply common
WCR	–	Write Current Connection to power supply common

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, 4.75 ≤ VCC ≤ 5.20, -5.50 ≤ VEE ≤ -4.75V, 0° ≤ T (junction) ≤ 125°C.

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNIT
Positive Supply Voltage, Vcc	6	VDC
Negative Supply Voltage, VEE	-6	VDC
Operating Junction Temperature	-20 to +130	°C
Storage Temperature	-65 to +150	°C
Lead Temperature (Soldering, 10 sec)	260	°C
Input Voltages		
Head Select (HS)	-0.4 to Vcc + 0.3	V
Chip Enable ($\overline{CS}$)	-0.4 to Vcc+ 0.3	V
Read Select (R/$\overline{W}$)	-0.4V to Vcc + 0.3	V
Write Data (WD, $\overline{WD}$)	-VEE to 0.3	V
Head Inputs (Read Mode)	-0.6 to 0.4	V
Outputs		
Read Data (RD, $\overline{RD}$)	Vcc - 2.5 to Vcc + 0.3	V
Write Unsafe (WUS)	-0.4V to Vcc + 0.3 and 20 mA	V
Write Select Verify (WSV)	-0.4V to Vcc + 0.3 and 20 mA	V
Current Monitor (IMF)	-0.4 to Vcc + 0.3	V
Current Reference (WC)	-1.0 mA to 5.0 mA	mA
Head Outputs (Write Mode)	-100 mA to 1.0 mA	mA

POWER SUPPLY

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Power Dissipation	Idle Mode			100	mW
	Read Mode			350	mW
	Write Mode, Iw = 40 mA			500	mW
Positive Supply Current (ICC)	Idle Mode			10	mA
	Read Mode			25	mA
	Write Mode			12	mA
Negative Supply Current (IEE)	Idle Mode			-8	mA
	Read Mode			-45	mA
	Write Mode			-40 - Iw	mA

DC CHARACTERISTICS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
High Level Input Voltage (VIH) ($\overline{CS}$, R/$\overline{W}$, HS1, HS2)		2.0			V
Low Level Input Voltage (VIL) ($\overline{CS}$, R/$\overline{W}$, HS1, HS2)				0.8	V
High Level Input Current (IIH) ($\overline{CS}$, R/$\overline{W}$)	(VIH=2.7V)			20	µA
Low Level Input Current (IIL) ($\overline{CS}$, R/$\overline{W}$)	(VIL=0.4V)			-400	µA
High Level Input Current (IIH) (HS1, HS2)	(VIH=2.7V)			250	µA
Low Level Input Current (IIL) (HS1, HS2)	(VIL=0.4V)			250	µA
High Level Input Voltage (VIH) (WD, $\overline{WD}$)		-1.0		.6	V
Low Level Input Voltage (VIL) (WD, $\overline{WD}$)		-2.0		-1.5	V
High Level Input Current (IIH) (WD, $\overline{WD}$)	(VIH=-0.6V, VIL=-2.0V)			150	µA
Low Level Input Current (IIL) (WD, $\overline{WD}$)	(VIL=-2.0V, VIH=-1.0V)	-20			µA
Output Off Leakage Curr. (IOFF) (WUS,- WSV)	(VOFF=5.0V)			100	µA
Low Level Output Voltage (VOL) (WUS, -WSV)	(IOL=8.0 mA)			0.4	V
Output Leakage Current (IOFF) (IMF)	(VOFF=5.0V)			20	µA
Output on Current (ION) (IMF)	(VON=0.5V to 5.0V)	2.4		3.5	mA
Data Input Voltage Range		-2.0		0.6	V
Data Input Current (per side)	Chip Enabled			150	µA
Data Input Capacitance	per side to GND			10	pF

ELECTRICAL CHARACTERISTICS (Continued)

READ MODE

Tests performed with 100Ω load resistors from RD and $\overline{RD}$ through series isolation diodes to VCC.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Differential Voltage Gain	Vin = 1m Vrms, f = 300 KHz	100	125	150	V/V
Voltage Bandwidth (-3dB)	Zs < 5z, Vin = 1m Vpp f midband = 300 KHz	55		100	MHz
Input Noise Voltage	Zs = 0Ω , Vin = 0V, Power Bandwidth = 30 MHz			0.8	$nV\sqrt{Hz}$
Differential Input Capacitance	Vin = 0V, f = 5 MHz			35	pF
Differential Input Resistance	Vin = 0V, f = 5 MHz	500		1800	Ω
Input Bias Current (per side)	Vin = 0V			0.17	mA
Dynamic Range	DC input voltage where AC gain falls to 90% of the gain with .5m Vpp input signal	-3.0		3.0	mV
Common Mode Rejection Ratio	Vin = 100m Vpp, 0V DC 1 MHz ≤ f ≤10 MHz	50			dB
	f = 20 MHz	46			dB
Power Supply Rejection Ratio	VCC or VEE = 100m Vpp 1 MHz ≤ f ≤ 10 MHz	65			dB
	f = 20 MHz	40			dB
Channel Separation	The three unselected channels are driven with Vin = 20m Vpp 1 MHz ≤ f ≤ 10 MHz	46			dB
	f = 20 MHz	40			dB
Output Offset Voltage		-360		360	mV
Output Leakage Current	Idle Mode			0.01	mA
Output Common Mode Voltage		VCC -0.75		VCC -0.45	V
Single Ended Output Resistance		10			KΩ
Single Ended Output Capacitance				10	pF

WRITE MODE

Current Tolerance	Current set to nominal value by Rex = 1.6K to 3.6 KΩ, Tj = 50 °C	-8		+8	%
Differential Head voltage swing	Iw = 40 mA	3.8			Vpp

WRITE MODE (continued)

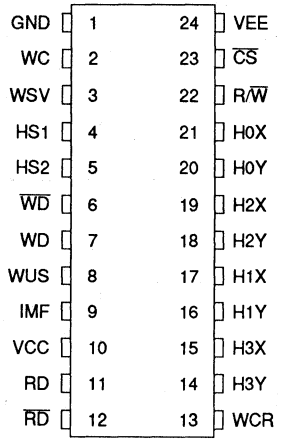
PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Current Range (Iw)	Rwc = 3600Ω to 1600Ω	25		45	mA
Differential Output Resistance, Rd		1700		2600	Ω
Differential Output Capacitance				10	pF
WD, $\overline{WD}$ Transition Frequency	WUS = low	1.0			MHz

SWITCHING CHARACTERISTICS

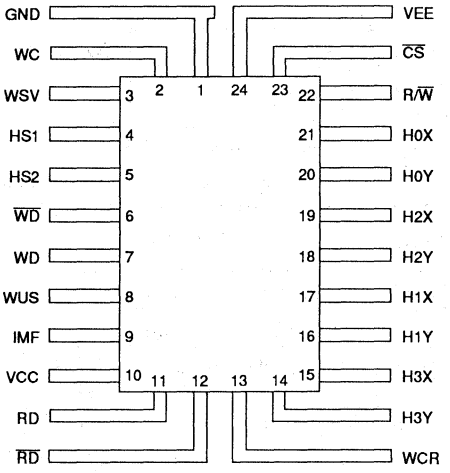
Idle to Read/Write Transition Time				0.5	µs
Read/Write to Idle Transition Time				0.5	µs
Read to Write Transition Time	VL$\overline{CS}$ = 0.8V, Delay to 90% of Iw			0.5	µs
Write to Read Transition Time	VL$\overline{CS}$ = 0.8V, Delay to 90% of 20 MHz Read Signal envelope, Iw decay to 10%			0.5	µs
Head Select Switching Delay	Read or Write Mode			0.5	µs
Head Current Transition Time 10% to 90%	Iw = 40 mA, Lh = 0.15 µH, Rh = 20Ω			10	ns
Head Current Overshoot	Iw = 40 mA, Lh = 0.15 µH, Rh = 20Ω, relative to total current charge			50	%
Head Current Switching Time Symmetry	Iw = 40 mA, Lh = 0.15 µH, Rh = 20Ω, WD & $\overline{WD}$ transitions 2nS, switching time symmetry 0.2 nS			1.5	ns
WSV Transition Time	Delay from 50% of write select swing to 90% of final WSV voltage, Load = 2KΩ // 20 pF			0.25	µs
Unsafe to Safe Delay After Write Data Begins (WUS)	f(data) = 5 MHz			0.5	µs
Safe to Unsafe Delay, (WUS)	Head open or shorted to GND, no write current, head select input open			0.5	µs
Safe to Unsafe Delay, (WUS)	Non-switching write data	0.5		2.0	µs
IMF Switching Time	Delay from 50% of $\overline{CS}$ to 90% of final IMF current			0.25	µs

SSI 32R525R
4-Channel Thin Film Read/Write Device

PACKAGE PIN DESIGNATIONS
(TOP VIEW)



24-Pin SOL



24-Pin Flatpack

ORDERING INFORMATION

PART DESCRIPTION	ORDERING NUMBER	PACKAGE MARK
SSI 32R525R		
24-Pin Flatpack	SSI 32R525R-4F	32R525R-4F
24-Pin SOL	SSI 32R525R-4L	32R525R-4L

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32R526R
4-Channel Thin Film Read/Write Device

Preliminary Data

1

July, 1990

DESCRIPTION

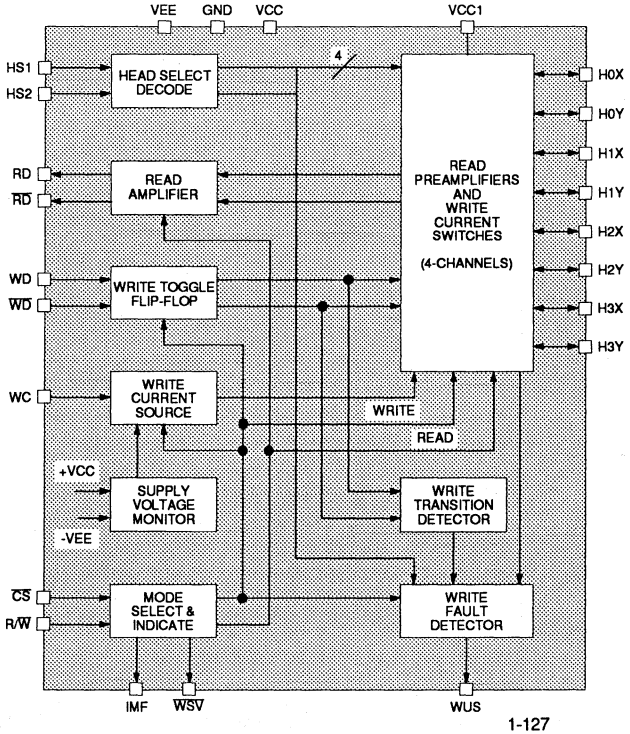
The SSI 32R526 is an integrated read/write circuit designed for use with non-center tapped thin film heads in disk drive systems. Each chip controls four heads and has three modes of operation: read, write, and idle. The circuit contains four channels of read amplifiers and write drivers and also has an internal write current source.

A current monitor (IMF) output is provided that allows a multichip enable fault to be detected. An enabled chip's output will produce one unit of current. An open collector output, write select verify (WSV), will go low if the write current source transistor is forward biased. The circuit operates on +5 volt, and -5 volt power and is available in 24-pin Flatpack and 24-pin SOL packages.

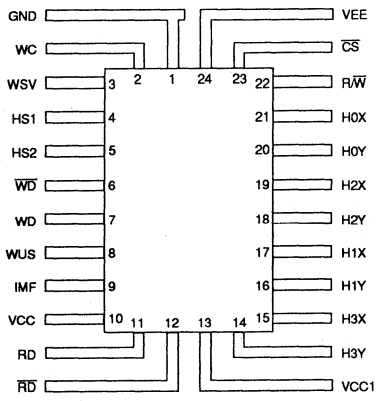
FEATURES

- **High performance**
  - **Read Mode Gain = 100 V/V**
  - **Input Noise = 0.6 nV/$\sqrt{Hz}$ max**
  - **Input Capacitance = 65 pF max**
  - **Write Current Range = 17 mA to 50 mA**
  - **Write Current Rise Time = 12 ns max**
  - **Head Voltage Swing = 8.0 Vpp min**
- **Write unsafe detection**
- **-5V, +5V power supplies**

BLOCK DIAGRAM



PIN DIAGRAM



24-Pin Flatpack

CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 32R526R
4-Channel Thin Film Read/Write Device

FUNCTIONAL DESCRIPTION

WRITE MODE

In Write Mode (R/$\overline{W}$ and $\overline{CS}$ low) the circuit functions as a differential current switch. The Head Select Inputs (HS1 and HS2) determine the selected head. The recording current is steered through the head in a direction determined by the state of a toggle flip-flop. The Write Data Inputs (WD, $\overline{WD}$) determine the polarity of the head current. The write current magnitude is adjusted by an external resistor Rex between WC and VEE.

$$\left[\frac{Vwc}{Rex} = Iw\left(1+\frac{Rh}{90}\right) - Ioffset\right]$$

WRITE MODE FAULT DETECT CIRCUIT

Several circuits are dedicated to detecting fault conditions associated with the write mode. A logical high (off) level will be present at the Write Unsafe (WUS) terminal if any of the following write fault conditions are present:

- Open head circuit
- Resistive component of head shorted
- Head shorted to ground
- No write current
- Write current transition frequency too low
- Head select input(s) open circuit
- Write mode not logically selected

The Write Unsafe output is open-collector and is usually terminated by an external resistor connected to Vcc.

Additionally, power voltage monitoring circuits are used to detect Vcc and Vee voltage levels. If either is too low to permit valid data recording, write current is inhibited. With any combination of Vcc and VEE voltage above the inhibiting levels, logical control of write current is provided by the mode selection inputs.

READ MODE

In Read Mode, (R/$\overline{W}$ high and $\overline{CS}$ low), the circuit functions as a low noise differential amplifier. The read amplifier input terminals are determined by the Head Select inputs. The read amplifier outputs (RD, $\overline{RD}$) are open collector, requiring external load resistors connected to Vcc. The amplifier gain polarity is non-inverting between HX, Y inputs and RD outputs.

The switch from Write to Read Modes also changes the resistance across HnX and HnY from its write damping valve of 100Ω to its Read Mode input valve of 500Ω.

IDLE MODE

Taking $\overline{CS}$ high selects the idle mode which switches the RD and $\overline{RD}$ outputs into a high impedance state and deactivates the internal write current source. This facilitates multi-device installations by allowing the read outputs to be wired OR'ed.

MODE SELECTION AND INDICATION CIRCUIT

Logical control inputs which select mode and head channel are TTL compatible. Their functions are described in Tables 1 and 2.

Selection of the write mode is indicated by a low (on) state of the Write Select Verify ($\overline{WSV}$) terminal. The open collector output is usually terminated by an external resistor connected to Vcc.

The selection of either the write or read mode is indicated by the flow of a unit of current into the Current Monitor (IMF) terminal. By summing the currents from multiple circuits, the user can determine that one, and only one, circuit is active.

Table 1: Head Select Table

Head Selected	HS2	HS1
0	0	0
1	0	1
2	1	0
3	1	1

Table 2: Mode Select Table

Mode Select			Indicating & Fault Outputs		
$\overline{CS}$	R/$\overline{W}$	Selected Mode	IMF	$\overline{WSV}$	WUS
1	X	Idle	off	off	off
0	1	Read	on	off	off
0	0	Write	on	on	on*

*Provided that no fault is detected.

PIN DESCRIPTIONS

NAME	TYPE	DESCRIPTION
CONTROL INPUT PINS		
$\overline{CS}$	I	Chip Select input. A logical low level enables the circuit for a read or write operation. Has internal pull up.
R/$\overline{W}$	I	Read/Write select. A logical low level enables the write mode (when $\overline{CS}$ is low). Has internal pull up.
HS1,HS2	I	Head Select inputs. Logical combinations (Table 1) select one of four heads.
HEAD TERMINAL PINS		
H0X - H3X H0Y - H3Y	I/O	Connection to read/write magnetic head terminals
DATA INPUT/OUTPUT PINS		
WD, $\overline{WD}$	I	Differential Write Toggle inputs used to write data patterns on the disk
RD, $\overline{RD}$	I	Differential Read Data pattern output amplified play back from the disk. These outputs are normally terminated in 100Ω resistors to Vcc.
EXTERNAL COMPONENT CONNECTION PINS		
WC	I	Resistor connected to VEE to provide desired value of write current
CURRENT MONITOR PINS		
$\overline{WSV}$	O	Write Select Verify is an open collector output with the on state indicating that the circuit has been selected for a write operation. It is normally terminated to +Vcc through a resistor.
WUS	O	Write Unsafe is an open collector output with the off state indicating that conditions are not proper for a write operation.
IMF	O	High impedance output sinks a unit of monitor current when the chip is enabled.
POWER, GROUND PINS		
Vcc	I	Positive power supply voltage for circuit functions
Vcc1	I	Positive power supply voltage for head current
VEE	I	Negative power supply voltage
GND	I/O	Power supply common

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, 4.75 ≤ VCC ≤ 5.25, -5.50 ≤ VEE ≤ -4.75V, 0° ≤ T (junction) ≤ 125°C.

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNIT
Positive Supply Voltage, Vcc	6	VDC
Negative Supply Voltage, VEE	-6	VDC
Operating Junction Temperature	-20 to +130	°C
Storage Temperature	-65 to 130	°C
Lead Temperature (Soldering, 10 sec)	260	°C
Input Voltages		
Head Select (HS)	-0.4 to Vcc + 0.3	V
Chip Enable ($\overline{CS}$)	-0.4 to Vcc+ 0.3	V
Read Select (R/$\overline{W}$)	-0.4V to Vcc + 0.3	V
Write Data (WD, $\overline{WD}$)	-VEE to 0.3	V
Head Inputs (Read Mode)	-0.6 to 0.4	V
Outputs		
Read Data (RD, $\overline{RD}$)	Vcc - 2.5 to Vcc + 0.3	V
Write Unsafe (WUS)	-0.4V to Vcc + 0.3 and 20 mA	V
Write Select Verify ($\overline{WSV}$)	-0.4V to Vcc + 0.3 and 20 mA	V
Current Monitor (IMF)	-0.4 to Vcc + 0.3	V
Current Reference (WC)	-100 mA to 1.0 mA	mA
Head Outputs (Write Mode)	-100 mA to 1.0 mA	mA

POWER SUPPLY

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Power Dissipation	Idle			187	mW
	Read			540	mW
	Write mode			550 + 10.5 x Iw	mW
Positive Supply Current (ICC)	Idle Mode			15	mA
	Read Mode			35	mA
	Write Mode			35	mA

POWER SUPPLY (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Positive Supply Current (ICC1)	Idle Mode			5	mA
	Read Mode			5	mA
	Write Mode			20 + Iw	mA
Negative Supply Current (IEE)	Idle Mode			-15	mA
	Read Mode			-60	mA
	Write Mode			-50 - Iw	mA

DC CHARACTERISTICS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Chip Select High Voltage (VHCS)	Idle Mode	2.0			V
Chip Select Low Voltage (VLCS)	Read or Write Mode			0.8	V
Chip Select Low Current (ILCS)	VLCS = 0.4V			-0.40	mA
Chip Select High Current (IHCS)	VHCS = 2.7V			20	µA
Read Select High Voltage (VHR/$\overline{W}$)	Read or Idle Mode	2.0			V
Read Select Low Voltage (VLR/$\overline{W}$)	Write or Idle Mode			0.8	V
Read Select high Current (IHR/$\overline{W}$)	VHR/W = 2.0V			20	µA
Read Select Low Current (ILR/$\overline{W}$)	VLR/W = 0V			-0.40	mA
Head Select High Voltage (VHHS)		2.0			V
Head Select Low Voltage (VLHS)				0.8	V
Head Select High Current (IHHS)	VHHS = 2.7V			0.25	mA
Head Select Low Current (ILHS)	VLHS = 0.4V			0.25	mA
WUS, $\overline{WSV}$ Low Level Voltage	ILUS = 8 mA (denotes safe condition)			0.5	V
WUS, $\overline{WSV}$ High Level Current	VHUS = 5.0V (denotes unsafe condition)			100	µA
IMF on Current		2.2		3.7	mA
IMF off Current				0.02	mA
IMF Voltage Range		0.5		VCC + 0.3	V
VCC Fault Voltage				3.5	V
VEE Fault Voltage				-3.5	V
Differential Data Voltage, (WD – $\overline{WD}$)		0.20			V
Data Input Voltage Range		-1.87		+0.1	V
Data Input Current (per side)	Chip Enabled			150	µA
Data Input Capacitance	per side to GND			10	pF

ELECTRICAL CHARACTERISTICS (Continued)

READ MODE

Tests performed with 100Ω load resistors from RD and $\overline{RD}$ through series isolation diodes to VCC.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Differential Voltage Gain	Vin = 1m Vpp, f = 300 KHz	75		125	V/V
Voltage Bandwidth (-3dB)	Zs < 5Ω, Vin = 1m Vpp -3dB	55		100	MHz
	f midband = 300 KHz -1dB	20		100	MHz
Input Noise Voltage	Zs = 0Ω , Vin = 0V, Power Bandwidth = 34 MHz			0.6	$nV\sqrt{Hz}$
Differential Input Capacitance	Vin = 0V, f = 5 MHz			65	pF
Differential Input Resistance	Vin = 0V, f = 5 MHz	250		1000	Ω
Dynamic Range	DC input voltage where AC gain falls to 90% of the gain with .5m Vpp input signal	-2.0		2.0	mV
Common Mode Rejection Ratio	Vin = 100m Vpp, 0V DC 1 MHz ≤ f ≤10 MHz	50			dB
	f = 20 MHz	46			dB
Power Supply Rejection Ratio	VCC or VEE = 100m Vpp 1 MHz ≤ f ≤ 10 MHz	65			dB
	f = 20 MHz	40			dB
Channel Separation	The three unselected channels are driven with Vin = 20m Vpp 1 MHz ≤ f ≤ 10 MHz	46			dB
	f = 20 MHz	37			dB
Output Offset Voltage		-360		360	mV
Output Leakage Current	Idle Mode			0.01	mA
Output Common Mode Voltage		VCC - 0.9		VCC - 0.3	V
Single Ended Output Resistance		10			KΩ
Single Ended Output Capacitance				10	pF

WRITE MODE

Current Tolerance	Current set to nominal value by Rx = 425 to 180Ω, Tj = 50°C	-8		+8	%
(Iw) (Rh) Product		0.3		1.25	V
Differential Head voltage swing	Iw = 45 mA	8.0			Vpp
Ioffset			6.0		mA
Write Current Voltage	Rex = 46Ω		2.25		V

WRITE MODE (continued)

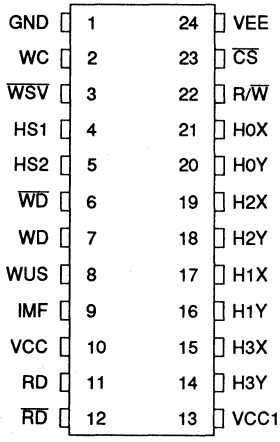
PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Unselected Head Transient Current	Iw = 45 mA, Lh = 0.5 µH, Rh = 20Ω, non-adjacent heads tested to minimize external coupling effects			1	mAp
Current Range (Iw)		17		50	mA
Differential Output Resistance, Rd		70	100	130	Ω
Differential Output Capacitance				30	pF
WD, $\overline{WD}$ Transition Frequency	WUS = low	5.0			MHz

SWITCHING CHARACTERISTICS Rh = 0, Lh = 0 (Unless otherwise specified)

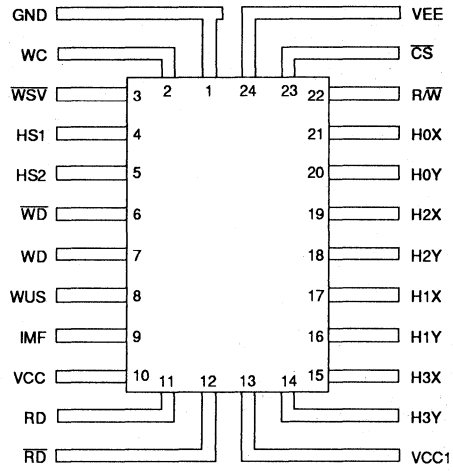
Idle to Read/Write Transition Time				0.4	µs
Read/Write to Idle Transition Time				0.4	µs
Read to Write Transition Time	VLCS = 0.8V, Delay to 90% of Iw			0.4	µs
Write to Read Transition Time	VLCS = 0.8V, Delay to 90% of 20 MHz Read Signal envelope, Iw decay to 10%			0.4	µs
Head Select Switching Delay	Read or Write Mode			0.2	µs
Head Current Transition Time 10% to 90%	Iw = 40 mA, Lh = 0.56 µH, Rh = 20Ω			12	ns
Head Current Overshoot	Iw = 40 mA, Lh = 0.56 µH, Rh = 20Ω, relative to total current change			15	%
Head Current Switching Time Symmetry	Iw = 40 mA, Lh = 0.56 µH, Rh = 20Ω, WD & $\overline{WD}$ transitions 2nS, switching time symmetry 0.2 nS			0.5	ns
WSV Transition Time	Delay from 50% of write select swing to 90% of final $\overline{WSV}$ voltage, Load = 2KΩ // 20 pF			0.3	µs
Unsafe to Safe Delay After Write Data Begins (WUS)	f_{WDI} = 10 MHz			0.2	µs
Safe to Unsafe Delay, (WUS)	Head open or shorted to GND, no write current, head select input open			0.5	µs
Safe to Unsafe Delay, (WUS)	Non-switching write data			0.5	µs
IMF Switching Time	Delay from 50% of CS to 90% of final IMF current			0.25	µs

SSI 32R526R
4-Channel Thin Film Read/Write Device

PACKAGE PIN DESIGNATIONS
(TOP VIEW)



24-Pin SOL



24-Pin Flatpack

ORDERING INFORMATION

PART DESCRIPTION	ORDERING NO.	PKG. MARK
SSI 32R526R		
24-Pin Flatpack	SSI 32R526R-4F	32R526R-4F
24-Pin SOL	SSI 32R526R-4L	32R526R-4L

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32R527R
8 & 9-Channel Thin Film Read/Write Device

Preliminary Data

1

July, 1990

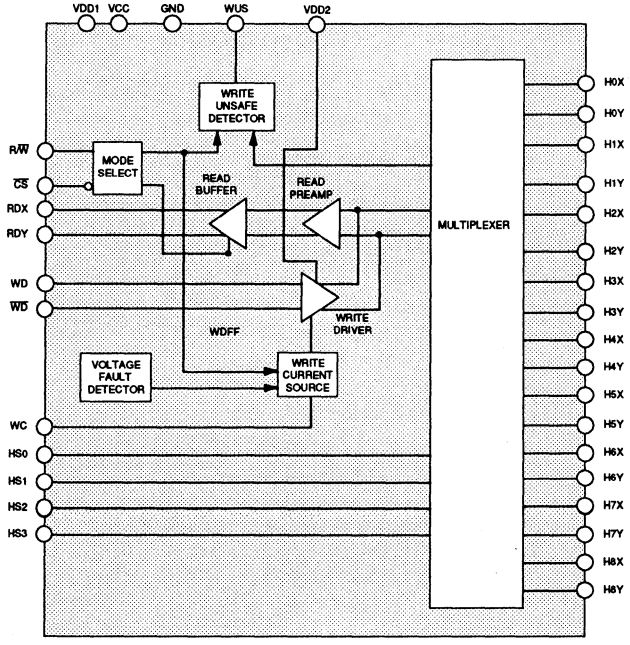
DESCRIPTION

The SSI 32R527R Read/Write devices are bipolar monolithic integrated circuits designed for use with two terminal thin film recording heads. They provide a low noise read amplifier, write current control and data protection circuitry for eight or nine channels. Power supply fault protection is provided by disabling the write current generator during power sequencing. They require +5V and +12V power supplies and are available in a variety of package configurations. A mirror image pinout option is available to simplify flex circuit layout in multiple R/W device applications. The SSI 32R527R provides internal 500Ω damping resistors.

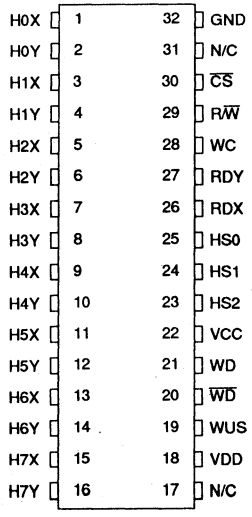
FEATURES

- **High performance:**
  - **Read mode gain = 120 V/V**
  - **Input noise = 0.85 nV/√Hz max.**
  - **Input capacitance = 35 pF max.**
  - **Write current range = 10 mA to 40 mA**
  - **Head voltage swing = 7 Vpp**
  - **Write current rise time = 9 ns**
- **Enhanced system write to read recovery time**
- **Differential ECL-like write data input**
- **Open collector read outputs**
- **Power supply fault protection**
- **Compatible with two & three terminal thin film heads**
- **Write unsafe detection**
- **+5V, +12V power supplies**
- **Mirror image pinout option**

BLOCK DIAGRAM



PIN DIAGRAM



32-LEAD SOW, FLATPACK

CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 32R527R
8 & 9-Channel Thin Film Read/Write Device

CIRCUIT OPERATION

The SSI 32R527R addresses up to nine two-terminal thin film heads providing write drive or read amplification. Head selection and mode control is accomplished with pins HSn, $\overline{CS}$ and R/$\overline{W}$, as shown in Tables 1 & 2. Internal resistor pullups, provided on pins $\overline{CS}$ and R/$\overline{W}$ will force the device into a non-writing condition if either control line is opened accidentally.

WRITE MODE

The write mode configures the SSI 32R527R as a current switch and activates the Write Unsafe (WUS) detection circuitry. The Write Data Inputs (WD, $\overline{WD}$) determine the polarity of the head current. There is no internal toggle flip-flop.

The magnitude of the write current (0-pk) given by:

$$Iw = \frac{Vwc}{RWC}$$

where Vwc (WC pin voltage) = 1.65V ± 5%, is programmed by an external resistor RWC, connected from pin WC to ground. In multiple device applications, a single RWC resistor may be made common to all devices. The actual head current Ix, y is given by:

$$Ix,y = \frac{Iw}{1 + Rh/Rd}$$

where:
Rh = head resistance + external wire resistance, and
Rd = damping resistance.

Power supply fault protection improves data security by disabling the write current generator during a voltage fault or power supply sequencing. Additionally, the write unsafe detection circuitry will flag any of the conditions listed below as a high level on the open collector output pin, WUS. Two transitions on pin WD and $\overline{WD}$, after the fault is corrected, are required to clear the WUS flag.

- WD frequency too low
- Device not selected
- Device in read mode
- No write current

Power dissipation in Write Mode may be reduced by placing a resistor, Rw, between VDD1 and VDD2. The resistor value should be chosen such that Iw Rw ≤ 3.0V for an accompanying reduction of $(Iw)^2$ Rw in power dissipation. If a resistor is not used, VDD2 should be connected to VDD1. Note that Rw will also provide current limiting in the event of a head short.

READ MODE

The read mode configures the SSI 32R527R as a low noise differential amplifier and deactivates the write current generator and write unsafe detection circuitry. The RDX and RDY outputs are open collectors and are in phase with the "X" and "Y" head ports. The termination resistors for RDX/RDY should be 100Ω to Vcc.

IDLE MODE

The idle mode deactivates the internal write current generator, the write unsafe detector and switches the RDX, RDY outputs into a high impedance state. This facilitates multiple device applications by enabling the read outputs to be wire OR'ed and the write current programming resistor to be common to all devices. If multiple devices are wire OR'ed, series Schottky isolation diodes are recommended to reduce parasitic capacitance without degrading dynamic range.

FIGURE 1: OR'ed Devices w/ Schottky Isolation Diodes

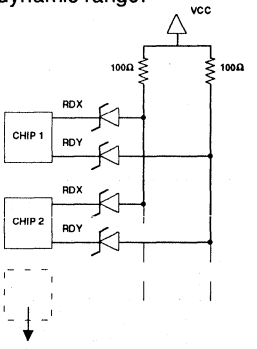


TABLE 1: Mode Select

$\overline{CS}$	R/$\overline{W}$	MODE
0	0	Write
0	1	Read
1	0	Idle
1	1	Idle

TABLE 2: Head Select 0 = Low level 1 = High level

HS3	HS2	HS1	HS0	HEAD
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8

PIN DESCRIPTIONS

NAME	TYPE	DESCRIPTION
HS0 - HS3	I	Head Select
$\overline{CS}$	I	Chip Select: a low level enables the device
R/$\overline{W}$	I	Read/Write: a high level selects Read mode
WUS	O*	Write Unsafe: Open collector output, a high level indicates an unsafe writing condition
WD,$\overline{WD}$	I	Write Data In: a negative polarity passes write current in the x-direction of the head.
H0X - H8X H0Y - H8Y	I/O	X, Y Head Connections: Current in the X-direction flows into the X-port
RDX, RDY	O*	X, Y Read Data: differential read data output, require 100Ω termination resistor to Vcc
WC	*	Write Current: used to set the magnitude of the write current
VCC	-	+5V Logic Circuit Supply
VDD1	-	+12V
VDD2	-	Positive power supply for write current drivers: VDD1 - 3.0V ≤ VDD2 ≤ VDD1
GND	-	Ground

*When more than one R/W device is used, these signals can be wire OR'ed.

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

PARAMETER		SYMBOL	VALUE	UNITS
DC Supply Voltage		VDD	-0.3 to +14	VDC
		VCC	-0.3 to +7	VDC
Write Current		Iw	100	mA
Digital Input Voltage		Vin	-0.3 to VCC +0.3	VDC
Head Port Voltage		VH	-0.3 to VDD +0.3	VDC
WUS Pin Voltage Range		Vwus	-0.3 to +14	VDC
Output Current	WUS	Iwus	+12	mA
Storage Temperature		Tstg	-65 to +150	°C

RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	VALUE	UNITS
DC Supply Voltage	VDD	12 ± 10%	VDC
	VCC	5 ± 10%	VDC
Operating Temperature	Tj	+25 to +135	°C

DC CHARACTERISTICS

Unless otherwise specified, recommended operating conditions apply.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
VDD Supply Current	Read Mode	-	-	34	mA
	Write Mode	-	-	38 + Iw	mA
	Idle Mode	-	-	14	mA
VCC Supply Current	Read Mode	-	-	52	mA
	Write Mode	-	-	45	mA
	Idle Mode	-	-	42	mA
Power Dissipation (Tj = +135°C)	Read Mode	-	-	670	mW
	Write Mode: Iw = 20 mA, VDD2 = VDD1 VDD2 = VDD1 - 3.0V	- -	- -	900 900	mW
	Idle Mode	-	-	400	mW
Input Low Voltage (VIL)		-	-	0.8	VDC
Input High Voltage (VIH)		2.0	-	-	VDC
Input Low Current (IIL)	VIL = 0.8v	-0.4	-	-	mA
Input High Current (IHL)	VIH = 2.0v	-	-	100	µA
WUS Output Low Voltage (VOL)	Iol = 8 mA	-	-	0.5	VDC
VDD Fault Voltage		8.5	-	10.0	VDC
VCC Fault Voltage		3.5	-	4.2	VDC
Head Current (HnX, HnY)	Write Mode, 0≤VCC ≤3.5V 0≤VDD ≤8.5V	-200	-	+200	µA
	Read/Idle Mode 0≤VCC ≤5.5V 0≤VDD ≤13.2V	-200	-	+200	µA
Data Input Capacitance	WD or $\overline{WD}$ to GND			10	pF
Data Input Current	WD or $\overline{WD}$			150	µA
Differential Data Voltage	WD - $\overline{WD}$	0.2			VDC
WD, $\overline{WD}$ Data Input Voltage Range	Low Level (WD VIL)	VCC -1.9			VDC
	High Level (WD VIH)			VCC + 0.1	VDC

WRITE CHARACTERISTICS
Unless otherwise specified, recommended operating conditions apply, Iw = 20 mA, Lh = 1.0 µH, Rh = 30Ω and f(WD) = 5 MHz.

PARAMETER	CONDITIONS	MIN.	NOM	MAX	UNITS
WC Pin Voltage (Vwc)		-	1.65 ±5%	-	V
Differential Head Voltage Swing		7	-	-	Vpp
Unselected Head Current		-	-	1	mA(pk)
Differential Output Capacitance		-	-	25	pF
Differential Output Resistance		400	500	750	Ω
WD, $\overline{WD}$ Transition Frequency	WUS = low	.85	-	-	MHz
Write Current Range		10	-	40	mA

READ CHARACTERISTICS
Unless otherwise specified, recommended operating conditions apply CL (RDX, RDY) < 20pF and RL1 (RDX, VCC) = RL2 (RDY, VCC) = 100Ω

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
Differential Voltage Gain		Vin=1mVpp @ 300 KHz Tj = 25°C	85	-	150	V/V
Bandwidth	-1dB	|Zs|<5Ω, Vin=1 mVpp @ 300 kHz	25	-	-	MHz
	-3dB	|Zs|<5Ω, Vin=1 mVpp @ 300 kHz	45	-	-	MHz
Input Noise Voltage		BW = 15 MHz, Lh = 0, Rh = 0	-	0.62	0.85	nV/√Hz
Differential Input Capacitance		Vin = 1 mVpp, f = 5 MHz	-	-	35	pF
Differential Input Resistance		Vin = 1 mVpp, f = 5 MHz	280	320	-	Ω
Dynamic Range		AC peak-to-peak input voltage where gain falls to 90% of its small signal value, f = 5 MHz	6	-	-	mV
Common Mode Rejection Ratio		Vin = 0 VDC+100 mVpp				
		1 MHz<f< 10 MHz	54	-	-	dB
		10 MHz<f< 20 MHz	48	-	-	dB
Power Supply Rejection Ratio		VPD or Vcc @ 100mVpp				
		1 MHz<f< 10 MHz	54	-	-	dB
		10 MHz<f< 20 MHz	40	-	-	dB
Channel Separation		All unselected channels driven with 100 mVpp				
		1 MHz<f< 10 MHz	43	-	-	dB
		10 MHz<f< 20 MHz	37	-	-	dB
Output Offset Voltage			-300	-	+300	mV
RDX, RDY Common Mode Output Voltage		Read Mode	VCC - 1.1		VCC - .3	VDC
		Write Mode	-	VCC	-	VDC
Single Ended Output Resistance		f = 5 MHz	10	-		KΩ

READ CHARACTERISTICS (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Output Current		-	6	-	mA
Single Ended Output Capacitance	f = 5 MHz	-	-	10	pF

SWITCHING CHARACTERISTICS (See Figure 1)
Unless otherwise specified, recommended operating conditions apply, Iw = 20 mA, Lh = 1.0 µH, Rh = 30Ω and f(WD) = 5 MHz.

PARAMETER	CONDITIONS	MIN	MAX	UNITS
R/$\overline{W}$				
R/$\overline{W}$ to Write Mode	Delay to 90% of write current	-	0.6	µs
R/$\overline{W}$ to Read Mode	Delay to 90% of 100mV 10MHz Read signal envelope or to 90% decay of write current	-	0.6	µs
$\overline{CS}$				
$\overline{CS}$ to Select	Delay to 90% of write current or to 90% of 100mV 10MHz Read signal envelope	-	0.6	µs
$\overline{CS}$ to Unselect	Delay to 10% of write current	-	0.6	µs
HSn				
HS0, 1, 2 to any Head	Delay to 90 % of 100mV 10MHz Read signal envelope	-	0.4	µs
WUS				
Safe to Unsafe - TD1		0.6	3.6	µs
Unsafe to Safe - TD2		-	1	µs
Head Current				
Prop. Delay - TD3	From 50 % points, Lh=0µh, Rh=0Ω	-	32	ns
Asymmetry	WD has 50 % duty cycle and 1ns rise/fall time, Lh=0µh, Rh=0Ω	-	1	ns
Rise/Fall Time	10% - 90% points, Lh=0µh, Rh=0Ω	-	9	ns

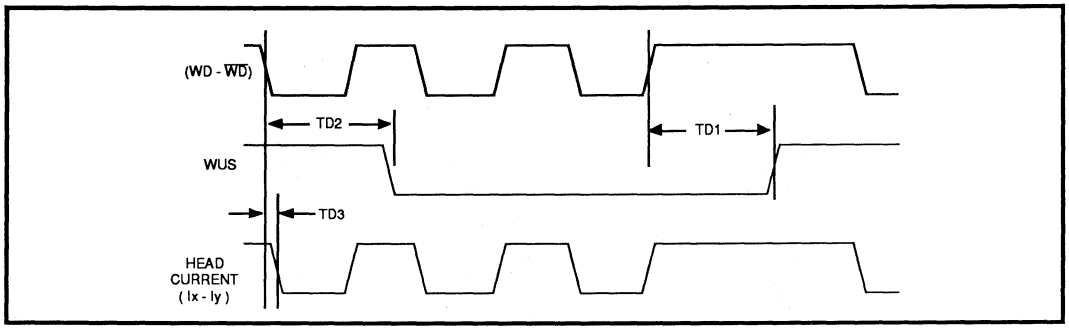


FIGURE 1: Write Mode Timing Diagram

APPLICATIONS INFORMATION

The specifications, provided in the data section, account for the worst case values of each parameter taken individually. In actual operation, the effects of worst case conditions on many parameters correlate. Tables 3 & 4 demonstrate this for several key parameters. Notice that under the conditions of worst case input noise, the higher read back signal resulting from the higher input impedance can compensate for the higher input noise. Accounting for this correlation in your analysis will be more representative of actual performance.

TABLE 3: Key Parameters Under Worst Case Input Noise Conditions

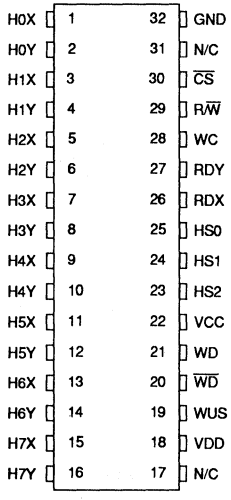
PARAMETER	Tj = 25°C	Tj = 135°C	UNITS
Input Noise Voltage (Max.)	0.70	0.85	nV/$\sqrt{Hz}$
Differential Input Resistance (Min.)	320	340	Ω
Differential Input Capacitance (Max.)	32	34	pF

TABLE 4: Key Parameters Under Worst Case Input Impedance Conditions

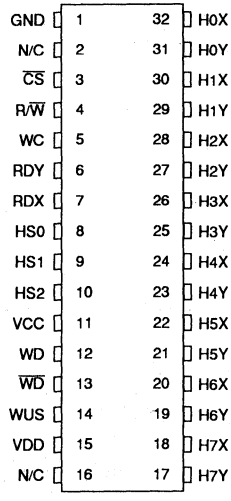
PARAMETER	Tj = 25°C	Tj = 135°C	UNITS
Input Noise Voltage (Max.)	0.58	0.71	nV/$\sqrt{Hz}$
Differential Input Resistance (Min.)	260	290	Ω
Differential Input Capacitance (Max.)	33	35	pF

SSI 32R527R
8 & 9-Channel Thin Film Read/Write Device

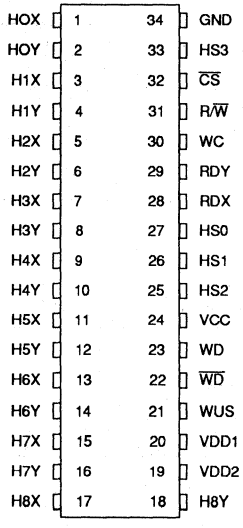
PACKAGE PIN DESIGNATIONS (Top View)



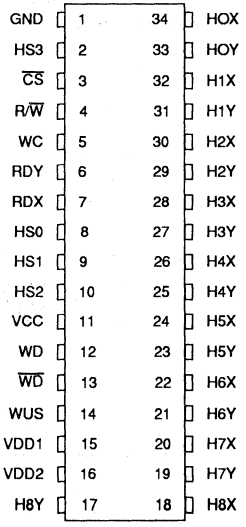
8-Channel 32-Lead SOW



8-Channel 32-Lead SOW Mirror



9-Channel 34-Lead SOL



9-Channel 34-Lead SOL Mirror

THERMAL CHARACTERISTICS: Øja

32-Lead SOW	55°C/W
34-Lead SOL	50°C/W

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32R527R with Internal Damping Resistor		
8-Channel SOW	SSI 32R527R-8CW	32R527R-8CW
9-Channel SOL	SSI 32R527R-9CL	32R527R-9CL
SSI 32R527RM Mirror Image with Damping Resistor		
8-Channel SOW	SSI 32R527RM-8CW	32R527RM-8CW
9-Channel SOL	SSI 32R527RM-9CL	32R527RM-9CL

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32R528/528R
8 & 9-Channel Thin Film Read/Write Device
Preliminary Data

1

July, 1990

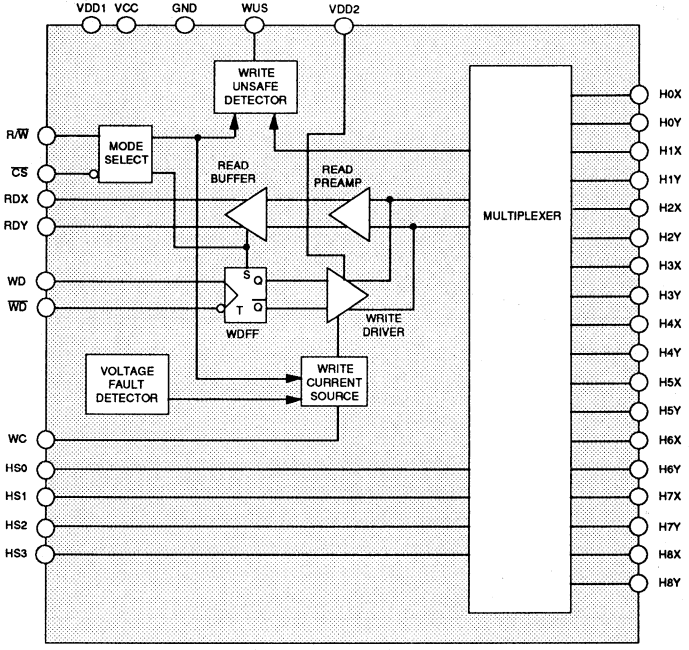
DESCRIPTION

The SSI 32R528/528R Read/Write devices are bipolar monolithic integrated circuits designed for use with two terminal thin film recording heads. They provide a low noise read amplifier, write current control and data protection circuitry for eight or nine channels. Power supply fault protection is provided by disabling the write current generator during power sequencing. System write to read recovery time is significantly improved by controlling the read channel common mode output voltage shift in the write mode. They require +5V and +12V power supplies and are available in a variety of package configurations. The SSI 32R528R option provides internal 700Ω damping resistors.

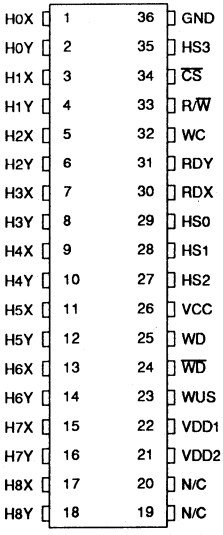
FEATURES

- **High performance:**
  - **Read mode gain = 150 V/V**
  - **Input noise = 0.85 nV/√Hz max.**
  - **Input capacitance = 35 pF max.**
  - **Write current range = 10 mA to 40 mA**
  - **Head voltage swing = 7 Vpp**
  - **Write current rise time = 9 ns**
- **Enhanced system write to read recovery time**
- **Differential ECL-like Write Data input**
- **Power supply fault protection**
- **Compatible with two & three terminal TFH**
- **Write unsafe detection**
- **+5V, +12V power supplies**

BLOCK DIAGRAM



PIN DIAGRAM



36-Lead SOM

CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 32R528/528R
8 & 9-Channel Thin Film Read/Write Device

CIRCUIT OPERATION

The SSI 32R528 addresses up to nine two-terminal thin film heads providing write drive or read amplification. Head selection and mode control is accomplished with pins HSn, $\overline{CS}$ and R/$\overline{W}$, as shown in Tables 1 & 2. Internal resistor pullups, provided on pins $\overline{CS}$ and R/$\overline{W}$ will force the device into a non-writing condition if either control line is opened accidentally.

WRITE MODE

The write mode configures the SSI 32R528 as a current switch and activates the Write Unsafe (WUS) detection circuitry. Write current is toggled between the X and Y direction of the selected head on each low to high transition of the WD, Write Data Input.

A preceding read operation initializes the Write Data Flip Flop (WDFF) to pass write current in the X-direction of the head, i.e. into the X-port.

The magnitude of the write current (0-pk) given by:

$$Iw = \frac{Vwc}{RWC}$$

where Vwc (WC pin voltage) = 1.65V ± 5%, is programmed by an external resistor RWC, connected from pin WC to ground. In multiple device applications, a single RWC resistor may be made common to all devices. The actual head current Ix, y is given by:

$$Ix,y = \frac{Iw}{1 + Rh/Rd}$$

where:
Rh = head resistance + external wire resistance, and
Rd = damping resistance.

Power supply fault protection improves data security by disabling the write current generator during a voltage fault or power supply sequencing. Additionally, the write unsafe detection circuitry will flag any of the conditions listed below as a high level on the open collector output pin, WUS. Two negative transitions on the WD/$\overline{WD}$ lines, after the fault is corrected, are required to clear the WUS flag.

- WD frequency too low
- Device not selected
- Head open
- Device in read mode
- No write current

Power dissipation in Write Mode may be reduced by placing a resistor, Rw, between VDD1 and VDD2. The resistor value should be chosen such that Iw Rw ≤ 3.0V for an accompanying reduction of $(Iw)^2$ Rw in power dissipation. If a resistor is not used, VDD2 should be connected to VDD1. Note that Rw will also provide current limiting in the event of a head short.

READ MODE

The read mode configures the SSI 32R528 as a low noise differential amplifier and deactivates the write current generator and write unsafe detection circuitry. The RDX and RDY outputs are emitter followers and are in phase with the "X" and "Y" head ports. These outputs should be AC coupled to the load. The RDX, RDY common mode voltage is maintained at the write mode value, minimizing the transient between write mode and read mode, substantially reducing the write to read recovery time in the subsequent Pulse Detection circuitry.

IDLE MODE

The idle mode deactivates the internal write current generator, the write unsafe detector and switches the RDX, RDY outputs into a high impedance state. This facilitates multiple device applications by enabling the read outputs to be wire OR'ed and the write current programming resistor to be common to all devices.

TABLE 1: Mode Select

$\overline{CS}$	R/$\overline{W}$	MODE
0	0	Write
0	1	Read
1	0	Idle
1	1	Idle

TABLE 2: Head Select

HS3	HS2	HS1	HS0	HEAD
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8

0 = Low level 1 = High level

PIN DESCRIPTIONS

NAME	TYPE	DESCRIPTION
HS0 - HS3	I	Head Select: TTL level
$\overline{CS}$	I	Chip Select: a low TTL level enables the device
R/$\overline{W}$	I	Read/Write: a high TTL level selects Read mode
WUS	O*	Write Unsafe: Open collector output, a high level indicates an unsafe writing condition
WD, $\overline{WD}$	I	Differential Write Data inputs: a positive transition on WD toggles the direction of the head current
H0X - H8X H0Y - H8Y	I/O	X, Y Head Connections: Current in the X-direction flows into the X-port
RDX, RDY	O*	X, Y Read Data: differential read data output
WC	*	Write Current: used to set the magnitude of the write current
VCC	-	+5V Logic Circuit Supply
VDD1	-	+12V
VDD2	-	Positive Power Supply for Write current drivers
GND	-	Ground

*When more than one R/W device is used, these signals can be wire OR'ed.

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

Operation outside these rating limits may permanently damage the device.

PARAMETER		SYMBOL	VALUE	UNITS
DC Supply Voltage		VDD1, 2	-0.3 to +14	VDC
		VCC	-0.3 to +7	VDC
Write Current		Iw	100	mA
Digital Input Voltage		Vin	-0.3 to VCC +0.3	VDC
Head Port Voltage		VH	-0.3 to VDD2 +0.3	VDC
WUS Pin Voltage Range		Vwus	-0.3 to +14	VDC
Output Current	RDX, RDY	Io	-10	mA
	WUS	Iwus	+12	mA
Storage Temperature		Tstg	-65 to +150	°C

RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	VALUE	UNITS
DC Supply Voltage	VDD1	12 ± 10%	VDC
	VDD2	VDD1 - 3.0 to VDD1	VDC
	VCC	5 ± 10%	VDC
Operating Temperature	Tj	0 to +135	°C

DC CHARACTERISTICS
Unless otherwise specified, recommended operating conditions apply.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
VDD1 Supply Current	Read Mode	-	-	42	mA
	Write Mode	-	-	50	mA
	Idle Mode	-	-	22	mA
VDD2 Supply Current	Read Mode	-	-	200	µA
	Write Mode	-	-	Iw + 0.4	mA
	Idle Mode	-	-	200	µA
VCC Supply Current	Read Mode	-	-	68	mA
	Write Mode	-	-	48	mA
	Idle Mode	-	-	55	mA
Power Dissipation (Tj = +135°C)	Read Mode	-	-	850	mW
	Write Mode: Iw = 20 mA, VDD2 = VDD1	-	-	1100	mW
	Write Mode: Iw = 40 mA, VDD1 - VDD2 = 3.0V	-	-	1200	mW
	Idle Mode	-	-	550	mW
WD, $\overline{WD}$ Input Low Current (IIL1)	VIL1 = VCC -1.625V			80	µA
WD, $\overline{WD}$ Input High Current (IIH1)	VIH1 = VCC -0.72V			100	µA
WD, $\overline{WD}$ Input Low Voltage (VIL1)		VCC -1.870		VCC -1.625	VDC
WD, $\overline{WD}$ Input High Voltage (VIH1)		VCC -1.00		VCC -0.720	VDC
R/$\overline{W}$, $\overline{CS}$, HS0-HS3 Input Low Current (IIL2)	VIL2 = 0.8V	-0.4			mA
R/$\overline{W}$, $\overline{CS}$, HS0-HS3 Input High Current (IIH2)	VIH2 = 2.0V			100	µA
R/$\overline{W}$, $\overline{CS}$, HS0-HS3 Input Low Voltage (VIL2)				0.8	VDC
R/$\overline{W}$, $\overline{CS}$, HS0-HS3 Input High Voltage (VIH2)		2.0			VDC

DC CHARACTERISTICS (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
WUS Output Low Voltage (VOL)	ILUS = 8.0 mA			0.5	VDC
VDD Fault Voltage		8.5	-	10.0	VDC
VCC Fault Voltage		3.5	-	4.2	VDC
Head Current (HnX, HnY)	Write Mode, 0 ≤ VCC ≤ 3.5V 0 ≤ VDD1 ≤ 8.5V	-200	-	+200	µA
	Read/Idle Mode 0 ≤ VCC ≤ 5.5V 0 ≤ VDD1 ≤ 13.2V	-200	-	+200	µA

WRITE CHARACTERISTICS

Unless otherwise specified, recommended operating conditions apply, Iw = 20 mA, Lh = 1.0 µH, Rh = 30Ω and f(WD) = 5 MHz.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
WC Pin Voltage (Vwc)		-	1.65 ±5%	-	V
Differential Head Voltage Swing		7	-	-	Vpp
Unselected Head Current		-	-	1	mA(pk)
Differential Output Capacitance		-	-	25	pF
Differential Output Resistance	32R528R	500	700	950	Ω
	32R528	4	-	-	kΩ
WD Transition Frequency	WUS = low	1.7	-	-	MHz
Write Current Range	0 - pk	10	-	40	mA

READ CHARACTERISTICS

Unless otherwise specified, recommended operating conditions apply CL (RDX, RDY) < 20 pF and RL (RDX,RDY) = 1 kΩ.

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
Differential Voltage Gain		Vin = 1 mVpp @ 1 MHz	125	-	175	V/V
Bandwidth	-1dB	|Zs| < 5Ω, Vin=1 mVpp	25	-	-	MHz
	-3dB	|Zs| < 5Ω, Vin=1 mVpp	45	-	-	MHz
Input Noise Voltage		BW = 15 MHz, Lh = 0, Rh = 0	-	0.62	0.85	nV/√Hz
Differential Input Capacitance		Vin = 1 mVpp, f = 5 MHz	-	-	35	pF
Differential Input Resistance	32R528R	Vin = 1 mVpp, f = 5 MHz	300	-	-	Ω
	32R528	Vin = 1 mVpp, f = 5 MHz	640	-	-	Ω
Dynamic Range		Peak-to-peak ac input voltage where gain falls to 90% of its small signal value, f = 5 MHz	6	-	-	mVpp

READ CHARACTERISTICS (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Common Mode Rejection Ratio	Vin = 0 VDC+100 mVpp @ 5 MHz	54	-	-	dB
Power Supply Rejection Ratio	100 mVpp @ 5 MHz on VDD1 100 mVpp @ 5 MHz on VCC	54	-	-	dB
Channel Separation	Unselected channels driven with 100 mVpp @ 5 MHz, Vin = 0 mVpp	45	-	-	dB
Output Offset Voltage		-360	-	+360	mV
RDX, RDY Common Mode	Read Mode	2.2	2.9	3.6	VDC
Output Voltage	Write Mode	-	2.9	-	VDC
Single Ended Output Resistance	f = 5 MHz	-	-	40	Ω
Output Current	AC Coupled Load, RDX to RDY	3.2	-	-	mA

SWITCHING CHARACTERISTICS (See Figure 1)
Unless otherwise specified, recommended operating conditions apply, Iw = 20 mA, Lh = 1.0 µH, Rh = 30Ω and f(WD) = 5 MHz.

PARAMETER	CONDITIONS	MIN	MAX	UNITS
R/$\overline{W}$				
R/$\overline{W}$ to Write Mode	Delay to 90% of write current	-	0.6	µs
R/$\overline{W}$ to Read Mode	Delay to 90% of 100 mV 10 MHz Read signal envelope or to 90% decay of write current	-	0.6	µs
$\overline{CS}$				
$\overline{CS}$ to Select	Delay to 90% of write current or to 90% of 100 mV 10 MHz Read signal envelope	-	0.6	µs
$\overline{CS}$ to Unselect	Delay to 10% of write current	-	0.6	µs
HSn				
HS0, 1, 2, 3 to any Head	Delay to 90% of 100 mV 10 MHz Read signal envelope	-	0.4	µs
WUS				
Safe to Unsafe - TD1		0.6	3.6	µs
Unsafe to Safe - TD2		-	1	µs
Head Current				
Prop. Delay - TD3	From 50% points, Lh=0µh, Rh=0Ω	-	32	ns
Asymmetry	WD has 50% duty cycle and 1ns rise/fall time, Lh=0µh, Rh=0Ω	-	1	ns
Rise/Fall Time	10% - 90% points, Lh=0µh, Rh=0Ω	-	9	ns

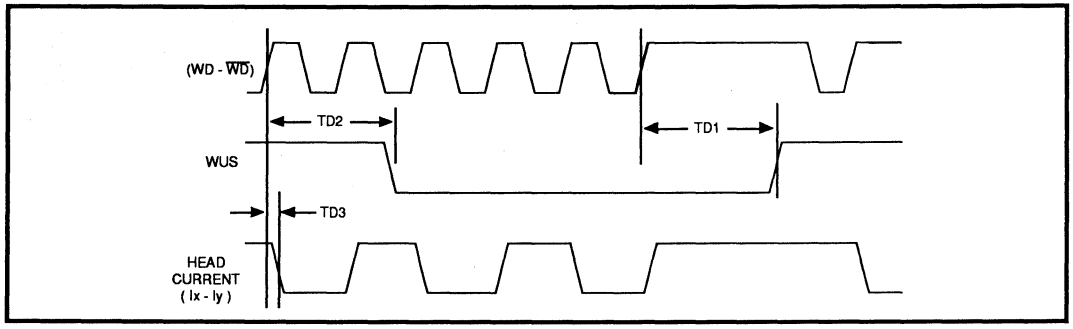


FIGURE 1: Write Mode Timing Diagram

APPLICATIONS INFORMATION

The specifications, provided in the data section, account for the worst case values of each parameter taken individually. In actual operation, the effects of worst case conditions on many parameters correlate. Tables 3 & 4 demonstrate this for several key parameters. Notice that under the conditions of worst case input noise, the higher read back signal resulting from the higher input impedance can compensate for the higher input noise. Accounting for this correlation in your analysis will be more representative of actual performance.

TABLE 3: Key Parameters Under Worst Case Input Noise Conditions

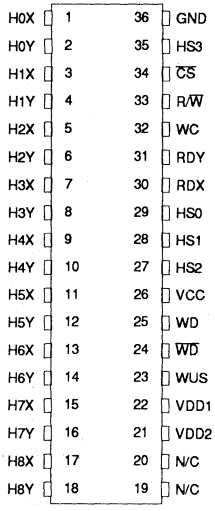
PARAMETER		Tj = 25°C	Tj = 135°C	UNITS
Input Noise Voltage (Max.)		0.70	0.85	nV/$\sqrt{Hz}$
Differential Input Resistance (Min.)	32R528R	390	420	Ω
	32R528	1200	1500	Ω
Differential Input Capacitance (Max.)		32	34	pF

TABLE 4: Key Parameters Under Worst Case Input Impedance Conditions

PARAMETER		Tj = 25°C	Tj = 135°C	UNITS
Input Noise Voltage (Max.)		0.58	0.71	nV/$\sqrt{Hz}$
Differential Input Resistance (Min.)	32R528R	310	350	Ω
	32R528	643	846	Ω
Differential Input Capacitance (Max.)		33	35	pF

SSI 32R528/528R
8 & 9-Channel Thin Film Read/Write Device

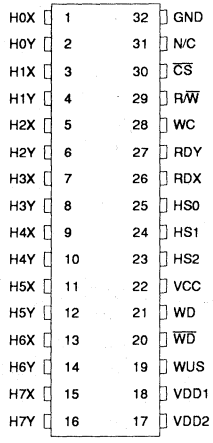
PACKAGE PIN DESIGNATIONS
(Top View)



36-Lead SOM

THERMAL CHARACTERISTICS: Ø ja

32-Lead SOW	55°C/W
36-Lead SOM	50°C/W



32-Lead SOW, FLATPACK

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32R528 Read/Write IC		
8-Channel SOW	SSI 32R528-8W	32R528-8W
9-Channel SOM	SSI 32R528-9M	32R528-9M
SSI 32R528R with Internal Damping Resistor		
8-Channel SOW	SSI 32R528R-8W	32R528R-8W
9-Channel SOM	SSI 32R528R-9M	32R528R-9M

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32R529R
8-Channel Thin Film Read/Write Device

Preliminary Data

1

July, 1990

DESCRIPTION

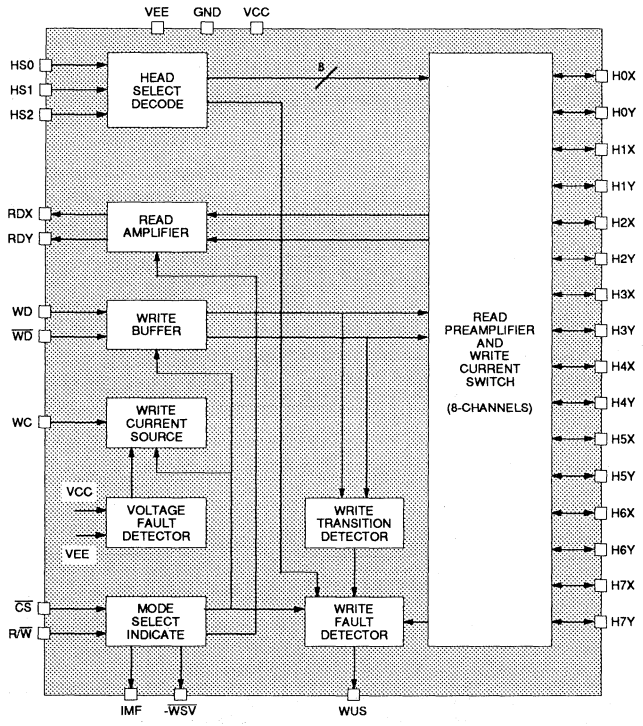
The SSI 32R529 is an integrated read/write circuit designed for use with non-center tapped thin film heads in disk drive systems. Each chip controls eight heads and has three modes of operation: read, write, and idle. The circuit contains eight channels of read amplifiers and write drivers and also has an internal write current source.

A current monitor (IMF) output is provided that allows a multichip enable fault to be detected. The circuit operates on +5 volt, and -5 volt power and is available in 32-pin and 34-pin SOL packages.

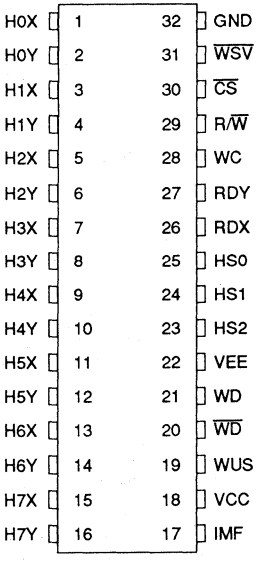
FEATURES

- **High performance**
  - **Read Mode Gain = 125 Typ V/V**
  - **Input Noise = 0.8 nV/$\sqrt{Hz}$ max**
  - **Input Capacitance = 38 pF**
  - **Write Current Range = 17 mA to 50 mA**
  - **Write Current Rise Time = 12 ns**
  - **Head Voltage Swing = 8.0 Vpp min**
- **Write unsafe detection**
- **Power supply fault protection**
- **-5V, +5V power supplies**

BLOCK DIAGRAM



PIN DIAGRAM



32-PIN SOW

CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 32R529R
8-Channel Thin Film Read/Write Device

FUNCTIONAL DESCRIPTION

WRITE MODE

In Write Mode (R/$\overline{W}$ and $\overline{CS}$ low) the circuit functions as a differential current switch. The Head Select Inputs HS0, HS1 and HS2 determine the selected head. The Write Data Inputs (WD, $\overline{WD}$) determine the polarity of the head current. The write current magnitude is adjusted by an external resistor Rex (1%) from WC to VEE.

$$[\frac{Vwc}{Rex} = Iw(1+\frac{Rh}{90}) - Ioffset\ ]$$

WRITE MODE FAULT DETECT CIRCUIT

Several circuits are dedicated to detecting fault conditions associated with the write mode. A logical high (off) level will be present at the Write Unsafe (WUS) terminal if any of the following write fault conditions are present:

- Open head circuit
- Resistive component of head shorted
- Head shorted to ground
- No write current
- Write current transition frequency too low
- Head select input(s) open circuit
- Write mode not logically selected

The Write Unsafe output is open-collector and is usually terminated by an external resistor connected to VCC.

Additionally, power voltage monitoring circuits are used to detect VCC and VEE voltage levels. If either is too low to permit valid data recording, write current is inhibited. With VCC and VEE voltage above the inhibiting levels, logical control of write current is provided by the mode selection inputs.

READ MODE

In Read Mode, (R/$\overline{W}$ high and $\overline{CS}$ low), the circuit functions as a low noise differential amplifier. The read amplifier input terminals are determined by the Head Select inputs. The read amplifier outputs (RDX, RDY) are open collector, requiring external load resistors connected to VCC. The amplifier gain polarity is non-inverting between HX, HY inputs and RDX, RDY outputs.

IDLE MODE

Taking $\overline{CS}$ high selects the idle mode which switches the RDX and RDY outputs into a high impedance state and deactivates the internal write current source. This facilitates multi device installations by allowing the read outputs to be wired OR'ed and the write current programming resistor to be common to all devices.

MODE SELECTION AND INDICATION CIRCUIT

Logical control inputs which select mode and head channel are TTL compatible. Their functions are described in Table 1 and 2. Selection of the write mode is indicated by a low (on) state of the Write Select Verify ($\overline{WSV}$) terminal. The open collector output is usually terminated by an external resistor connected to VCC. The selection of either the write or read mode is indicated by the flow of a unit of current into the Current Monitor (IMF) terminal. By summing the currents from multiple circuits, the user can determine that one, and only one, circuit is active.

The mode select inputs have internal pull up circuits so that if an input is open it will rise to the upper logic level.

TABLE 1: Head Select

Head Selected	HS2	HS1	HS0
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

TABLE 2: Mode Select

Mode Select			Indicating & Fault Outputs		
$\overline{CS}$	R/$\overline{W}$	Selected Mode	IMF	-WSV	WUS
1	X	Idle	off	off	off
0	1	Read	on	off	off
0	0	Write	on	on	on*

*Provided that no fault is detected.

PIN DESCRIPTIONS

CONTROL INPUT PINS

NAME	TYPE	DESCRIPTION
$\overline{CS}$	I	Chip Select Input. A logical low level enables the circuit for a read or write operation. Has internal pull up.
R/$\overline{W}$	I	Read/write select. A logical low level enables the write mode (when CS is low). Has internal pull up.
HSO, HS1, HS2	I	Head select inputs. Logical combinations select one of eight heads. See Table 1.
HEAD TERMINAL PINS		
H0X-H7X, H0Y-H7Y	I/O	Connection to read/write magnetic terminals.
DATA INPUT/OUTPUT PINS		
WD, $\overline{WD}$	I/O	Differential Write Data inputs used to write data patterns on the disk.
RDX, RDY	I/O	Differential Read Data pattern output amplified playback from the disk. These outputs are normally terminated in 100Ω resistors to VCC.
EXTERNAL COMPONENT CONNECTION PINS		
WC	I/O	Resistor connected to VEE to provide desired value of write current.
CIRCUIT MONITOR PINS		
$\overline{WSV}$	O	Write Select Verify is an open-collector output with the on-state indicating that the circuit has been selected for a write operation. It is normally terminated to VCC through a resistor.
WUS	O	Write Unsafe is an open-collector output with the off-state indicating that conditions are not proper for a write operation.
IMF	O	High-impedance output sinks a unit of monitor current when chip is enabled.
POWER, GROUND PINS		
VCC	I	Positive power supply voltage for circuit functions.
VEE	I	Negative power supply voltage.
GND	I	Power supply common.

FAULT DETECTION CHARACTERISTICS

Test Conditions (Unless otherwise specified). VCC = 4.75 to 5.25V, Tj = 0 to +125°C, VEE = -4.75 to -5.5V, Lh = 560 nH, Rh = 20Ω, ± WD 20%-80% Tr, Tf < 2 nsec, Rex = 46Ω, ±WD Min. Switching Freq. = 1 MHz, ±WD Max. Switching Freq. = 18 Mhz (Sq. Wave)

CHARACTERISTIC	SYMBOL	MIN	MAX	UNIT
Maximum VCC Value for Write Current Turn off (Ih < 1 mA)	Vccth	–	3.5	V
Maximum VEE Value for Write Current Turn off (Ih < 1 mA)	Veeth	–	-3.5	V
Max Resistance of Head to GND for Short Detect (Iw = 50 mA)	Rsh	–	4	Ω
Voltage across Head for Short Detect (Iw = 17 to 50 mA)	Vsth	0.05	0.30	V
Voltage across Head for Open Circuit Detect (Iw = 17 to 50 mA)	Voth	1.25	1.75	V
Minimum Switching Rate of Write Current for Safe Condition	Fth	1	–	MHz

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, 4.75 ≤ VCC ≤ 5.50, -5.5 ≤ VEE ≤ -4.75V, 0° ≤ T (junction) ≤ 125°C.

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNIT
Positive Supply Voltage, VCC	6	VDC
Negative Supply Voltage, VEE	-6	VDC
Operating Junction Temperature	-20 to +130	°C
Storage Temperature	-65 to +130	°C
Lead Temperature (Soldering, 10 sec)	260	°C
Input Voltages		
Head Select (HS0,1,2)	-0.4 to VCC + 0.3	VDC
Chip Select ($\overline{CS}$)	-0.4 to VCC+ 0.3	VDC
Read Select (R/$\overline{W}$)	-0.4V or -2 mA to VCC + 0.3	VDC
Write Data (WD, $\overline{WD}$)	VEE to 0.3	VDC
Head Inputs (Read Mode)	-0.6 to 0.4	VDC
Outputs		
Read Data (RDX, RDY)	VCC -2.5 to VCC + 0.3	VDC
Write Unsafe (WUS)	-0.4V to VCC + 0.3 and 20 mA	VDC
Write Select Verify ($\overline{WSV}$)	-0.4V to VCC + 0.3 and 20 mA	VDC

ELECTRICAL CHARACTERISTICS (Continued)

Unless otherwise specified, 4.75 ≤ VCC ≤ 5.50, -5.5 ≤ VEE ≤ -4.75V, 0° ≤ T (junction) ≤ 125°C.

ABSOLUTE MAXIMUM RATINGS (Continued)

PARAMETER	RATING	UNIT
Outputs (Continued)		
Current Monitor (IMF)	VCC -0.4 to VCC + 0.3	VDC
Current Reference (WC)	100 mA to 1.0 mA and 8 mA	VDC
Head Outputs (Write Mode)	-100 mA to 1.0 mA	mA

POWER SUPPLY

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Power Dissipation	Idle mode			155	mW
	Read mode			560	mW
	Write mode			550 +10.5 x Iw	mW
Positive Supply Current (ICC)	Idle Mode			15	mA
	Read Mode			35	mA
	Write Mode			38	mA
Positive Supply Current (ICC1)	Idle Mode			1	mA
	Read Mode			1	mA
	Write Mode			17 + Iw	mA
Negative Supply Current (IEE)	Idle Mode			-12	mA
	Read Mode			-56	mA
	Write Mode			-45 - Iw	mA

DC CHARACTERISTICS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
High-level Input Voltage VIH ($\overline{CS}$, R/$\overline{W}$, HS0, HS1, HS2)		2.0		-	V
Low-level Input Voltage VIL ($\overline{CS}$, R/$\overline{W}$, HS0, HS1, HS2)				0.8	V
High-level Input Current IIH ($\overline{CS}$, R/$\overline{W}$)	VIH = 2.7V			20	µA
Low-level Input current IIL ($\overline{CS}$, R/$\overline{W}$)	VIL = 0.4V			-400	µA
High-level Input Current IIH (HS0, HS1, HS2)	VIH = 2.7V			250	µA

DC CHARACTERISTICS (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Low-level Input Current IIL (HS0, HS1, HS2)	VIL = 0.4V			250	µA
High-level Input voltage VIH (WD, $\overline{WD}$)		-1.10		-0.81	V
Low-level Input Voltage VIL (WD, $\overline{WD}$)		-1.95		-1.475	V
High-level input Current IIH (WD, $\overline{WD}$)	VIH = -0.81V, VIL = -1.95V			0.5	mA
Low-level Input Current IIL (WD, $\overline{WD}$)	VIL = -1.475V, VIH = -1.1V	-0.5			mA
WUS, WSV Low Level Voltage	ILUS = 8 mA (denotes safe condition)			0.5	V
WUS, WSV High Level Current	VHUS = 5.0V (denotes safe condition)			100	V
VCC Fault Voltage				3.5	V
VEE Fault Voltage				-3.5	V
IMF on Current		2.20		3.70	mA
IMF off Current				20	µA
IMF Voltage Range		0		VCC + 0.3	V
Differential Data Voltage, (WD – $\overline{WD}$)		0.20			V
Data Input Voltage Range Differential		-1.87		+0.1	V
Data Input Current (per side)	Chip Enabled			150	µA
Data Input Capacitance	per side to GND			10	pF

WRITE MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Current Range (Iw)	28Ω ≤ Rex ≤ 106Ω	17		50	mA
Write Current Voltage	Current set to nominal value by Rex = 46Ω Tj = 50°C		2.25 ±8% (above VEE)		V
Differential Head voltage Swing	Iw = 50 mA	8.0			Vpp
Unselected Head Transient Current	Iw = 40 mA, Lh = 0.5 µH, Rh = 20Ω, Non adjacent heads tested to minimize external coupling effects			1	mA(pk)
Ioffset			6.0		mA

WRITE MODE (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Head Damping Resistance		88	110	150	Ω
Differential Output Capacitance			25	30	pF
WD, $\overline{WD}$ Transition Frequency	WUS = Low	1.0			MHz

READ MODE
Tests performed with 100Ω load resistors from RD and $\overline{RD}$ through series isolation diodes to VCC.

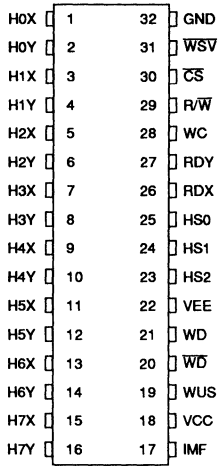
PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Differential Voltage Gain	Vin = 1 mVpp, f = 300 KHz	95	125	155	V/V
Voltage Bandwidth (-3dB)	Zs < 5Ω, Vin = 1 mVpp f midband = 300 KHz	55		100	MHz
Input Noise Voltage	Zs = 0Ω , Vin = 0V, Power Bandwidth = 15 MHz			0.8	$nV\sqrt{Hz}$
Differential Input Capacitance	Vin = 0V, f = 5 MHz			35	pF
Differential Input Resistance	Vin = 0V, f = 5 MHz	275		1250	Ω
Input Bias Current (per side)	Vin = 0V			0.17	mA
Dynamic Range	DC input voltage where AC gain falls to 90% of the gain with 0.5 mVpp input signal	-2		2	mV
Common Mode Rejection Ratio	Vin = 100 mVpp, 0V DC 1 MHz ≤ f ≤ 10 MHz	50			dB
	f = 20 MHz	46			dB
Power Supply Rejection Ratio	VCC or VEE = 100 mVpp f = 1 MHz	65			dB
	f = 20 MHz	40			dB
Channel Separation	The unselected channels are driven with Vin = 100 mVpp	46			dB
Output Offset Voltage		-360		360	mV
Output Leakage Current	Idle Mode			0.01	mA
Output Common Mode Voltage		VCC - 0.9		VCC - 0.3	V

SWITCHING CHARACTERISTICS

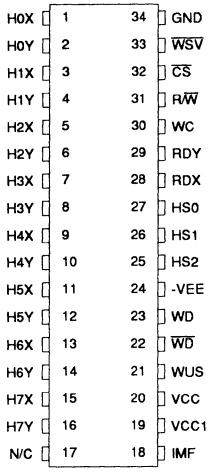
PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Idle to Read/Write Transition Time				0.6	µs
Read/Write to Idle Transition Time				0.6	µs
Read to Write Transition Time	VLCS = 0.8V, Delay to 90% of Iw			0.6	µs
Write to Read Transition Time	VLCS = 0.8V, Delay to 90% of 20 MHz Read Signal envelope, Iw decay to 10%			0.6	µs
Head Select Switching Delay	Read or Write Mode			0.30	µs
Head Current Transition Time 10% to 90%	Iw = 50 mA, Lh = 0.56 µH, Rh=20Ω			12	ns
	Iw = 50 mA, LH < 50nH Rh=.1Ω			6	ns
Head Current Switching Time Symmetry	Iw = 40 mA, Lh = 0.56 µH, Rh = 20Ω, WD & $\overline{WD}$ transitions 2 ns, switching time symmetry 0.2 ns			1.0	ns
WSV Transition Time	Delay from 50% of write select swing to 90% of final $\overline{WSV}$ voltage, Load = 2KΩ // 20 pF			0.5	µs
Unsafe to Safe Delay After Write Data Begins (WUS)	f(data) = 5 MHz			0.20	µs
Safe to Unsafe Delay, (WUS)	Head open or shorted to GND, no write current, head select input open			0.50	µs
Safe to Unsafe Delay, (WUS)	Non-switching write data	3		10	µs
IMF Switching Time	Delay from 50% of $\overline{CS}$ to 90% of final IMF current			0.250	µs

PACKAGE PIN DESIGNATIONS

(TOP VIEW)



32-Pin SOW



34-Pin SOL

*NOTE: 32 Pin SOW has VCC & VCC1 internally bonded together

ORDERING INFORMATION

PART DESCRIPTION	ORDERING NO.	PKG. MARK
SSI 32R529R		
32-Pin SOW	SSI 32R529R-8CW	32R529R-8CW
34-Pin SOL	SSI 32R529R-8CL	32R529R-8CL

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32R1200/1200R

+5V, 4-Channel Ferrite/MIG Read/Write Device

Advance Information

1

June, 1990

DESCRIPTION

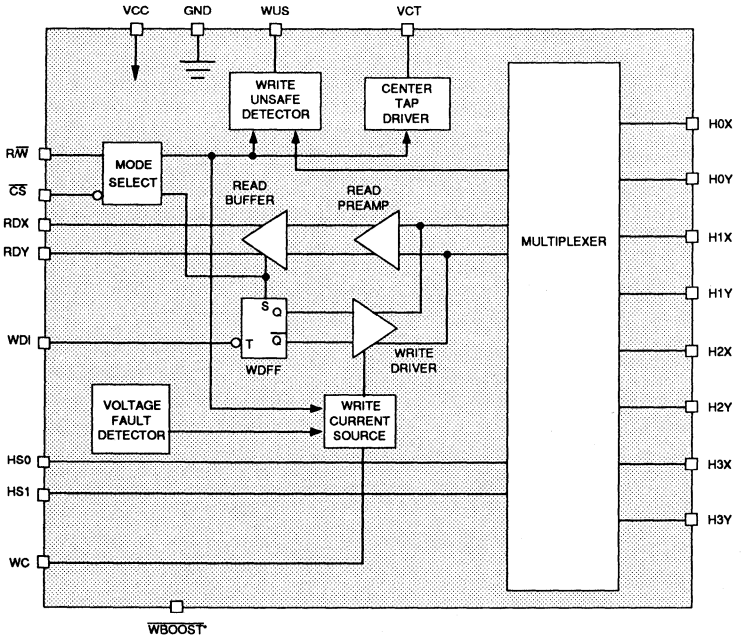
The SSI 32R1200/1200R are bipolar monolithic integrated circuits designed for use with center-tapped ferrite or MIG recording heads. They provide a low noise read path, write current control, and data protection circuitry for as many as 4 channels. Power supply fault protection is provided by disabling the write current generator during power sequencing. Power is significantly reduced in this device, in addition a power down mode (idle) is provided to reduce power consumption to less than 10 mW.

The SSI 32R1200R option provides internal 750Ω damping resistors. The SSI 32R1200/1200R requires only a +5V power supply and is available in a variety of packages.

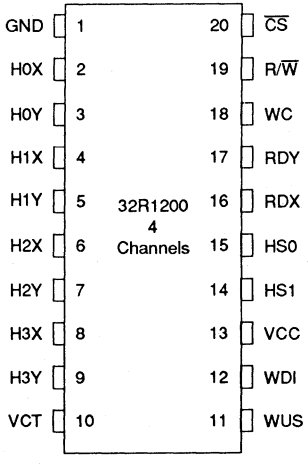
FEATURES

- **+5V only power supply**
- **Low power**
  - **Pd ≤ 140 mW read mode**
- **High Performance**
  - **Read mode gain = 200 V/V**
  - **Input noise = 1.2 nV/$\sqrt{Hz}$ max.**
  - **Input capacitance = 17 pF max.**
  - **Write current range = 15 - 50 mA**
  - **Head voltage swing = 6.0 Vpk**
- **Designed for center-tapped ferrite or MIG heads**
- **Power supply fault protection**
- **Includes write unsafe detection**
- **Enhanced Write to Read recovery**

BLOCK DIAGRAM



PIN DIAGRAM



20-Pin SOL

CAUTION: Use handling procedures necessary for a static sensitive component.

* Not available in 20-pin SOL

SSI 32R1200/1200R
+5V, 4-Channel Ferrite/MIG Read/Write Device

DESCRIPTION

WRITE MODE

A source of recording current is provided to the head center tap by an internal voltage reference, VCT. The current is conducted through the head alternately into an HnX terminal or an HnY terminal according to the state of an internal flip-flop. The flip-flop is triggered by the negative transition of the Write Data Input line (WDI). A proceeding read mode selection initializes the write data flip-flop, WDFF, to pass write current through the "x" side of the head. The write current magnitude is determined by the value of an external resistor RWC connected between WC terminal and GND, and is given by:

Iw = K/RWC, where K = Write Current Constant

WRITE MODE FAULT DETECT CIRCUIT

Several circuits are dedicated to detecting fault conditions associated with the write mode. A logical high level will be present at the Write Unsafe (WUS) terminal if any of the following write fault conditions are present:

- Head open
- Head center tap open
- Head shorted
- Head shorted to ground
- No write current
- WDI frequency too low
- Device in read or idle mode

The Write Unsafe output is open-collector and is usually terminated by an external resistor connected to VCC. Two negative transitions on WDI, after the fault is corrected, will clear the WUS flag.

Additionally, a power voltage monitoring circuit is used to detect VCC voltage level. If it is too low to permit valid data recording, write current is inhibited. With VCC voltage level above the inhibiting value, control of write current is provided by the mode selection inputs.

READ MODE

In Read Mode, (R/$\overline{W}$ high and $\overline{CS}$ low), the circuit functions as a low noise differential amplifier. The read amplifier input terminals are determined by the Head Select inputs. The read amplifier outputs (RDX, RDY) are emitter follower sources, providing low impedance outputs. The amplifier gain polarity is non-inverting between HnX, HnY inputs and RDX, RDY outputs.

IDLE MODE

Taking $\overline{CS}$ high selects the idle mode which switches the RDX and RDY outputs into a high impedance state and deactivates the device. Power consumption in this mode is held to a minimum.

MODE SELECTION AND INDICATION CIRCUIT

Logical control inputs which select mode and head channel are TTL compatible. Their functions are described in Table1 and Table 2.

TABLE 1: Head Select Table

Head Selected	HS1	HS0
0	0	0
1	0	1
2	1	0
3	1	1

TABLE 2: Mode Select Table

Mode Select		Selected Mode	Indicating & Fault Outputs
$\overline{CS}$	R/$\overline{W}$		WUS
1	X	Idle	off
0	1	Read	off
0	0	Write	on

PIN DESCRIPTIONS

NAME	I/O	DESCRIPTION
HS0-HS1	I	Head Select. Logical combinations select one of four Heads. Table 1
$\overline{CS}$	I	Chip Select: a low level enables device. Has internal pull-up.
R/$\overline{W}$	I	Read/Write: a high level selects read mode. Has internal pull-up.
WUS	O*	Write Unsafe: a high level indicates an unsafe writing condition
WDI	I	Write Data In: negative transition toggles direction of head current
H0X-H3X H0Y-H3Y	I/O	X, Y head connections
RDX, RDY	O*	X, Y Read Data: differential read signal out
WC	-	Write Current: used to set the magnitude of the write current
$\overline{WBOOST}$**	I	A logic low signal on this pin increases the magnitude of write current by typically 30%
VCT	-	Voltage Center Tap: voltage source for head center tap
VCC	-	+5V
GND	-	Ground

* When more than one R/W device is used, these signals can be wire OR'ed.
** $\overline{WBOOST}$ not available in 20-pin SOL

ABSOLUTE MAXIMUM RATINGS (All voltages referenced to GND. Currents into device are positive.)

PARAMETER		VALUE	UNITS
DC Supply Voltage	VCC	-0.3 to +6	VDC
Digital Input Voltage Range	VIN	-0.3 to VCC + 0.3	VDC
Head Port Voltage Range	VH	-0.3 to VCC + 0.3	VDC
WUS Pin Voltage Range	Vwus	-0.3 to +6	VDC
Write Current Zero–Peak	IW	60	mA
RDX, RDY Output Current	Io	-10	mA
VCT Output Current Range	IVCT	-60 mA to +10 µA	mA
WUS Output Current Range	Iwus	1.0 mA to -10 mA	mA
Storage Temperature Range	Tstg	-65 to 130	°C
Lead Temperature PDIP, Flat Pack (10 sec Soldering)		260	°C
Package Temperature PLCC, SO (20 sec Reflow)		215	°C

RECOMMENDED OPERATION CONDITIONS

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
DC Supply Voltage	VCC		4.75	5.0	5.25	VDC
Head Inductance	Lh		1		15	µH
Damping Resistor	RD	32R1200 only	500		2000	Ω
Write Current Range	IW		15		50	mA
Junction Temperature Range	Tj		+25		+135	°C

DC CHARACTERISTICS

(Unless otherwise specified, recommended operating conditions apply.)

POWER SUPPLY

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
VCC Supply Current (ICC)	Read Mode		28	38	mA
	Idle Mode Iw = 30 mA		1.4	1.9	mA
	Write Mode			40 + Iw	mA
Power Dissipation	Read Mode		140	200	mW
	Idle Mode		7	10	mW
	Write Mode			210 + 4 Iw	mW

DIGITAL I/O

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
VIL	Input Low Voltage $\overline{CS}$, R/$\overline{W}$ WDI, HS0, HS1				0.8	VDC
VIH	Input High Voltage $\overline{CS}$, R/$\overline{W}$ WDI, HS0, HS1		2.0			VDC
IIL	Input Low Current $\overline{CS}$, R/$\overline{W}$ WDI, HS0, HS1	VIL = 0.4V	-0.4			mA
IIH	Input High Current $\overline{CS}$, R/$\overline{W}$ WDI, HS0, HS1	VIH = 2.7V			20	µA
VOL	WUS Output Low Voltage	IOL = 4.0 mA			0.5	VDC
IOH	WUS Output High Current	VOH = 5.0V			100	µA

WRITE MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Center Tap Voltage VCT	Write Mode		Vcc - 0.9		VDC
Head Current (per side)	Write Mode, 0 ≤ VCC ≤ 3.9V	-200		200	µA
Write Current Range	1.0 kΩ ≤ Rext ≤ 3.3 kΩ	15		50	mA
Write Current Constant "K"		46	50	54	
Iwc to Head Current Gain			20		mA/mA
$\overline{\text{WBOOST}}$ - Write Current Boost Factor*	$\overline{\text{WBOOST}}$ = Low	1.25		1.35	mA/mA
Unselected Head Leakage Current				85	µA
RDX, RDY Common Mode Output Voltage		2.0	Vcc - 2.4	3.5	VDC
RDX, RDY Leakage	RDX, RDY = 4V Idle Mode	-100		100	µA

* Not available in 20-pin SOL.

READ MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Center Tap Voltage	Read Mode		Vcc - 1.5		VDC
Input Bias Current (Differential)				45	µA
Output Offset Voltage	Read Mode	-200		+200	mV
Common Mode Output Voltage	Read Mode	2	Vcc - 2.4	3.5	VDC
Common Mode Output Voltage Change from Write to Read Mode		-100		+100	mV

FAULT DETECTION CHARACTERISTICS

Unless otherwise specified recommended conditions apply, Iw = 30 mA, Lh = 5 µH, Rd = 750. (SSI 32R1200 only), F(WDI) = 10 MHz.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Minimum Rate of WDI Input for Safe condition		1.25			MHz
Maximum Rate of WDI Input for Unsafe condition				250	kHz
Minimum Vcc value for guaranteed write current turn-on		4.4			VDC
Maximum Vcc value for guaranteed write current turn-off				3.9	VDC

DYNAMIC CHARACTERISTICS AND TIMING

(Unless otherwise specified, recommended operating conditions apply and Iw = 30 mA, Lh = 5 µH, Rd = 750Ω 32R1200 only, f(WDI) = 5 MHz, CL(RDX, RDY) ≤ 20 pF.)

WRITE MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Differential Head Voltage Swing		6.0			V(pk)
Unselected Head Transient Current				2	mA(pk)
Differential Output Capacitance				10	pF
Differential Output Resistance	32R1200	10			kΩ
	32R1200R	600		960	Ω

READ MODE

Differential Voltage Gain	Vin = 1 mV RMS	160	200	240	V/V
Bandwidth (-3dB)	|Zs| < 5Ω, Vin = 1 mVpp	30			MHz
Input Noise Voltage	BW = 15 MHz, Lh = 0, Rh = 0			1.2	$nV/\sqrt{Hz}$
Differential Input Capacitance				17	pF
Differential Input Resistance	32R1200 f = 5 MHz	2.0			kΩ
	32R1200R	462			Ω
Common Mode Rejection Ratio	Vcm = 100 mVpp@1 MHz < f < 10 MHz	50			dB
Power Supply Rejection Ratio	Vcs =100 mVpp@1 MHz < f < 10 MHz	45			dB
Channel Separation	Unselected Channels: Vin = 20 mVpp 1 MHz < f < 10 MHz	45			dB
Single Ended Output Resistance				30	Ω
Output Current	AC Coupled Load, RDX to RDY	±1.5			mA

DYNAMIC CHARACTERISTICS AND TIMING (continued)

SWITCHING CHARACTERISTICS

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
R/$\overline{W}$	Read to Write	R/W to 90% of write current			1.0	µs
	Write to Read	R/W to 90% of 100 mV. 10 MHz Read signal envelope			1.0	µs
$\overline{CS}$	Unselect to Select	$\overline{CS}$ to 90% Iw or to 90% of 100 mV. 10 MHz Read signal envelope			2.0	µs
	Select to Unselect				0.6	µs
HS0, 1, 2 to any Head		To 90% of 100 mV. 10 MHz Read signal envelope			0.6	µs
WUS:	Safe to Unsafe (TD1)	f = 5 MHz	1.6		8	µs
	Unsafe to Safe (TD2)				1.0	µs
Head Current		From 50% Points, Lh = 0				
	Prop. Delay - TD3	Rh = 0			30	ns
	Asymmetry	WDI has 50% Duty Cycle and 1 ns Rise/Fall Time			2	ns
	Rise/Fall Time	10% - 90% Points			20	ns

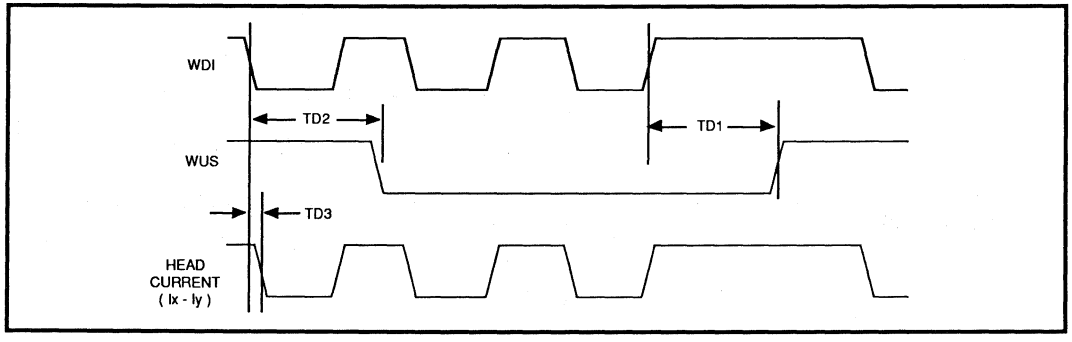
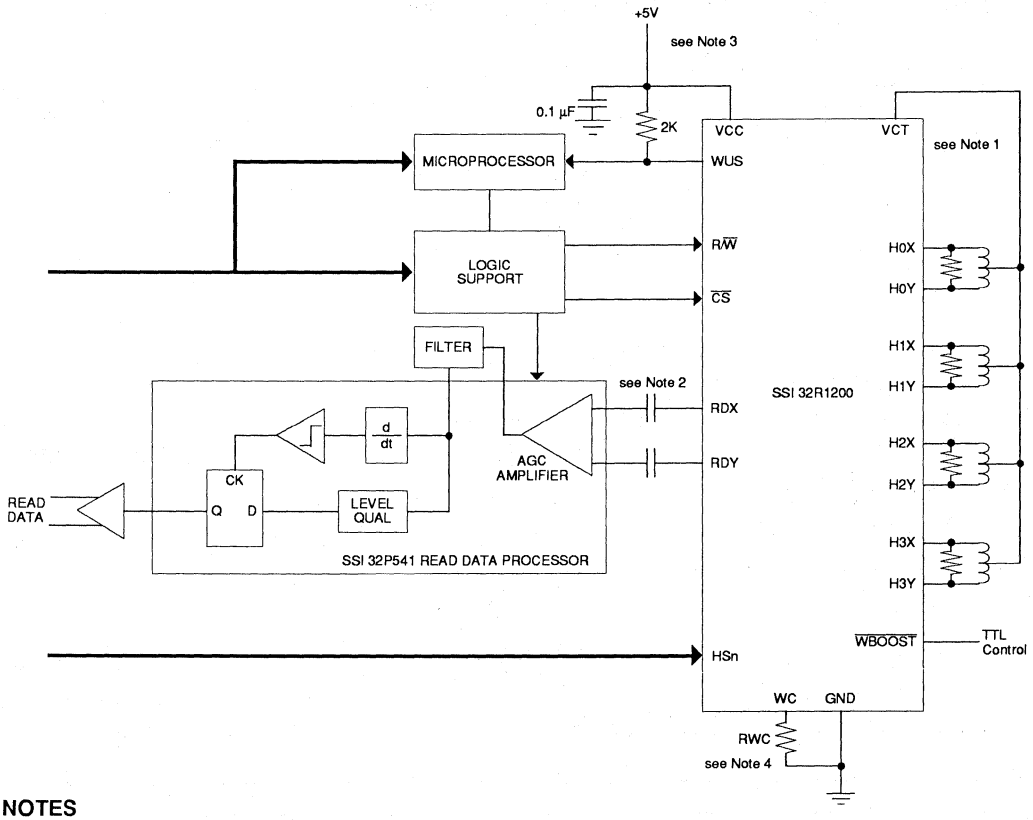


FIGURE 1: Write Mode Timing Diagram

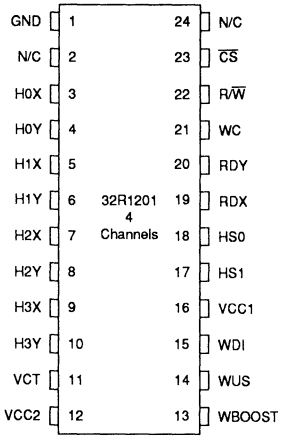


NOTES

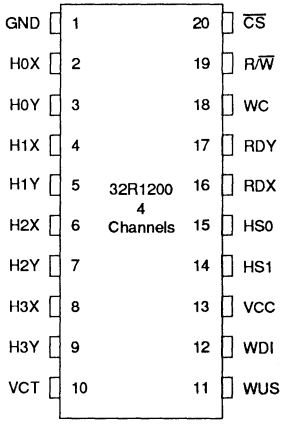
1. Damping resistors not required on 32R1200R versions.
2. Limit DC current from RDX and RDY to 100 µA and load capacitance to 20 pF. In multi-chip application these outputs can be wire-OR'ed.
3. The power bypassing capacitor must be located close to the 32R1200 with its ground returned directly to device ground, with as short a path as possible.
4. To reduce ringing due to stray capacitance this resistor should be located close to the 32R1200. Where this is not desirable a series resistor can be used to buffer a long WC line.

FIGURE 2: Applications Information

PACKAGE PIN DESIGNATIONS
(TOP VIEW)



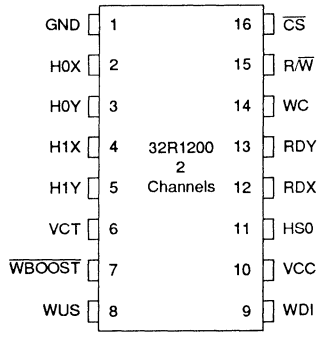
24-Pin SOL



20-Pin SOL

THERMAL CHARACTERISTICS: Ø ja

24-lead	SOL	80°C/W
20-lead	SOL	80°C/W
16-lead	SOL	100°C/W



16-Pin SOL - TBD

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32R2010R
10-Channel Thin Film Read/Write Device

Advance Information

1

July, 1990

DESCRIPTION

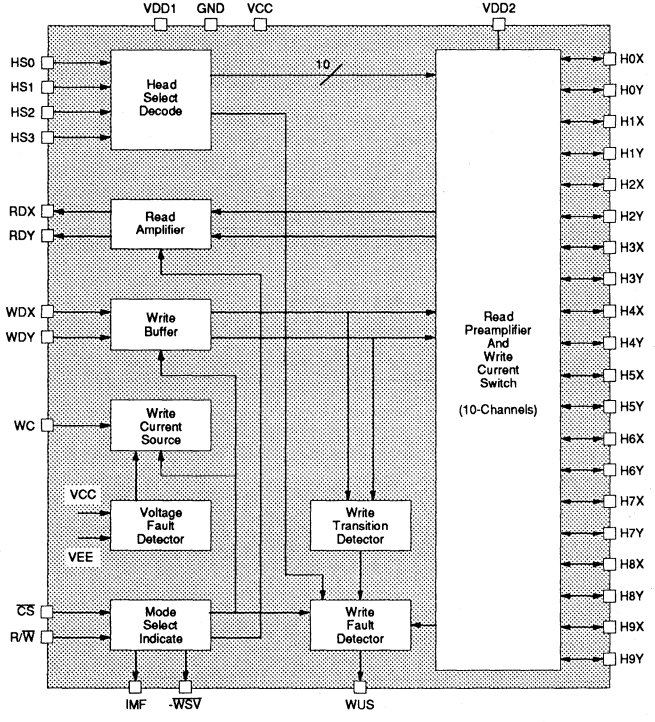
The SSI 32R2010R is an integrated read/write circuit designed for use with non-center tapped thin film heads in disk drive systems. Each chip controls ten heads and has three modes of operation: read, write, and idle. The circuit contains ten channels of read amplifiers and write drivers and also has an internal write current source.

A current monitor (IMF) output is provided that allows a multichip enable fault to be detected. The circuit operates on +5 volt, and +12 volt power and is available in a 44-pin package.

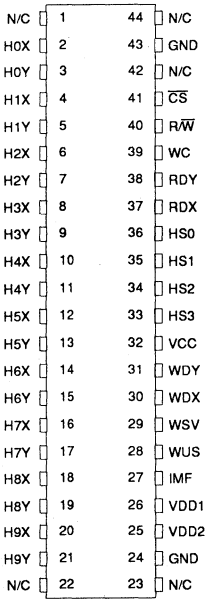
FEATURES

- **High performance**
  - **Read Mode Gain = 150 Typ V/V**
  - **Input Noise = 0.85 nV/$\sqrt{Hz}$ max**
  - **Input Capacitance = 26 pF max**
  - **Write Current Range = 17 mA to 50 mA**
  - **Write Current Rise Time = 12 ns**
  - **Head Voltage Swing = 6 Vpp min**
- **Write unsafe detection**
- **Switch from 300Ω damping resistor to 1 kΩ read input resistance**
- **Power supply fault protection**
- **+5V, +12V power supplies**

BLOCK DIAGRAM



PIN DIAGRAM



44-PIN SOM

CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 32R2010R
10-Channel Thin Film Read/Write Device

FUNCTIONAL DESCRIPTION

WRITE MODE

In Write Mode (R/$\overline{W}$ and $\overline{CS}$ low) the circuit functions as a differential current switch. The Head Select Inputs HS0, HS1, HS2 and HS3 determine the selected head. The Write Data Inputs (WDX, WDY) determine the polarity of the head current. The write current magnitude is adjusted by an external resistor, RWC, from WC to GND, and is given by:

$$Iwc = Vwc/Rwc$$

Note that actual lead current, Ihd, is:

$$Ihd = Iwc/(1 + \frac{Rh}{Rd}) - Ioffset$$

where Rh is head resistance, Rd is write damping resistance and Ioffset is a constant DC offset current.

WRITE MODE FAULT DETECT CIRCUIT

Several circuits are dedicated to detecting fault conditions associated with the write mode. A logical high (off) level will be present at the Write Unsafe (WUS) terminal if any of the following write fault conditions are present:

- Open head circuit
- Resistive component of head shorted
- Head shorted to ground
- No write current
- Write current transition frequency too low
- Write mode not logically selected

The circuit will turn off write current when the head is shorted to ground to prevent excessive heat dissipation, this results in a pulsating WUS signal. The head short is disabled at high data rates (>8 MHz) to avoid false alarms caused by head ringing.

After the fault condition is removed, two negative transitions on the differential write data input lines are required to clear WUS.

The Write Unsafe output is open-collector and is usually terminated by an external resistor connected to VCC.

Additionally, power voltage monitoring circuits are used to detect VCC and VDD1, VDD2 voltage levels. If either is too low to permit valid data recording, write current is inhibited.

READ MODE

In Read Mode, (R/$\overline{W}$ high and $\overline{CS}$ low), the circuit functions as a low noise differential amplifier. The read amplifier input terminals are determined by the Head Select inputs. The read amplifier outputs (RDX, RDY) are open collector, requiring external load resistors connected to VCC. The amplifier gain polarity is non-inverting between HnX, HnY inputs and RDX, RDY outputs.

The switch from write to read modes also changes the resistance across HnX and HnY from its write damping value of 300Ω to its read mode input value of 1 kΩ.

IDLE MODE

Taking $\overline{CS}$ high selects the idle mode which switches the RDX and RDY outputs into a high impedance state and deactivates the internal write current source. This facilitates multi device installations by allowing the read outputs to be wired OR'ed and the write current programming resistor to be common to all devices.

MODE SELECTION AND INDICATION CIRCUIT

Logical control inputs which select mode and head channel are TTL compatible. Their functions are described in Table 1 and 2. Selection of the write mode is indicated by a low (on) state of the Write Select Verify ($\overline{WSV}$) terminal. The open collector output is usually terminated by an external resistor connected to VCC. The selection of either the write or read mode is indicated by the flow of a unit of current into the Current Monitor (IMF) terminal. By summing the currents from multiple circuits, the user can determine that one, and only one, circuit is active.

The mode select inputs have internal pull up circuits so that if an input is open it will rise to the upper logic level.

TABLE 1: Head Select

Head Selected	HS3	HS2	HS1	HS0
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

TABLE 2: Mode Select

Mode Select			Indicating & Fault Outputs		
$\overline{CS}$	R/$\overline{W}$	Selected Mode	IMF	$\overline{WSV}$	WUS
1	X	Idle	off	off	off
0	1	Read	on	off	off
0	0	Write	on	on	on*

*Provided that no fault is detected.

PIN DESCRIPTIONS

CONTROL INPUT PINS

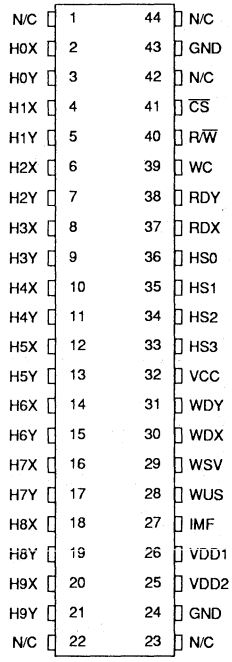
NAME	TYPE	DESCRIPTION
$\overline{CS}$	I	Chip Select Input. A logical low level enables the circuit for a read or write operation. Has internal pull up.
R/$\overline{W}$	I	Read/write select. A logical low level enables the write mode (when CS is low). Has internal pull up.
HS0, HS1, HS2, HS3	I	Head select inputs. Logical combinations select one of ten heads. See Table 1.
HEAD TERMINAL PINS		
H0X-H9X, H0Y-H9Y	I/O	X, Y Head connections: Current in the X-direction flows into X-port.
DATA INPUT/OUTPUT PINS		
WDX, WDY	I/O	Differential Write Data inputs used to write data patterns on the disk.
RDX, RDY	I/O	Differential Read Data pattern output amplified playback from the disk. These outputs are normally terminated in 100Ω resistors to VCC.
EXTERNAL COMPONENT CONNECTION PINS		
WC	I/O	Resistor connected to GND to provide desired value of write current.
CIRCUIT MONITOR PINS		
$\overline{WSV}$	O	Write Select Verify is an open-collector output with the on-state indicating that the circuit has been selected for a write operation. It is normally terminated to VCC through a resistor.
WUS	O	Write Unsafe is an open-collector output with the off-state indicating that conditions are not proper for a write operation.
IMF	O	High-impedance output sinks a unit of monitor current when chip is enabled.
POWER, GROUND PINS		
VCC	I	+5V Logic circuit supply.
VDD1	I	+12V
VDD2	I	Positive power supply for write current drivers.
GND	I	Power supply common.

SSI 32R2010R
10-Channel Thin Film Read/Write Device

PACKAGE PIN DESIGNATIONS
(TOP VIEW)

THERMAL CHARACTERISTICS: Ø ja

44-Lead SOM	**50°C/W**



44-Pin SOM

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only. Do not use for final design.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32R4610/4611

5V, 2, 4-Channel Thin-Film Read/Write Device

Preliminary Data

1

June, 1990

DESCRIPTION

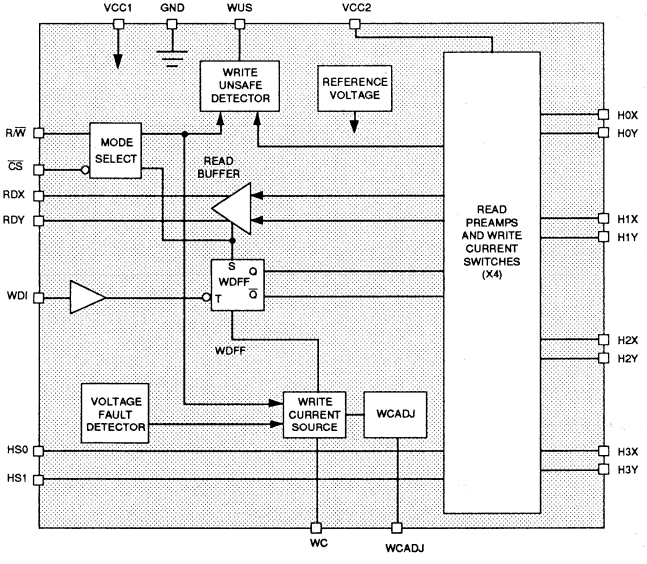
The SSI 32R4610/4611 are bipolar monolithic integrated circuits designed for use with two-terminal thin-film recording heads. They provide a low noise read amplifier, write current control, and data protection circuitry for up to four channels. The SSI 32R4610R/4611R option provides internal 700Ω damping resistors. Power supply fault protection is provided by disabling the write current generator during power sequencing. System write to read recovery time is significantly improved by controlling the read channel common mode output voltage shift in the write mode. The 32R4611 option provides for an additional feature providing the user with a controllable write current adjustment feature.

The SSI 32R4610/4611 require only +5V power supplies and are available in a variety of packages.

FEATURES

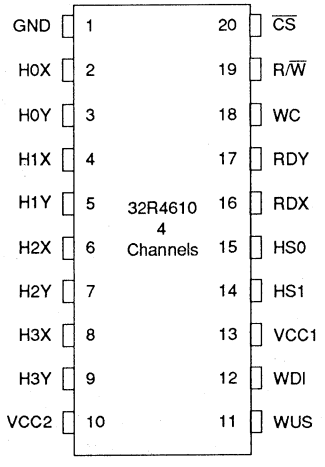
- **+5V only**
- **Low power**
  - **PD = 175 mW read mode (Nom)**
- **High Performance:**
  - **Read mode gain = 200 V/V**
  - **Input noise = 0.85 nV/√Hz max**
  - **Input capacitance = 35 pF max**
  - **Write current range = 10-35 mA**
- **Designed for two-terminal thin-film heads**
- **Programmable write current source**
- **Write unsafe detection**
- **Enhanced system write to read recovery time**
- **Power supply fault protection**
- **Head short to ground protection**

BLOCK DIAGRAM



WCADJ available on 32R4611 24-pin option only

20-PIN SOL



CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 32R4610/4611
5V, 2, 4-Channel Thin-Film Read/Write Device

CIRCUIT OPERATION

The SSI 32R4610/4611 has the ability to address up to 4 two-terminal thin-film heads and provide write drive or read amplification. Head selection and mode control are described in Tables 2 and 3. The TTL inputs R/$\overline{W}$ and $\overline{CS}$ have internal pull-up resistors to prevent an accidental write condition. HS0 and HS1 have internal pulldowns. Internal clamp circuitry will protect the IC from a head short to ground condition in any mode.

TABLE 1: Mode Select

$\overline{CS}$	R/$\overline{W}$	Mode
0	0	Write
0	1	Read
1	0	Idle
1	1	Idle

TABLE 2: Head Select

HS1	HS0	Head
0	0	0
0	1	1
1	0	2
1	1	3

PIN DESCRIPTIONS

NAME	TYPE	DESCRIPTION
HS0, HS1 †	I	Head Select: selects one of four heads
$\overline{CS}$	I	Chip Select: a high inhibits the chip
R/$\overline{W}$ †	I	Read/Write : a high selects Read mode
WUS †	O	Write Unsafe: a high indicates an unsafe writing condition
WDI †	I	Write Data In: changes the direction of the current in the recording head
H0X - H3X; H0Y - H3Y	I/O	X, Y Head Connections
RDX, RDY †	O	X, Y Read Data: differential read data output
WC †		Write Current: used to set the magnitude of the write current
WCADJ* †		Write Current Adjust: Used to decrease the write current by a finite amount
VCC1	I	+5V Supply
VCC2	I	+5V Supply for Write current drivers
GND	I	Ground

*Available on 32R4611 24-pin option only

† These signals can be wire OR'ed

WRITE MODE

Taking both $\overline{CS}$ and R/$\overline{W}$ low selects write mode which configures the SSI 32R4610/4611 as a current switch and activates the Write Unsafe (WUS) detector circuitry. Head current is toggled between the X and Y side of the selected head on each high to low transition of the Write Data Input (WDI). Note that a preceding read or idle mode select initializes the Write Data Flip-Flop to pass write current through the "X" side of the head. The magnitude of the write current (0-pk) is given by:

$$IW = \frac{K * VWC}{RWC}$$

RWC is connected from pin WC to GND. Note the actual head current Ix, y is given by:

$$Ix, y = \frac{Iw}{1 + Rh/Rd}$$

Where:

Rh = Head resistance plus external wire resistance
Rd = Damping resistance

The 32R4611 adds a feature which allows the user to adjust the Iw current by a finite amount. The WCADJ pin is used to adjust write current for write operations on different zones of the disk. It is used by switching a separate write current adjust resistor in and out on the WCADJ pin or by connecting a DAC to that pin to sink a controllable amount of current. The WCADJ pin is nominally biased to VCC/2. Sinking current from this pin to ground will divert a proportional amount of current from the actual head current while maintaining a constant current through the WC resistor and VCC. Allowing WCADJ to float or pulling it high will cut off the circuit and it will have no effect. For example, if the nominal head current is set to 30 mA through WC with WCADJ open, then for a 7.25 mA head current decrease, a 10 kΩ resistor would be connected from the WCADJ pin to ground. A TTL gate could be used as a switch with a small degradation in accuracy. To perform the same function, a DAC could be used, by programming it to sink 0.25 mA from the WCADJ pin.

Iw head (Decrease) = (29 • V_{WCADJ} / R_{WCADJ})
Where:
VWCADJ = Voltage on WCADJ pin
RWCADJ = Write current adjust setting resistor

VOLTAGE FAULT

A voltage Fault detection circuit improves data security by disabling the write current generator during a voltage fault or power startup regardless of mode.

Any of the following conditions will be indicated as a high level on the Write Unsafe, WUS, open collector output.

- WDI frequency too low
- Device in Read mode
- Chip disabled
- No write current
- Head opened

After fault condition is removed, one negative transition on WDI is required to clear WUS.

READ MODE

The Read mode configures the SSI 32R4610/4611 as a low noise differential amplifier and deactivates the write current generator. The RDX and RDY output are driven by emitter followers. They should be AC coupled to the load. The (X,Y) inputs are non-inverting to the (X,Y) outputs.

Note that in Idle or Write mode, the read amplifier is deactivated and RDX, RDY outputs become high impedance. This facilitates multiple R/W applications (wired-OR RDX, RDY) and minimizes voltage drifts when switching from Write to Read mode. Note also that the write current source is deactivated for both the Read and Idle mode.

IDLE MODE

Taking $\overline{CS}$ high selects the idle mode which switches the RDX and RDY outputs into a high impedance state and deactivates the device. Power consumption in this mode is held to a minimum.

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

Operation above maximum ratings may permanently damage the device.

PARAMETER		RATING	UNIT
DC Supply Voltage	VCC1	-0.3 to +7	VDC
	VCC2	-0.3 to +7	VDC
Write Current	IW	80	mA
Digital Input Voltage	Vin	-0.3 to VCC1 +0.3	VDC
Head Port Voltage	VH	-0.3 to VCC2 +0.3	VDC
Output Current: RDX, RDY	I0	-10	mA
WUS		+12	mA
Storage Temperature	Tstg	-65 to +150	°C

RECOMMENDED OPERATING CONDITIONS

PARAMETER		RATING	UNIT
DC Supply Voltage	VCC1	5 ±5%	VDC
	VCC2	5 ±5%	VDC
Operating Junction Temperature	Tj	+25 to +110	°C

DC CHARACTERISTICS

Recommended operating conditions apply unless otherwise specified.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VCC1 Supply Current	Read Mode			33	mA
	Write Mode			27	mA
	Idle Mode			12	mA
VCC2 Supply Current	Read Mode			11	mA
	Write Mode			10 + Iw	mA
	Idle Mode			0.4	mA
Power Dissipation	Read Mode		175	230	mW
	Write Mode		150 + 4Iw	190 + 4Iw	mW
	Idle Mode		50	65	mW

DIGITAL INPUTS

Input Low voltage (VIL)				0.8	VDC
Input High Voltage (VIH)		2.0			VDC
Input Low Current	VIL = 0.8V	-0.4			mA
Input High Current	VIH = 2.0V			100	µA
WUS Output Low Voltage (VOL)	Iol = 2 mA max			0.5	VDC
VCC1 Fault Voltage	IW < 0.2 mA	3.8	4.0	4.2	VDC

WRITE CHARACTERISTICS

Recommended operating conditions apply unless otherwise specified.

Write Current Constant "K"			.99		
Write Current Voltage (VWC)		1.15	1.25	1.35	V
WCADJ Voltage SSI 32R4611/4611R	I_{WCADJ} = 0 to .5 mA	2.0	VCC/2	3.0	VDC
$I_{head(Decrease)}/I_{WCADJ}$ SSI 32R4611/4611R		26	29	32	mA/mA
I_{WCADJ} Range SSI 32R4611/4611R		0.0		0.5	mA

WRITE CHARACTERISTICS (continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Differential Head Voltage Swing		3.4			Vpp
Unselected Head Current				1	mA (pk)
Head Differential Load Capacitance				25	pF
Head Differential Load Resistance (Rd)	SSI 32R4610/32R4611	4K			Ω
	SSI 32R4610R/32R4611R	560	700	950	Ω
WDI Transition Frequency	WUS = low	1.0			MHz
Write Current Range (IW)		10		35	mA

READ CHARACTERISTICS
Recommended operating conditions apply unless otherwise specified. CL (RDX, RDY) < 20 pF, RL (RDX, RDY) = 1 kΩ.

Differential Voltage Gain	Vin = 1 mVpp @1 MHz	160	200	240	V/V
Voltage BW -1dB	|Zs| < 5Ω, Vin = 1 mVpp	20			MHz
-3dB		35			MHz
Input Noise Voltage	BW = 15 MHz, Lh = 0, Rh = 0		0.6	0.85	$nV/\sqrt{Hz}$
Differential Input Capacitance	Vin = 1 mVpp, f = 5 MHz		27	35	pF
Differential Input Resistance	Vin = 1 mVpp, f = 5 MHz SSI 32R4610/4611	835			Ω
	SSI 32R4610R/4611R	360			Ω
Dynamic Range	AC input voltage where gain falls to 90% of its small signal gain value, f = 5 MHz	3			mVpp
Common Mode Rejection Ratio	Vin = 0 VDC + 100 mVpp @ 5 MHz	45			dB
Power Supply Rejection Ratio	100 mVpp @ 5 MHz on VCC	40			dB
Channel Separation	Unselected channels driven with Vin = 0 VDC + 100 mVpp	45			dB
Output Offset Voltage		-300		+300	mV
Single Ended Output Resistance	f = 5 MHz			40	Ω
Output Current	AC coupled load, RDX to RDY	1.4			mA
RDX, RDY Common Mode Output Voltage		2.0	2.5	3.5	VDC

SWITCHING CHARACTERISTICS

Recommended operating conditions apply unless otherwise specified. IW = 20 mA, Lh = 1.0 µH, Rh = 30Ω f(Data) = 5 MHz.

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
R/$\overline{W}$	Read to Write	R/W to 90% of write current		0.1	1.0	µs
	Write to Read	R/W to 90% of 100 mV Read signal envelope		0.5	1.0	µs
$\overline{CS}$	Unselect to Select	$\overline{CS}$ to 90% of write current or to 90% of 100 mV 10 MHz		0.4	1.0	µs
	Select to Unselect	$\overline{CS}$ to 10% of write current		0.4	1.0	µs
HS0,1 to any Head		To 90% of 100 mV 10 MHz Read signal envelope		0.2	1.0	µs
WUS:	Safe to Unsafe (TD1)		0.6	2.0	3.6	µs
	Unsafe to Safe (TD2)			0.2	1.0	µs
Head Current:		Lh = 0, Rh = 0				
	WDI to Ix - Iy (TD3)	from 50% points			32	ns
	Asymmetry	WDI has 1 ns rise/fall time			1.0	ns
	Rise/fall Time	10% to 90% points			12	ns

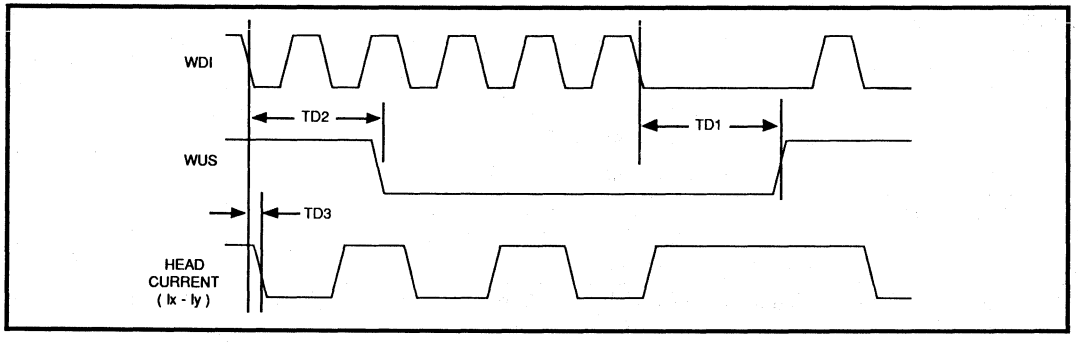


FIGURE 1: Write Mode Timing Diagram

Worst Case Read Input Noise Voltage vs. Input Impedance for SSI 32R4610R/4611R

Case 1: IC Base sheet resistance = Maximum
Hence, IC bias Current = Minimum

	Tj = 25°C	Tj = 110°C	Units
Vn (Max)	TBD	TBD	$nV/\sqrt{Hz}$
Rin (Min)	450	475	Ω
Cin (Max)	28	30	pF

Case 2: IC Base sheet resistance = Minimum
Hence, IC bias Current = Maximum

	Tj = 25°C	Tj = 110°C	Units
Vn (Max)	TBD	TBD	$nV/\sqrt{Hz}$
Rin (Min)	360	400	Ω
Cin (Max)	33	35	pF

Worst Case Read Input Noise Voltage vs. Input Impedance for SSI 32R4610/4611

Case 1: IC Base sheet resistance = Maximum
Hence, IC bias Current = Minimum

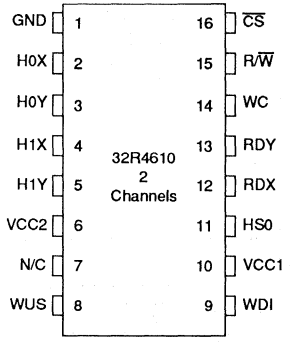
	Tj = 25°C	Tj = 110°C	Units
Vn (Max)	TBD	TBD	$nV/\sqrt{Hz}$
Rin (Min)	1525	1895	Ω
Cin (Max)	28	30	pF

Case 2: IC Base sheet resistance = Minimum
Hence, IC bias Current = Maximum

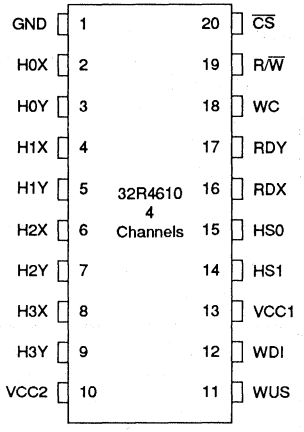
	Tj = 25°C	Tj = 110°C	Units
Vn (Max)	TBD	TBD	$nV/\sqrt{Hz}$
Rin (Min)	835	1100	Ω
Cin (Max)	33	35	pF

SSI 32R4610/4611
5V, 2, 4-Channel Thin-Film Read/Write Device

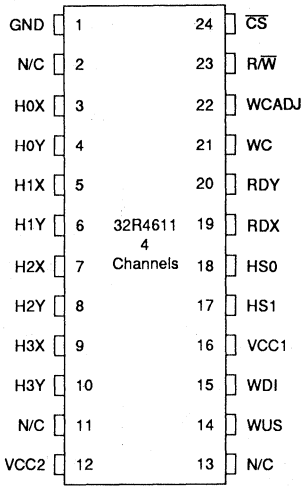
PACKAGE PIN DESIGNATIONS
(TOP VIEW)



16-Pin SOL



20-Pin SOL



24-Pin SOL

ORDERING INFORMATION

PART DESCRIPTION	ORDERING NO.	PACKAGE MARK
SSI 32R4610/4611 Read/Write IC		
2-Channel 16-lead SOL	SSI 32R4610-2CL	32R4610
4-Channel 20-lead SOL	SSI 32R4610-4CL	32R4610
4-Channel 24-lead SOL w/WCADJ	SSI 32R4611-4CL	32R4611-4CL
SSI 32R4610R/4611R Read/Write IC w/ Internal Damping Resistors		
2-Channel 16-lead SOL	SSI 32R4610R-2CL	32R4610R
4-Channel 20-lead SOL	SSI 32R4610R-4CL	32R4610R
4-Channel 24-lead SOL w/WCADJ	SSI 32R4611R-4CL	32R4611R-4CL

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Section 2

HDD PULSE DETECTION

SSI 32P541
Read Data Processor

February, 1990

2

DESCRIPTION

The SSI 32P541 is a bipolar integrated circuit that provides all data processing necessary for detection and qualification of MFM or RLL encoded read signals. The circuit will handle data rates up to 15 Mbit/s.

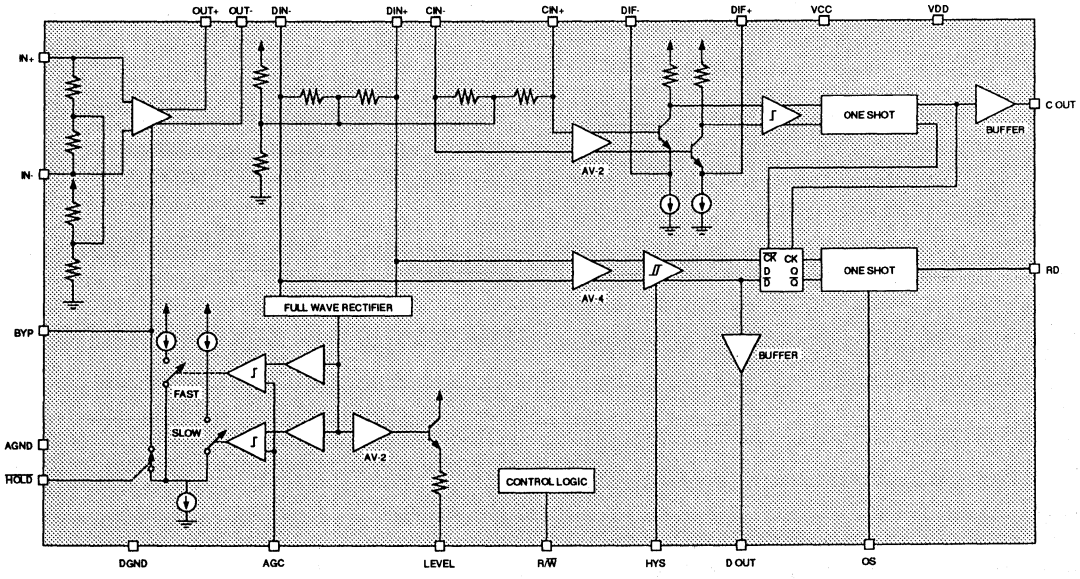
In read mode the SSI 32P541 provides amplification and qualification of head preamplifier outputs. Pulse qualification is accomplished using level qualification of differentiated input zero crossings. An AGC amplifier is used to compensate for variations in head preamp output levels, presenting a constant input level to the pulse qualification circuitry. The AGC loop can be disabled so that a constant gain can be used for embedded servo decoding or other processing needs.

In write mode the circuitry is disabled and the AGC gain stage input impedance is switched to a lower level to allow fast setting of the input coupling capacitors during a write to read transition. The SSI 32P541 requires +5V and +12V power supplies and is available in a 24–pin DIP and 28–pin PLCC.

FEATURES

- **Level qualification supports high resolution MFM and RLL encoded data retrieval**
- **Wide bandwidth AGC input amplifier**
- **Supports data rates up to 15 Mbit/s**
- **Standard 12V ± 10% and 5V ± 10% supplies**
- **Supports embedded servo pattern decoding**
- **Write to read transient suppression**
- **Fast and slow AGC attack regions for fast transient recovery**

BLOCK DIAGRAM



CIRCUIT OPERATION

READ MODE

In the read mode (R/$\overline{W}$ input high or open) the input read signal is amplified and qualified using an AGC amplifier and pulse level qualification of the detected signal peaks.

The amplified head signals are AC coupled to the IN + and IN - pins of the AGC amplifier that is gain controlled by full wave rectifying and amplifying the (DIN+ - DIN–) voltage level and comparing it to a reference level at the AGC pin. A fast attack mode, which supplies a 1.7 mA charging current for the capacitor at the BYP pin, is entered whenever the instantaneous DIN ± level is more than 125% of set level. Between 100% and 125% the slow attack mode is invoked, providing 0.18 mA of charging current. The two attack modes allow rapid AGC recovery from a write to read transition while reducing zero crossing distortion once the amplifier is in range.

The level at the AGC pin should be set such that the differential voltage level at the DIN+, DIN- pins is 1.00 Vpp at the OUT+, OUT- pins which allows for up to 6 dB loss in any external filter connected between the OUT+, OUT- outputs and the DIN+, DIN- inputs.

Gain of the AGC section is nominally

$$\frac{Av2}{Av1} = \exp -\left(\frac{V2 - V1}{5.8 + Vt}\right)$$

Where: Av1 and Av2 are initial and final amplifier gains. V1, V2 are initial and final voltages on the BYP pin.

Vt = (K x T)/q = 26 mV at room temperature.

One filter for both data (DIN+, DIN- input) and clock (CIN+, CIN- input) paths, or a separate filter for each path may be used. If two filters are used, care must be exercised to control time delays so that each path is timed properly. A multi-pole Bessell filter is typically used for its linear phase or constant group delay characteristics.

The filtered data path signal is fed into a hysteresis comparator that is set at a fraction of the input signal level by using an external filter/network between the LEVEL and HYS pins. Using this approach allows setting the AGC slow attack and decay times slow enough to minimize distortion of the clock path signal. This "feed-forward" technique, utilizing a fraction of the rectified data path input available at the LEVEL pin as the hysteresis threshold, is especially useful in the slow decay mode of the AGC loop. By using a short time constant for the hysteresis level, the qualification method can continue as the AGC amplifier gain is slowly ramped up. This level will also shorten the write to read transient recovery time without affecting data timing as the circuit will be properly decoding before the AGC gain has settled to its final value. The comparator output is the "D" input of a D type flip-flop. The DOUT pin provides a buffered test point for monitoring this function.

The filtered clock path signal is differentiated to transform signal peaks to zero-crossings which clock an edge-trigger circuit to provide output pulses at each zero-crossing. The pulses are used to clock the D type flip-flop. The COUT pin is a buffered test point for monitoring this function.

The differentiator function is set by an external network between the DIF+, DIF- pins. The transfer function is:

$$AV = \frac{-2000Cs}{LCs^2 + (R + 92)Cs + 1}$$

Where: C = external capacitor (20 pF to 150 pF)

L = external inductor

R = external resistor

$s = j\omega = j2\pi f$

During normal operation the differentiator circuit clocks the D flip-flop on every positive and negative peak of the signal input to CIN+, CIN-. The D input to the flip–flop only changes state when the signal applied to the DIN+, DIN- inputs exceeds the hysteresis comparator threshold opposite in polarity to the previous peak that exceeded the threshold.

The clocking path, then, determines signal timing and the data path determines validity by blocking signal peaks that do not exceed the hysteresis comparator threshold.

The delays from CIN+, CIN- inputs to the flip-flop clock input and from the DIN+, DIN- inputs to the flip-flop D input are well matched.

WRITE (DISABLED) MODE

In the write or disabled mode (R/$\overline{W}$ input low) the digital circuitry is disabled and the AGC amplifier input impedance is reduced. In addition the AGC amplifier, gain is set to maximum so that the loop is in its fast attack mode when changing back to Read Mode. The lowered input impedance facilitates more rapid settling of the write to read transient by reducing the time constant of the network between the SSI 32P541 and read/write preamplifier, such as the SSI 32R510.

Internal SSI 32P541 timing is such that this settling is accomplished before the AGC loop is activated when going to read mode. Coupling capacitors should be chosen with as low a value as possible, consistent with bandwidth requirements, to allow more rapid settling.

LAYOUT CONSIDERATIONS

The SSI 32P541 is a high gain wide bandwidth device that requires care in layout. The designer should keep analog signal lines as short as possible and well balanced. Use of a ground plane is recommended along with supply bypassing and separation of the SSI 32P541 and associated circuitry grounds from other circuits on the disk drive PCB.

R/$\overline{W}$	$\overline{HOLD}$	MODE
1	1	READ - Read amp on, AGC active, Digital section active
1	0	HOLD - Read amp on, AGC gain held constant Digital section active
0	X	WRITE - AGC gain switched to maximum, Digital section inactive, common mode input resistance reduced

PIN DESCRIPTION

NAME	TYPE	DESCRIPTION
VCC	-	5 volt power supply
VDD	-	12 volt power supply
AGND, DGND	-	Analog and Digital ground pins
R/$\overline{W}$	I	TTL compatible read/write control pin
IN+, IN-	I	Analog signal input pins
OUT+, OUT-	O	AGC Amplifier output pins
BYP	-	The AGC timing capacitor is tied between this pin and AGND
$\overline{HOLD}$	I	TTL compatible pin that holds the AGC gain when pulled low
AGC	I	Reference input voltage level for the AGC circuit
DIN+, DIN-	I	Analog input to the hysteresis comparator
HYS	I	Hysteresis level setting input to the hysteresis comparator
LEVEL	O	Provides rectified signal level for input to the hysteresis comparator
DOUT	O	Buffered test point for monitoring the flip-flop D input
CIN+, CIN-	I	Analog input to the differentiator
DIF+, DIF-	-	Pins for external differentiating network
COUT	O	Buffered test point for monitoring the clock input to the flip-flop
OS	-	Connection for read output pulse width setting capacitor
RD	O	TTL compatible read output

ELECTRICAL CHARACTERISTICS

Unless otherwise specified 4.5 ≤ VCC ≤ 5.5V, 10.8V ≤ VDD ≤ 13.2V, 25 °C ≤ Tj ≤ 135 °C.

ABSOLUTE MAXIMUM RATINGS

Operation above absolute maximum ratings may permanently damage the device.

PARAMETER	RATING	UNIT
5V Supply Voltage, VCC	6	V
12V Supply Voltage, VDD	14	V
Storage Temperature	-65 to 150	°C
Lead Temperature	260	°C
R/$\overline{W}$, IN+, IN-, $\overline{HOLD}$	-0.3 to VCC + 0.3	V
RD	-0.3V to VCC + 0.3V or +12	mA
All others	-0.3 to VDD + 0.3	V

POWER SUPPLY

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
ICC - VCC Supply Current	Outputs unloaded			14	mA
IDD - VDD Supply Current	Outputs unloaded			70	mA
Pd - Power Dissipation	Outputs unloaded, Tj = 135°C			730	mW

LOGIC SIGNALS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VIL - Input Low Voltage		-0.3		0.8	V
VIH - Input High Voltage		2.0			V
IIL - Input Low Current	VIL = 0.4V	0.0		-0.4	mA
IIH - Input High Current	VIH = 2.4V			100	µA
VOL - Output Low Voltage	IOL = 4.0 mA			0.4	V
VOH - Output High Voltage	IOH = -400 µA	2.4			V

MODE CONTROL

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Read to Write Transition Time				1.0	µs
Write to Read Transition Time	AGC settling not included, transition to high input resistance	1.2		3.0	µs
Read to Hold Transition Time				1.0	µs

WRITE MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Common Mode Input Impedance (both sides)	R/$\overline{W}$ pin = low		250		Ω

READ MODE

Unless otherwise specified IN+ and IN- are AC coupled, OUT+, and OUT- are loaded differentially with > 600Ω and each side is loaded with < 10 pF to GND, a 2000 pF capacitor is connected between BYP and GND, OUT+ is AC coupled to DIN+, OUT- is AC coupled to DIN-, AGC pin voltage is 2.2 VDC.

AGC AMPLIFIER

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Differential Input Resistance	V(IN+ – IN-) = 100 mVpp @ 2.5 MHz		5K		Ω
Differential Input Capacitance	V(IN+ – IN-) = 100 mVpp @ 2.5 MHz			10	pF
Common Mode Input Impedance	R/$\overline{W}$ pin high		1.8		kΩ
(both sides)	R/$\overline{W}$ pin low		0.25		kΩ
Minimum Gain Range	1.0 Vpp ≤ V(OUT+ – OUT-) ≤ 2.5 Vpp	4.0		83	V/V
Input Noise Voltage	Gain set to maximum			30	nV/$\sqrt{Hz}$
Bandwidth	Gain set to maximum -3 dB point	30			MHz
Maximum Output Voltage Swing	Set by AGC pin voltage	3.0			Vpp
Maximum AGC Amplifier Output Offset	Vout offset (max. gain) - Vout offset (min. gain) V_{BYP} = 2.5V to 4.5V			600	mV
OUT+ to OUT- Pin Current	No DC path to GND	±3.2			mA
Output Resistance		12		32	Ω
Output Capacitance				15	pF
(DIN+ – DIN-) Input Voltage Swing VS AGC Input Level	30 mVpp V(IN+ – IN-) ≤ 550 mVpp 0.5 Vpp ≤ V(DIN+ – DIN-) ≤ 1.5 Vpp	0.37		0.56	Vpp/V
(DIN+ – DIN-) Input Voltage Swing Variation	30 mVpp V(IN+ – IN-) ≤ 550 mVpp AGC Fixed, over supply & temperature			8	%
Gain Decay Time (Td)	Vin = 300 mVpp–> 150 mVpp @ 2.5 MHz, Vout to 90% of final value Figure 1a		50		µs
Gain Attack time (Ta)	From Write to Read transition to Vout at 110% of final value Vin = 400 mVpp @ 2.5 MHz. Figure 1b		4		µs

AGC AMPLIFIER (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Fast AGC Capacitor Charge Current	V(DIN+ - DIN-) = 1.6V V(AGC) = 2.2V	1.3		2.0	mA
Slow AGC Capacitor Charge Current	V(DIN+ – DIN-) = 1.6V Vary V(AGC) until slow discharge	0.14		0.22	mA
Fast to Slow Attack Switchover Point	$\frac{V(DIN+-DIN-)}{V(DIN+-DIN-)\ Final}$		1.25		
AGC Capacitor Discharge Current	V(DIN+ – DIN-) = 0.0V Read Mode		4.5		µA
	Hold Mode V_{BYP} = 5.0V	-0.2		+0.2	µA
	6.1V<V_{BYP}<8.1V	-0.45		+30	µA
CMRR (Input Referred)	V(IN+) = V(IN-) = 100 mVpp @ 5 MHz,gain at max.	40			dB
PSRR (Input Referred)	ΔVCC or ΔVDD = 100 mVpp @ 5 MHz, gain at max.	30			dB

HYSTERESIS COMPARATOR

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Input Signal Range				1.5	Vpp
Differential Input Resistance	V(DIN+ – DIN-) = 100 mVpp @ 2.5 MHz	5		11	kΩ
Differential Input Capacitance	V(DIN+ – DIN-) = 100 mVpp @ 2.5 MHz			6.0	pF
Common Mode Input Impedance	(both sides)		2.0		kΩ
Comparator Offset Voltage	HYS pin at GND, ≤ 1.5 kΩ across DIN+, DIN-			10	mV
Peak Hysteresis Voltage vs. HYS pin voltage (input referred)	At DIN+, DIN- pins 1V < V (HYS) < 3V	0.16		0.25	V/V
HYS Pin Input Current	1V < V (HYS) < 3V	0.0		-20	µA
Level Pin Output Voltage vs V(DIN+ – DIN-)	0.6 < | V (DIN+ – DIN-) | <1.3 Vpp, 10 kΩ from LEVEL pin to GND	1.5		2.5	V/Vpp
LEVEL Pin Max Output Current		3.0			mA
LEVEL Pin Output Resistance	I(LEVEL) = 0.5 mA		180		Ω
DOUT Pin Output Low Voltage	0.0 ≤ IOL ≤ 0.5 mA	VDD -4.0		VDD -2.8	V
DOUT Pin Output High Voltage	0.0 ≤ IOH ≤ 0.5 mA	VDD -2.5		VDD -1.8	V

ACTIVE DIFFERENTIATOR

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Input Signal Range				1.5	Vpp
Differential Input Resistance	V(CIN+ – CIN-) = 100 mVpp @ 2.5 MHz	5.8		11.0	kΩ
Differential Input Capacitance	V(CIN+ – CIN-) = 100 mVpp @ 2.5 MHz			6.0	pF
Common mode Input Impedance	(both sides)		2.0		kΩ
Voltage Gain From CIN± to DIF±	R(DIF+ to DIF-) = 2 kΩ	1.7		2.2	V/V
DIF+ to DIF- Pin Current	Differentiator Impedance must be set so as not to clip signal at this current level	±1.3			mA
Comparator Offset Voltage	DIF+, DIF- are AC Coupled			10.0	mV
COUT Pin Output Low Voltage	0.0 ≤ IOH ≤ 0.5 mA		VDD -3.0		V
COUT Pin Output Pulse voltage V(high) - V(low)	0.0 ≤ IOH ≤ 0.5 mA		+0.4		V
COUT Pin Output Pulse Width	0.0 ≤ IOH ≤ 0.5 mA		30		ns

OUTPUT DATA CHARACTERISTICS (See Figure 2)
Unless otherwise specified V(CIN+ – CIN-) = V(DIN+ – DIN-) = 1.0 Vpp AC coupled since wave at 2.5 MHz differentiating network between DIF+ and DIF- is 100Ω in series with 65 pF, V (Hys) = 1.8 DC, a 60 pF capacitor is connected between OS and VCC, RD- is loaded with a 4 kΩ resistor to VCC and a 10 pF capacitor to GND.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
D-Flip-Flop Set Up Time (Td1)	Min delay from V(DIN+ DIN-) exceeding threshold to V(DIF+ – DIF-) reaching a peak	0			ns
Propagation Delay (Td3)				110	ns
Output Data Pulse Width Variation	Td5 = 670 Cos, 50 pF ≤ Cos ≤ 200 pF			±15	%
Pulse Pairing	Td3 - Td4			3	ns
Output Rise Time	VOH = 2.4V			14	ns
Output Fall Time	VOL = 0.4V			18	ns

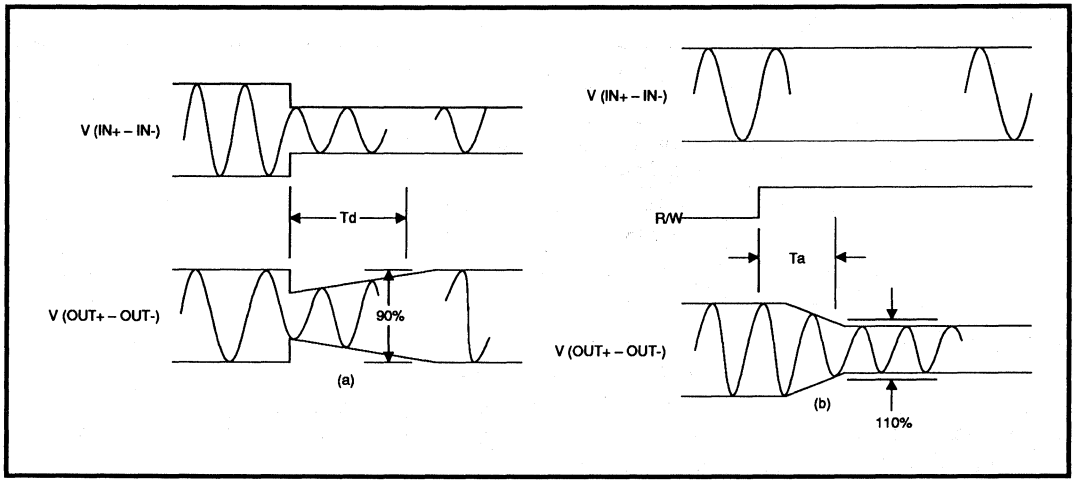


FIGURE 1(a), (b): AGC Timing Diagrams

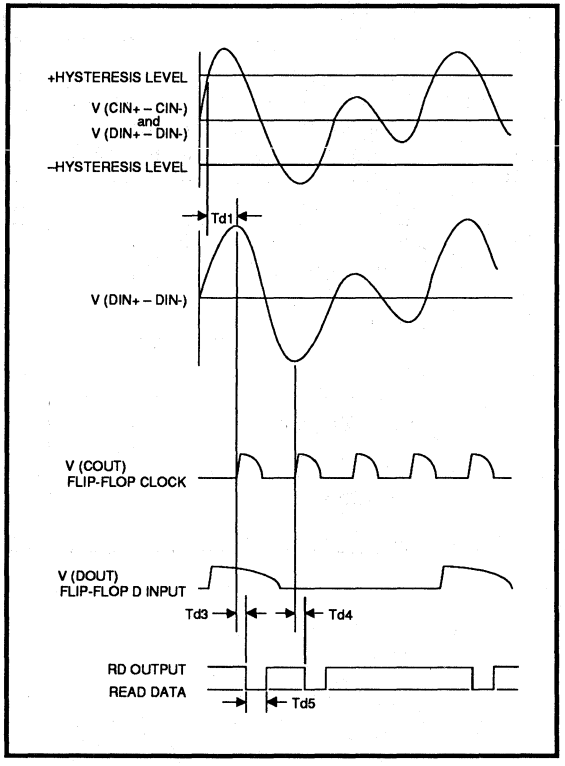
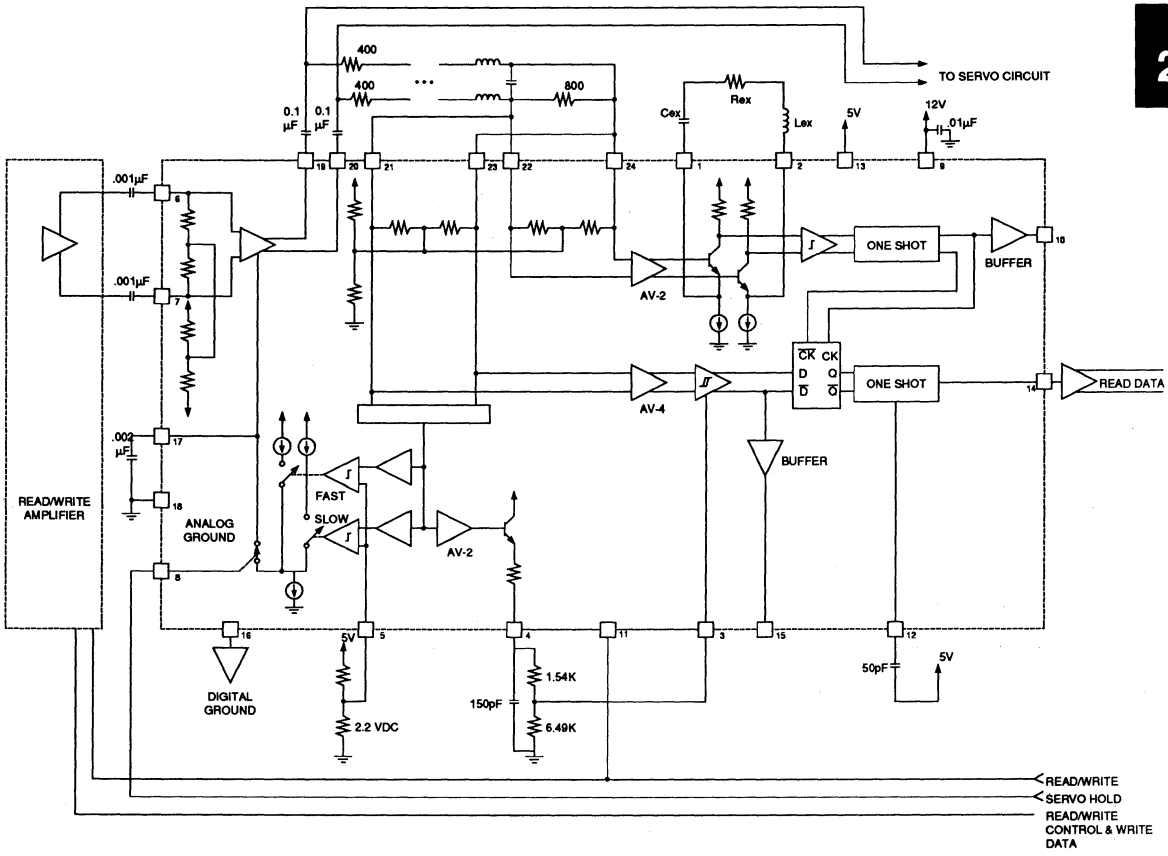


FIGURE 2: Timing Diagram



NOTES: Circuit traces for the 12V bypass capacitor and the AGC Hold Capacitor should be as short as possible with both capacitors returned to the Analog Ground Pin.

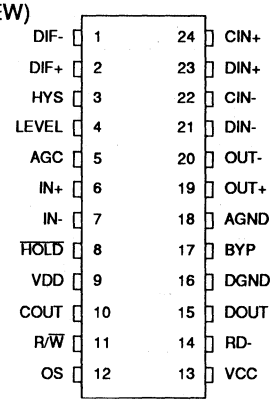
Component values, where given, are for a 5 Mbit/s system.

FIGURE 3: Typical Read/Write Electronics Set Up

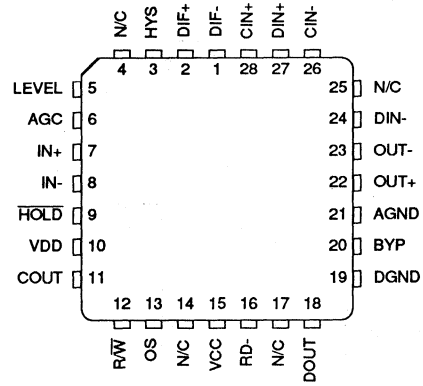
SSI 32P541
Read Data Processor

PACKAGE PIN DESIGNATIONS

(TOP VIEW)



24-Lead PDIP, SOL



28-Lead PLCC

THERMAL CHARACTERISTICS: Ø ja

24-Lead PDIP	115°C/W
24-Lead SOL	80°C/W
28-Lead PLCC	65°C/W

CAUTION: Use handling procedures necessary for a static sensitive component.

ORDERING INFORMATION

PART DESCRIPTION	ORDERING NUMBER	PACKAGE MARK
SSI 32P541 Read Data Processor		
24-Lead PDIP	SSI 32P541-P	SSI 32P541-P
28-Lead PLCC	SSI 32P541-CH	SSI 32P541-CH
24-Lead SOL	SSI 32P541-CL	SSI 32P541-CL

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX: (714) 731-5457

SSI 32P541A
Read Data Processor

Preliminary Data

July, 1990

2

DESCRIPTION

The SSI 32P541A is a bipolar integrated circuit that provides all data processing necessary for detection and qualification of MFM or RLL encoded read signals.

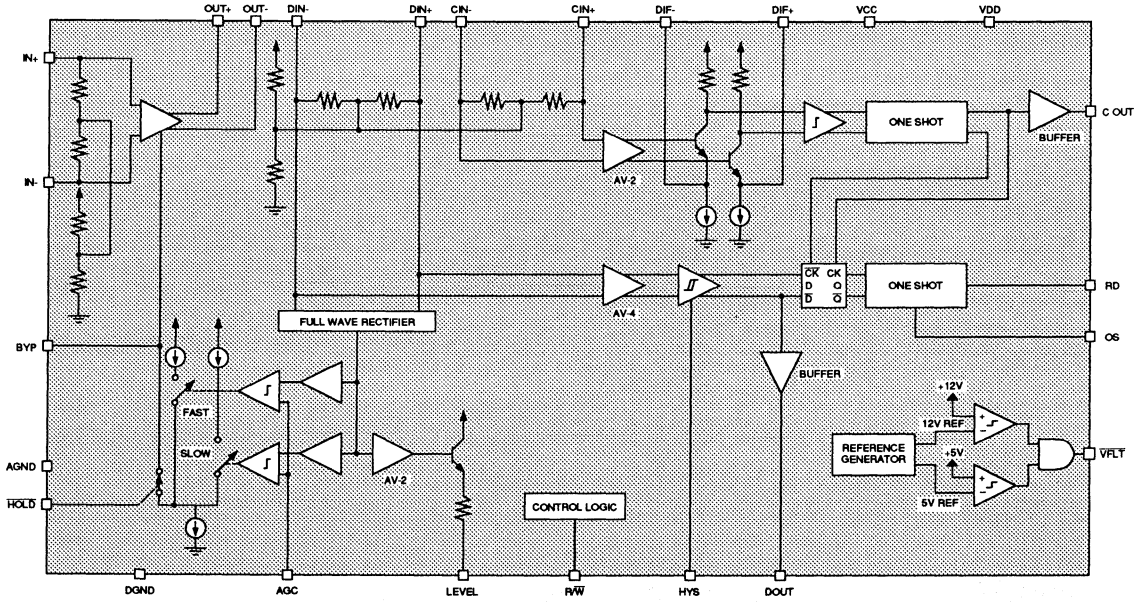
In read mode the SSI 32P541A provides amplification and qualification of head preamplifier outputs. Pulse qualification is accomplished using level qualification of differentiated input zero crossings. An AGC amplifier is used to compensate for variations in head preamp output levels, presenting a constant input level to the pulse qualification circuitry. The AGC loop can be disabled so that a constant gain can be used for embedded servo decoding or other processing needs.

In write mode the circuitry is disabled and the AGC gain stage input impedance is switched to a lower level to allow fast setting of the input coupling capacitors during a write to read transition. The SSI 32P541A requires +5V and +12V power supplies and is available in a 28-pin PLCC, 24-pin DIP and 24-pin SOL.

FEATURES

- **Level qualification supports high resolution MFM and RLL encoded data retrieval**
- **Wide bandwidth AGC input amplifier**
- **Standard 12V ± 10% and 5V ± 10% supplies**
- **Supports embedded servo pattern decoding**
- **Write to read transient suppression**
- **Fast and slow AGC attack regions for fast transient recovery**
- **Internal voltage fault indicator**
- **≤ ±1.5 ns pulse pairing**

BLOCK DIAGRAM



CIRCUIT OPERATION

READ MODE

In the read mode (R/$\overline{W}$ input high or open) the input read signal is amplified and qualified using an AGC amplifier and pulse level qualification of the detected signal peaks.

The amplified head signals are AC coupled to the IN + and IN - pins of the AGC amplifier that is gain controlled by full wave rectifying and amplifying the (DIN+ - DIN–) voltage level and comparing it to a reference level at the AGC pin. A fast attack mode, which supplies a 1.7 mA charging current for the capacitor at the BYP pin, is entered whenever the instantaneous DIN ± level is more than 125% of set level. Between 100% and 125% the slow attack mode is invoked, providing 0.18 mA of charging current. The two attack modes allow rapid AGC recovery from a write to read transition while reducing zero crossing distortion once the amplifier is in range.

The level at the AGC pin should be set such that the differential voltage level at the DIN+, DIN- pins is 1.00 Vpp at the OUT+, OUT- pins which allows for up to 6 dB loss in any external filter connected between the OUT+, OUT- outputs and the DIN+, DIN- inputs.

Gain of the AGC section is nominally

$$\frac{Av2}{Av1} = \exp -\left(\frac{V2 - V1}{5.8 + Vt}\right)$$

Where: Av1 and Av2 are initial and final amplifier gains. V1, V2 are initial and final voltages on the BYP pin.

Vt = (K x T)/q = 26 mV at room temperature.

One filter for both data (DIN+, DIN- input) and clock (CIN+, CIN- input) paths, or a separate filter for each path may be used. If two filters are used, care must be exercised to control time delays so that each path is timed properly. A multi-pole Bessell filter is typically used for its linear phase or constant group delay characteristics.

The filtered data path signal is fed into a hysteresis comparator that is set at a fraction of the input signal level by using an external filter/network between the LEVEL and HYS pins. Using this approach allows setting the AGC slow attack and decay times slow enough to minimize distortion of the clock path signal. This "feed-forward" technique, utilizing a fraction of the rectified data path input available at the LEVEL pin as the hysteresis threshold, is especially useful in the slow decay mode of the AGC loop. By using a short time constant for the hysteresis level, the qualification method can continue as the AGC amplifier gain is slowly ramped up. This level will also shorten the write to read transient recovery time without affecting data timing as the circuit will be properly decoding before the AGC gain has settled to its final value. The comparator output is the "D" input of a D type flip-flop. The DOUT pin provides a buffered test point for monitoring this function.

The filtered clock path signal is differentiated to transform signal peaks to zero-crossings which clock an edge-trigger circuit to provide output pulses at each zero-crossing. The pulses are used to clock the D type flip-flop. The COUT pin is a buffered test point for monitoring this function.

The differentiator function is set by an external network between the DIF+, DIF- pins. The transfer function is:

$$AV = \frac{-2000Cs}{LCs^2 + (R + 92)Cs + 1}$$

Where: C = external capacitor (20 pF to 150 pF)

L = external inductor

R = external resistor

$s = j\omega = j2\pi f$

During normal operation the differentiator circuit clocks the D flip-flop on every positive and negative peak of the signal input to CIN+, CIN-. The D input to the flip–flop only changes state when the signal applied to the DIN+, DIN- inputs exceeds the hysteresis comparator threshold opposite in polarity to the previous peak that exceeded the threshold.

The clocking path, then, determines signal timing and the data path determines validity by blocking signal peaks that do not exceed the hysteresis comparator threshold.

The delays from CIN+, CIN- inputs to the flip-flop clock input and from the DIN+, DIN- inputs to the flip-flop D input are well matched.

WRITE (DISABLED) MODE

In the write or disabled mode (R/$\overline{W}$ input low) the digital circuitry is disabled and the AGC amplifier input impedance is reduced. In addition the AGC amplifier, gain is set to maximum so that the loop is in its fast attack mode when changing back to Read Mode. The lowered input impedance facilitates more rapid settling of the write to read transient by reducing the time constant of the network between the SSI 32P541A and read/write preamplifier, such as the SSI 32R510.

Internal SSI 32P541A timing is such that this settling is accomplished before the AGC loop is activated when going to read mode. Coupling capacitors should be chosen with as low a value as possible, consistent with bandwidth requirements, to allow more rapid settling.

LAYOUT CONSIDERATIONS

The SSI 32P541A is a high gain wide bandwidth device that requires care in layout. The designer should keep analog signal lines as short as possible and well balanced. Use of a ground plane is recommended along with supply bypassing and separation of the SSI 32P541A and associated circuitry grounds from other circuits on the disk drive PCB.

LOW VOLTAGE FAULT DETECTION

A low voltage detection circuit monitors both supplies and pulls an open collector TTL output low when either supply drops below their trip point. This option is available only in the 28-pin PLCC package.

R/$\overline{W}$	$\overline{HOLD}$	MODE
1	1	READ - Read amp on, AGC active, Digital section active
1	0	HOLD - Read amp on, AGC gain held constant Digital section active
0	X	WRITE - AGC gain switched to maximum, Digital section inactive, common mode input resistance reduced

PIN DESCRIPTION

NAME	TYPE	DESCRIPTION
VCC		5 volt power supply
VDD		12 volt power supply
AGND, DGND		Analog and Digital ground pins
R/$\overline{W}$	I	TTL compatible read/write control pin
IN+, IN-	I	Analog signal input pins
OUT+, OUT-	O	AGC Amplifier output pins
BYP		The AGC timing capacitor is tied between this pin and AGND
$\overline{HOLD}$	I	TTL compatible pin that holds the AGC gain when pulled low
AGC	I	Reference input voltage level for the AGC circuit
DIN+, DIN-	I	Analog input to the hysteresis comparator
HYS	I	Hysteresis level setting input to the hysteresis comparator
LEVEL	O	Provides rectified signal level for input to the hysteresis comparator
DOUT	O	Buffered test point for monitoring the flip-flop D input

PIN DESCRIPTION (Continued)

NAME	TYPE	DESCRIPTION
CIN+, CIN-	I	Analog input to the differentiator
DIF+, DIF-		Pins for external differentiating network
COUT	O	Buffered test point for monitoring the clock input to the flip-flop
OS		Connection for read output pulse width setting capacitor
RD	O	TTL compatible read output
$\overline{VFLT}$*	O	Open collector output that goes low when a low power supply fault is detected.

*$\overline{VFLT}$ output offered in 28-pin PLCC package only.

ELECTRICAL CHARACTERISTICS

Unless otherwise specified 4.5 ≤ VCC ≤ 5.5V, 10.8V ≤ VDD ≤ 13.2V, 25°C ≤ Tj ≤ 135°C.

ABSOLUTE MAXIMUM RATINGS

Operation above absolute maximum ratings may permanently damage the device.

PARAMETER	RATING	UNIT
5V Supply Voltage, VCC	6	V
12V Supply Voltage, VDD	14	V
Storage Temperature	-65 to 150	°C
Lead Temperature	260	°C
R/$\overline{W}$, IN+, IN-, $\overline{HOLD}$, $\overline{VFLT}$	-0.3 to VCC + 0.3	V
RD	-0.3V to VCC + 0.3V or +12	mA
All others	-0.3 to VDD + 0.3	V

POWER SUPPLY

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
ICC - VCC Supply Current	Outputs unloaded			14	mA
IDD - VDD Supply Current	Outputs unloaded			70	mA
Pd - Power Dissipation	Outputs unloaded, Tj = 135°C			730	mW

LOGIC SIGNALS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VIL - Input Low Voltage		-0.3		0.8	V
VIH - Input High Voltage		2.0			V
IIL - Input Low Current	VIL = 0.4V	0.0		-0.4	mA
IIH - Input High Current	VIH = 2.4V			100	µA
VOL - Output Low Voltage	IOL = 4.0 mA			0.4	V
VOH - Output High Voltage	IOH = -400 µA	2.4			V

MODE CONTROL

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Read to Write Transition Time				1.0	µs
Write to Read Transition Time	AGC settling not included, transition to high input resistance	1.2		3.0	µs
Read to Hold Transition Time				1.0	µs

WRITE MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Common Mode Input Impedance (both sides)	R/$\overline{W}$ pin = low		250		Ω

READ MODE

Unless otherwise specified IN+ and IN- are AC coupled, OUT+, and OUT- are loaded differentially with > 600Ω and each side is loaded with < 10 pF to GND, a 2000 pF capacitor is connected between BYP and GND, OUT+ is AC coupled to DIN+, OUT- is AC coupled to DIN-, AGC pin voltage is 2.2 VDC.

AGC AMPLIFIER

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Differential Input Resistance	V(IN+ – IN-) = 100 mVpp @ 2.5 MHz		5K		Ω
Differential Input Capacitance	V(IN+ – IN-) = 100 mVpp @ 2.5 MHz			10	pF
Common Mode Input Impedance	R/$\overline{W}$ pin high		1.8		KΩ
(both sides)	R/$\overline{W}$ pin low		0.25		KΩ
Minimum Gain Range	1.0 Vpp ≤ V(OUT+ – OUT-) ≤ 2.5 Vpp	4.0		83	V/V
Input Noise Voltage	Gain set to maximum			30	nV/$\sqrt{Hz}$

AGC AMPLIFIER (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Bandwidth	Gain set to maximum -3 dB point	30			MHz
Maximum Output Voltage Swing	Set by AGC pin voltage	3.0			Vpp
OUT+ to OUT- Pin Current	No DC path to GND	±3.2			mA
Output Resistance		12		32	Ω
Output Capacitance				15	pF
Maximum AGC Amplifier Output Offset	Vout offset (max. gain) -Vout offset (min. gain) V_{BYP} = 2.5 to 4.5V			300	mV
(DIN+ – DIN-) Input Voltage Swing VS AGC Input Level	30 mVpp V(IN+ – IN-) ≤ 550 mVpp 0.5 Vpp ≤ V(DIN+ – DIN-) ≤ 1.5 Vpp	0.37		0.56	Vpp/V
(DIN+ – DIN-) Input Voltage Swing Variation	30 mVpp V(IN+ – IN-) ≤ 550 mVpp AGC Fixed, over supply & temperature			8	%
Gain Decay Time (Td)	Vin = 300 mVpp–> 150 mVpp at 2.5 MHz, Vout to 90% of final value Figure 1a		50		µs
Gain Attack time (Ta)	From Write to Read transition to Vout at 110% of final value Vin = 400 mVpp @ 2.5 MHz. Figure 1b		4		µs
Fast AGC Capacitor Charge Current	V(DIN+ - DIN-) = 1.6V V(AGC) = 2.2V	1.3		2.0	mA
Slow AGC Capacitor Charge Current	V(DIN+ – DIN-) = 1.6V Vary V(AGC) until slow discharge	0.14		0.22	mA
Fast to Slow Attack Switchover Point	$\frac{V(DIN+-DIN-)}{V(DIN+-DIN-)\ Final}$		1.25		
AGC Capacitor Discharge Current	V(DIN+ – DIN-) = 0.0V Read Mode		4.5		µA
	Hold Mode	-0.2		+0.2	µA
CMRR (Input Referred)	V(IN+) = V(IN-) = 100 mVpp @ 5 MHz,gain at max.	40			dB
PSRR (Input Referred)	ΔVCC or ΔVDD = 100 mVpp @ 5 MHz, gain at max.	30			dB

HYSTERESIS COMPARATOR

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Input Signal Range				1.5	Vpp
Differential Input Resistance	V(DIN+ – DIN-) = 100 mVpp @ 2.5 MHz	5		11	KΩ
Differential Input Capacitance	V(DIN+ – DIN-) = 100 mVpp @ 2.5 MHz			6.0	pF
Common Mode Input Impedance	(both sides)		2.0		KΩ
Comparator Offset Voltage	HYS pin at GND, ≤ 1.5 KΩ across DIN+, DIN-			10	mV
Peak Hysteresis Voltage vs HYS pin voltage (input referred)	At DIN+, DIN- pins 1V < V (HYS) < 3V	0.16		0.25	V/V
HYS Pin Input Current	1V < V (HYS) < 3V	0.0		-20	µA
Level Pin Output Voltage vs V(DIN+ – DIN-)	0.6 < | V (DIN+ – DIN-) | <1.3 Vpp, 10 KΩ from LEVEL pin to GND	1.5		2.5	V/Vpp
Hysteresis threshold margin as a % of V(DIN+ – DIN-) peak	V(HYS) = At a typical of 60% *V(AGC) or V(LEVEL) 1V < V(HYS) < 3V *see figures 5 & 6	-15		+15	%Peak
LEVEL Pin Max Output Current		3.0			mA
LEVEL Pin Output Resistance	I(LEVEL) = 0.5 mA		180		Ω
DOUT Pin Output Low Voltage	0.0 ≤ IOL ≤ 0.5 mA	VDD -4.0		VDD -2.8	V
DOUT Pin Output High Voltage	0.0 ≤ IOH ≤ 0.5 mA	VDD -2.5		VDD -1.8	V

* In an open loop configuration where reference is V(AGC) tolerance can be slightly higher.

ACTIVE DIFFERENTIATOR

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Input Signal Range				1.5	Vpp
Differential Input Resistance	V(CIN+ – CIN-) = 100 mVpp @ 2.5 MHz	5.8		11.0	KΩ
Differential Input Capacitance	V(CIN+ – CIN-) = 100 mVpp @ 2.5 MHz			6.0	pF
Common mode Input Impedance	(both sides)		2.0		KΩ
Voltage Gain From CIN± to DIF±	R(DIF+ to DIF-) = 2 KΩ	1.7		2.2	V/V
DIF+ to DIF- Pin Current	Differentiator Impedance must be set so as not to clip signal at this current level	±1.3			mA

ACTIVE DIFFERENTIATOR (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Comparator Offset Voltage	DIF+, DIF- are AC Coupled			10.0	mV
COUT Pin Output Low Voltage	0.0 ≤ IOH ≤ 0.5 mA		VDD -3.0		V
COUT Pin Output Pulse voltage V(high) - V(low)	0.0 ≤ IOH ≤ 0.5 mA		+0.4		V
COUT Pin Output Pulse Width	0.0 ≤ IOH ≤ 0.5 mA		30		ns

OUTPUT DATA CHARACTERISTICS (See Figure 2)
Unless otherwise specified V(CIN+ – CIN-) = V(DIN+ – DIN-) = 1.0 Vpp AC coupled sine wave at 2.5 MHz differentiating network between DIF+ and DIF- is 100Ω in series with 65 pF, V (Hys) = 1.8 DC, a 60 pF capacitor is connected between OS and VCC, RD- is loaded with a 4 KΩ resistor to VCC and a 10 pF capacitor to GND.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
D-Flip-Flop Set Up Time (Td1)	Min delay from V(DIN+ DIN-) exceeding threshold to V(DIF+ – DIF-) reaching a peak	0			ns
Propagation Delay (Td3)				110	ns
Output Data Pulse Width Variation	Td5 = 670 Cos, 50 pF ≤ Cos ≤ 200 pF			±15	%
Pulse Pairing	(Td3 - Td4)			±1.5	ns
Output Rise Time	VOH = 2.4V			14	ns
Output Fall Time	VOL = 0.4V			18	ns

SUPPLY VOLTAGE FAULT DETECTION

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VDD Fault Threshold		9.1		10.3	V
VCC Fault Threshold		4.1		4.4	V
VOL Output Low Voltage	4.5 < VCC < 5.5V, IOL = 1.6 mA			0.4	V
	1.0 < VCC < 4.5V, IOL = 0.5 mA			0.4	V
IOH Output High Current				25	µA

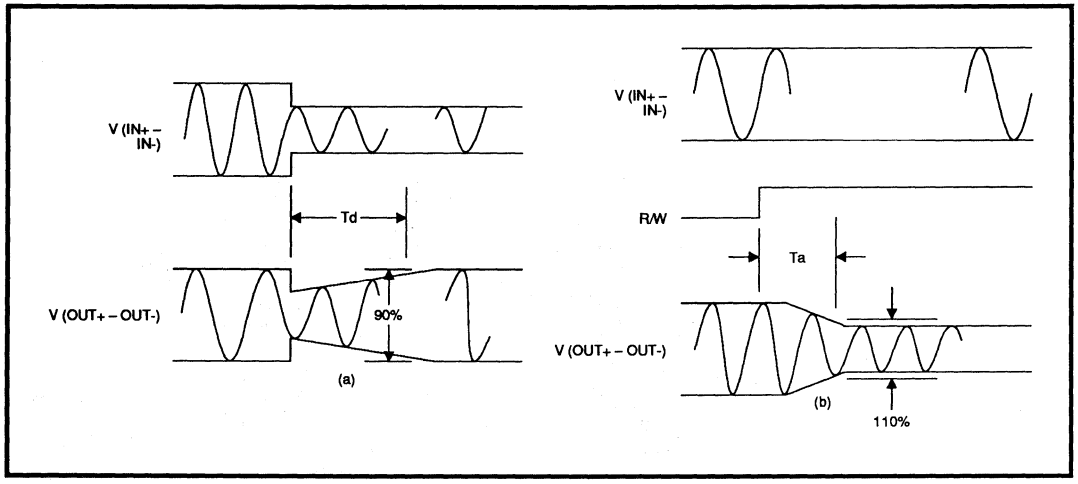


FIGURE 1(a), (b): AGC Timing Diagrams

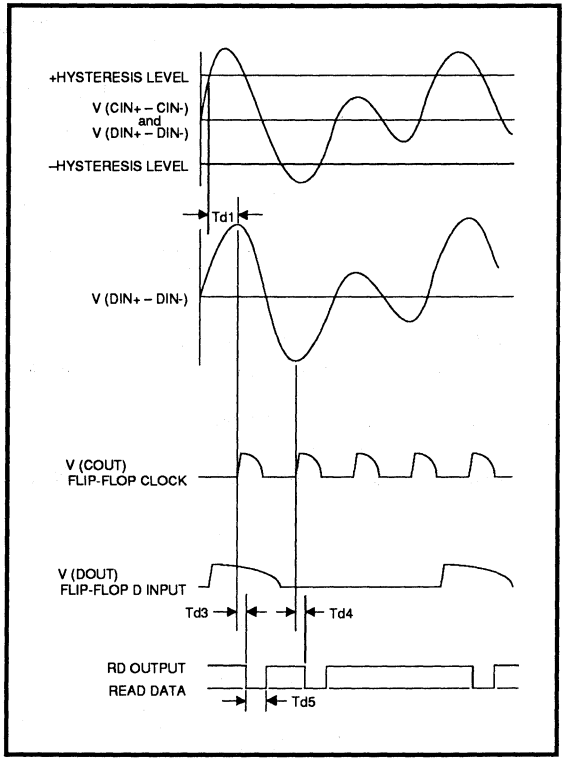
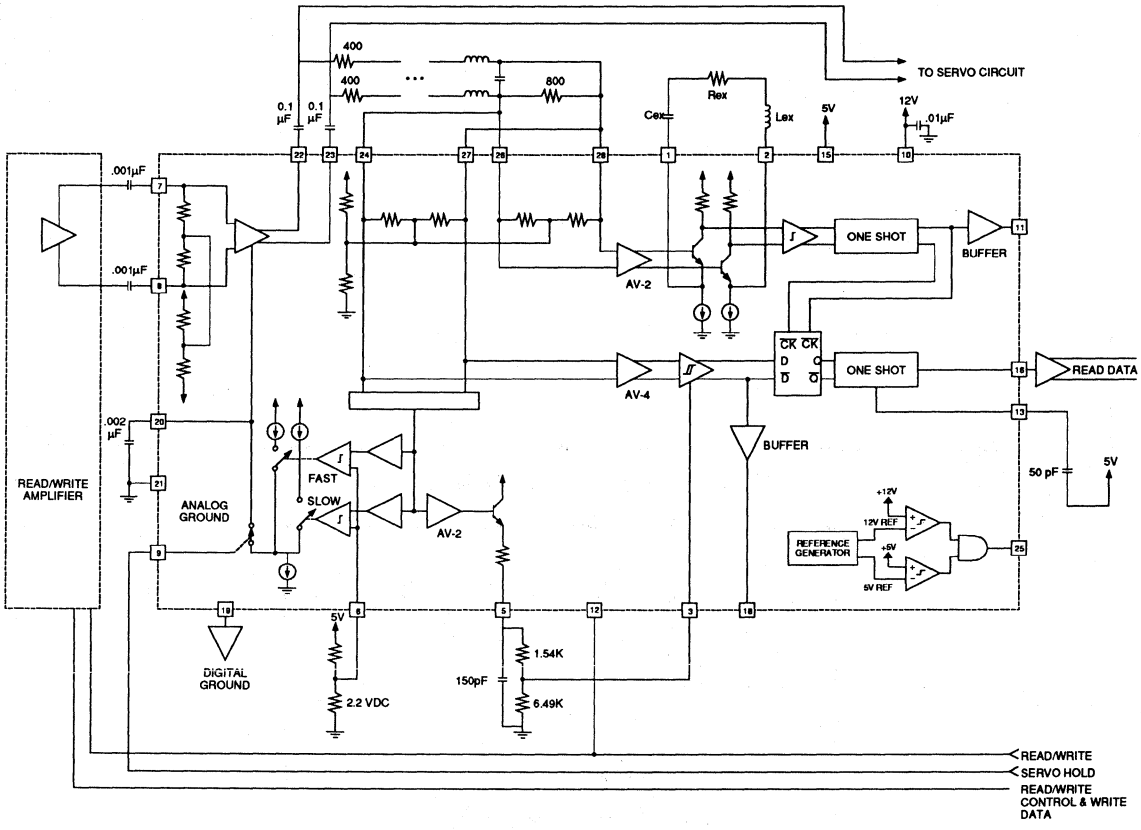


FIGURE 2: Timing Diagram



NOTE: Circuit traces for the 12V bypass capacitor and the AGC Hold capacitor should be as short as possible with both capacitors returned to the Analog Ground Pin. Component values, where given, are for a 5Mbit/s system.
Above pin numbers are for the 28-pin PLCC package.

FIGURE 3: Typical Read/Write Electronics Set Up

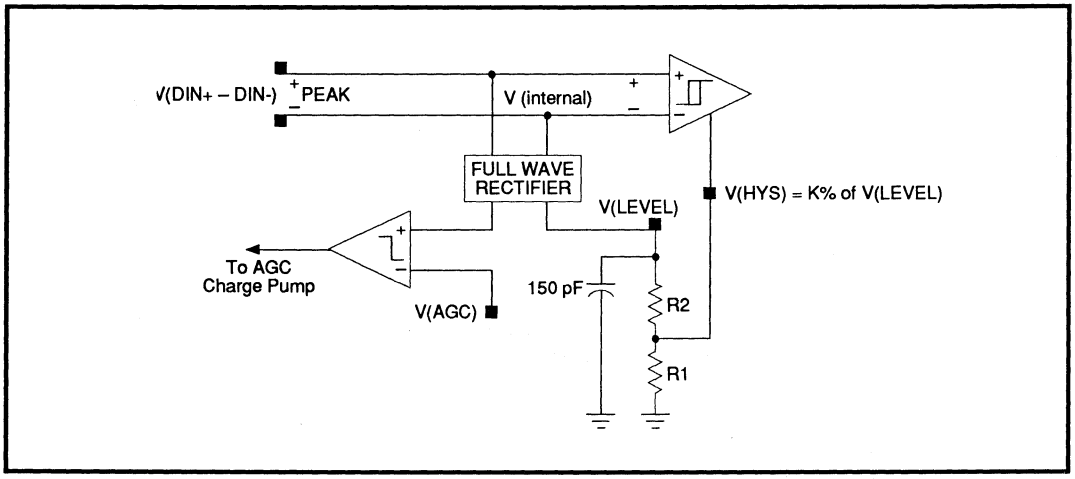


FIGURE 4: Feed Forward Mode

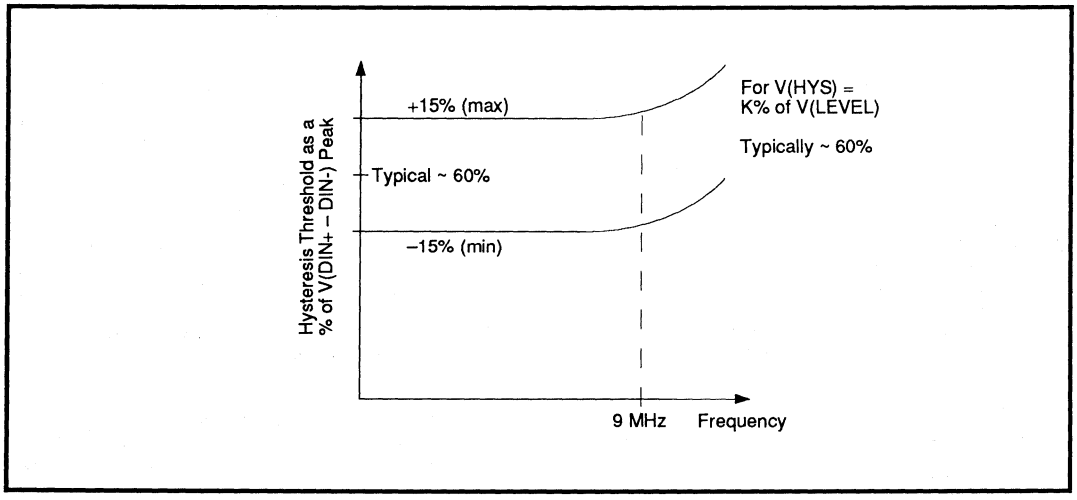
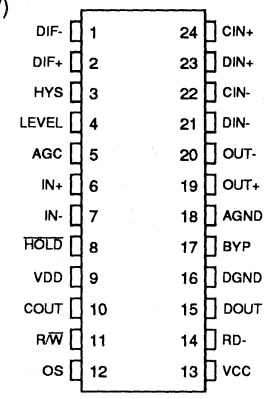


FIGURE 5: Percentage Threshold vs. Frequency

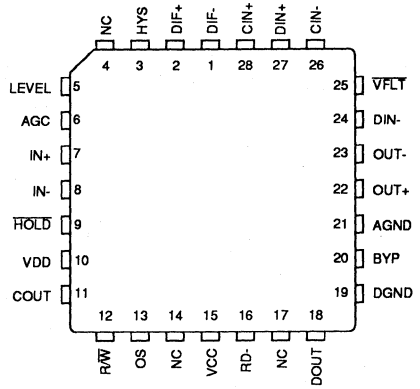
SSI 32P541A
Read Data Processor

PACKAGE PIN DESIGNATIONS

(TOP VIEW)



24-Lead PDIP, SOL



28-Lead PLCC

CAUTION: Use handling procedures necessary for a static sensitive component.

THERMAL CHARACTERISTICS: Ø ja

24-Lead PDIP	115°C/W
24-Lead SOL	80°C/W
28-Lead PLCC	65°C/W

ORDERING INFORMATION

PART DESCRIPTION	ORDERING NO.	PKG. MARK
SSI 32P541A Read Data Processor		
24-Lead PDIP	SSI 32P541A-P	SSI 32P541A-P
28-Lead PLCC	SSI 32P541A-CH	SSI 32P541A-CH
24-Lead SOL	SSI 32P541A-CL	SSI 32P541A-CL

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32P541B
Read Data Processor

Preliminary Data

June, 1990

2

DESCRIPTION

The SSI 32P541B is a bipolar integrated circuit that provides all data processing necessary for detection and qualification of MFM or RLL encoded read signals.

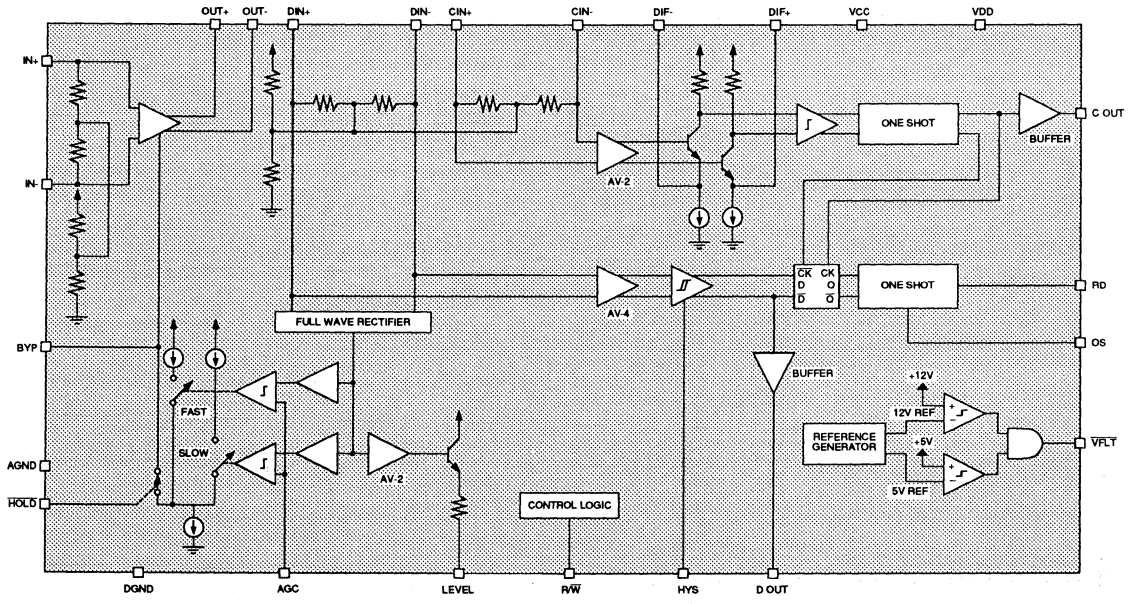
In read mode the SSI 32P541B provides amplification and qualification of head preamplifier outputs. Pulse qualification is accomplished using level qualification of differentiated input zero crossings. An AGC amplifier is used to compensate for variations in head preamp output levels, presenting a constant input level to the pulse qualification circuitry. The AGC loop can be disabled so that a constant gain can be used for embedded servo decoding or other processing needs.

In write mode the circuitry is disabled and the AGC gain stage input impedance is switched to a lower level to allow fast setting of the input coupling capacitors during a write to read transition. The SSI 32P541B requires +5V and +12V power supplies and is available in a 28-pin PLCC, 24-pin DIP and 24-pin SOL.

FEATURES

- **Level qualification supports high resolution MFM and RLL encoded data retrieval**
- **Wide bandwidth AGC input amplifier**
- **Standard 12V ± 10% and 5V ± 10% supplies**
- **Supports embedded servo pattern decoding**
- **Write to read transient suppression**
- **Fast and slow AGC attack regions for fast transient recovery**
- **Internal voltage fault indicator**
- **≤ ±1.0 ns pulse pairing**
- **24 Mb/s operation**

BLOCK DIAGRAM



CIRCUIT OPERATION

READ MODE

In the read mode (R/$\overline{W}$ input high or open) the input read signal is amplified and qualified using an AGC amplifier and pulse level qualification of the detected signal peaks.

The amplified head signals are AC coupled to the IN + and IN - pins of the AGC amplifier that is gain controlled by full wave rectifying and amplifying the (DIN+ - DIN–) voltage level and comparing it to a reference level at the AGC pin. A fast attack mode, which supplies a 1.7 mA charging current for the capacitor at the BYP pin, is entered whenever the instantaneous DIN ± level is more than 125% of set level. Between 100% and 125% the slow attack mode is invoked, providing 0.18 mA of charging current. The two attack modes allow rapid AGC recovery from a write to read transition while reducing zero crossing distortion once the amplifier is in range.

The level at the AGC pin should be set such that the differential voltage level at the DIN+, DIN- pins is 1.00 Vpp at the OUT+, OUT- pins which allows for up to 6 dB loss in any external filter connected between the OUT+, OUT- outputs and the DIN+, DIN- inputs.

Gain of the AGC section is nominally

$$\frac{Av2}{Av1} = \exp - \left(\frac{V2 - V1}{5.8 + Vt} \right)$$

Where: Av1 and Av2 are initial and final amplifier gains. V1, V2 are initial and final voltages on the BYP pin.

Vt = (K x T)/q = 26 mV at room temperature.

One filter for both data (DIN+, DIN- input) and clock (CIN+, CIN- input) paths, or a separate filter for each path may be used. If two filters are used, care must be exercised to control time delays so that each path is timed properly. A multi-pole Bessell filter is typically used for its linear phase or constant group delay characteristics.

The filtered data path signal is fed into a hysteresis comparator that is set at a fraction of the input signal level by using an external filter/network between the LEVEL and HYS pins. The fullwave rectifier and hysteresis comparator are designed to have a sufficient 1dB bandwidth to insure constant level pin outputs and hysteresis qualification up to 9 MHz (analog sine wave input). Using this approach allows setting the AGC slow attack and decay times slow enough to minimize distortion of the clock path signal. This "feed-forward" technique, utilizing a fraction of the rectified data path input available at the LEVEL pin as the hysteresis threshold, is especially useful in the slow decay mode of the AGC loop. By using a short time constant for the hysteresis level, the qualification method can continue as the AGC amplifier gain is slowly ramped up. This level will also shorten the write to read transient recovery time without affecting data timing as the circuit will be properly decoding before the AGC gain has settled to its final value. The comparator output is the "D" input of a D type flip-flop. The DOUT pin provides a buffered test point for monitoring this function.

The filtered clock path signal is differentiated to transform signal peaks to zero-crossings which clock an edge-trigger circuit to provide output pulses at each zero-crossing. The pulses are used to clock the D type flip-flop. The COUT pin is a buffered test point for monitoring this function.

The differentiator function is set by an external network between the DIF+, DIF- pins. The transfer function is:
Where: C = external capacitor (20 pF to 150 pF)

$$AV = \frac{-2000Cs}{LCs^2 + (R + 92)Cs + 1}$$

L = external inductor

R = external resistor

$s = j\omega = j2\pi f$

During normal operation the differentiator circuit clocks the D flip-flop on every positive and negative peak of the signal input to CIN+, CIN-. The D input to the flip–flop only changes state when the signal applied to the DIN+, DIN- inputs exceeds the hysteresis comparator threshold opposite in polarity to the previous peak that exceeded the threshold.

The clocking path, then, determines signal timing and the data path determines validity by blocking signal peaks that do not exceed the hysteresis comparator threshold.

The delays from CIN+, CIN- inputs to the flip-flop clock input and from the DIN+, DIN- inputs to the flip-flop D input are well matched.

WRITE (DISABLED) MODE

In the write or disabled mode (R/$\overline{W}$ input low) the digital circuitry is disabled and the AGC amplifier input impedance is reduced. In addition the AGC amplifier, gain is set to maximum so that the loop is in its fast attack mode when changing back to Read Mode. The lowered input impedance facilitates more rapid settling of the write to read transient by reducing the time constant of the network between the SSI 32P541B and read/write preamplifier, such as the SSI 32R512.

Internal SSI 32P541B timing is such that this settling is accomplished before the AGC loop is activated when going to read mode. Coupling capacitors should be chosen with as low a value as possible, consistent with bandwidth requirements, to allow more rapid settling.

LAYOUT CONSIDERATIONS

The SSI 32P541B is a high gain wide bandwidth device that requires care in layout. The designer should keep analog signal lines as short as possible and well balanced. Use of a ground plane is recommended along with supply bypassing and separation of the SSI 32P541B and associated circuitry grounds from other circuits on the disk drive PCB.

LOW VOLTAGE FAULT DETECTION

A low voltage detection dircuit monitors both supplies and pulls an open collector TTL output low when either supply drops below their trip point. This option is available only in the 28-pin PLCC package.

R/$\overline{W}$	$\overline{HOLD}$	MODE
1	1	READ - Read amp on, AGC active, Digital section active
1	0	HOLD - Read amp on, AGC gain held constant Digital section active
0	X	WRITE - AGC gain switched to maximum, Digital section inactive, common mode input resistance reduced

PIN DESCRIPTION

NAME	TYPE	DESCRIPTION
VCC		5 volt power supply
VDD		12 volt power supply
AGND, DGND		Analog and Digital ground pins
R/$\overline{W}$	I	TTL compatible read/write control pin
IN+, IN-	I	Analog signal input pins
OUT+, OUT-	O	AGC Amplifier output pins
BYP		The AGC timing capacitor is tied between this pin and AGND
$\overline{HOLD}$	I	TTL compatible pin that holds the AGC gain when pulled low
AGC	I	Reference input voltage level for the AGC circuit
DIN+, DIN-	I	Analog input to the hysteresis comparator
HYS	I	Hysteresis level setting input to the hysteresis comparator
LEVEL	O	Provides rectified signal level for input to the hysteresis comparator
DOUT	O	Buffered test point for monitoring the flip-flop D input

PIN DESCRIPTION (Continued)

NAME	TYPE	DESCRIPTION
CIN+, CIN-	I	Analog input to the differentiator
DIF+, DIF-		Pins for external differentiating network
COUT	O	Buffered test point for monitoring the clock input to the flip-flop
OS		Connection for read output pulse width setting capacitor
RD	O	TTL compatible read output
$\overline{VFLT}$*	O	Open collector output that goes low when a low power supply fault is detected.

*$\overline{VFLT}$ output offered in 28-pin PLCC package only.

ELECTRICAL CHARACTERISTICS

Unless otherwise specified 4.5 ≤ VCC ≤ 5.5V, 10.8V ≤ VDD ≤ 13.2V, 25 °C ≤ Tj ≤ 135 °C.

ABSOLUTE MAXIMUM RATINGS

Operation above absolute maximum ratings may permanently damage the device.

PARAMETER	RATING	UNIT
5V Supply Voltage, VCC	6	V
12V Supply Voltage, VDD	14	V
Storage Temperature	-65 to 150	°C
Lead Temperature	260	°C
R/$\overline{W}$, IN+, IN-, $\overline{HOLD}$, $\overline{VFLT}$	-0.3 to VCC + 0.3	V
RD	-0.3V to VCC + 0.3V or +12	mA
All others	-0.3 to VDD + 0.3	V

POWER SUPPLY

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
ICC - VCC Supply Current	Outputs unloaded			14	mA
IDD - VDD Supply Current	Outputs unloaded			70	mA
Pd - Power Dissipation	Outputs unloaded, Tj = 135°C			730	mW

LOGIC SIGNALS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VIL - Input Low Voltage		-0.3		0.8	V
VIH - Input High Voltage		2.0			V
IIL - Input Low Current	VIL = 0.4V	0.0		-0.4	mA
IIH - Input High Current	VIH = 2.4V			100	µA
VOL - Output Low Voltage	IOL = 4.0 mA			0.4	V
VOH - Output High Voltage	IOH = -400 µA	2.4			V

MODE CONTROL

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Read to Write Transition Time				1.0	µs
Write to Read Transition Time	AGC settling not included, transition to high input resistance	1.2		3.0	µs
Read to Hold Transition Time				1.0	µs

WRITE MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Common Mode Input Impedance (both sides)	R/$\overline{W}$ pin = low		250		Ω

READ MODE

Unless otherwise specified IN+ and IN- are AC coupled, OUT+, and OUT- are loaded differentially with > 600Ω and each side is loaded with < 10 pF to GND, a 2000 pF capacitor is connected between BYP and GND, OUT+ is AC coupled to DIN+, OUT- is AC coupled to DIN-, AGC pin voltage is 2.2 VDC.

AGC AMPLIFIER

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Differential Input Resistance	V(IN+ – IN-) = 100 mVpp @ 2.5 MHz		5K		Ω
Differential Input Capacitance	V(IN+ – IN-) = 100 mVpp @ 2.5 MHz			10	pF
Common Mode Input Impedance	R/$\overline{W}$ pin high		1.8		kΩ
(both sides)	R/$\overline{W}$ pin low		0.25		kΩ
Minimum Gain Range	1.0 Vpp ≤ V(OUT+ – OUT-) ≤ 2.5 Vpp	4.0		83	V/V
Input Noise Voltage	Gain set to maximum			30	nV/$\sqrt{Hz}$

AGC AMPLIFIER (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Bandwidth	Gain set to maximum -3 dB point	30			MHz
Maximum Output Voltage Swing	Set by AGC pin voltage	3.0			Vpp
OUT+ to OUT- Pin Current	No DC path to GND	±3.2			mA
Output Resistance		12		32	Ω
Output Capacitance				15	pF
(DIN+ – DIN-) Input Voltage Swing VS AGC Input Level	30 mVpp V(IN+ – IN-) ≤ 550 mVpp 0.5 Vpp ≤ V(DIN+ – DIN-) ≤ 1.5 Vpp	0.37		0.56	Vpp/V
(DIN+ – DIN-) Input Voltage Swing Variation	30 mVpp V(IN+ – IN-) ≤ 550 mVpp AGC Fixed, over supply & temperature			8	%
Gain Decay Time (Td)	Vin = 300 mVpp–> 150 mVpp at 2.5 MHz, Vout to 90% of final value Figure 1a		50		µs
Gain Attack time (Ta)	From Write to Read transition to Vout at 110% of final value Vin = 400 mVpp @ 2.5 MHz. Figure 1b		4		µs
Fast AGC Capacitor Charge Current	V(DIN+ - DIN-) = 1.6V V(AGC) = 2.2V	1.3		2.0	mA
Slow AGC Capacitor Charge Current	V(DIN+ – DIN-) = 1.6V Vary V(AGC) until slow discharge	0.14		0.22	mA
Fast to Slow Attack Switchover Point	$\frac{V(DIN+-DIN-)}{V(DIN+-DIN-)\ Final}$		1.25		
AGC Capacitor Discharge Current	V(DIN+ – DIN-) = 0.0V Read Mode		4.5		µA
	Hold Mode	-0.2		+0.2	µA
CMRR (Input Referred)	V(IN+) = V(IN-) = 100 mVpp @ 5 MHz,gain at max.	40			dB
PSRR (Input Referred)	ΔVCC or ΔVDD = 100 mVpp @ 5 MHz, gain at max.	30			dB
Maximum AGC Amplifier Output Offset	V(IN+ - IN-) = 0 Min to max gain			200	mV

HYSTERESIS COMPARATOR

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Input Signal Range				1.5	Vpp
Differential Input Resistance	V(DIN+ – DIN-) = 100 mVpp @ 2.5 MHz	5		11	kΩ
Differential Input Capacitance	V(DIN+ – DIN-) = 100 mVpp @ 2.5 MHz			6.0	pF
Common Mode Input Impedance	(both sides)		2.0		kΩ
Comparator Offset Voltage	HYS pin at GND, ≤ 1.5 kΩ across DIN+, DIN-			10	mV
Peak Hysteresis Voltage vs HYS pin voltage (input referred)	At DIN+, DIN- pins 1V < V (HYS) < 3V	.16		.22	V/V
HYS Pin Input Current	1V < V (HYS) < 3V	0.0		-20	µA
Hysteresis Threshold margin as a % of V (DIN+ – DIN-) peak	V (Hys) = some % of *V (AGC) or V (LEVEL) IV < V (Hys) < 3V; f = 0-9 MHz	-15		+15	% Peak
Level Pin Output Voltage vs V(DIN+ – DIN-)	0.6 < | V (DIN+ – DIN-) | <1.3 Vpp, 10 kΩ from LEVEL pin to GND	1.7		2.2	V/Vpp
LEVEL Pin Max Output Current		3.0			mA
LEVEL Pin Output Resistance	I(LEVEL) = 0.5 mA		180		Ω
DOUT Pin Output Low Voltage	0.0 ≤ IOL ≤ 0.5 mA	VDD -4.0		VDD -2.8	V
DOUT Pin Output High Voltage	0.0 ≤ IOH ≤ 0.5 mA	VDD -2.5		VDD -1.8	V

*In an open loop configuration where reference is V(AGC) tolerance can be slightly higher

ACTIVE DIFFERENTIATOR

Input Signal Range				1.5	Vpp
Differential Input Resistance	V(CIN+ – CIN-) = 100 mVpp @ 2.5 MHz	5.8		11.0	kΩ
Differential Input Capacitance	V(CIN+ – CIN-) = 100 mVpp @ 2.5 MHz			6.0	pF
Common mode Input Impedance	(both sides)		2.0		kΩ
Voltage Gain From CIN± to DIF±	R(DIF+ to DIF-) = 2 kΩ	1.7		2.2	V/V
DIF+ to DIF- Pin Current	Differentiator Impedance must be set so as not to clip signal at this current level	±1.3			mA
Comparator Offset Voltage	DIF+, DIF- are AC Coupled			10.0	mV
COUT Pin Output Low Voltage	0.0 ≤ IOH ≤ 0.5 mA		VDD -3.0		V
COUT Pin Output Pulse voltage V(high) - V(low)	0.0 ≤ IOH ≤ 0.5 mA		+0.4		V
COUT Pin Output Pulse Width	0.0 ≤ IOH ≤ 0.5 mA		30		ns

OUTPUT DATA CHARACTERISTICS (See Figure 2)
Unless otherwise specified V(CIN+ – CIN-) = V(DIN+ – DIN-) = 1.0 Vpp AC coupled sine wave at 2.5 MHz differentiating network between DIF+ and DIF- is 100Ω in series with 65 pF, V (Hys) = 1.8 DC, a 33 pF capacitor is connected between OS and VCC, RD- is loaded with a 4 kΩ resistor to VCC and a 10 pF capacitor to GND.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
D-Flip-Flop Set Up Time (Td1)	Min delay from V(DIN+ DIN-) exceeding threshold to V(DIF+ – DIF-) reaching a peak	0			ns
Propagation Delay (Td3)				110	ns
Output Data Pulse Width Variation	Td5 = 11.4 ns + 740 • Cos 50% - 50% 15 pF ≤ Cos ≤ 150 pF			±15	%
Pulse Pairing	|Td3 - Td4|			±1.0	ns
Output Rise Time	VOH = 2.4V, 10% - 90%			15	ns
Output Fall Time	VOL = 0.4V, 90% - 10%			9	ns

SUPPLY VOLTAGE FAULT DETECTION

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VDD Fault Threshold		9.1		10.3	V
VCC Fault Threshold		4.1		4.4	V
VOL Output Low Voltage	4.5 < VCC < 5.5V, IOL = 1.6 mA			0.4	V
	1.0 < VCC < 4.5V, IOL = 0.5 mA			0.4	V
IOH Output High Current				25	µA

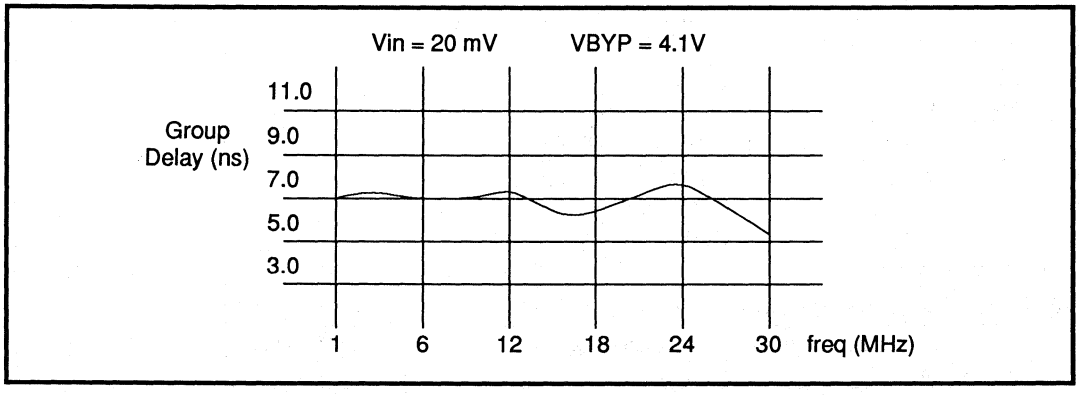


FIGURE 1: AGC Amplifier - Typical Group Delay Variation

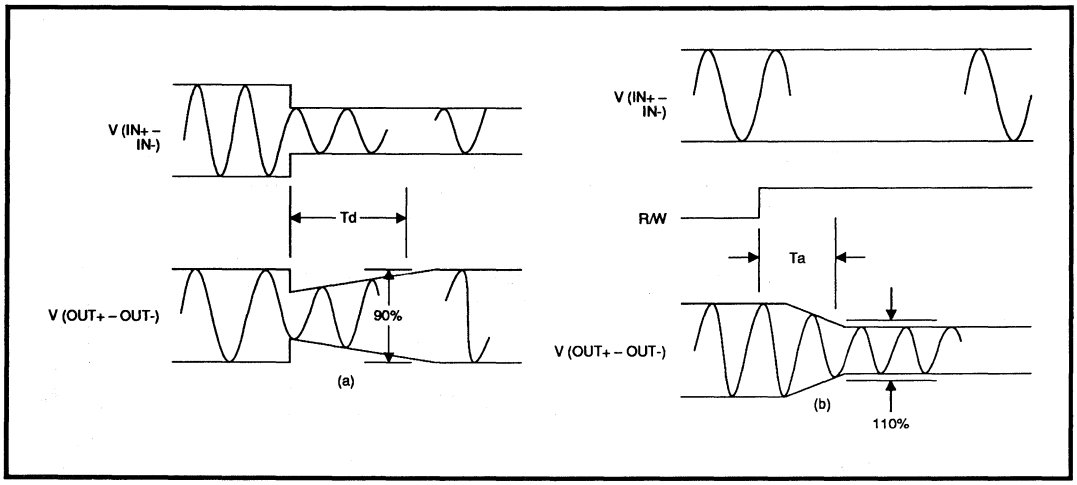


FIGURE 1(a), (b): AGC Timing Diagrams

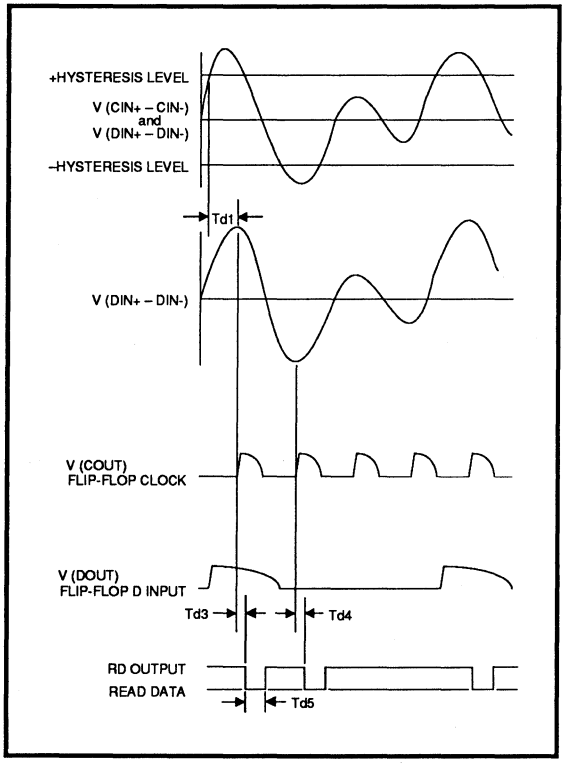
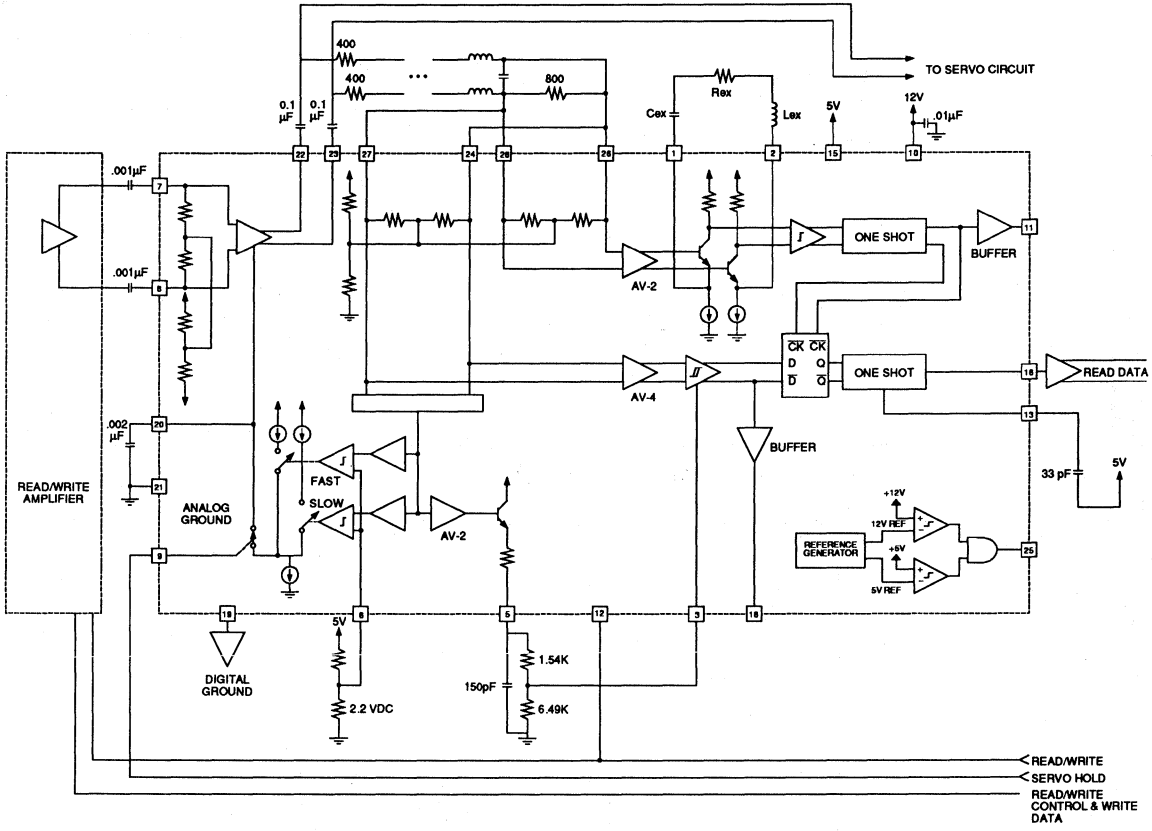


FIGURE 2: Timing Diagram



NOTE: Circuit traces for the 12V bypass capacitor and the AGC Hold Capacitor should be as short as possible with both capacitors returned to the Analog Ground Pin.
Component values, where given, are for a 24 Mbit/s System.
Above pin numbers are for the 28-pin PLCC package.

FIGURE 3: Typical Read/Write Electronics Set Up

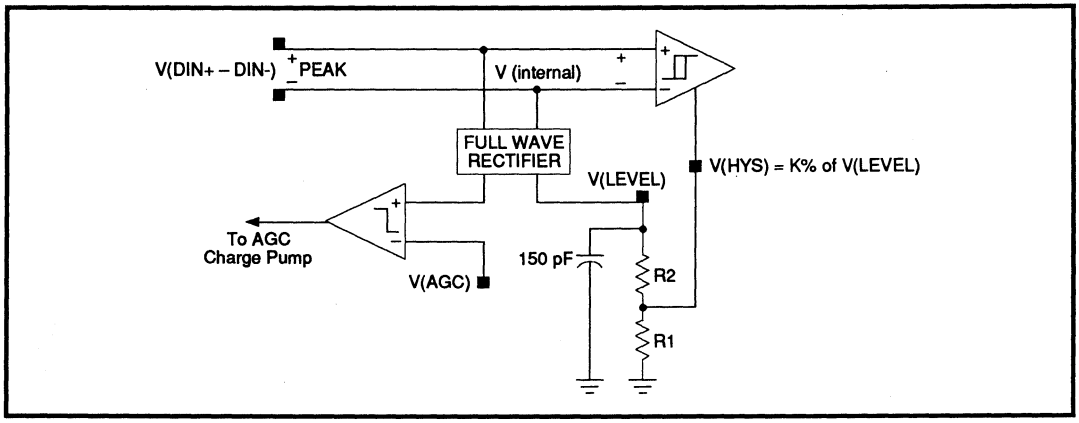


FIGURE 4: Feed Forward Mode

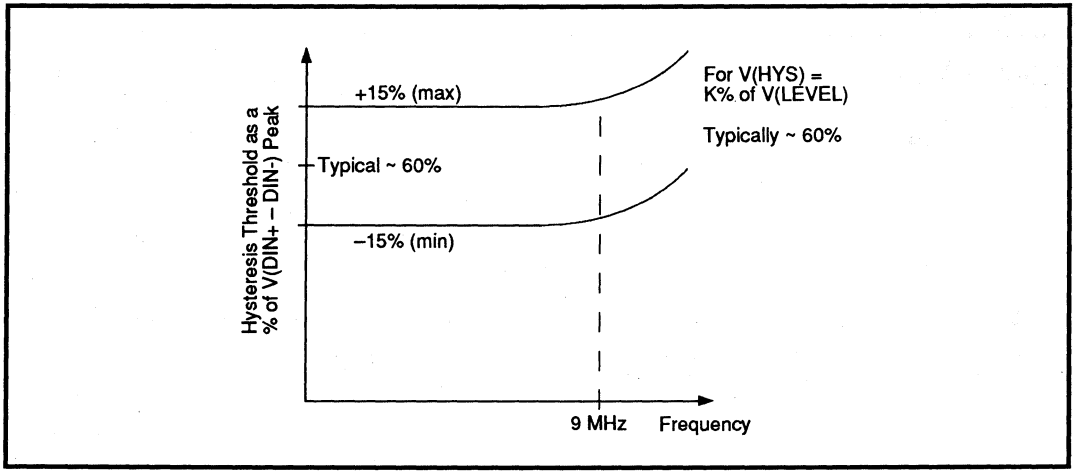
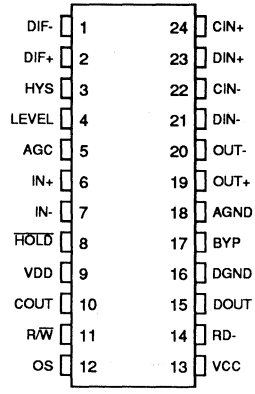


FIGURE 5: Percentage Threshold Versus Frequency

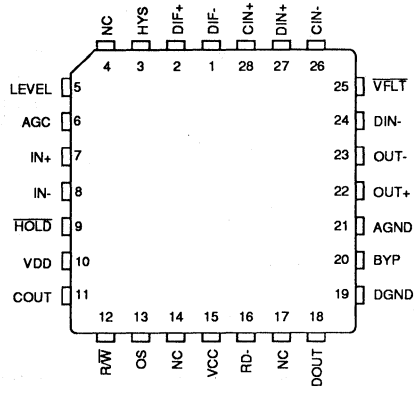
SSI 32P541B
Read Data Processor

PACKAGE PIN DESIGNATIONS

(TOP VIEW)



24-Lead PDIP, SOL



28-Lead PLCC

THERMAL CHARACTERISTICS: Ø ja

24-Lead PDIP	115°C/W
24-Lead SOL	80°C/W
28-Lead PLCC	65°C/W

CAUTION: Use handling procedures necessary for a static sensitive component.

ORDERING INFORMATION

PART DESCRIPTION	ORDERING NUMBER	PACKAGE MARK
SSI 32P541B Read Data Processor		
24-Lead PDIP	SSI 32P541B-P	SSI 32P541B-P
28-Lead PLCC	SSI 32P541B-CH	SSI 32P541B-CH
24-Lead SOL	SSI 32P541B-CL	SSI 32P541B-CL

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32P544
Read Data Processor and Servo Demodulator

July, 1990

2

DESCRIPTION

The SSI 32P544 Read Data Processor and Servo Demodulator has a fully integrated bipolar circuit that detects and validates amplitude peaks in the output from a disk drive read amplifier, as well as detecting embedded servo information to provide position error signals used for read head positioning.

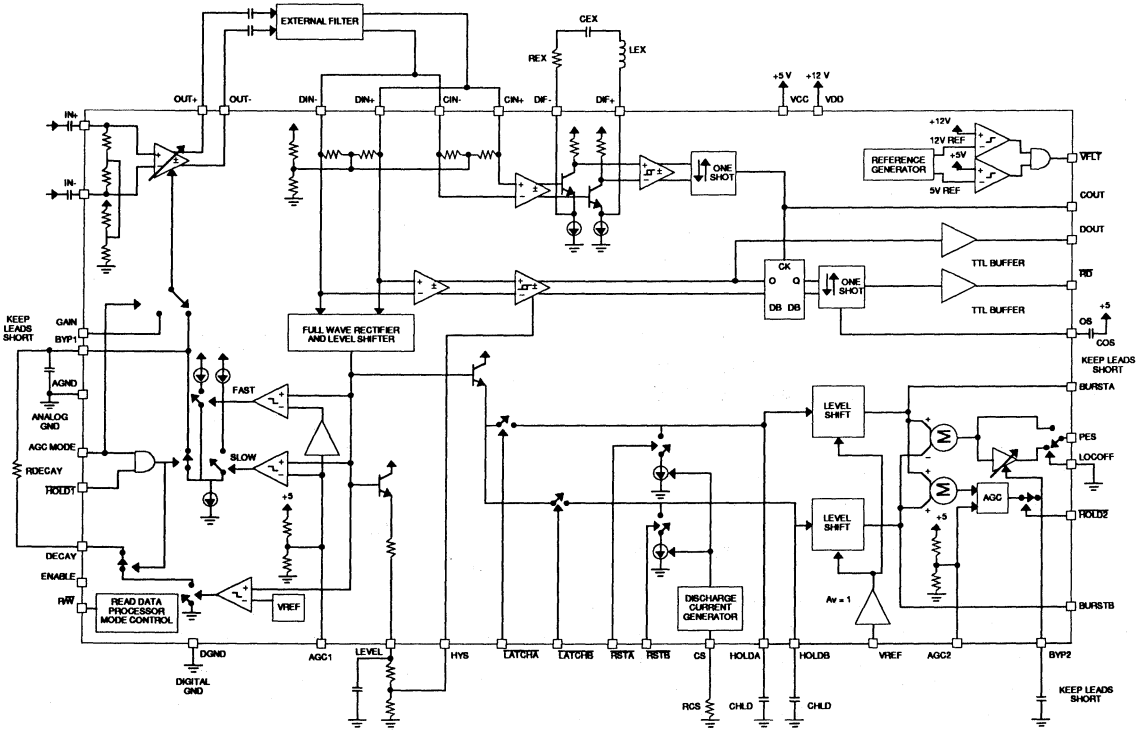
Time and amplitude qualification are used to provide a TTL compatible output that accurately duplicates the time position of input signal peaks. An AGC control loop, using a dual rate charge pump, provides a constant imput amplitude for the level qualifier. Level qualification can be implemented as a fixed threshold or a constant percentage that tracks signal amplitude that enhances qualification during AGC loop transients.

(Continued)

FEATURES

- **Wide bandwidth AGC input amplifier**
- **Level qualification supports MFM and RLL encoded data retrieval**
- **Fast and slow AGC attack and decay regions for fast transient recovery**
- **Embedded servo channel provides servo burst capture and difference circuits**
- **Local servo AGC provided based on servo burst output amplitude sum**
- **Standard ±10%, 12V and 5V supplies**
- **Write to Read transient suppression**

BLOCK DIAGRAM



DESCRIPTION (Continued)

The Servo Demodulator consists of two peak detector channels that capture rectified servo data peaks. Buffered individual channel outputs are provided along with a difference output. Servo channel gain can be controlled by an AGC signal based on maintaining the amplitude of the sum of both channels.

The circuit also provides a voltage fault flag that indicates a low voltage condition on either supply.

The SSI 32P544 requires standard ±10% tolerance +5V and +12V supplies and is available in a 44-pin PLCC package.

CIRCUIT OPERATION

READ MODE

In Read Mode the SSI 32P544 is used to process either data or servo signals. In the Data Read Mode the input signal is amplified and qualified using an AGC amplifier and pulse level qualification of the detected signal peaks. In the Servo Read Mode the input signal is amplified and an error signal based on amplitude comparison is made available.

DATA READ MODE

An amplified head output signal is AC coupled to the IN+ and IN- pins of the AGC amplifier. Gain control is accomplished by full wave rectifying and amplifying the [(DIN+) - (DIN-)] voltage level and comparing it to a reference voltage level at the AGC1 pin.

Two attack modes are entered depending on the instantaneous level at DIN±. For DIN± levels above 125% of desired level a fast attack mode is invoked that supplies 1.7 mA charging current to the network on the BYP1 pin. Between 125% and 100% of the desired level the circuit enters a slow attack mode and supplies 0.18 mA of charging current. This allows the AGC to rapidly recover during a write to read transition but reduces distortion once the AGC amplifier is in range.

Two decay modes are available that apply a discharge current to the BYP1 pin network when DIN± falls below the desired level. An internal decay current sink will supply 4.5 µA of discharge current. Also, if |(DIN+) - (DIN-)| is above 200 mVop a decay current, controlled by a resistor from BYP1 to DECAY, is switched in to decrease decay time. The amount of charge pulled from the AGC timing capacitor on each data pulse is:

$$Q_{DECAY} = K_1(Ton + Ts)/R_{DECAY}$$

Where:

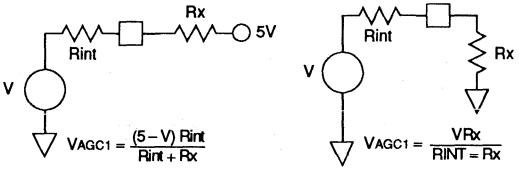
K_1 = 4.0V typ.

Ton = Time in seconds that the data pulse at DIN± is greater than 200 mVop

Ts = Switching time in seconds (<2 µs, max)

The AGC1 pin is internally biased so that the target differential voltage input at DIN± is 1.0 Vpp at nominal conditions. The AGC1 voltage can be modified by tying a resistor between AGC1 and ground or VCC. A resistor to ground decreases the voltage level while a resistor to VCC increases it. The resultant AGC1 voltage level is:

Where:



V = Voltage at AGC1 with pin open (2.2V, nom.)

Rint = AGC1 pin input impedance (6.7 kΩ, typ.)

Rx = External resistor.

The new DIN± input target level is nominally 0.48 Vpp/ V_{AGC1}

The AGC amplifier can swing 3.0 Vpp at OUT± which allows for up to 6 dB loss in any external filter between OUT± and DIN±.

Gain of the AGC amplifier is nominally:

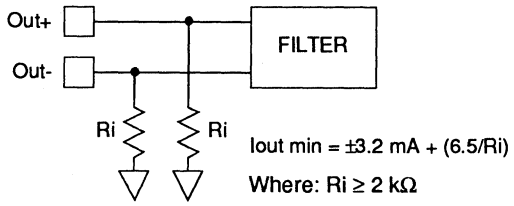
$$Av1/Av2 = e^{[6.9\,(V2 - V1)]}$$

Where:

Av1, Av2 are initial and final amplifier gains.

V1, V2 are initial and final voltages on the BYP1 pin.

The minimum output current from the AGC amplifier is ±3.2 mA. In cases where more current is required to drive a low impedance load the current can be increased by connecting load resistors Ri from OUT± to GND, as shown below.



One filter for both amplitude (DIN± input) and time (CIN± input) channels, or a separate filter for each may be used. If two filters are used, attention must be paid to time delays so that each channel is timed properly. A multi-pole Bessel filter is typically used for its linear phase or constant group delay characteristics.

In the amplitude channel the signal is sent to a hysteresis comparator. The hysteresis threshold level is set so that it will be tripped only by valid signal pulses and not by baseband noise. It can be fixed level or a fraction of the DIN± voltage level.

The latter approach is accomplished by using an external filter/network between the LEVEL and HYS pins. This allows setting the AGC slow attack and decay times slow enough to minimize time channel distortion and setting a shorter time constant for the hysteresis level. The LEVEL pin output is a rectified and amplified version of DIN±, 1.0 Vpp at DIN± results in 2.0 Vop nominally, at the LEVEL pin. A voltage divider is used from LEVEL to ground to set the Hysteresis threshold at a percentage of the peak DIN± voltage. For example, if DIN± is 1.0 Vpp, then using an equal valued resistor divider will result in 1.0 Vop at the HYS pin. This will result in a nominal ±0.210V threshold or a 42% threshold of a ±0.500V DIN± input. The capacitor is chosen to set an appropriate time constant. This "feed forward" technique speeds up transient recovery by allowing qualification of the input pulses while the AGC is still settling. This helps in the two critical areas of write to read and head change recovery. Some care in the selection of the hysteresis level time constant must be exercised so as to not miss pattern (resolution) induced lower amplitude signals. The output of the hysteresis comparator is the "D" input of a D-type flip-flop. The DOUT pin provides a buffered TTL compatible comparator output signal for testing purposes or for use in the servo circuit if required.

In the time channel the signal is differentiated to transform signal peaks to zero crossings which are detected and used to trigger a bi-directional one-shot. The one-shot output pulses are used as the clock input of the D flip-flop. The COUT pin provides the one-shot output for test purposes.

The differentiator function is accomplished by an external network between the DIF+ and DIF- pins. The transfer function from CIN± to the comparator input (not DIF±) is:

$$Av = \frac{-1000(Abuf)(Cs)}{2LCs^2 + C(R+92)s + 1}$$

Where: C, L, R are external passive components
20 pF < C < 150 pF
Abuf = Gain From CIN± to DIF±
$s = j\omega = j2\pi f$

During normal operation, the time channel clocks the D flip-flop on every positive and negative peak of the CIN± input. The D input to the flip-flop only changes state when the DIN± input exceeds the hysteresis comparator threshold opposite in polarity to the previous threshold exceeding peak.

The time channel, then, determines signal peak timing and the amplitude channel determines validity by blocking signal peaks that do not exceed the hysteresis comparator threshold. The delays in each of these channels to the D flip-flop inputs are well matched.

The D flip-flop output triggers a one-shot that sets the $\overline{RD}$ output pulse width. Width is controlled by an external capacitor from the OS pin to VCC.

SERVO READ MODE

A position error signal (PES) is generated based on the relative amplitude of two servo signals, A and B. Several methods are made available for maintaining channel gain during servo signal processing.

SERVO READ MODE (Continued)

Rectified servo signal peaks are captured on hold capacitors at the HOLDA/B pins. This is accomplished by pulling $\overline{\text{LATCHA}}$ or $\overline{\text{LATCHB}}$ low for a sample period. Additionally, a hold capacitor discharge current of up to 1.0 mA can be turned on by pulling $\overline{\text{RSTA}}$ or $\overline{\text{RSTB}}$ low. The discharge current is determined by a resistor tied between CS and ground. Its magnitude is:

$$I_{CS} = 2.6/(R_{CS} + 750)\ A, \text{ typ.}$$

Where: R_{CS} = resistor from CS to ground

Outputs BURSTA/B & PES are referenced to an external reference applied to the VREF pin.

As noted, several methods are used to determine channel gain in Servo Read Mode. These methods make use of the data read mode AGC loop, the servo AGC loop and external or fixed AGC loop gain. Two methods are used that control the channel gain based on maintaining the sum of A & B channel amplitudes.

In one case (see Figure 1) the BYP2 pin is connected to the GAIN pin and the servo channel gain is determined by the read channel gain as controlled by the sum of the A and B amplitudes. In this case a current is sourced/sinked to/from the capacitor on the GAIN/BYP2 pin whenever the $\overline{\text{HOLD2}}$ pin is pulled high. The current magnitude and direction is determined by:

$$I_C = K_4[(K_5 \cdot V_{AGC2}) - Va(DIN)pp - Vb(DIN)pp]$$

Where:

V_{AGC2} = AGC2 pin voltage

K_4 = 650 µA/Vpp

K_5 = 0.39 V/V

Va/b(DIN)pp = peak to peak A or B servo pattern Signal voltages at DIN±

The other case (see Figure 2) controls the channel by fixing the Read Data channel gain by taking $\overline{\text{HOLD1}}$ low and closing the loop about the Servo Channel AGC (LOCOFF is held low for this mode).

$\overline{\text{HOLD2}}$ is used to update the control voltage on the AGC capacitor at the BYP2 pin. This AGC function has a time constant defined by:

$$\text{Time Constant} = K_6 \cdot C_{BYP2}$$

Where: K_6 = 1.64 to 7.5 kΩ

C_{BYP2} = BYP2 pin capacitor value in farads

Another method (see Figure 5) uses either a fixed voltage at the GAIN pin to determine channel gain or a gain based on preamble data amplitude. In this case no AGC methods are used that are based on servo signal amplitudes. Gain, as determined by an external voltage has been covered above. In the preamble method $\overline{\text{HOLD1}}$ is taken low during a preamble and the channel gain, determined by that necessary to maintain DIN± as programmed by the AGC1 voltage, is held during servo data processing.

WRITE MODE

In Write Mode the SSI 32P544 is disabled and preset for the following Read Mode. The digital circuitry is disabled, the input AGC amplifier gain is set to maximum and the AGC amplifier input impedance is reduced.

Resetting the AGC amplifier gain and input impedance shortens system Write to Read recovery times. With the AGC gain at maximum when returning to Read mode the AGC loop is in fast attack mode.

The lowered input impedance improves settling time by reducing the time constant of the network between the SSI 32P544 and a read preamplifier such as the SSI 32R510A. Write to read timing is controlled to maintain the reduced impedance for 1.2 to 3.0 µs before the AGC circuitry is activated. Coupling capacitors should be chosen with as low a value as possible consistent with adequate bandwidth to allow more rapid settling.

POWER DOWN MODE

A power down mode is provided to reduce power usage during the idle periods. Taking ENABLE pin low selects this mode. Recovery from this state can be slow due to the necessity of charging external capacitors.

LOW VOLTAGE FAULT DETECTION

A low voltage detection circuit monitors both supplies and pulls an open collector TTL output low whenever either supply drops below their trip point.

MODE CONTROL

The SSI 32P544 circuit mode is controlled by the ENABLE, R/$\overline{\text{W}}$, AGCMODE, $\overline{\text{HOLD1}}$, $\overline{\text{HOLD2}}$, and LOCOFF pins as shown in Table 1.

Data Read Mode

AGC active and controlled by data, Digital section active

Data Read Mode, Hold

AGC gain held constant, Digital section active. Gain will drift higher at rate determined by C_{BYP1} and Hold mode discharge current.

Servo Read Mode I (See Figures 1 & 3)

The BYP2 and GAIN pins are tied together. Read amplifier AGC control voltage developed from sum of Servo signal levels. $\overline{HOLD2}$ is toggled to update the control voltage after each Servo frame.

Servo Read Mode II (See Figures 2 & 4)

Read amplifier AGC gain held fixed ($\overline{HOLD1}$ low). Servo AGC loop activated with $\overline{HOLD2}$ toggled to update or hold gain based on a constant servo signal sum.

Servo Mode III (See Figure 5)

Read channel gain determined by voltage on GAIN pin.

Write

Read amplifier input impedance reduced. BYP1 pin voltage pulled low to select maximum amplifier gain. Digital section deactivated.

Power Down

Circuit switched to a low current disabled mode.

Note: When AGCMODE is switched to a low state the voltage at the BYP1 pin will be held subject to Hold mode discharge current induced drift. So, when returning to Data Read Mode, the channel gain will be the same as it was prior to AGCMODE switching or slightly higher.

TABLE 1: SSI 32P544 Circuit Mode Control

ENABLE	R/$\overline{W}$	AGC MODE	$\overline{HOLD1}$	$\overline{HOLD2}$	LOCOFF	READ PATH MODES
1	1	1	1	-	-	Data Read Mode
1	1	1	0	-	-	Data Read Mode Hold
1	1	0	-	1	1	Servo Read Mode I
1	1	0	-	0	1	
1	1	1	0	0	0	Servo Read Mode II
1	1	1	0	1	0	
1	1	0	-	-	-	Servo Mode III
1	0	-	-	-	-	Write
0	-	-	-	-	-	Power Down

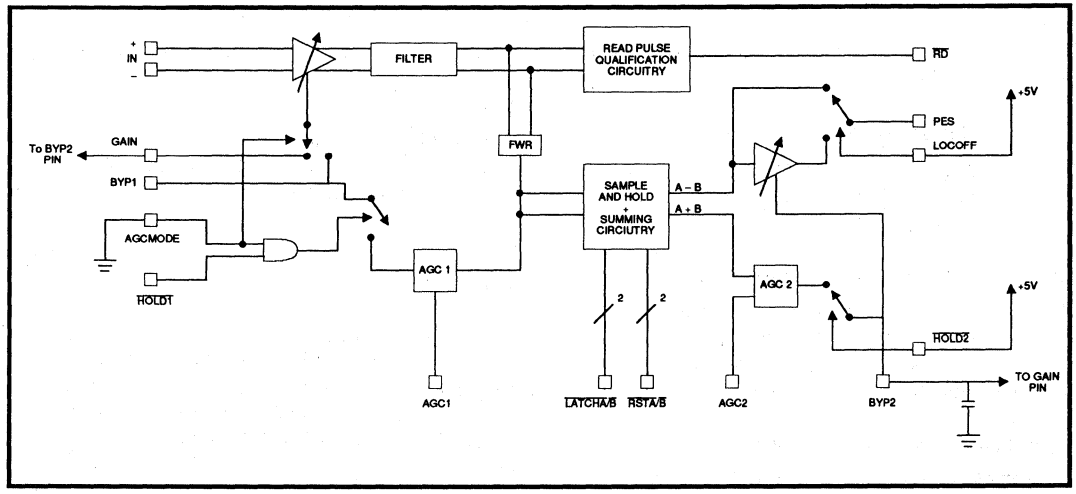


FIGURE 1: Servo Read Mode I

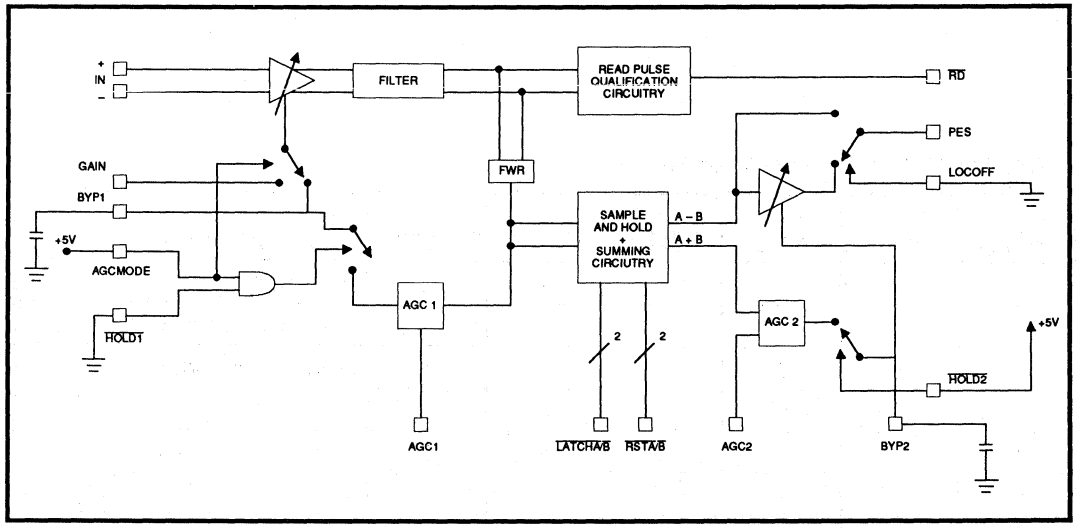


FIGURE 2: Servo Read Mode II

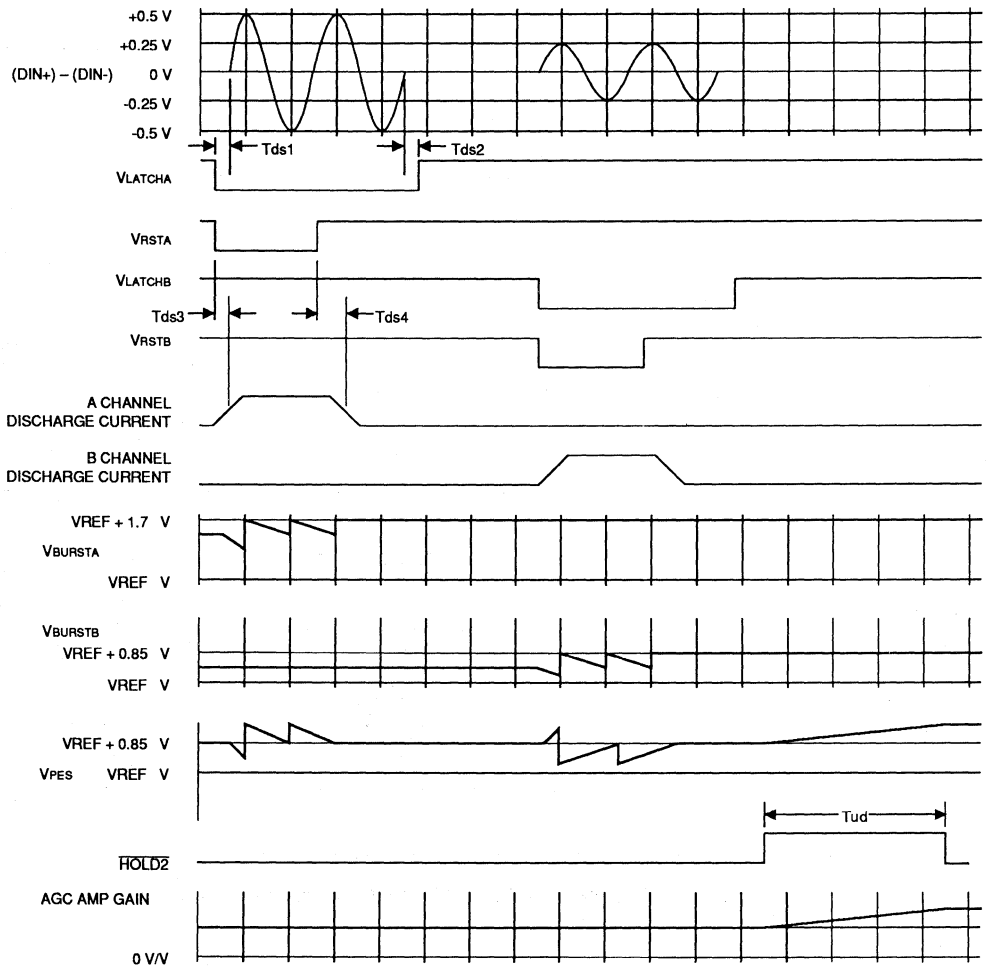


FIGURE 3: Servo Read Mode I Timing Diagram

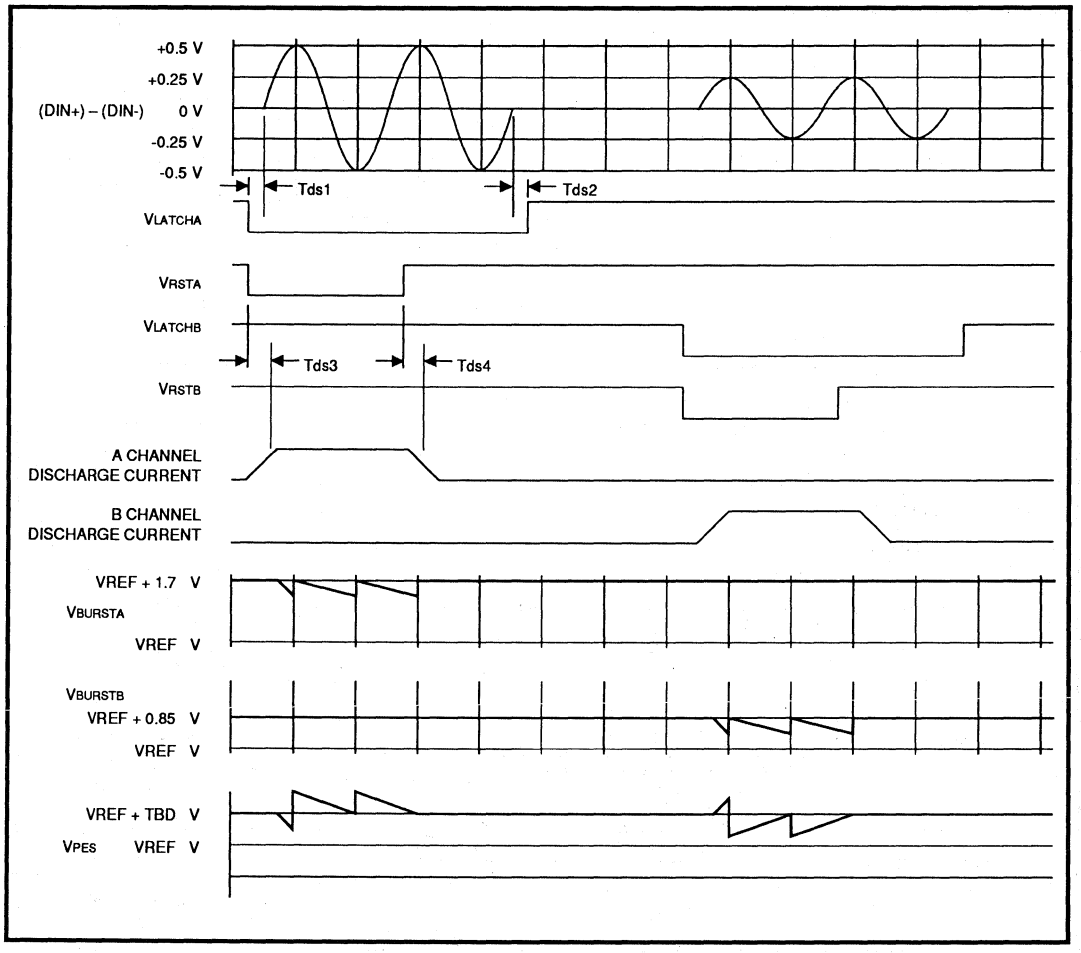


FIGURE 4: Servo Read Mode II Timing Diagram

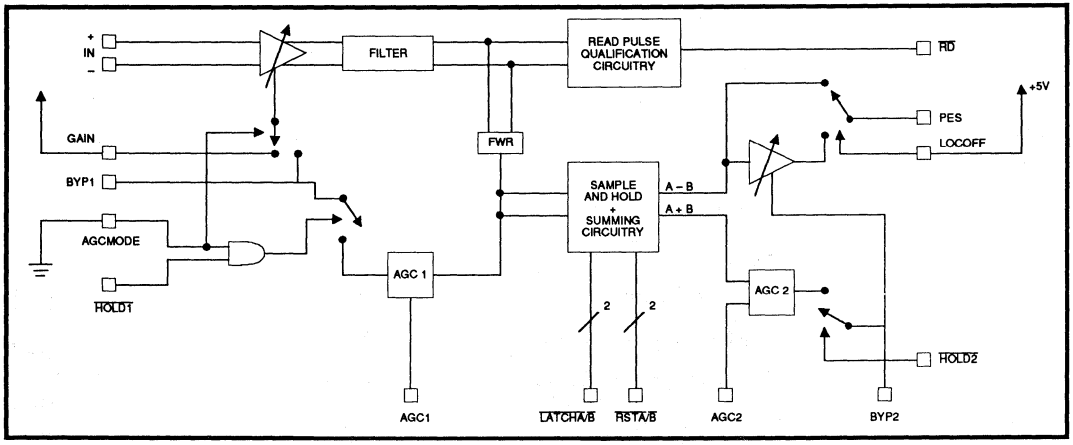


FIGURE 5: Servo Read Mode III

PIN DESCRIPTIONS

POWER SUPPLY AND CONTROL

NAME	DESCRIPTION
VCC	5 volt power supply.
VDD	12 volt power supply.
AGND, DGND	Analog and digital ground pins.
R/$\overline{W}$*	TTL compatible read/write control pin
ENABLE*	TTL compatible power up control pin. A low input selects a low power state.
$\overline{VFLT}$	Open collector output that goes low when a low power supply fault is detected.

AGC GAIN STAGE

IN+, IN-	Analog signal input pins.
OUT+, OUT-	Read path AGC amplifier output pins.
AGC1	Reference input voltage level for the read path AGC loop.
AGCMODE*	TTL compatible pin that selects the AGC loop control input. A high selects BYP1, a low GAIN.
BYP1	An AGC timing capacitor or network is tied between this pin and AGND.
GAIN	A voltage at this pin may be used to control AGC gain.
DECAY	A resistor to control the AGC loop decay time constant may be tied between this pin and BYP1.
$\overline{HOLD1}$*	TTL compatible control pin that holds the read path AGC loop gain constant when low.

PIN DESCRIPTIONS (Continued)

DIGITAL PROCESSING STAGE

NAME	DESCRIPTION
DIN+, DIN-	Analog input to the hysteresis comparator.
CIN+, CIN	Analog input to the differentiator.
DIF+, DIF-	Pins for external differentiating network.
LEVEL	Output from full wave rectifier that may be used for input to the hysteresis-comparator.
HYS	Threshold setting input to the hysteresis-comparator.
DOUT	Buffered TTL output for monitoring the flip-flop D input. Provided for testing or servo use.
COUT	Test point for monitoring the flip-flop clock input.
OS	Connection for output pulse width setting capacitor.
$\overline{RD}$	TTL compatible read output.

SERVO BURST CAPTURE STAGE

$\overline{LATCHA}$, $\overline{LATCHB}$	TTL compatible inputs that switch channels A or B into peak acquisition mode when low.
HOLDA, HOLDB	Peak holding capacitors are tied from each of these pins to AGND.
$\overline{RSTA}$, $\overline{RSTB}$	TTL compatible inputs that enable discharge of Channel A or B hold capacitors when low.
CS	Hold capacitor discharge current magnitude is controlled by a resistor from this pin to ground.
VREF	Reference voltage input for servo outputs.
AGC2	Reference input voltage level for the servo AGC loop.
BYP2	An AGC timing capacitor or network is tied between this pin and AGND.
$\overline{HOLD2}$	TTL compatible control pin that holds the servo AGC loop gain constant when low.
BURSTA, BURSTB	Buffered hold capacitor voltage outputs.
PES	Position error signal A minus B output.
LOCOFF*	TTL compatible input to select path for PES signal. (Local On/Off) Selects between AGC amp. output or A-B output.

* These inputs have internal pull-ups, so an open connection is the same as a high input.

ELECTRICAL SPECIFICATION

ABSOLUTE MAXIMUM RATINGS

Operation outside these rating limits may cause permanent damage to this device.

PARAMETER	RATING	UNIT
5V Supply Voltage, VCC	6.0	V
12V Supply Voltage, VDD	14.0	V
Pin Voltage GAIN, BYP1/2, AGC1/2 LEVEL, HYS, HOLDA/B, VREF BURSTA/B, PES, COUT, DIF±, OUT±	-0.3 to VDD + 0.3	V
Pin Voltage IN±, AGCMODE, $\overline{\text{HOLD1/2}}$, ENABLE, R/$\overline{\text{W}}$, $\overline{\text{LATCHA/B}}$, $\overline{\text{RSTA/B}}$, CS, LOCOFF, OS, CIN±, DIN±	-0.3 to VCC + 0.3	V
Pin Voltage RD, DOUT, DECAY, $\overline{\text{VFLT}}$	-0.3 to VCC + 0.3 or +12 mA	V
Storage Temperature	65 to 150	°C
Lead Temperature (Soldering 10 sec.)	260	°C

RECOMMENDED OPERATING CONDITIONS

Currents flowing into the chip are positive.

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
VCC	Supply Voltage		4.5	5.0	5.5	V
VDD	Supply Voltage		10.8	12.0	13.2	V
Ta	Ambient Temperature		0		70	°C

ELECTRICAL CHARACTERISTICS

POWER SUPPLY

Recommended conditions apply unless otherwise specified.

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
ICC	VCC Supply Current	Outputs unloaded, ENABLE = high or open			20	mA
ICC		ENABLE = low			17	mA
IDD	VDD Supply Current	Outputs unloaded, ENABLE = high or open			90	mA
IDD		ENABLE = low			25	mA

POWER SUPPLY (Continued)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
Pd	Power dissipation	Tj = 145°C, ENABLE = high, Outputs unloaded			1.0	W
		ENABLE = low, Outputs unloaded			0.35	W

LOGIC SIGNALS

VIL	Input Low Voltage		-0.3		0.8	V
VIH	Input High Voltage		2.0		VCC+0.3	V
IIL	Input Low Current	VIL = 0.4V	0.0		-0.4	mA
IIH	Input Low Current	VIH = 2.4V			100	µA
VOL	Output Low Voltage	IOL = 4.0 mA			0.4	V
VOH	Output High Voltage	IOH = 400 µA	2.4			V
	Output rise time	VOH = 2.4V*			15.0	ns
	Output full time	VOL = 0.4V*			9.0	ns

*10 - 90%, 10 pF capacitor to DGND

MODE CONTROL

Enable to/from Disable Transition Time	Settling time of external capacitors not included ENABLE pin high to/from low			10	µs
Read to Write Transition Time	R/$\overline{W}$ pin high to low			1.0	µs
Write to Read Transition Time	R/$\overline{W}$ pin low to high AGC setting not included	1.2		3.0	µs
AGC On to/from AGC Off Transition Time	AGCMODE pin high to/from low			2.0	µs
$\overline{HOLD1}$ On to/from $\overline{HOLD2}$ Off Transition Time	$\overline{HOLD1}$ pin high to/from low			1.0	µs
$\overline{HOLD2}$ On to $\overline{HOLD2}$ Off Transition Time	$\overline{HOLD2}$ pin high to/from low			1.0	µs

WRITE MODE

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
Common Mode Input Impedance	R/$\overline{W}$ pin = low		250		Ω

READ MODE

READ PATH AGC AMPLIFIER

Unless otherwise specified, recommended operating conditions apply. Input signals are AC coupled to IN±. OUT± are loaded differentially with >600Ω, and each side is loaded with < 10 pF to AGND, and AC coupled to DIN±. A 2000 pF capacitor is connected between BYP1 and AGND. AGC1 pin is open. R/$\overline{W}$ is high.

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
Gain Range	1.0 Vpp ≤ (OUT+) – (OUT-) ≤ 3.0 Vpp	4		83	V/V
Output Offset Voltage	Over entire gain range	-400		+400	mV
Maximum Output Voltage Swing	Set by BYP1 pin	3.0			Vpp
Differential Input Resistance	(IN+) – (IN-) = 100 mVpp @ 2.5 MHz		5.0		kΩ
Differential Input Capacitance	(IN+) – (IN-) = 100 mVpp @ 2.5 MHz			10	pF
Common Mode Input Impedance	R/$\overline{W}$ = high		1.8		kΩ
	R/$\overline{W}$ = Low		250		Ω
Input Noise Voltage	Gain set to maximum			30	nV/$\sqrt{Hz}$
Bandwidth	-3 dB bandwidth at maximum gain	28			MHz
OUT+ to OUT- Pin Current	No DC path to AGND	±3.0			mA
Output Resistance		20		50	Ω
CMRR (Input Referred)	(IN+) = (IN-) = 100 mVpp @ 5 MHz, gain set to max	40			dB

READ PATH AGC AMPLIFIER (Continued)

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
PSRR (Input Referred)	VDD or VCC = 100 mVpp @ 5 MHz, gain set to max	30			dB
Externally controlled Gain Constants $AV = K_2 \cdot e^{(K3 \cdot VGAIN)}$ V/V	K_2, AGCMODE = Low K_3, AGCMODE = Low	.89 1.95		2.3 2.64	
Gain pin parasitic Input current	AGCMODE & $\overline{HOLD1}$ = low	0.2		+0.2	µA
(DIN+) – (DIN-) Input Swing vs. AGC1 Input	30 mVpp ≤ (IN+) – (IN-) ≤ 550 mVpp 0.5 Vpp ≤ (DIN+) – (DIN-) ≤ 1.5 Vpp, AGCMODE & $\overline{HOLD1}$ = high	0.36		0.56	Vpp/V
(DIN+) – (DIN-) Input Voltage Swing Variation	30 mVpp ≤ (IN+) – (IN-) ≤ 550 mVpp			8.0	%
AGC1 Voltage	AGC1 open, $V_{(ACC1)}$ = 2.35V	-5		+5	%
AGC1 Pin Input Impedance		5.0		8.3	kΩ
Fast Decay Threshold (DIN+) – (DIN-)	AGCMODE = high		±0.3		V
Slow AGC Capacitor Discharge Current	(DIN+) – (DIN-) = 0V V_{BYP} = 4.5V		4.0		µA
AGC Capacitor Leakage Current	AGCMODE = high, $\overline{HOLD1}$ = low, 2.5V < V_{BYP} < 5.5V	-0.2		+0.2	µA
Slow AGC Capacitor Charge Current	(DIN+) – (DIN-) = 0.75 VDC, vary AGC1 until slow charge begins	-0.14		-0.22	mA
Fast AGC Capacitor Charge Current	(DIN+) – (DIN-) = 0.75 VDC, V_{AGC1} = 3.0V	-1.3		-2.0	mA
Fast to Slow Attack Switchover Point	[(DIN+) – (DIN-)] – [(DIN+) – (DIN-)]FINAL		0.2		Vpp
Gain Decay Time (Td) (See Figure 6a)	(IN+) – (IN-) = 300 mVpp to 150 mVpp @ 2.5 MHz DECAY pin open, (OUT+) – (OUT-) to 90% final value.		50		µs

READ PATH AGC AMPLIFIER (Continued)

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
Gain Attack Time (Ta) (See Figure 6b)	R/$\overline{W}$ = low to high (IN+) – (IN-) = 400 mVpp @ 2.5 MHz, (OUT+) – (OUT-) to 110% final value		4		µs

HYSTERESIS COMPARATOR

Unless otherwise specified, recommended operating conditions apply. Input (DIN+) – (DIN-) is an AC coupled, 1.0 Vpp, 2.5 MHz sine wave. 1.8 VDC is applied to the HYS pin. ENABLE and R/$\overline{W}$ pins are high.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Input Signal Range				1.5	Vpp
Differential Input Resistance	(DIN+) – (DIN-) = 100 mVpp @ 2.5 MHz	10		18.0	kΩ
Differential Input Capacitance	(DIN+) – (DIN-) = 100 mVpp @ 2.5 MHz			4.0	pF
Common Mode Input Impedance (Both Sides)		2.25		5.0	kΩ
Level Pin Output Voltage vs. (DIN+) – (DIN-)	0.6 Vpp < (DIN+) – (DIN-) < 1.5 Vpp, 10K between LEVEL and AGND	1.2		2.2	V/Vpp
Level Pin Output Impedance	I_{LEVEL} = 0.5 mA		180		
Level pin Maximum Output Current		3.0			mA
Hysteresis Voltage at DIN± vs. HYS Pin Voltage	1 V < HYS < 3V	0.16		0.25	V/V
Hysteresis threshold margin as a % of V(DIN+) – (DIN-) peak	V(HYS) = some % of *V(AGC) or V(LEVEL) 1V < V(HYS) < 3V *see Figures 8 & 9	-15		+15	%Peak
HYS Pin Current	1 V < HYS < 3V	0.0		-20	µA
Comparator Offset Voltage	HYS pin at AGND ≤ 1.5 kΩ across DIN±			10.0	mV

* In an open loop configuration where reference is V(AGC) tolerance can be slightly higher.

ACTIVE DIFFERENTIATOR

Unless otherwise specified, recommended operating conditions apply. Input (CIN+) – (CIN-) is an AC-coupled, 1.0 Vpp, 2.5 MHz sine wave. 100Ω in series with 65 pF are tied from DIF+ to DIF-.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Input Signal Range				1.5	Vpp
Differential Input Resistance	(CIN+) – (CIN-) = 100 mVpp @ 2.5 MHz	10		18.0	kΩ
Differential Input Capacitance	(CIN+) – (CIN-) = 100 mVpp @ 2.5 MHz			4.0	pF
Common Mode Input Impedance	Both sides	2.25		5.0	kΩ
Voltage Gain From CIN± to DIF±	(DIF+ to DIF-) = 2 kΩ	1.7		2.2	V/V
DIF+ to DIF- PIn Current	Differentiator impedance must be set so as to not clip the signal for this current level	±1.2			mA
Comparator Offset Voltage	DIF+, DIF- are AC-coupled			10.0	mV
COUT Pin Output Low Voltage	0 ≤ IOL ≤ 0.5 mA		VDD-3.0		V
COUT pin Output Pulse Voltage, V_{HIGH} - V_{LOW}	0 ≤ IOL ≤ 0.5 mA		0.4		V
COUT pin Output Pulse Width	0 ≤ IOH ≤ 0.5 mA		30		ns

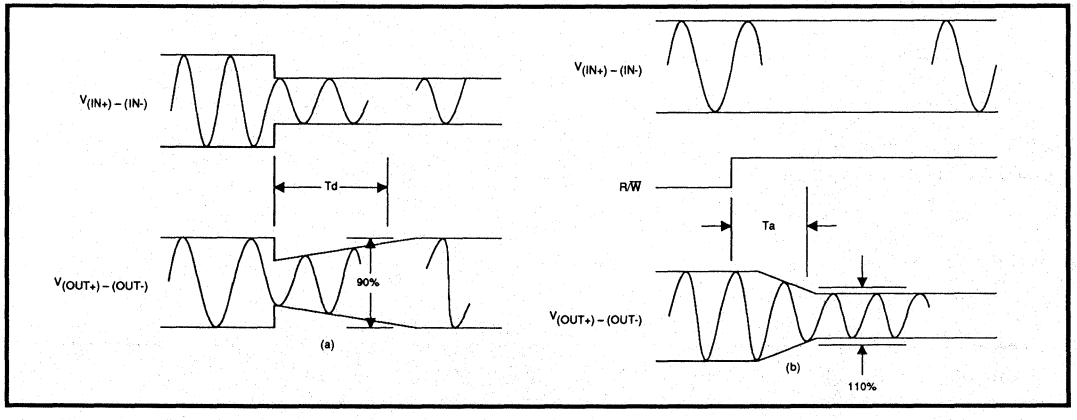


FIGURE 6: AGC Timing Diagram

OUTPUT DATA CHARACTERISITICS (See Figure 7)

Unless otherwise specified, recommended operating conditions apply. Inputs (CIN+) – (CIN-) and (DIN+) – (DIN-) are in-place as a coupled, 1.0 Vpp, 2.5 MHz sine wave. 100Ω in series with 65 pF are tied from DIF+ to DIF-. 1.8V is applied to the HYS pin. A 60 pF capacitor is tied between OS and VCC. $\overline{RD}$ is loaded with a 4 kΩ resistor to VCC and a 10 pF capacitor to DGND. ENABLE and R/$\overline{W}$ pins are high.

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
Td1	D Flip-Flop Set Up Time	Minimum allowable time delay from (DIN+) – (DIN-) exceeding hysterisis point to (DIF+) – (DIF-) hitting a peak value.	0			ns
Td3	Propagation Delay				110	ns
Td5	Output Pulse Width Variation	Td5 = 800(Cos) @ V_{RD} = 1.4V 50 pF ≤ Cos ≤ 200 pF			±15	%
|Td3-Td4|	Pulse Pairing				1.5	ns

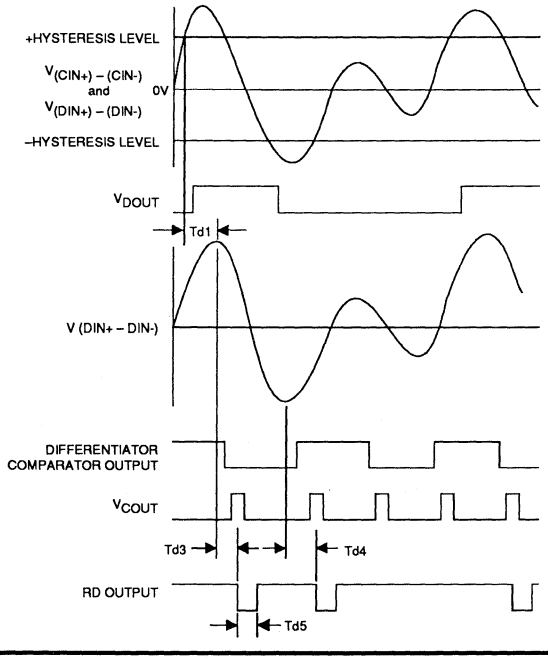


FIGURE 7: Read Mode Digital Section Timing Diagram

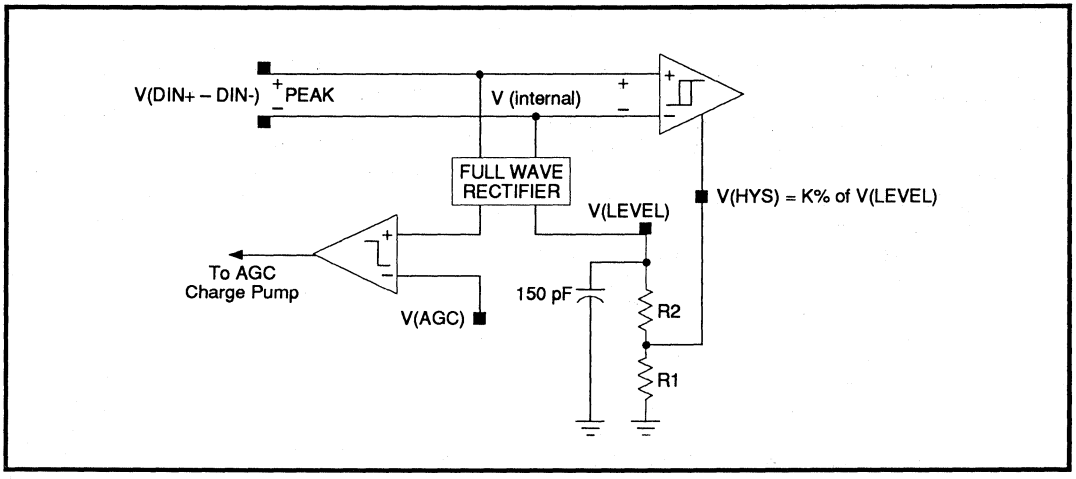


FIGURE 8: Feed Forward Mode

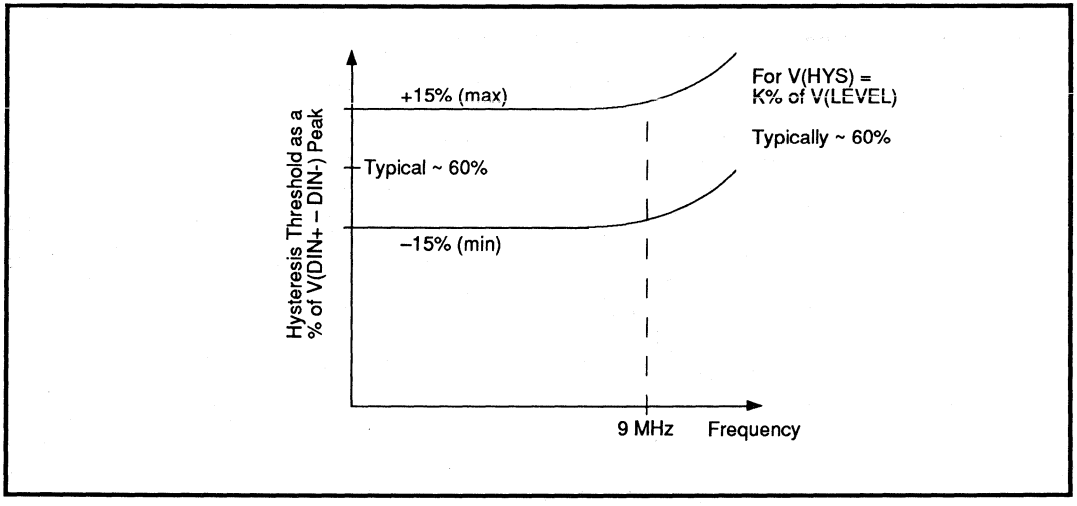


FIGURE 9: Percentage Threshold vs. Frequency

SERVO SECTION (Unless otherwise specified, recommended operating conditions apply.)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VREF Voltage Range		3.9		6.0	V
AGC2 Pin Voltage	AGC2 Pin Open, $V_{(AGC2)}$ = 3.4V	-5		+5	%
AGC2 Pin Input Impedance		5.0		9.1	kΩ
BURSTA/B pin Output Voltage vs (DIN+) – (DIN-)	$\overline{LATCHA/B}$ = Low $\frac{V_{BURSTA/B} - VREF}{(DIN+) - (DIN-)}$ = 1.7 V/Vp-p	-6.5		+6.5	%
BURSTA/B Output Offset Voltage V_{BURST} - VREF	$\overline{LATCHA/B}$ = Low, (DIN+) = (DIN-), RCS = 38.3 kΩ	-80		+80	mV
BURSTA - BURSTB Output Offset Match	$\overline{LATCHA/B}$ = low (DIN+) = (DIN-)	-15		+15	mV
Maximum PES Pin Output Voltage	Controlled by AGC2			5.0	Vpp
PES Pin Output Offset Voltage	V_{PES} - VREF, (DIN+) = (DIN-) $\overline{LATCHA/B}$ = Low After 30 sec. temp. stable	-50		+50	mV
Output Resistance, BURSTA/B & PES pins				20	Ω
Hold A/B Charge Current	$\overline{LATCHA/B}$ = Low	25			mA
HOLDA/B Discharge Current Tolerance	$\overline{RSTA/B}$ = Low, ICS = 2.6V/(RSC + 750Ω)	-15		+15	%
	$\overline{RSTA/B}$ = High, $\overline{LATCHA/B}$ = High	-0.5		+0.5	µA
Load Resistance BURSTA/B, PES pins	Resistors to VREF	10.0			kΩ
Load Capacitance BURSTA/B, PES pins				20	pF
$\overline{LATCHA/B}$ pin set up time	(Tds1 in Figures 3 & 4)	150			ns
$\overline{LATCHA/B}$ pin Hold Time	(Tds2 in Figures 3 & 4)	150			ns
Channel A/B Discharge Current Turn On time	(Tds3 in Figures 3 & 4)			150	ns
Channel A/B discharge Current Turn Off time	(Tds4 in Figures 3 & 4)			150	ns
BYP2 Pin Parasitic Input Current	$\overline{HOLD2}$ = Low LOCOFF = Low LOCOFF = High	 -0.02 -9.0		 +0.02 +9.0	 µA µA

SERVO SECTION (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
BYP2 Pin Charge/Discharge Current $I_C = K_4[(K_5 \bullet V_{AGC2}) - V_{A(DIN)pp} - V_{B(DIN)pp}]$	K_4, $\overline{HOLD2}$ = High	487	650	813	µA/Vpp
	K_5, $\overline{HOLD2}$ = High	0.35		0.43	V/V
*AGC Gain Range	LOCOFF=Low	0.6		6.0	V/Vpp
V_{PES} pp vs. V_{AGC2}	V_{PES} pp/V_{AGC2} LOCOFF = Low	1.24	1.38	1.52	Vpp/V
	LOCOFF = High	1.42	1.5	1.58	
	V_{PES} pp/V_{AGC2} AGC2=Open LOCOFF = Low	5.03	5.3	5.56	Vpp Vpp/V
	LOCOFF = High	5.32	5.6	5.88	
BURSTA/B Pin Output vs. V_{AGC2}	$(V_A + V_B - 2VREF)/V_{AGC2}$ LOCOFF = High		0.77		V/V
	$V_A + V_B$ - 2VREF, AGC2=Open LOCOFF = High		2.85		V

*Av = (VPES - VREF)/($V_{A(DIN)pp}$ + $V_{B(DIN)pp}$)

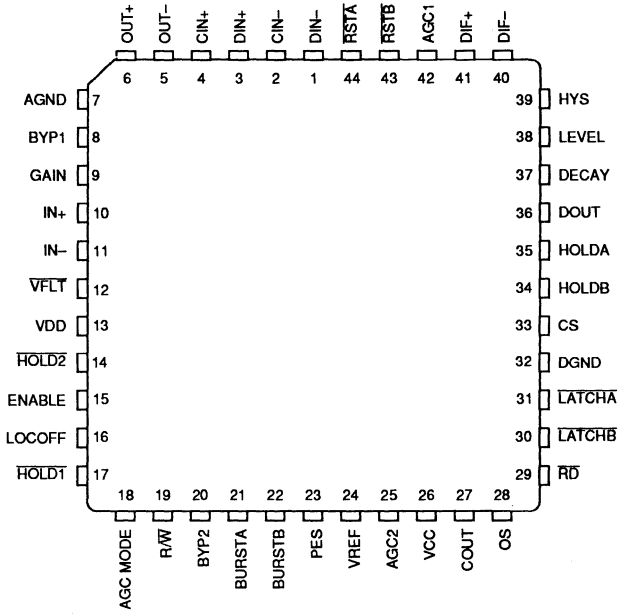
Supply Voltage Fault Detection

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
VDD Fault Threshold		9.1		10.5	V
VCC Fault Threshold		4.1		4.4	V
VOL Output Low	4.5 < VCC < 5.5V, IOL = 1.6 mA			0.4	V
	1.0 < VCC < 4.5, IOL = 0.5 mA			0.4	V
IOH Output High Current				25	µA

PACKAGE PIN DESIGNATIONS

(Top View)

CAUTION: Use handling procedures necessary for a static sensitive component.



44-pin PLCC

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32P544 - 44-pin PLCC	SSI 32P544-CH	32P544-CH

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32P547
High Performance Pulse Detector

Advance Information

July, 1990

2

DESCRIPTION

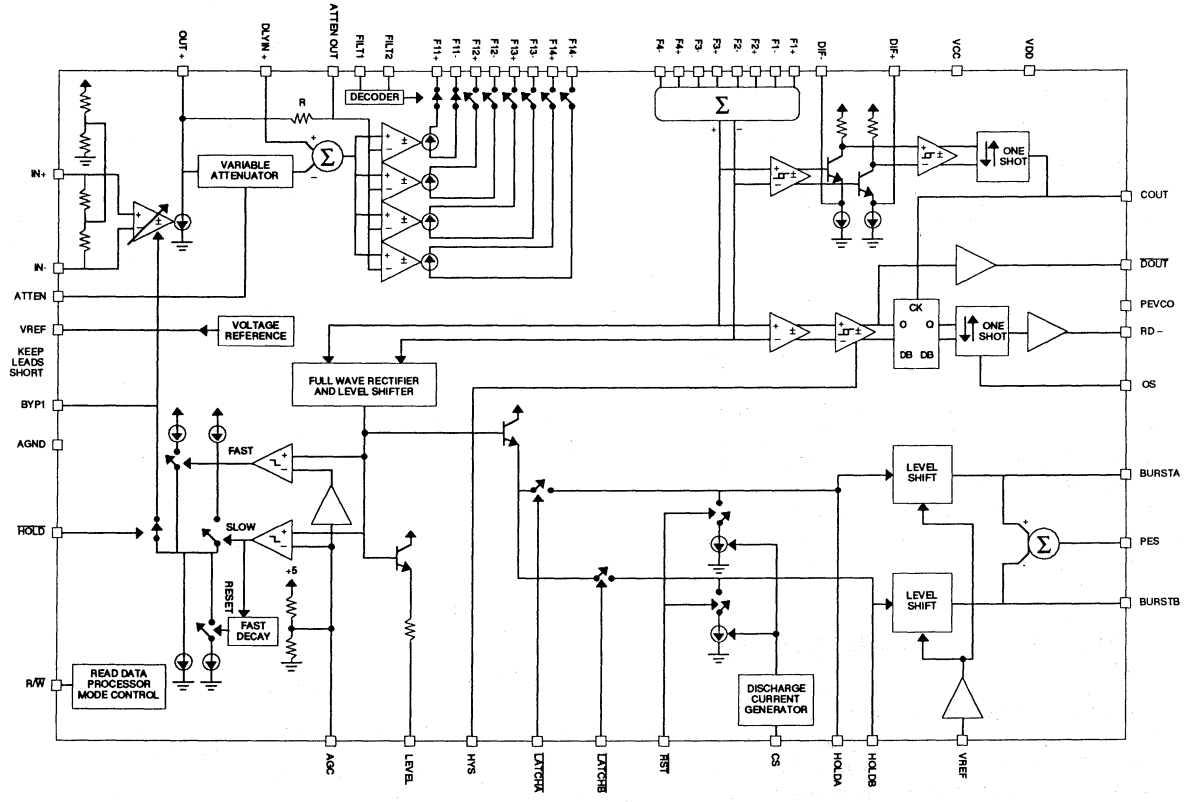
The SSI 32P547 Read Data Processor and Servo Demodulator with Variable Pulse Slimming and Zone Filter Mux is a fully integrated bipolar circuit that detects and validates amplitude peaks in the output from a disk drive read amplifier, as well as detecting embedded servo information to provide position error signals used for read head positioning.

Time and amplitude qualification are used to provide a PECL output that accurately duplicates the time position of input signal peaks. An AGC control loop, using a dual rate charge pump, provides a constant input amplitude for the level qualifier.

FEATURES

- **Wide bandwidth AGC input amplifier**
- **Uses standard +12V and +5V ± 10% supplies**
- **Level qualification supports MFM or RLL codes**
- **Servo burst capture circuit for use in embedded servo**
- **Four input differential filter MUX**
- **Pulse Slimming with Variable Attenuation**

BLOCK DIAGRAM



CIRCUIT OPERATION

Level qualification can be implemented as fixed threshold or a constant percentage that tracks signal amplitude that enhances qualification during AGC loop transients.

The Servo Demodulator consists of two peak detector channels that capture rectified servo data peaks. Buffered individual channel outputs are provided along with a difference output.

The SSI 32P547 requires standard ±10% tolerance +5V and +12V supplies and is available in a 52-pin Quad PLCC package.

MODE CONTROL

The circuit mode is controlled by the R/$\overline{W}$, and $\overline{HOLD}$ as shown in Table 1.

READ MODE

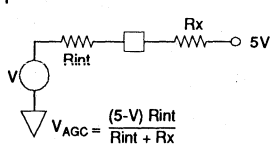
The circuit is placed in the read mode when the R/$\overline{W}$ pin is high or open and is disabled (write mode) when the R/$\overline{W}$ pin is low. In the write mode the digital circuitry is disabled, the AGC amplifier gain is set to maximum and the input impedance of the input analog stage is reduced to allow more rapid settling of the input coupling capacitors from the read/write circuit (such as the SSI 32R510A) upon transition to the read mode. Write to read transition timing is controlled to allow settling of the coupling capacitors between the read/write circuit and the SSI 32P547 before the AGC circuitry is activated when going to the read mode. Coupling capacitors should be chosen with as low a value as possible consistent with adequate bandwidth to allow for more rapid settling. When the R/$\overline{W}$, and $\overline{HOLD}$ pins are high or open the input amplifier is in the read data AGC mode and gain is controlled to keep a constant read data peak level. When the $\overline{HOLD}$ pin is pulled low the gain of the analog circuit is held at the level determined when the $\overline{HOLD}$ pin was high (the gain will slowly drift due to leakage).

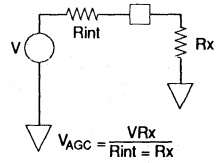
READ DATA AUTOMATIC GAIN CONTROL CIRCUIT

In this mode an amplified head output signal, such as the output of the SSI 32R117, 32R501, or 32R510A read/write circuits, is AC coupled to the IN+ and IN- inputs. In the read mode the level at the Fx +/- pins is controlled by full wave rectifying the level at the summer output and comparing it to a reference level supplied at the AGC pin. When the input level at the filter outputs is greater than 125% of the desired level as set by the AGC pin, the circuit is in a fast attack mode and will supply about 1.4mA of charging current at the BYP pin. When the input level is between 125% and 100% of the desired level, the circuit enters a slower attack mode and will supply about 0.16mA of charging current. This allows the AGC to rapidly recover when going from write to read but reduces zero crossing distortion once the AGC amplifier is in range.

To reduce the effect of gain attack overshoot on settling time (due to offsets) a fast decay mode is entered if slow decay mode exceeds 1.6 µsec (nom). Fast decay discharge current is 0.8 mA and slow decay discharge current is 4.5 µA.

The AGC pin is internally biased so that the level at the filter input pins is 0.83 Vpp. The level at the filter input pins can be increased by tying a resistor from the AGC pin to VCC or reduced by tying a resistor from the AGC pin to GND.





Where:

V = Voltage at AGC with pin open (2.4V, nom.)

Rint = AGC pin input impedance (6.7 KΩ, typ.)

Rx = External resistor.

The new DIN+/- input target level is nominally 0.43 Vp-p/V_{AGC}.

Gain of the AGC section in the AGC mode is approximately: $\left(\frac{Av1}{Av2}\right) = \exp\left[6.9 \times (V2 - V1)\right]$

Where:

Av1, Av2 are initial and final amplifier gains. V1, V2 are initial and final voltages on the BYP pin.

READ DATA PULSE SLIMMING CIRCUIT

The Pulse Slimming Circuit uses an external delay line and an analog controllable Variable Attenuator to implement pulse slimming. Input biasing for this stage is accomplished by low pass filtering the signal at the

OUT+ pin with an on chip resistor and external capacitor tied to the INREF pin and using that signal as a reference to the following single ended to differential stage.

$$\text{Freq}(-3\text{dB}) = \frac{1}{2\pi RC}$$

Where: R (lowpass) is the on-chip resistor = 6KΩ
C (ext) is the external capacitor

The ratio between the gains of the attenuated and non-attenuated signal paths (K) is controlled by varying the gain of the on-chip attenuator:

K = Ko - G x V (ATTEN) / VREF2_2

Where G is the gain factor, V (ATTEN) is the voltage applied to the ATTEN pin. VREF2_2 is the voltage on the VREF2_2 pin and Ko is the initial value for K when V(ATTEN) = 0.0V.

SELECTABLE EXTERNAL FILTER DRIVER/RECEIVER

The on-chip circuitry allows four separate filters to be used for support of constant density recording. A filter is selected by using the two TTL input filter select pins; FILT1, and FILT2. Filter selection is as follows:

Filter1	Filter 2	Channel
0	0	F11
0	1	F12
1	0	F13
1	1	F14

READ MODE DIGITIZING SECTION

In the data path the signal is sent to a hysteresis comparator. The comparator hysteresis level can be set at a fixed level or, with the addition of an external filter network, a fraction of the signal level.

The latter approach allows setting the AGC circuit decay and slow attack times slow enough to minimize distortion of the signal going into the clocking path and setting a short time constant for the hysteresis level. Thus when switching to a head with a different output level or when switching from write to read the circuit is properly decoding data before the AGC circuit gain has settled to its final steady state value. The output of the hysteresis comparator is the "D" input of a D flip-flop. The $\overline{\text{DOUT}}$ pin provides a PECL comparator output digital signal for testing purposes and, if required, for use in the servo circuit.

In the clocking path the signal is sent to a differentiator circuit whose characteristics are set by external components. The differentiator transfer expression from Fx+/- to the comparator input (which is not the DIF+/- output) is:

$$Av = \frac{-2\,Cex\,Ris}{2\,Lex\,Cex\,s^2 + Cex\,(Rex + 2Re)\,s + 1}$$

Where: Ri= on chip resistors = 1.0 KΩ nominally; Re= emitter resistance seen at DIF+ or DIF- = 46 Ω nominally; Cex= external capacitor, allowable range is 20 pF to 150 pF; Rex= external resistor; Lex= external inductor.

The output of the differentiator circuit is sent to the edge trigger circuit which creates an output pulse on every zero crossing of the output of the differentiator. The output of the edge trigger is the clock input of the D flip-flop. During normal system operation the differentiator circuit clocks the D flip-flop once every positive and negative peak of the input signal.

The data path D input to the flip-flop only changes state when the signal applied to the filter inputs exceeds the hysteresis comparator threshold in a polarity opposite the polarity of the peak which last exceeded the threshold. Therefore, the clocking path determines signal timing and the data path blocks spurious peaks if they do not exceed the hysteresis comparator threshold. Figure 5 shows circuit operation of the digital section. The two digital signal path delays between the Fx+, Fx- inputs to the flip flop inputs are well matched.

SERVO BURST CAPTURE SECTION

Rectified servo data peaks are latched into the A or B servo channels by pulling the TTL compatible inputs $\overline{\text{LATCHA}}$ or $\overline{\text{LATCHB}}$ low, respectively. A chip-generated discharge current is turned on for channels A or B by pulling the TTL compatible input $\overline{\text{RST}}$ low. The magnitude of this discharge current is set by a resistor tied to the CS pin.Outputs of the BURSTA, BURSTB, and PES are referenced to an externally generated reference applied at the VREF pin.

PIN DESCRIPTIONS

POWER SUPPLY AND CONTROL

NAME	I/O	DESCRIPTION
VCC		5 Volt power supply.
PEVCC		Collector of PECL emitter follower output which is to be connected to the 5 volt power supply.
VDD		12 volt power supply
AGND		Analog ground pin
R/$\overline{W}$	I	TTL compatible read/write control pin

AGC GAIN STAGE

IN+,IN-		Analog signal input pins
OUT+		Transconductance output for the AGC amplifier and input to the variable attenuator
DLYIN		Delayed input signal to the pulse slimming amplifier
INREF		Reference DC voltage to the single ended to differential gain stage
VREF2_2		Internally generated voltage used as a reference by the external DAC used to control the attenuator gain
BYP		The AGC timing capacitor is tied between this pin and AGND
$\overline{HOLD}$	I	TTL compatible control pin which holds the input AGC amplifier AGC level when pulled low
ATTEN		An Analog input which controls the attenuation value from 0 to 0.80 for the Variable Attenuator
AGC		Reference input voltage for the AGC circuit

SERVO BURST CAPTURE STAGE

$\overline{LATCHA}$	I	TTL inputs which initiates capture of a servo burst
$\overline{LATCHB}$		Peak on channel A or B when pulled low
HOLDA HOLDB		Peak holding capacitors are tied from each pin to GND
$\overline{RST}$	I	TTL input which initiates discharge of channel A and B hold capacitors when pulled low
CS		Pin to control magnitude of discharge current during active discharge of channel A and B hold capacitors
VREF		Reference level for servo circuit
BURSTA BURSTB		Buffered burst peak outputs
PES		BURST_B minus BURST_A output

NOTE: COUT, $\overline{DOUT}$, $\overline{RSTA}$ and $\overline{RSTB}$ are not brought out in a 44-pin package.

DIGITAL PROCESSING STAGE

NAME	I/O	DESCRIPTION
FIX± FX±		Differential filter I/O to the four external filters
FILT1 FILT2	I	TTL compatible inputs to control multiplexer for selection of 1 of 4 filters
HYS		Hysteresis level setting input to the hysteresis level detect comparator
LEVEL		Provides rectified signal level for input into the hysteresis circuit
$\overline{DOUT}$	O	A Pseudo ECL D input into D flip-flop provided for testing or servo use
DIF+,DIF-		Pins for external differentiator components
COUT	O	Clock input into D flip-flop provided for testing
OS		Pin for external capacitor in the one shot which determines read channel output one-shot pulse width
RD	O	A Pseudo ECL (PECL) read output

TABLE 1: Mode Control

MODE	R/$\overline{W}$	$\overline{HOLD}$	CONDITIONS
Read/AGC	1	1	Read amp on, AGC active and controlled by data, Digital section active
Read/Hold	1	0	Read amp on at fixed gain, AGC level held constant Digital section active
Write	0	-	Read amp on with reduced input impedance AGC level pulled low, Digital section deactivated, BYP pin set for maximum AGC gain

ABSOLUTE MAXIMUM RATING

Operation above absolute maximum ratings may permanently damage the device.

PARAMETER	RATING	UNITS
+5V Supply Voltage,VCC, PEVCC	6.0	V
+12V Supply Voltage,VDD	14.0	V
Pin Voltage BYP, AGC, LEVEL, HYS, HOLD_A/B, VREF, BURST_A/B, PES, DIF+/-, FIX±	-0.3 to VDD+0.3	V
Pin Voltage IN+/-, $\overline{HOLD}$, R/$\overline{W}$, $\overline{RST}$, ATTEN, $\overline{LATCHA/B}$, CS, OS, FILT1-2, FIX±, OUT+, DLYIN, INREF, VREF2_2	-0.3 to VCC+0.3	V

ABSOLUTE MAXIMUM RATING (continued)

PARAMETER	RATING	UNITS
RD, $\overline{DOUT}$, COUT	-0.3 to VCC+0.3 or +12mA	V
Storage Temperature	-65 to +150	°C
Lead temperature (soldering 10 sec)	260	°C

RECOMMENDED OPERATING CONDITIONS

Currents flowing into the chip are positive.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VCC Supply Voltage		4.5	5.0	5.5	V
VDD Supply Voltage		10.8	12.0	13.2	V
Tj Junction Temperature		25		145	C
Ta Ambient Temperature		0		70	C

ELECTRICAL CHARACTERISTICS

POWER SUPPLY

Recommended conditions apply unless otherwise specified.

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
ICC	VCC Supply Current	Outputs unloaded			50.0	mA
IDD	VDD Supply Current	Outputs unloaded			80.0	mA
Pd	Power dissipation	Ta=70° C Outputs unloaded			1.25	W

MODE CONTROL

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Read-to-Write Transition time	R/$\overline{W}$ Pin High → Low			1.0	µs
Write to Read Transition time	R/$\overline{W}$ Pin Low → High AGC settling not included	1.2		3.0	µs
Hold On ↔ Hold off Transition time	$\overline{HOLD}$ Pin High ↔ Low R/$\overline{W}$ Pin High			1.0	µs

LOGIC SIGNALS ($\overline{HOLD}$, FILT1-2, R/$\overline{W}$, $\overline{LATCHA}$,$\overline{B}$, $\overline{RST}$ Pins)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
VIL Input Low Voltage		-0.3		0.8	V
VIH Input High Voltage		2.0		VCC+0.3	V
IIL Input Low Current	VIL = 0.4V	0.0		* -0.8	mA
IIH Input High Current	VIH = 2.4V			100	µA

*For $\overline{RST}$ only.

PECL OUTPUT: RD, $\overline{DOUT}$ PINS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Output Low Voltage				VCC-1.625	V
Output High Voltage		VCC-1.02			V
Output Rise Time	10 to 90 %			5.0	ns
Output Fall Time	90 to 10 %			5.0	ns

*Output load is a 2.5 KΩ resistor to GND, and a 5 pF capacitor to ground.

AUTOMATIC GAIN CONTROL CIRCUIT

All of the measurements in the AGC gain mode are made with the following conditions unless otherwise stated:

1. The circuit is in the read mode (R/$\overline{W}$, and $\overline{HOLD}$ pins high).
2. The circuit is connected as in figure 4.
3. The amplifier inputs, IN+ and IN- , are AC coupled.
4. The OUT+ pin is loaded with 100 Ω to Vcc and Fx+, Fx- 200Ω each to V_{DD}.
5. A 2000 pF capacitor is tied between BYP and GND.
6. The AGC pin is left open.

READ DATA MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Slow AGC Capacitor Discharge Current	V(Fx+ - Fx-)=0.0		4.5		µA
Fast AGC Capacitor Discharge Current	V(Fx+ -Fx-)=0.0		0.8		mA
Fast Decay Hold Off Time	Slow Attack Threshold Not Reached	0.7	1.6	3.0	µs
AGC Capacitor Leakage Current	R/$\overline{W}$ pin high, $\overline{HOLD}$ low	-0.2		0.2	µA

ELECTRICAL CHARACTERISTICS (continued)

READ DATA MODE (continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Slow AGC Capacitor Charge Current	V(Fx+ - Fx-)=0.41 Vdc, Vary V(AGC) until slow discharge begins	-0.14		-0.22	mA
Fast AGC Capacitor Charge Current	V(Fx+ - Fx-)=0.8 Vdc V(AGC)=3.0V, Vary AGC until fast charge begins	-1.3		-2.0	mA
Fast → Slow Attack Switchover Point	V(Fx+ – Fx–) V(Fx+ – Fx–) Final; AGC pin open		0.15		V
Gain Attack Time (Ta) See Fig. 1	R/$\overline{W}$ = low → high, Vin= 400 mVpp @ 2.5 Mhz, V(Fx) to 110% final value		4		µs
Fx+ - Fx- Input Voltage Swing vs AGC Input Voltage	15 mVpp < V(IN+ - IN-) < 250 mVpp, 0.4 Vpp < V(Fx+ - Fx-) < 1.25 Vpp	0.25		0.48	Vpp/V
Fx+ - Fx- Input Voltage Swing Variation	15 mVpp < V(IN+ - IN-) < 250 mVpp 0.4 Vpp < V(Fx+ - Fx-) < 1.25 Vpp			8.0	%
AGC Pin Input Impedance		5.0		8.3	KΩ
AGC Pin Voltage	AGC pin open	2.28	2.4	2.52	V

AGC AMPLIFIER CHARACTERISTICS

Gain Range	Z Load = 100Ω	0.3		16.5	V/V
Output DC Voltage Variation	V(OUT+) DC level from min. to max gain V(IN+) = V(IN-)			±150	mV
Maximum Output Voltage Swing on OUT+ pin				360	mVpp
Differential Input Resistance	V(IN+ - IN-)=100 mVpp @ 2.5 Mhz		5.0		KΩ
Differential Input Capacitance	V(IN+ - IN-)=100 mVpp @ 2.5 Mhz			10.0	pF
Common Mode Input Impedance (Both Sides)	R/$\overline{W}$ pin = high R/$\overline{W}$ pin = low		1.8 250		KΩ Ω
Input Noise	Gain set to 16 V/V			25	$\frac{nV}{\sqrt{(Hz)}}$

AGC AMPLIFIER CHARACTERISTICS (continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Bandwidth	Transconductance (Iout/Vin) ± 3 dB bandwidth	40			MHz
Common Mode Rejection Ratio (Input Referred)	V(IN+) = V(IN-) = 100 mV, 5 Mhz, Gain set to 16 V/V	40			dB
Output DC Current on OUT+ Pin	IN+, IN- Shorted Together	TBD	4.5		mA
Output Impedance, OUT+ Pin		TBD	50		KΩ
Allowable DC Load Resistance To VCC on OUT+ Pin		88		112	Ω
Allowable AC Load Impedance on OUT+ Pin		88		112	Ω
Power Supply Rejection Ratio (input referred)	ΔV(VDD) or ΔV(VCC) = 100 mVpp, 5mHz, gain set at 16 V/V	22			dB

PULSE SLIMMER, EXTERNAL FILTER DRIVERS AND VARIABLE ATTENUATOR

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
R (low pass) Internal		5		9	KΩ
Gain from OUT+ pin to (F1x+ - F1x-)	V (ATTEN) = 0.0 VREF2_2		9		V/V
Attenuator Gain Ratio Range	$K = \frac{Av\ (attenuated)}{Av\ (non-attenuated)}$	0.05	0.83	0.84	
	K = Kmin K = Kmax	 0.84		0.05	
Gain Factor G Tolerance	G = 0.82, V(ATTEN) = VREF2_2	-2.5		+2.5	%
Initial K, Ko Tolerance	Ko = 0.83, V(ATTEN) = 0.0	-1.5		+1.5	%
Attenuator Gain K Ratio Linearity	0.0 < V(ATTEN) < VREF2_2	-0.0		-3.5	%
OUT+ to INREF pin resistance	C (INREF) = .01μF	5		9	KΩ
Output Voltage Ref VREF2_2 Pin	Iload = -.7mA	1.95	2.28	2.45	V
Output Voltage Ref VREF2_2 Pin	Iload = -.7mA		4		Ω
Output Current Load VREF2_2 Pin			-.7	-1.0	mA
Maximum Output Voltage Swing		1.25			Vpp
Input Resistance OUT+ Pin			50		KΩ
Input Capacitance OUT+ Pin			5		pF

ELECTRICAL CHARACTERISTICS (continued)

PULSE SLIMMER AND EXTERNAL FILTER DRIVERS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Input Resistance DLYIN Pin			200		KΩ
Input Capacitance DLYIN Pin			5		pF
Bandwidth	Transconductance I(FIX± 1V(out+)	40			MHz
Allowable External DC Load Resistance	FIX± to VDD	190		210	Ω
Power Supply Rejection Ratio (Input Referred)	ΔV (12) or ΔV (5) = 100 mVpp, 5 MHz Delayline Shorted	45			dB
Input Resistance ATTEN Pin			200		KΩ
Input Bias Current ATTEN Pin			8		μA

READ MODE DIGITIZING SECTION

All of the measurements in the read mode digital section are made with the following conditions unless otherwise stated:

1. The circuit is in the read mode (R/$\overline{W}$ pin is high).
2. The Filter input pins, (Fx+, Fx-) receive AC coupled 2.5 MHz, 0.83 Vpp sine wave input signal.
3. 100 Ω in series with 65 pF are tied between DIF+ and DIF-.
4. A 1.8 Vdc voltage is applied to the HYS pin.
5. OS is tied to the 5V supply with a 60 pF capacitor, Cos.
6. The $\overline{DOUT}$ pin is loaded with a 2.5 KΩ resistor to GND volts and a 5 pF capacitor to GND.
7. The RD pin is loaded with a 2.5 KΩ resistor to GND volts and a 5 pF capacitor to GND.

SUMMER AND BUFFER

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Input Signal Range	V(Fx+ - Fx-)			1.25	Vpp
Differential Input Resistance	V(Fx+ -Fx-) =100 mVpp DC	10		18	KΩ
Differential Input Capacitance	V(Fx+ - Fx-) =100 mVpp @2.5 MHz			4.0	pF
Common Mode Input Impedance	On all Fx+ to Fx- Fx+/- tied together	2.5		4.5	KΩ
Bandwidth	V(DIFI) V(FXI)	45			MHz

HYSTERESIS COMPARATOR CIRCUIT

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
LEVEL Pin Output Voltage vs Fx+ - Fx- Input Voltage	0.4 < V(Fx+ -Fx-) < 1.25 Vpp, 10 KΩ between LEVEL pin and GND	1.5		3.0	V/Vpp
LEVEL Pin Output Impedance	I(LEVEL) = 0.5 mA		180		Ω
LEVEL Pin Maximum Output Current		3.0			mA
Comparator and Summer Offset Voltage	HYS pin at GND, ≤1.5 KΩ across Fx+,Fx-.			20.0	mV
Input referred Hysteresis Voltage (at Fx+ - Fx- Pins) vs HYS Pin Voltage	1 V < V(HYS) < 3 V	0.16		0.25	V/V
Hysteresis threshold margin as a % of V(Fx+ - Fx-) peak	V(HYS) = At a typical of 60% *V(AGC) or V(LEVEL) 1V < V(HYS) < 3V *see figures 2 & 3	-15		+15	%Peak
HYS Pin Input Current	1 V < V(HYS) < 3 V	0.0		-20	µA

* In an open loop configuration where reference is V(AGC) tolerance can be sightly higher.

DIFFERENTIATOR CIRCUIT

Voltage Gain from Fx+/- to DIF+/-	R(DIF+ to DIF-) = 2.0 KΩ	2.0		3.06	V/V
DIF+ to DIF- Pin Current	Differentiator impedance must be set so as to not clip the signal for this current level	±1.3			mA
Comparator Offset Voltage	DIF+, DIF- AC coupled not measured			10.0	mV
COUT Pin Output Low Voltage	0.0 ≤ Iol ≤ 0.5 mA		VDD-3.0		V
COUT Pin Voltage Pulse Voltage V(high) - V(low)	0.0 ≤ Ioh ≤ 0.5 mA		+0.4		V
COUT Pin Voltage Pulse Width	0.0 ≤ Ioh ≤ 0.5 mA		30		ns
Required DFF Set-up Time, Td1 in Fig. 6	Minimum allowable time delay from V(Fx+,Fx-) exceeding hysteresis point to V(DIF+,DIF-) hitting peak value peak value	0			ns
Propagation Delay, Td3 in Fig. 6				110	ns
One-shot Capacitor Value (Cos)		20		200	pF
Output Data Pulse Width and Pulse Width Variation at RD Pin, Td5 in Fig. 6	Td5 = 900 x Cos @ V(RD) = 50% 20 ≤ Cos ≤ 200 pF			±15	%

ELECTRICAL CHARACTERISTICS (continued)

READ DIGITAL SECTION AS SYSTEM

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Pulse Pairing |Td3 - Td4| Fig. 6	0.83 Vpp into Fx+/- pins at 2.5 MHz			1.5	ns
	0.83 Vpp into Fx+/- pins at 9.0 MHz			1.0	ns

SERVO BURST CAPTURE CIRCUIT

All of the measurements are made with the following conditions unless otherwise stated:

1. The circuit is connected as in Fig. 5.
2. A and B bursts are sampled onto $\overline{\text{BURSTA}}$ and $\overline{\text{BURSTB}}$ pins.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VREF Voltage Range		3.9		6.0	V
BURSTA, BURSTB Pin Output Voltage vs (Fx+ - Fx-) Input Voltage	$AV=\frac{V(BURST)-VREF}{V(Fx+-Fx-)}=2.6\,V/Vpp$ $\overline{\text{LATCHA}}$ or $\overline{\text{LATCHB}}$ = Low			±11	%
BURSTA, BURSTB Output Offset Voltage	V(BURST) - V(VREF), $\overline{\text{LATCHA}}$, $\overline{\text{LATCHB}}$ Low, V(Fx+) = V(Fx-), RCS = 38.3 KΩ, or $\overline{\text{RST}}$ low			±50	mV
BURSTA - BURSTB Output Offset Voltage Match	V(BURSTA)-V(BURSTB), $\overline{\text{LATCHA}}$, $\overline{\text{LATCHB}}$ Low, V(Fx+) = V(Fx-)			±15	mV
PES Pin Output Offset Voltage	V(PES) - V(VREF), $\overline{\text{LATCHA}}$, $\overline{\text{LATCHB}}$ Low, V(Fx+) = V(Fx-)			±50	mV
PES Pin Output Voltage vs. Va(Fx)pp - Vb(Fx)pp	$AV=\frac{V(PES)-VREF}{Va(Fx)pp-Vb(Fx)pp}=2.6V/Vpp$			±15	%
Output Resistance BURSTA, BURSTB PES pins				20.0	Ω
HOLDA/B Charge Current		25			mA
HOLDA/B Discharge Current	$\overline{\text{RST}}$ = Low; Idis = 2.6/(RCS + 750)	-15		+15	%
	$\overline{\text{RST}}$ = High, LATCH_A/B = High			±0.5	µA
Load Resistance; BURSTA/B,PES pins	Resistor to VREF	10.0			KΩ
Load Capacitance; BURSTA/B,PES pins				20.0	pF

SERVO BURST CAPTURE CIRCUIT (continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
$\overline{\text{LATCHA/B}}$ Pin Setup Time (Tds1 in Fig. 2)		150			ns
$\overline{\text{LATCHA/B}}$ Pin Hold Time, (Tds2 in Fig. 2)		150			ns
Channel A/B Discharge Current Turn On Time (Tds3 in Fig. 2)				150	ns
Channel A/B Discharge Current Turn Off Time (Tds4 in Fig. 2)				150	ns

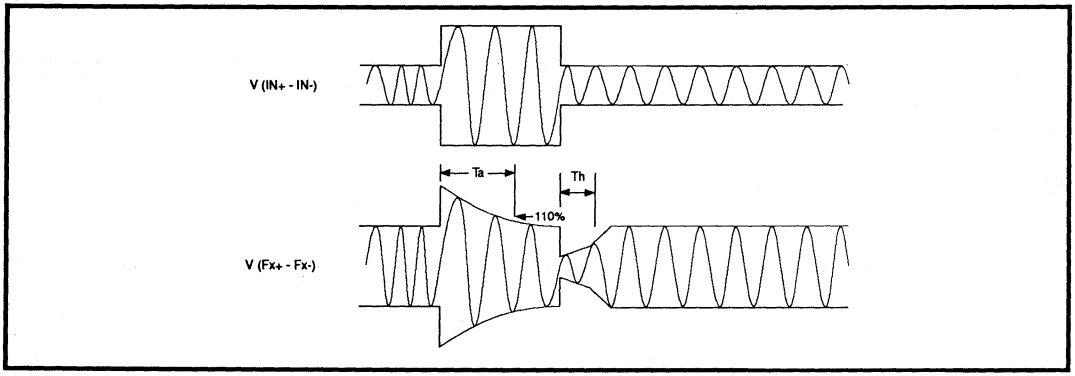


FIGURE 1: AGC Timing Diagram

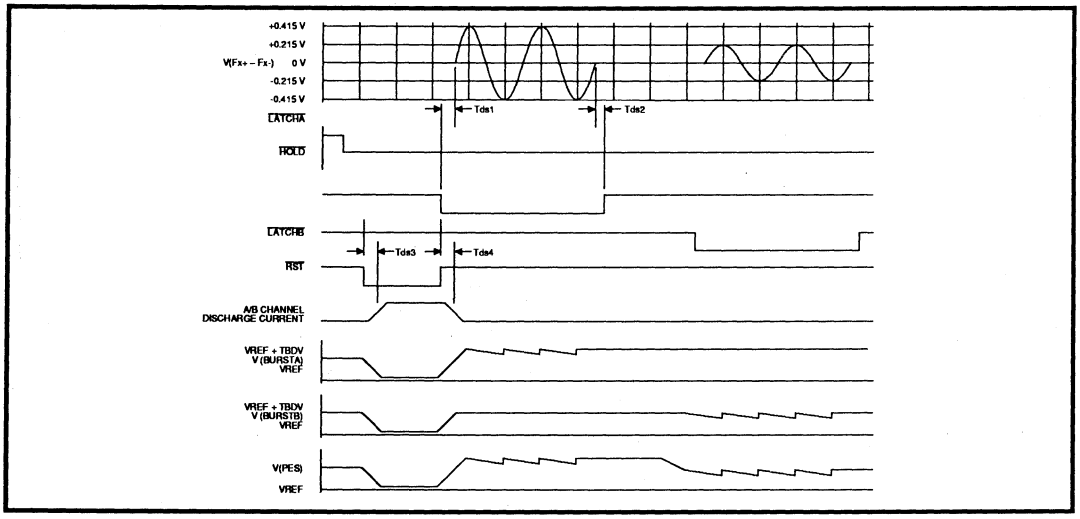


FIGURE 2: Servo Timing Diagram

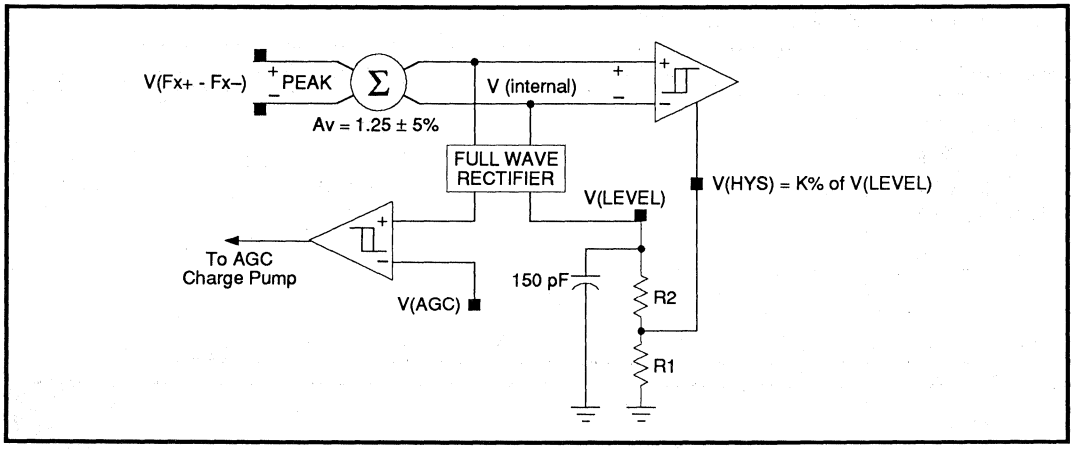


FIGURE 3: Feed Forward Mode

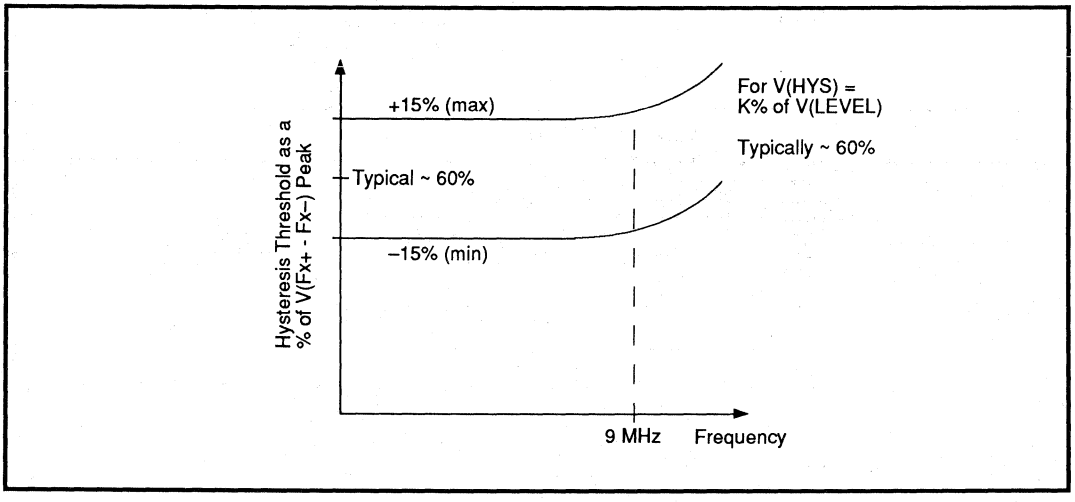


FIGURE 4: Percentage Threshold vs. Frequency

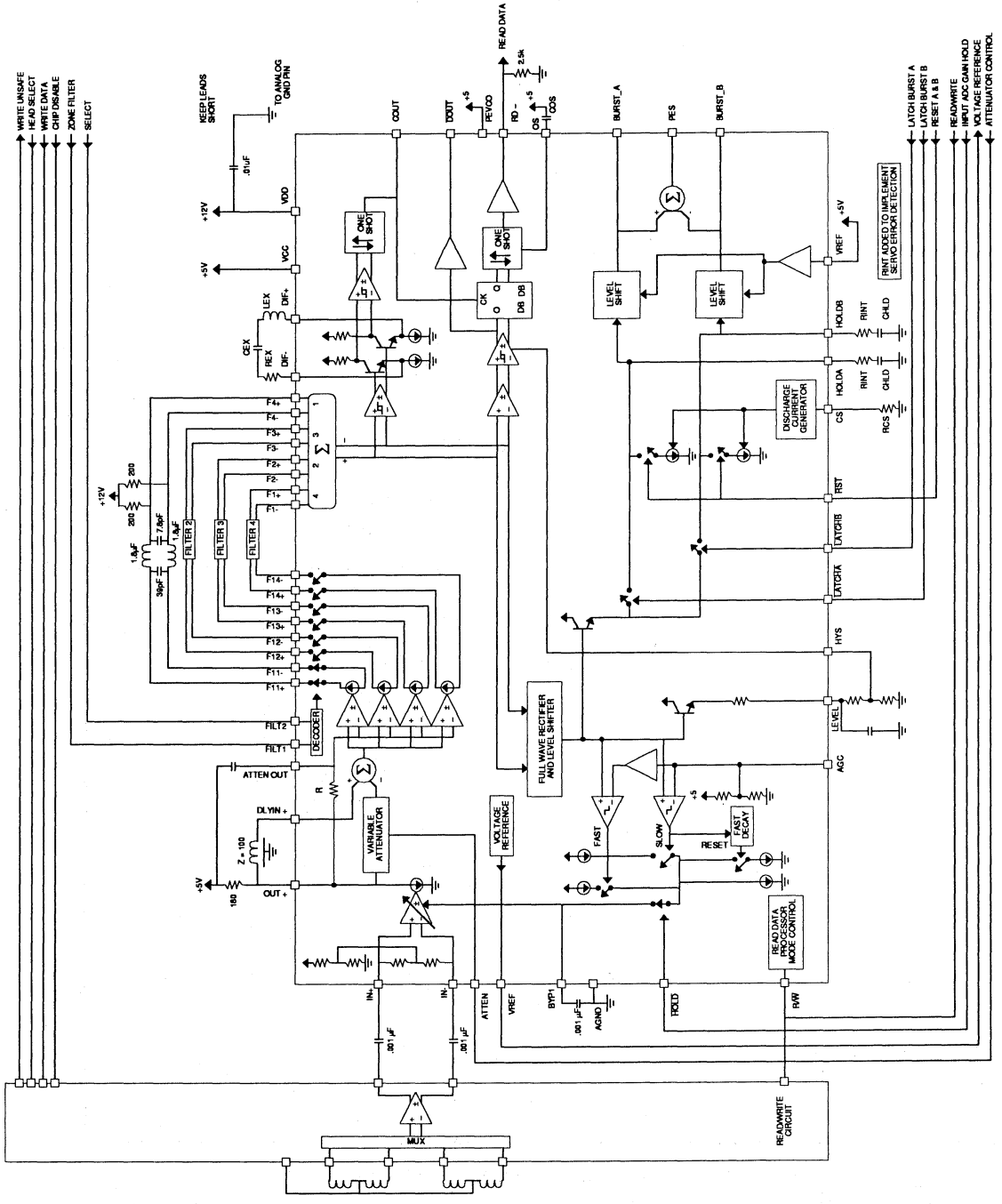


FIGURE 5: Applications Circuit Diagram

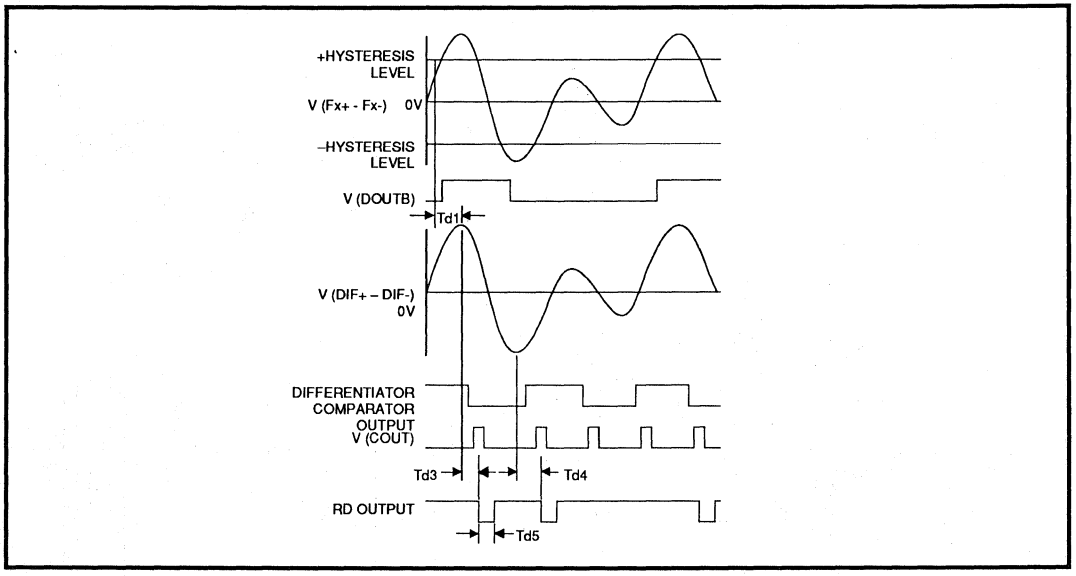


FIGURE 6: Read Mode Digital Section Timing Diagram

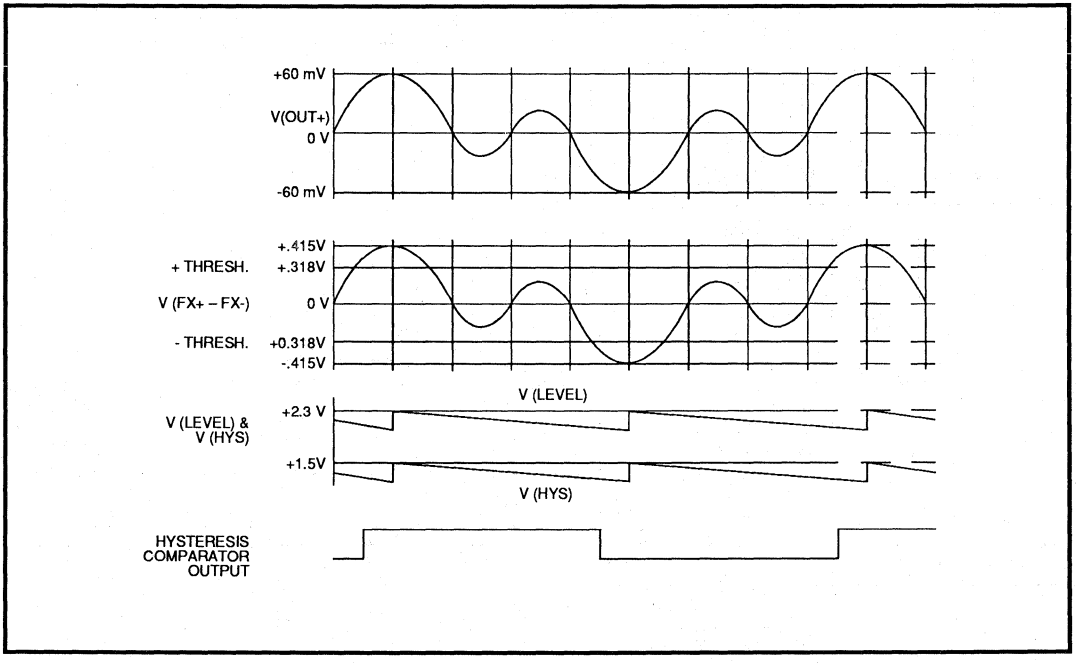
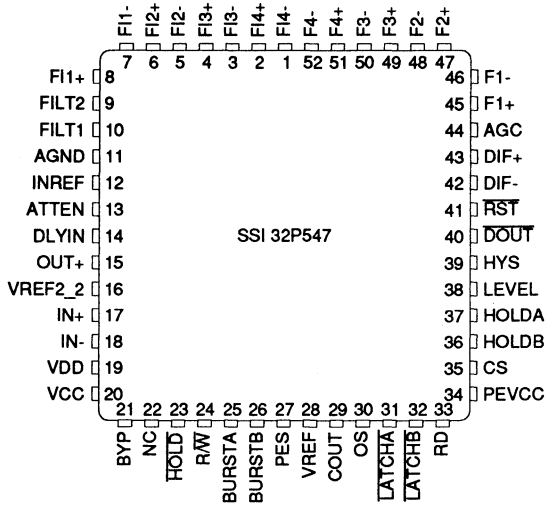


FIGURE 7: Expected Nominal Voltage Levels

PACKAGE PIN DESIGNATIONS
(Top View)

CAUTION: Use handling procedures necessary for a static sensitive component.



52 Pin Leaded Chip Carrier

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only. Do not use for final design.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32P548
Pulse Detector & Data Synchronizer
Advance Information

July, 1990

2

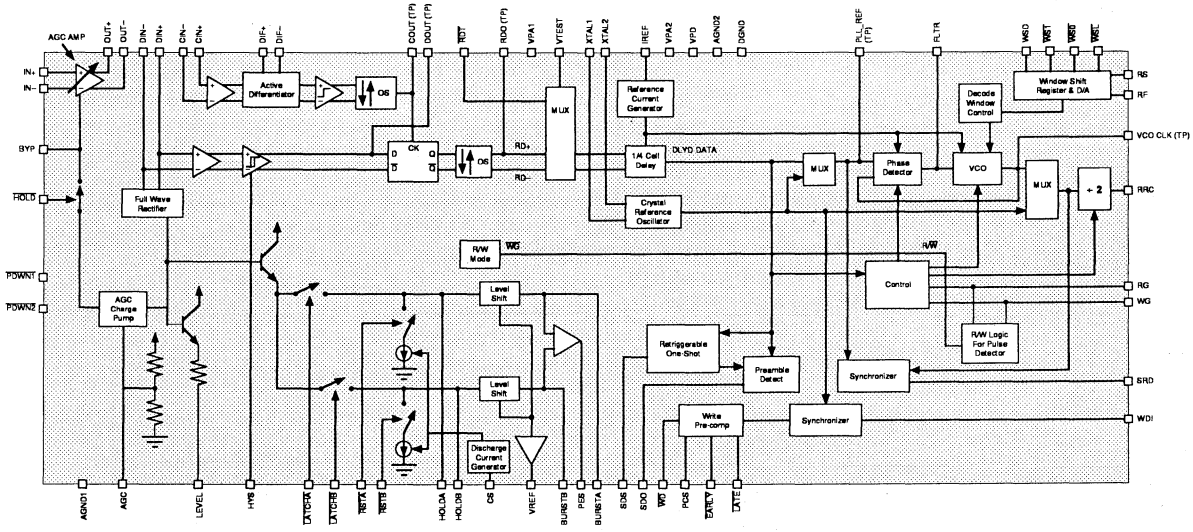
DESCRIPTION

The SSI 32P548 is a low power, high performance Pulse Detection, Data Synchronization combination device. This device is designed for use in low power applications requiring +5V only power supplies. The pulse detection portion of this device detects and validates amplitude peaks in the output from a disk drive read amplifier, as well as detecting embedded servo information to provide position signals used for read head positioning. The data synchronization portion is a 2, 7 data synchronizer with window shift and write pre-compensation capability. The SSI 32P548 achieves low system operating power three ways, with a low operating power (+5V only design) and with two independent power down modes. Mode 1 is a complete shutdown or sleep mode. Mode 2 is a low power mode for use while acquiring servo, where all circuitry not associated with obtaining servo information is powered down. The SSI 32P548 is available in a 52-pin fine pitch QFP, and 68-pin PLCC.

FEATURES

- **Highly Integrated Pulse Detector and Data Synchronizer**
- **+5V only Power Supplies**
- **Low Power <750 mW (max)**
- **Dual Power Down Modes**
- **Dual Servo Burst Channels with Position Error Signal**
- **Low Pulse Pairing (≤ ±1 ns)**
- **5-12 Mbit/s operation**

BLOCK DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

CIRCUIT OPERATION

PULSE DETECTOR SECTION

READ MODE

In read mode the SSI 32P548 is used to process either data or servo signals. In the Data Read Mode the input signal is amplified and qualified using an AGC amplifier and pulse level qualification of the detected signal peaks. In the servo read mode the input signal is amplified and rectified. Two servo burst channels are available that provide A and B burst levels.

DATA READ MODE

An amplified head output signal is AC coupled to the IN+ and IN- pins of the AGC amplifier. Gain control is accomplished by full wave rectifying and amplifying the [(DIN+)-(DIN-)] voltage level and comparing it to a reference voltage level at the AGC pin.

The SSI 32P548 contains a dual rate attack charge pump. The value of the attack current is dependent on the instantaneous level at DIN±. For signal levels above 125% of the desired level a fast attack mode is invoked that supplies a 1.3 mA charge current to the network on the BYP pin. Between 125% and 100% of the desired level the circuit enters a slow attack mode and supplies 0.18 mA of charge current to the BYP pin.

Two decay modes are available and are automatically controlled within the device.

Upon a switch to write mode, the device will hold the gain at its previous value. When the device is then switched back to read mode the AGC holds the gain and stays in a low impedance state for 0.9 µs. It then switches into a fast/slow attack mode if the new gain required is less than the previously held gain or a fast decay mode if the gain required is more than its previous value. The fast decay current is 0.12 mA and stays on 0.9 µs. After the 0.9 µs time period the device stays in a steady state slow attack, slow decay mode. The slow decay discharge current is 4.5 µA.

The AGC pin is internally biased so that the target differential voltage input at DIN± is 1.0 Vp-p under nominal conditions. The voltage on this pin can be modified by tying a resistor between AGC and GND or VPA. A resistor to GND decreases the voltage level, while a resistor to VPA increases it. The resulting AGC

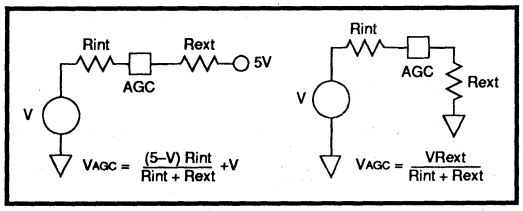


FIGURE 1: AGC Voltage

voltage level is shown in Figure 1; where:

V = Voltage at AGC w/pin open (2.3V, nom)

Rint = AGC pin input impedance (2.5 kΩ, typ)

Rext = External resistor

The new DIN± input target level is nominally 0.45 Vp-p/ V_{AGC}.

The maximum AGC amplifier output swing is 3.0 Vp-p at OUT±, which allows for up to 6dB loss in any external filter between OUT± and DIN±.

AGC gain is a linear function of the BYP-pin voltage (VBYP) as shown in Figure 2.

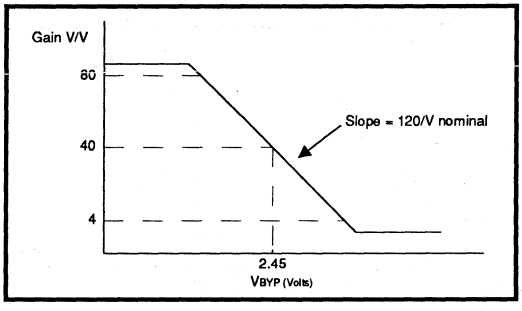


FIGURE 2: AGC Gain

The AGC amplifier has an open collector output and can sink 4.0 mA. For correct operation to the gain range the outputs should be pulled up to VPA through a 340Ω resistor as shown in Figure 3.

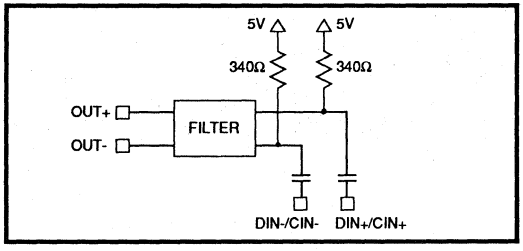


FIGURE 3: AGC Filter

In the 52-pin package configuration CIN+ and DIN+ will be bonded together, likewise CIN- and DIN- will be bonded together. In this situation one filter must be used for both time and amplitude channels. A multipole Bessel filter is typically used for its linear phase or constant group delay characteristics.

In the amplitude channel the signal is sent to a hysteresis comparator. The hysteresis threshold level is set so that it will be tripped only by valid signal pulses and not by baseband noise. It can be fixed level or a fraction of the DIN± voltage level.

The latter approach is accomplished by using an external filter/network between the LEVEL and HYS pins. This allows setting the AGC slow attack and decay times slow enough to minimize time channel distortion and setting a shorter time constant for the hysteresis level. The LEVEL pin output is a rectified and amplified version of DIN±, 1.0 p-p at DIN± results in 1.0 Vo-p nominally, at the LEVEL pin. A voltage divider is used from LEVEL to ground to set the Hysteresis threshold at a percentage of the peak DIN± voltage. For example, if DIN± is 1.0 Vp-p, then using an equal valued resistor divider will result in 0.5 Vpk at the HYS pin. This will result in a nominal ±0.18V threshold or a 36% threshold of a ±0.500V DIN± input. The capacitor is chosen to set an appropriate time constant. This "feed forward" technique speeds up transient recovery by allowing qualification of the input pulses while the AGC is still settling. This helps in the two critical areas of write to read and head change recovery. Some care in the selection of the hysteresis level time constant must be exercised so as to not miss pattern (resolution) induced lower amplitude signals. The output of the hysteresis comparator is the "D" input of a D-type flip-flop. The DOUT pin is a comparator output signal for testing purposes only.

In the time channel the signal is differentiated to transform signal peaks to zero crossings which are detected and used to trigger a bi-directional one-shot. The one-shot output pulses are used as the clock input of the D flip-flop. The COUT pin provides the one-shot output for test purposes.

The differentiator function is accomplished by an external network between the DIF+ and DIF- pins. The transfer function from CIN± to the comparator input (not DIF±) is:

$$Av = \frac{-2000Cs}{LCs^2 + C(R+92)s + 1}$$

where: C, L, R are external passive components
$20\ pF < C < 150\ pF$
$s = j\omega = j2\pi f$

During normal operation, the time channel clocks the D flip-flop on every positive and negative peak of the CIN± input. The D input to the flip-flop only changes state when the DIN± input exceeds the hysteresis comparator threshold opposite in polarity to the previous threshold exceeding peak.

The time channel, then, determines signal peak timing and the amplitude channel determines validity by blocking signal peaks that do not exceed the hysteresis comparator threshold. The delays in each of these channels to the D flip-flop inputs are well matched.

SERVO READ MODE

A position error signal (PES) is generated based on the relative amplitude of two servo signals, BURST A and BURST B.

Rectified servo signal peaks are captured on hold capacitors at the HOLDA/B pins. This is accomplished by pulling $\overline{\text{LATCHA}}$ or $\overline{\text{LATCHB}}$ low for a sample period. Additionally, a hold capacitor discharge current of up to 1.5 mA can be turned on by pulling $\overline{\text{RSTA}}/\overline{\text{RSTB}}$ low.

Outputs BURSTA/B and PES are referenced to an internal reference supplied by the VREF pin.

WRITE MODE

In Write Mode the SSI 32P548 Pulse Detector section is disabled and preset for the following Read Mode. The digital circuitry is disabled, the input AGC amplifier gain is held at its previous value and the AGC amplifier input impedance is reduced.

Holding the AGC amplifier gain and reducing input impedance shortens system Write to Read recovery times.

The lowered input impedance improves settling time by reducing the time constant of the network between the SSI 32P548 and a head preamplifier such as the SSI 32R1200R. Write to read timing is controlled to maintain the reduced impedance for 0.9 µs before the AGC circuitry is activated. Coupling capacitors should be chosen with as low a value as possible consistent with adequate bandwidth to allow more rapid settling.

SSI 32P548
Pulse Detector & Data Synchronizer

DATA SYNCHRONIZER SECTION

The SSI 32P548 is designed to perform data synchronization and write precompensation in rotating memory systems which utilize a 2, 7 RLL and MFM encoding format. In the Read Mode the SSI 32P548 performs Data Synchronization, and Preamble Detect. In the Write Mode, the SSI 32P548 performs write precompensation. The interface electronics and architecture of the SSI 32P548 have been optimized for use as a companion device to the WD 42C22 controllers.

The SSI 32P548 can operate with data rates ranging from 5 to 12 Mbit/s. This data rate is established by a single 1% external resistor, RR, connected from pin IREF to VPA2. This resistor establishes a reference current which sets the VCO center frequency, the phase detector gain, and the 1/4 cell delay. The value of this resistor is given by:

$$RR = 50/DR - 1.7\ (k\Omega)$$

Where: DR = Data Rate in Mbit/s

An internal crystal reference oscillator, operating at twice the data rate, generates the standby reference for the PLL. A series resonant crystal between XTAL1 and XTAL2 should be selected at twice the Data Rate. If a crystal oscillator is not desired, then an external TTL compatible reference may be applied to XTAL1, leaving XTAL2 open.

The SSI 32P548 employs a Dual Mode Phase Detector; Harmonic in the Read Mode and Non-Harmonic in Write and Idle Modes. In the Read Mode the Harmonic Phase Detector updates the PLL with each occurrence of a DLYD DATA pulse. In the Write and Idle Modes the Non-Harmonic Phase Detector is continuously enabled, thus maintaining both phase and frequency lock. By acquiring both phase and frequency lock to the crystal reference oscillator and utilizing a zero phase restart technique, false lock to DLYD DATA is eliminated.

The phase detector incorporates a charge pump in order to drive the loop filter directly. The polarity and width of the output current pulses correspond to the direction and magnitude of the phase error. Figure 4 depicts the average output current as function of the input phase error (relative to the VCO period.)

The READ GATE (RG), and WRITE GATE (WG), inputs control the device mode as described in Table 1. RG is an asynchrouous input and may be initiated or terminated at any position on the disk. WG is also an asynchronous input, but should not be terminated prior to the last output Write Data pulse.

READ OPERATION

The Data Synchronizer utilizes a fully integrated fast acquisition PLL to accurately develp the decode window. Read Gate, RG, initiates the PLL locking sequence and selects the PLL reference input; a high level (Read Mode) selects the Read Data input and low level selects the crystal reference oscillator.

In the Read Mode the rising edge of DLYD DATA enables the Phase Detector while the falling edge is phase compared to the rising edge of the VCO. As depicted in Figure 2, DLYD DATA is a 1/4 cell wide (TVCO/2) pulse whose leading edge is defined by the leading edge of Read Data. RRC is generated from the rising edges of the VCO clock. By utilizing a fully integrated symmetrical VCO running at twice the data rate, RRC is insured to be accurate and centered symmetrically about the falling edges of DLYD DATA. The accuracy of the 1/4 cell delay only affects the retrace angle of the phase detector and does not influence the accuracy of RRC.

Shifting the symmetry of the VCO clock effectively shifts the relative position of the DLYD DATA pulse within the decode window. This powerful capability easily facilitates defect mappings, automatic calibration, window margin testing, error recovery, and systematic error cancellation. For enhanced disk drive testability and error recovery, decode window control is provided via a µP port ($\overline{WSL}$, WSD, $\overline{WS0}$, $\overline{WS1}$) as described in Table 2. In application not utilizing this feature, $\overline{WSL}$ should be left open or connected to VPA2, while WSD, $\overline{WS0}$, and $\overline{WS1}$ can be left open.

Window shifts in the range of ±1.5% to ±7.5% of TORC are easily programmed by latching the appropriate control word into the Window Shift Register with the WSL pin. Shifts in the positive or negative directions result in early or late decode windows respectively, as depicted in Figure 6. Additionally, for small systematic error cancellation, a resistor, R, connected from either RS (Early) or RF (Late) to ground will provide analog control over the decode window. The magnitude of this shift, TSA is determined by:

$$TSA = 0.125\,TORC\left(1 - \frac{790+R}{1450+R}\right)$$

Where: R is in Ω

Pins RF and RS are intended to be used as a trim and should be restricted to ±1.5% window shifts. They can be used in conjunction with the digital control port.

In Non-Read Modes, the PLL is locked to the crystal reference oscillator. This forces the VCO to run at a frequency which is very close to that required for tracking actual data and thus minimizes the associated frequency step during acquisition. When RG transitions, the VCO is stopped momentarily, then restared in an accurate phase alignment with the next PLL reference input pulse. By minimizing the phase alignment in this manner (phase error ≤ 0.5 rads), the acquisition time is substantially reduced.

PREAMBLE DETECTION

Preamble detection timing is set by the sum of the 1/4 cell delay and the retriggerable one-shot delay. The 1/4 cell timing capacitor is included on-chip and its timing is externally set by resistor RR. The retriggerable one-shot timing is externally set by resistor Rd and capacitor Cd. The sum of their delays is set to exceed the preamble bit spacing. Therefore, a continuous stream of input pulses at the preamble pulse rate keeps the SDO high, and a longer bit cell time input period allows the one-shot to time out producing a low at SDO.

WRITE OPERATION

Write precompensation circuitry is provided to compensate for media bit shift caused by intersymbol interference. The magnitude of the time shift, TC, is determinded by an external R-C network on the PCS pin given by:

TC = 0.155 Rp Cp

Direction of the time shift is determined by the state of the $\overline{\text{EARLY}}$ and $\overline{\text{LATE}}$ inputs.

POWER DOWN MODE

Two power down modes are provided to reduce power usage during the idle periods. Taking $\overline{\text{PDWN1}}$ low causes the device to go into complete shutdown, and taking the $\overline{\text{PDWN2}}$ pin low shuts down all functions not required for servo aquisition.

MODE CONTROL

The SSI 32P548 circuit mode is controlled by the $\overline{\text{PDWN1}}$, $\overline{\text{PDWN2}}$, $\overline{\text{HOLD}}$, RG, and WG pins as shown in Table 1.

TABLE 1: Mode Control

WG	RG	$\overline{\text{HOLD}}$	$\overline{\text{PDWN1}}$	$\overline{\text{PDWN2}}$	
0	0	1	1	1	Read Mode VCO Locked to XTAL
0	1	1	1	1	Read Mode VCO Locked to Read Data
0	X	0	1	1	Read Mode AGC gain held constant*
1	0	X	1	1	Write Mode AGC gain held constant* Input impedance reduced
X	X	X	0	X	Power Down 1 - Power shutdown mode
X	X	X	1	0	Power Down 2 - Servo mode

* AGC gain will drift at a rate determined by BYP and Hold mode discharge current.

Ts, NOMINAL WINDOW SHIFT	WSD	$\overline{WS1}$	$\overline{WS0}$
+TS3	0	0	0
+TS2	0	0	1
+TS1	0	1	0
0	0	1	1
-TS3	1	0	0
-TS2	1	0	1
-TS1	1	1	0
0	1	1	1

TABLE 2: Decode Window Symmetry Control

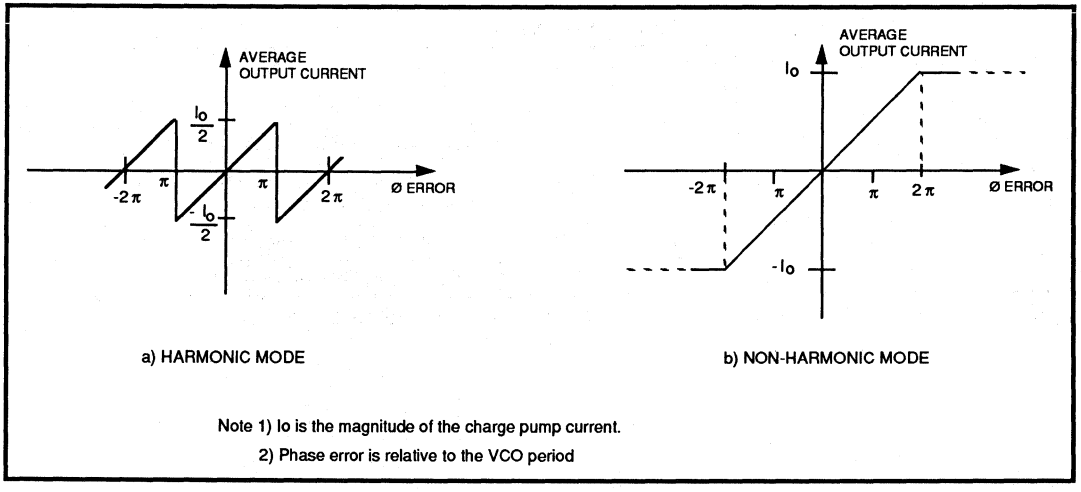


FIGURE 4: Phase Detector Transfer Function

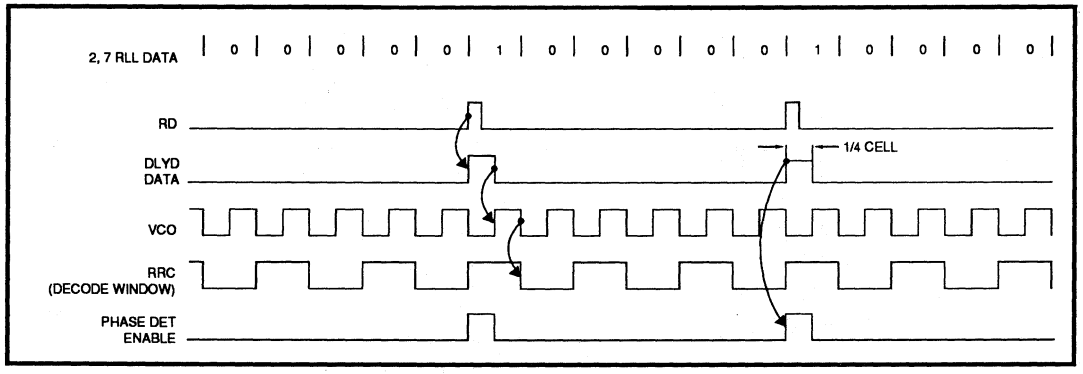


FIGURE 5: Data Synchronization Waveform Diagram

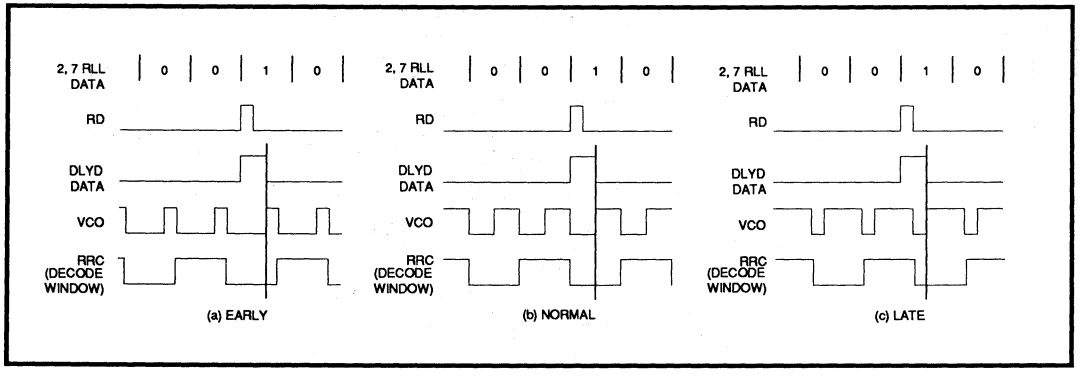


FIGURE 6: Decode Window

PIN DESCRIPTION

NAME	TYPE	DESCRIPTION
VPA1	I	Analog (+5V) power supply for pulse detector.
AGND1	I	Analog ground pin for pulse detector block.
VPA2	I	Analog (+5V) supply pin for data synchronizer block.
AGND2	I	Analog ground pin for data synchronizer block.
VPD	I	Digital (+5V) power supply pin.
DGND	I	Digital ground pin.
IN+, IN–	I	Analog signal input pins.
OUT+, OUT–	O	Read path AGC Amplifier output pins.
DIN+, DIN– *	I	Analog input to the hysteresis comparator.
CIN+, CIN– *	I	Analog input to the differentiator.
DIF+, DIF–	I/O	Pins for external differentiating network.
COUT	O	Test point for monitoring the flip-flop clock input.
DOUT	O	Test point for monitoring the flip-flop D-input.
RDO	O	Test point for ECL like read data prior to input to the data synchronizer.
BYP	I/O	An AGC timing capacitor or network is tied between this pin and AGND1.
AGC	I	Reference input voltage for the read data AGC loop.
LEVEL	O	Output from fullwave rectifier that may be used for input to the hysteresis comparator.
HYS	I	Hysteresis level setting input to the hysteresis comparator.
$\overline{\text{HOLD}}$	I	TTL compatible pin that holds the AGC gain when pulled low.
$\overline{\text{LATCHA}}$, $\overline{\text{LATCHB}}$	I	TTL compatible inputs that switch channel A or B into peak acquistion mode when low.
$\overline{\text{RST}}$, $\overline{\text{RSTA}}$, $\overline{\text{RSTB}}$ **	I	TTL compatible input that enables the discharge of channels A & B hold capacitors when held low.
CS***	I	Hold capacitor discharge current magnitude is controlled by a resistor from this pin to VPA or GND. If left open the default current is 1.5 mA.
HOLDA, HOLDB	I/O	Peak holding capacitors are tied from each of these pins to AGND1.
VREF	O	Reference voltage for Servo outputs.
BURSTA, BURSTB	O	Buffered hold capacitor voltage outputs.
PES	O	Position error signal, A minus B output.
$\overline{\text{PDWN1}}$	I	Low state on this pin puts the device in a low power "off" state.
$\overline{\text{PDWN2}}$	I	Low state on this pin disables all circuitry not required for use during Servo mode.
XTAL1, XTAL2	I	Crystal oscillator connections: if a crystal oscillator is not desired, XTAL1 may be driven by a TTL source with XTAL2 open.

*In 52-pin package CIN+ will be internally bonded to DIN+, CIN- will be internally bonded to DIN-.
**$\overline{\text{RSTA}}$ and $\overline{\text{RSTB}}$ will be internally bonded to $\overline{\text{RST}}$ in 52-pin package, and separately bonded out in 68-pin package.
***Not available in 52-pin package.

PIN DESCRIPTION (Continued)

NAME	TYPE	DESCRIPTION
IREF	I	Timing program pin: the VCO center frequency, Phase Detector Gain and the 1/4 cell delay are a function of the current source into pin IREF. The current is set by an external resistor, RR connected from IREF to VPA2.
FLTR	I/O	Filter pin: the phase detector output and VCO input node. The loop filter is connected to this pin.
SRD	O	Synchronized Read Data: read data that has been re-synchronized to read clock.
WSD	I	Window Symmetry Direction: controls the directions of the optional window symmetry shift. Pin WSD has an internal resistor pull-up.
$\overline{WS0}$	I	Window symmetry control bit: a low level introduces a window shift of 1.5% TORC (read reference clock period) in the direction established by WSD pin. $\overline{WS0}$ has an internal resistor pull-up.
$\overline{WS1}$	I	Window Symmetry Control bit: a low level introduces a window shift of 6% TORC (read reference clock period) in the direction established by WSD. A low level at both $\overline{WS0}$ and $\overline{WS1}$ will produce the sum of the two window shifts. Pin $\overline{WS1}$ has an internal resistor pull-up.
$\overline{WSL}$	I	Window Symmetry Latch: used to latch the input window symmetry control bits WSD, $\overline{WS0}$, $\overline{WS1}$ into the internal DAC. An active low level latches the input bits.
RF, RS*	I	WINDOW SYMMETRY ADJUST PINS: Provides analog control over the decode window symmetry; typically used to null out any window symmetry offset. A resistor connected from either RF or RS to AGND will provide magnitude and direction control. They can be used in conjunction with the digital control port WSD, $\overline{WS0}$, $\overline{WS1}$.
RRC	O	Read/Reference Clock: a multiplexed clock source used by the controller. In the read mode, this clock is the VCO frequency divided by two (1/TORC) and in the write mode it is the crystal reference frequency divided by two (1/TORO). No short clock pulses are generated during a mode change.
SDS	I	Sync Detect Set: used to program the preamble detect timing with an external RC Network. Connect the capacitor, Cd to VPA2 and the resistor, Rd, to AGND2.
RG	I	Read gate: selects the PLL reference input and initiates the PLL synchronization sequence. A high level selects the internal RD± inputs. A low level selects the crystal reference oscillator, Pin RG has an internal resistor pull-up.
WG	I	Write Gate: enables the write mode. Pin WG has an internal resistor pull-up.
SDO	O	Sync Detect Output: an active high output that indicates successful detection of the preamble sync field.
WDI	I	Write Data Input, active high.
$\overline{WD}$	O	Write Data: encoded write data output, active low.
PCS	I	Precomp Set: used to set the magnitude of the write pre-compensation time shift via an external capacitor, Cp to VPA2 and an external resistor, Rp to AGND2.
$\overline{EARLY}$	I	Early pin: shifts Write Data pulses earlier in their relative position; $\overline{EARLY}$ and $\overline{LATE}$ cannot be active simultaneously.

*Not available in 52-pin package.

PIN DESCRIPTION (Continued)

NAME	TYPE	DESCRIPTION
$\overline{\text{LATE}}$	I	Late Pin: shifts Write Data pulses later in their relative position $\overline{\text{LATE}}$ and $\overline{\text{EARLY}}$ cannot be active simultaneously.
PLL_REF	O	An open emitter ECL output test point. The positive edges of this output signal are phase locked with the positive edges of the VCO CLK signal. These two edges may be used to estimate window centering. The time jitter of the negative edge of the PLL_REF is an indication of media bit shift. Two external resistors are required to use this pin. They should be removed during normal operation for reduced power dissipation.
VCO CLK*	O	VCO CLK: An open emitter ECL output test point. Two external resistors are required to perform this test. They should be removed during normal operation for reduced power dissipation.
$\overline{\text{RDT}}$, VTEST*	I	Input test pins for testing the Data Synchronizer section only. To test the Data Synchronizer, connect VTEST pin to VPA2 and feed the TTL level test signal to $\overline{\text{RDT}}$ pin.

* Not available on 52-pin package

ELECTRICAL CHARACTERISTICS

Recommended conditions apply unless otherwise specified.

ABSOLUTE MAXIMUM RATINGS

Operation outside these rating limits may cause permanent damage to this device.

PARAMETER	RATING	UNIT
5V Supply Voltage, VPA1, VPA2, VPD	6.0	V
Pin Voltage (Analog pins)	-0.3 to VPA1, 2 + 0.3	V
Pin Voltage (All others)	-0.3 to VPD + 0.3 or +12 mA	V
Storage Temperature	65 to 150	°C
Lead Temperature (Soldering 10 sec.)	260	°C

RECOMMENDED OPERATING CONDITIONS

Currents flowing into the chip are positive.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Supply Voltage (VPA1, 2 & VPD)		4.75	5.0	5.25	V
Tj Junction Temperature		25		135	°C

POWER SUPPLY

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
IVPA1, 2 Supply Current IVPD	Outputs unloaded; $\overline{PDWN1}$, $\overline{PDWN2}$ = high or open			160	mA
Pd Power dissipation	Ta = 25°C, outputs unloaded		650	750	mW
	$\overline{PDWN1}$ = low, Outputs unloaded		300	380	mW
	$\overline{PDWN2}$ = low, $\overline{PDWN1}$ = high		450	550	mW

LOGIC SIGNALS

VIL	Input Low Voltage		-0.3		0.8	V
VIH	Input High Voltage		2.0		VCC+0.3	V
IIL	Input Low Current	VIL = 0.4V	0.0		-0.4	mA
IIL	WG Input Low Current	VIL = 0.4V	0.0		-0.8	mA
IIH	Input High Current	VIH = 2.7V			100	µA
VOL	Output Low Voltage	IOL = 4.0 mA			0.5	V
VOH	Output High Voltage	IOH = -400 µA	2.7			V
VIHX	XTAL1 Input High Voltage		2.6			V

* Output load is a 4K resistor to 5V and a 10 pF capacitor to DGND.

MODE CONTROL

Enable to/from $\overline{PDWN1}$, $\overline{PDWN2}$ Transition Time	Settling time of external capacitors not included, pin high to/from low			20	µs
Read to Write Transition Time	WG pin low to high			1.0	µs
Write to Read Transition Time	WG pin high to low AGC setting not included	0.5	0.9	1.3	µs
$\overline{HOLD}$ On to/from $\overline{HOLD}$ Off Transition Time	$\overline{HOLD}$ pin high to/from low			1.0	µs
RG Time Delay				100	ns

READ MODE WG is low

AGC AMPLIFIER

Unless otherwise specified, recommended operating conditions apply. Input signals are AC coupled to IN±. OUT± are loaded differentially with >340Ω x 2, and each side is loaded with < 10 pF to AGND, and AC coupled to DIN±. A 2000 pF capacitor is connected between BYP and AGND. AGC pin is open.

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
Gain Range	1.0 Vp-p ≤ (OUT+) - (OUT-) ≤ 3.0 Vp-p	4		80	V/V
Output Offset Voltage	Over entire gain range	-400		+400	mV
Maximum Output Voltage Swing	Set by BYP pin	3.0			Vp-p
Differential Input Resistance	(IN+) - (IN-) = 100 mVp-p @ 2.5 MHz		5.0		kΩ
Differential Input Capacitance	(IN+) - (IN-) = 100 mVp-p @ 2.5 MHz			10	pF
Common Mode Input	WG = low, IN+ or IN-		2.7		kΩ
Impedance	WG = high, IN+ or IN-			250	Ω
Input Noise Voltage	Gain set to maximum			15	nV/√Hz
Bandwidth	-3 dB bandwidth at maximum gain	16			MHz
OUT+ & OUT- Pin Current	No DC path to AGND		-4.0		mA
CMRR (Input Referred)	(IN+) = (IN-) = 100 mVp-p @ 5 MHz, gain set to max	40			dB
PSRR (Input Referred)	VPA1, 2 = 100 mVp-p @ 5 MHz, gain set to max	30			dB
(DIN+) - (DIN-) Input Swing vs. AGC Input	25 mVp-p ≤ (IN+) - (IN-) ≤ 250 mVp-p, $\overline{HOLD}$ = high, 0.5 Vp-p ≤ (DIN+) - (DIN-) ≤ 1.5 Vp-p	0.37	0.45	0.56	Vp-p/V
(DIN+) - (DIN-) Input Voltage Swing Variation	25 mVp-p ≤ (IN+) - (IN-) ≤ 250 mVp-p			8.0	%
AGC Voltage	AGC open		2.3		V
AGC Pin Input Impedance			2.5		kΩ
Slow AGC Discharge Current	(DIN+) - (DIN-) = 0V		4.5		µA
Fast AGC Discharge Current	Starts at 0.9 µs after WG goes low, stops at 1.8 µs after WG goes low	0.12			mA
AGC Leakage Current	$\overline{HOLD}$ = low	-0.2		+0.2	µA
Slow AGC Charge Current	(DIN+) - (DIN-) = 0.8 VDC, vary AGC until slow charge begins	-0.12	-0.18	-0.24	mA

AGC AMPLIFIER (Continued)

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
Fast AGC Charge Current	(DIN+) - (DIN-) = 0.8 VDC, V_{AGC} = 3.0V	-0.9	-1.3	-1.7	mA
Fast to Slow Attack Switchover Point	$\frac{[(DIN+)-(DIN-)]}{[(DIN+)-(DIN-)]FINAL}$		125		%
Gain Decay Time (Td)	(IN+) - (IN-) = 250 mVp-p to 125 mVp-p @ 2.5 MHz, (OUT+) - (OUT-) to 90% final value		12		µs
	(IN+) - (IN-) = 50 mVp-p to 25 mVp-p at 2.5 MHz (OUT+) - (OUT-) to 90% final value		60		µs
Gain Attack Time	WG = high to low (IN+) - (IN-) = 250 mVp-p @ 2.5 MHz, (OUT+) - (OUT-) to 110% final value		2		µs

WRITE MODE WG is high

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
Common Mode Input Impedance			250		Ω

HYSTERESIS COMPARATOR

Unless otherwise specified, recommended operating conditions apply. Input (DIN+) - (DIN-) is an AC coupled, 1.0 Vp-p, 2.5 MHz sine wave. 0.5 VDC is applied to the HYS pin. WG pin is low.

Input Signal Range				1.5	Vp-p
Differential Input Resistance	(DIN+) - (DIN-) = 100 mVp-p @ 2.5 MHz	8	10	14	kΩ
Differential Input Capacitance	(DIN+) - (DIN-) = 100 mVp-p @ 2.5 MHz			5.0	pF
Common Mode Input Impedance (Both Sides)		2	2.5	3.5	kΩ
Level Pin Output Voltage vs. (DIN+) - (DIN-)	0.6 Vp-p < (DIN+) - (DIN-) < 1.5 Vp-p, 10K between LEVEL and AGND		1		V/Vp-p
Level Pin Output Impedance	I_{LEVEL} = 0.2 mA		250		Ω
Level pin Maximum Output Current		1.5			mA
Hysteresis Voltage at DIN± vs. HYS Pin Voltage	0.3 V < HYS < 1.0V		0.36		V/V

HYSTERESIS COMPARATOR (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
HYS Pin Current	0.5 V < HYS < 1.5V	0.0		-10	µA
Comparator Offset Voltage	HYS pin at AGND ≤ 1.5 kΩ across DIN±			5.0	mV
DOUT Pin Output Low Voltage	5 kΩ from DOUT to GND		VPA2 -2		V
DOUT Pin Output High Voltage	5 kΩ from DOUT to GND		VPA2 -1.6		V

ACTIVE DIFFERENTIATOR

Unless otherwise specified, recommended operating conditions apply. Input (CIN+) - (CIN-) is an AC-coupled, 1.0 Vp-p, 2.5 MHz sine wave. 100Ω in series with 65 pF are tied from DIF+ to DIF-.

Input Signal Range				1.5	Vp-p
Differential Input Resistance	(CIN+) - (CIN-) = 100 mVp-p @ 2.5 MHz	8	10	14	kΩ
Differential Input Capacitance	(CIN+) - (CIN-) = 100 mVp-p @ 2.5 MHz			5.0	pF
Common Mode Input Impedance	Both sides	2.0	2.5	3.5	kΩ
Voltage Gain From CIN± to DIF±	(DIF+ to DIF-) = 2 kΩ		1		V/V
DIF+ to DIF- Pin Current	Differentiator impedance must be set so as to not clip the signal for this current level	±0.7			mA
Comparator Offset Voltage	DIF+, DIF- are AC-coupled			5.0	mV
COUT Pin Output Low Voltage	5 kΩ from COUT to GND		VPA2 -2		V
COUT Pin Output High Voltage	5 kΩ from COUT to GND		VPA2 -1.6		V
COUT Pin Output Pulse Width			30		ns

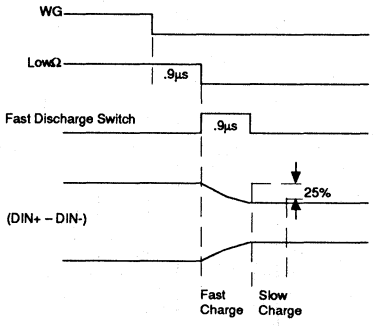


Figure A: AGC Attack Sequence

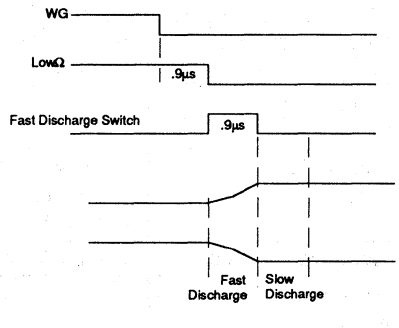


Figure B: AGC Decay Sequence

FIGURE 7: AGC Timing Diagram

QUALIFIER TIMING (See Figure 8)

Unless otherwise specified, recommended operating conditions apply. Inputs (CIN+) - (CIN-) and (DIN+) - (DIN-) are in-place as a coupled, 1.0 Vp-p, 2.5 MHz sine wave. 100Ω in series with 65 pF are tied from DIF+ to DIF-. 0.5V is applied to the HYS pin. COUT, DOUT and RD has a 5 kΩ pull-down resistor (for test purposes only.) WG pin is low.

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
Td1	D Flip-Flop Set Up Time	Minimum allowable time delay from (DIN+) - (DIN-) exceeding hysteresis point to (DIF+) - (DIF-) hitting a peak value.	0			ns
Td3	Propagation Delay			15		ns
|Td3-Td4|	Pulse Pairing				1.0	ns

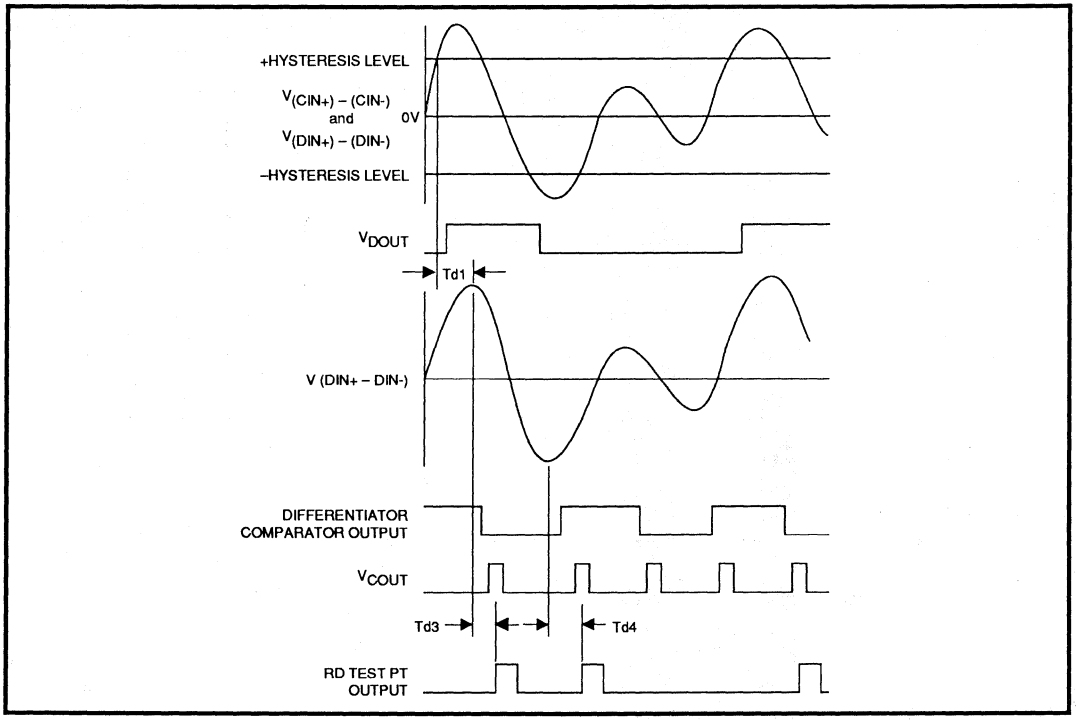


FIGURE 8: Read Mode Digital Section Timing Diagram

SERVO SECTION (Unless otherwise specified, recommended operating conditions apply.)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VREF Voltage Range Output			2.0		V
BURSTA/B Pin Output Voltage vs (DIN+) - (DIN-)	$\overline{LATCHA/B}$ = Low $\frac{V_{BURSTA/B} - VREF}{(DIN+) - (DIN-)}$		1.0		V/Vp-p
BURSTA/B Output Offset Voltage, V_{BURST} - VREF	$\overline{LATCHA/B}$ = Low, (DIN+) = (DIN-)	-50		+50	mV
BURSTA - BURSTB Output Offset Match	$\overline{LATCHA/B}$ = low (DIN+) = (DIN-)	-10		+10	mV
Output Resistance, BURSTA/B, PES				20	Ω
PES Pin Output Offset Voltage	V_{BURSTA} - V_{BURSTB} +VREF (DIN+) = (DIN-), $\overline{LATCHA/B}$ =Low	-10		+10	mV
HOLDA/B Discharge Current	$\overline{RST}$ = low,		1.5		mA
HOLDA/B Leakage Current	$\overline{RST}$ = high, $\overline{LATCHA/B}$ = high	-0.5		+0.5	µA
Load Resistance, BURSTA/B, PES	Resistors to VREF	10.0	20.0		kΩ
Load Capacitance, BURSTA/B, PES				20	pF
$\overline{LATCHA/B}$ pin set up time	TDS1, Figure 14	150			ns
$\overline{LATCHA/B}$ pin Hold Time	TDS2, Figure 14	150			ns
Channel A/B Discharge Current Turn On time	$\overline{RST}$ high → low			150	ns
Channel A/B Discharge Current Turn Off time	$\overline{RST}$ low → high			150	ns

SYNCHRONIZER SECTION

WRITE MODE (See Figure 9)

PARAMETER	CONDITIONS	MIN	MAX	UNIT
TWD, Write Data Pulse Width	CL ≤ 15 pF	(TORC/2)-12 -1.65 TPCO -TPC -12	(TORC/2)+12 -1.65 TPCO -TPC +12	ns
TFWD, Write Data Fall Time	2.0V to 0.8V, CL ≤ 15 pF		8	ns
TSWD, Write Data Input Setup Time	Either edge of WDI to either edge of RRC	15		ns

WRITE MODE (continued)

PARAMETER	CONDITIONS	MIN	MAX	UNIT
THWD, Write Data Input Hold Time	Either edge of RRC to either edge of WDI	3		ns
TSP, Early*/Late* Input Setup Time	Falling edge of Early*/Late* to either edge of RRC	15		ns
THP, Early*/Late* Input Hold Time	Rising edge of Early*/Late* to either edge of RRC	10		ns
TPC, Precompensation Time Shift Magnitude Accuracy	TPCO = 0.155 Rp Cp Rp = 1K to 2K	0.8TPC0	1.2TPC0	ns

READ MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
TRRC, Read Clock Rise Time	0.8V to 2.0V, CL ≤ 15 pF			8	ns
TFRC, Read Clock Fall Time	2.0V to 0.8V, CL ≤ 15 pF			5	ns
TSRD, Read Data Pulse Width		(TORC/2)-12		(TORC/2)+12	ns
TRSRD, Read Data Rise Time	0.8V to 2.0V, CL ≤ 15 pF			10	ns
TFSRD, Read Data Fall Time	2.0V to 0.8V, CL ≤ 15 pF			8	ns
TPSRD, SRD Output Setup/HoldTime		-15		15	ns
1/4 Cell + Retriggerable One-Shot Delay*	TD = 5.0 (RR +1.2) + 0.154 Rd (Cd +Cs)** ns RR in kΩ, Rd in kΩ, Cd in pF Cd = 68 pF to 100 pF	0.89TD		1.11TD	ns
1/4 Cell + Retriggerable One-Shot Detect Stability	4.5V < VPA2 < 5.5V	-4		+4	%

*Excludes External Capacitor and Resistor Tolerances. ** Cs = Stray Capacitance

WINDOW SYMMETRY CONTROL CHARACTERISTICS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
TWSS $\overline{WS0}$, $\overline{WS1}$, WSD Set Up Time		50			ns
TWSH $\overline{WS0}$, $\overline{WS1}$, WSD Hold Time		0			ns

DATA SYNCHRONIZATION

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TVCO	VCO Center Frequency Period	VCO IN = 2.7V TO = TBD VPA2 = 5.0V	0.8TO		1.2TO	sec
	VCO Frequency Dynamic Range	1.0V ≤ VCO IN ≤ VPA2-0.6V VPA2 = 5.0V	±27		±40	%
KVCO	VCO Control Gain	ωo = 2π / TO 1.0V ≤ VCO IN ≤ VPA2-0.6V	0.14 ωo		0.20 ωo	rad/s V
KD	Phase Detector Gain	KD = 0.62 / (RR+500) VPA2 = 5.0V, Input = 3T Sync Field	0.83 KD		1.17 KD	A/rad
*	KVCO x KD Product Accuracy		-28		+28	%
*	VCO Phase Restart Error			6		ns
	Decode Window Centering Accuracy				± (0.01 TORC + 2)	ns
	Decode Window		(TORC/2) -2			ns
TS1	Decode Window Time Shift Magnitude	TS1 = 0.015 TORC $\overline{WSO}$ = 0; $\overline{WSI}$ = 1	0.8 TS1 -0.5		1.2 TS1 +0.5	ns
TS2	Decode Window Time Shift Magnitude	TS2 = 0.06 TORC $\overline{WSO}$ = 1; $\overline{WSI}$ = 0	0.8 TS2		1.2 TS2	ns
TS3	Decode Window Time Shift Magnitude	TS3 = 0.075 TORC $\overline{WSO}$ = 0; $\overline{WSI}$ = 0	0.8 TS3		1.2 TS3	ns
TSA	Decode Window Time Shift Magnitude	$TWBA = 0.13 TORC \cdot \left(1 - \frac{78 + R}{1480 + R}\right)$	0.65 TSA		1.35 TSA	ns

* Not directly testable; design characteristics

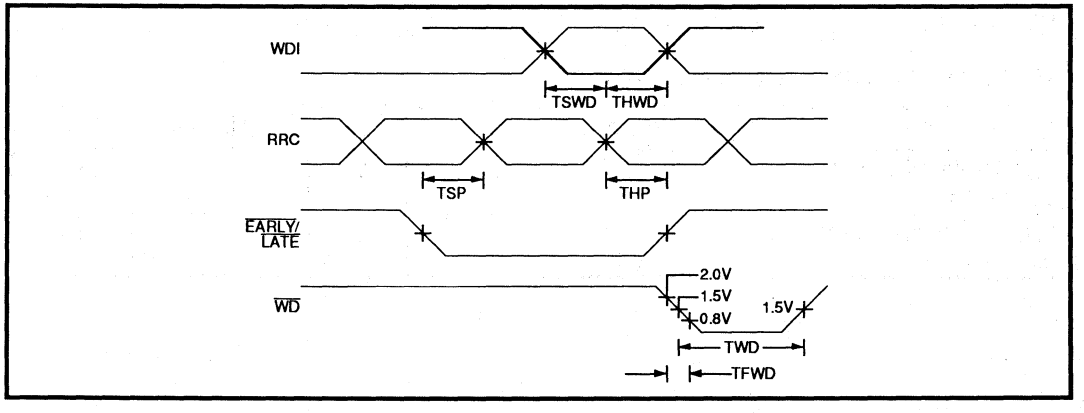


FIGURE 9: Write Mode Timing

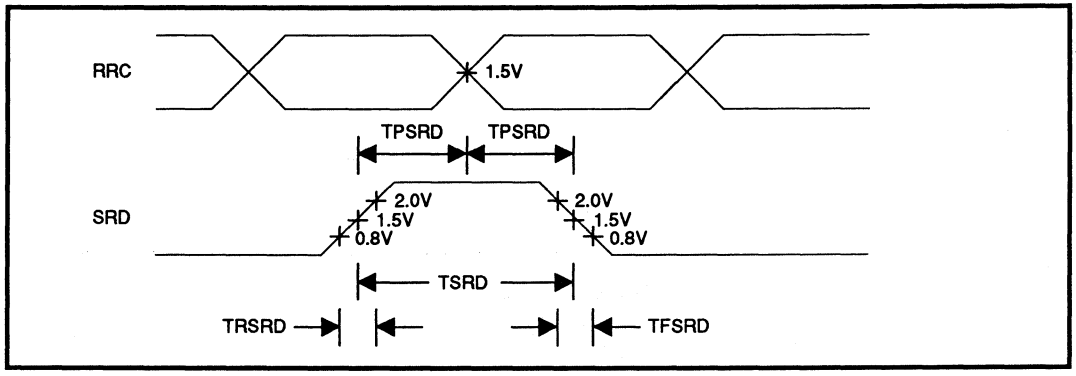


FIGURE 10: Read Mode Timing

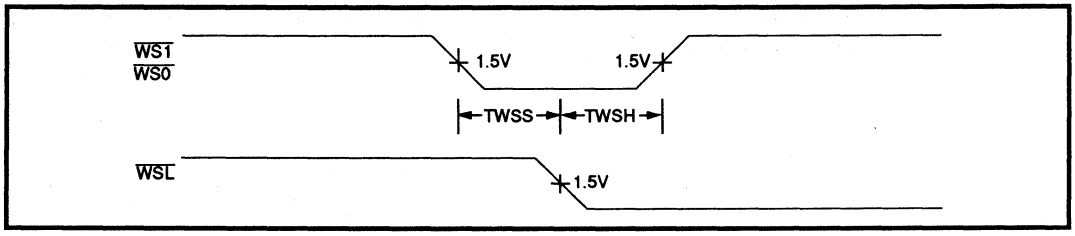


FIGURE 11: Window Symmetry Control Timing

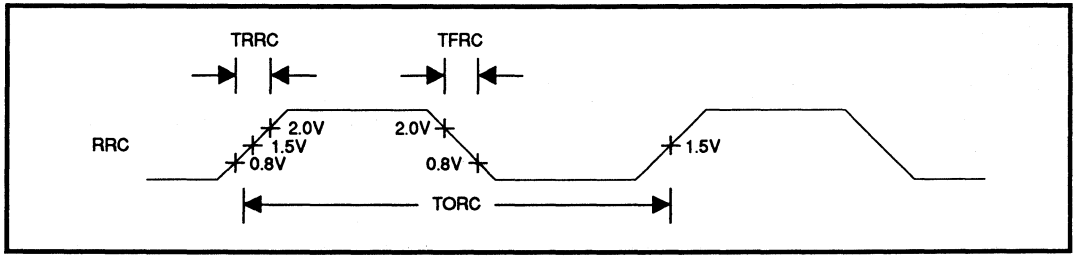


FIGURE 12: RRC Timing

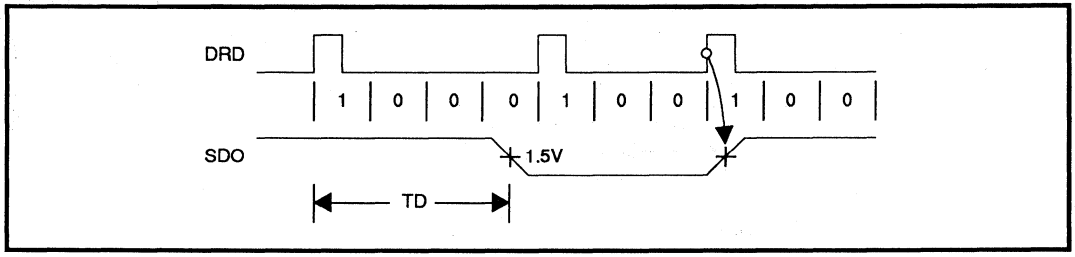


FIGURE 13: SDO Timing

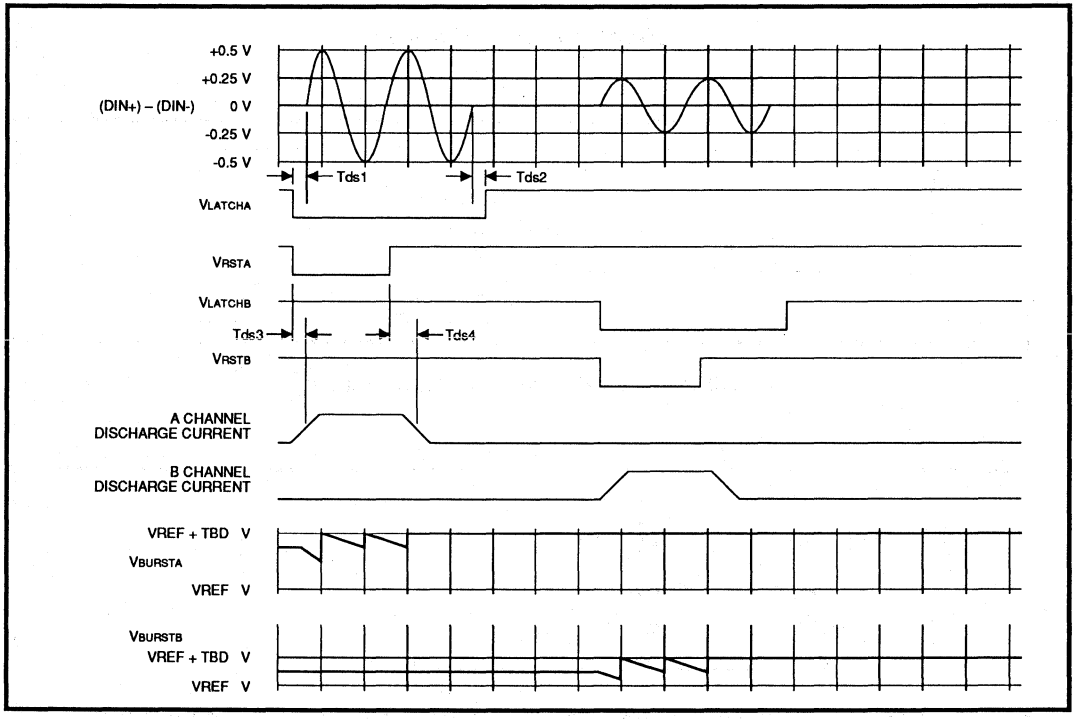


FIGURE 14: Servo Read Mode Timing

APPLICATIONS INFORMATION

The SSI 32P548 PLL uses a new architecture which incorporates an accurate quarter cell delay circuit. The standard architecture of a data synchronizer PLL is shown in Figure17A. In read mode, the rising edge of the quarter cell delay enables the phase detector, and the falling edge is locked to the VCO. Ideally, the quarter cell delay enables the phase detector one half of an encoded bit cell time before the phase comparison takes place. A data bit could then shift early or late by one half of an encoded bit cell time before a phase detector output error would occur. If the quarter cell delay is not exactly one half of an encoded bit cell time, a phase detector error will occur when the read data shifts by an amount that is smaller than one half of and encoded bit cell time when shifting in one direction and an amount larger than one half of an encoded bit cell time in the other direction. In addition, when an error occurs, the resulting charge pump output goes from maximum output one way to maximum output the other way. This can cause loss of lock to occur. The timing is shown in Figure 18.

The 32P548 achieves an accurate quarter cell delay time by using the VCO control voltage to compensate the quarter cell delay one-shot circuit for process, temperature and power supply induced timing variations. The modified architecture of the 32P548 data synchronizer is shown in Figure 19B. Because the quarter cell delay timing is adjusted by the VCO control voltage, there is an effect on the PLL transfer function due to the new quarter cell delay circuit.

The quarter cell delay circuit produces a time delay output in response to a voltage input. In order to include this function in a phase-locked loop, the time delay function must be converted into a phase function. This is straightforward, since a time delay is equivalent to a phase angle. The equivalent phase representation of the quarter cell delay is derived below.

For the VCO:

$$K_o = \frac{d\omega_o}{dV} \qquad (1a)$$

$$\frac{dT_O}{dV} = \frac{d}{dV}\left(\frac{1}{f_O}\right) = -\frac{1}{f_O{}^2}\frac{df_O}{dV} = -T_O{}^2\frac{df_O}{dV} = -\frac{T_O{}^2}{2\pi}\frac{dw_O}{dV} \qquad (1b)$$

where:

K_o = VCO gain
ω_o = VCO center frequency (rad/s)
f_o = VCO center frequency (Hz)
T_o = VCO center frequency (sec)

For the quarter cell delay,

$$K_T = \frac{dq_o}{dV} = \frac{2\pi}{T_o} a \frac{dT_o}{dV} = -\alpha T_o \frac{dw_o}{dV} = -\alpha T_o K_o$$

where:

θ_o = Phase due to quarter cell delay circuit
T_o = VCO center frequency period
T_Q = Quarter cell delay time
$\alpha = T_Q/T_o = 0.5$ for the 32P548

The gain of the quarter cell delay block is constant in the 32P548, regardless of the values of other components.

For the 32P548, the nominal value of K_T is 0.17π.

PLL TRANSFER FUNCTION

There are two modes of operation of the PLL, and two transfer functions. In write and idle modes, the PLL is locked to the reference oscillator, and the quarter cell delay does not enter into the transfer function. In read, mode, the PLL is locked to read data, and the quarter cell delay is included in the transfer function. In addition, the effective loop gain of the PLL increases in idle mode due to the phase detector. This will be explained later in more detail.

The transfer functions for read and idle modes are given in (3) and (4), respectively.

$$\frac{\theta_O(s)}{\theta_r(s)} = \frac{\frac{nK_OK_dF(s)}{S}}{1+nK_TK_dF(s)+\frac{nK_OK_dF(s)}{S}} \qquad (3)$$

$$\frac{\theta_O(s)}{\theta_r(s)} = \frac{\frac{nK_OK_dF(s)}{S}}{1+\frac{nK_OK_dF(s)}{S}} \qquad (4)$$

where:

K_T = Quarter cell delay one-shot gain
K_O = VCO gain
K_d = Phase detector gain
F(s) = Loop filter transfer function
n = Ratio of input freq. to reference freq.

In (3) the K term in the denominator is a result of the quarter cell delay. Substituting $K_T = \alpha K_O T_O$ into (3),

$$\frac{\theta_o(s)}{\theta_r(s)} = \frac{\frac{nK_OK_dF(s)}{S}}{1+(1-s\alpha T_O)\frac{nK_OK_dF(s)}{S}}$$

The additional $-s\alpha T_O$ term in the denominator due to the quarter cell delay introduces positive feedback. However, the gain of the positive feedback is always less than one, so there is no instability. The additional term is not always negligible, and must be taken into account in the loop analysis and design.

Two loop filter configurations, shown in Figure 15, will be considered. Both filters result in a second order type 2 loop transfer function, with only minor differences in the loop equation.

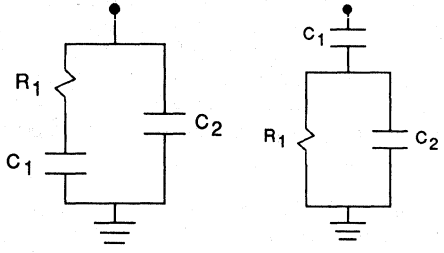


FIGURE 15: Loop Filter

The transfer function of the loop filter for a charge-pump PLL is the transimpedance, $V_o/I_i(s)$, where $V_o(s)$ is the output voltage, and $I_i(s)$ is the input current. The transfer functions of (a) and (b) are given by:

$$F_a(s) = \frac{sR_1C_1+1}{s(C_1+C_2)\left(sR_1\frac{C_1C_2}{C_1+C_2}+1\right)} \quad (6)$$

$$F_b(s) = \frac{sR_1(C_1+C_2)+1}{sC\left(sR_1C2+1\right)} \quad (7)$$

For loop filter (a), C is normally chosen to be much smaller than C so that it does not affect the loop transfer function significantly. Assuming the C » C and sRC « 1 at the frequencies of interest, (6) reduces to:

$$F_a(s) = \frac{sR_1C_1+1}{sC_1} \quad (8)$$

For loop filter (b), C is normallly chosen to be much smaller than C, so that it does not affect the loop transfer function significantly. Assuming the C » C and that sRC « 1 at the frequencies of interest, (7) reduces to:

$$F_b(s) = \frac{sR_1C_1+1}{sC_1} \quad (9)$$

Equations (8) and (9) are the same, and either loop filter may be used. Substituting (8) into (3) gives:

$$\frac{\theta_o(s)}{\theta_r(s)} = \frac{\frac{nK_OK_d}{C_1(1-\alpha T_OnK_OK_dR_1)}(sR_1C_1+1)}{s^2+s\frac{nK_OK_d}{1-\alpha T_OnK_OK_dR_1}\left(R_1-\frac{\alpha T_O}{C_1}\right)+\frac{nK_OK_d}{C_1(1-\alpha T_OnK_OK_dR_1)}} \quad (10)$$

This is in the form of a standard second order transfer fucntion. The denominator has the form:

$$D(s) = s^2 + 2\zeta\omega_n s + \omega_n^2 \quad (11)$$

where: ζ = damping factor
ω_n = natural frequency

The damping factor and natural frequency of (10) can be extracted:

$$\omega_n = \sqrt{\frac{nK_OK_d}{C_1(1-\alpha T_OnK_OK_dR_1)}} \quad (12)$$

$$\zeta = \frac{R_1-\frac{\alpha T_O}{C_1}}{2}\sqrt{\frac{nK_OK_dC_1}{1-\alpha T_OnK_OK_dR_1}} \quad (13)$$

Substituting (8) into (4) gives the transfer function for idle mode:

$$\frac{\theta_o(s)}{\theta_r(s)} = \frac{\frac{nK_OK_d}{C_1}(sR_1C_1+1)}{s^2+s(nK_OK_dR_1)+\frac{nK_OK_d}{C_1}} \quad (14)$$

Again, this is in the form of a second order transfer function. The damping factor and natural frequency are found to be:

$$\omega_n = \sqrt{\frac{nK_oK_d}{C_1}} \quad (15)$$

$$\zeta = \frac{R_1}{2}\sqrt{nK_oK_dC_1} \quad (16)$$

To design the loop for proper read mode operation using (12) and (13), R, and C, must be found in terms of the damping factor and natural frequency.

To do this, first find ζ/ω_n, then solve for R_1C_1.

$$R_1C_1 = \frac{2\zeta}{\omega_n} + \alpha T_o \quad (17)$$

Substitute this value for R_1C_1 into the equation for ω_n and solve for C_1.

$$C_1 = \frac{nK_oK_d}{\omega_n^2} + \alpha T_o nK_oK_d\left(\frac{2\zeta}{\omega_n} + \alpha T_o\right) \quad (18)$$

Now that C_1 is known, R_1 can be found by dividing (17) through by C_1.

$$R_1 = \left(\frac{2\zeta}{\omega_n} + \alpha T_o\right)\frac{1}{C_1} \quad (19)$$

EXAMPLE 1

Assume that the data rate is 10 Mbit/s, a 3T preamble pattern is used, and that $\omega_n = 10^6$ and $\zeta = 0.707$ are desired.

For the SSI 32P548:

$R_R = 50/DR - 1.7\ k\Omega$
$K_0 = 0.17\omega_0 = 21.4 \cdot 10^6$
$K_d = 0.62/(R_R+500) = 160 \cdot 10^6$
$K_T = 0.17\pi = 0.534$

Due to the 3T preamble pattern, the input frequency is one third the VCO frequency, so n = 1/3.

$\omega_0 = 2\pi(2 \cdot 10^7)$, $\alpha = 0.5$, and $T_0 = 1/(20 \cdot 10^6) = 50$ ns
$C_1 = 1160\ pF + 41.9\ pF = 1.21\ nF$
$R_1 = 1.20\ k\Omega$

The resulting loop filter is shown in Figure 16.

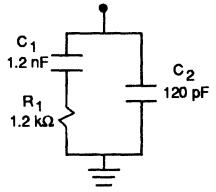


FIGURE 16

The value of $C_2 = C_1/10$ is chosen to damp out transients on the FILT pin and meet the requirement $C_2 \ll C_1$.

When the loop locks to the reference oscillator in idle mode, the loop transfer function is given by (14), and ω_n and ζ are given by (15) and (16). R_1 and C_1 from Example 1 can be substituted into these equations to find the resulting natural frequency and damping factor in idle mode.

EXAMPLE 2

When locking onto the reference oscillator, the input frequency is the same as the VCO frequency, so n = 1. Using the values of R_1 and C_1 found in Example 1, the values of ω_n and ζ when locking to the reference oscillator are found to be:

$\omega_n = 1.7 \cdot 10^6$ rad/s
$\zeta = 1.23$

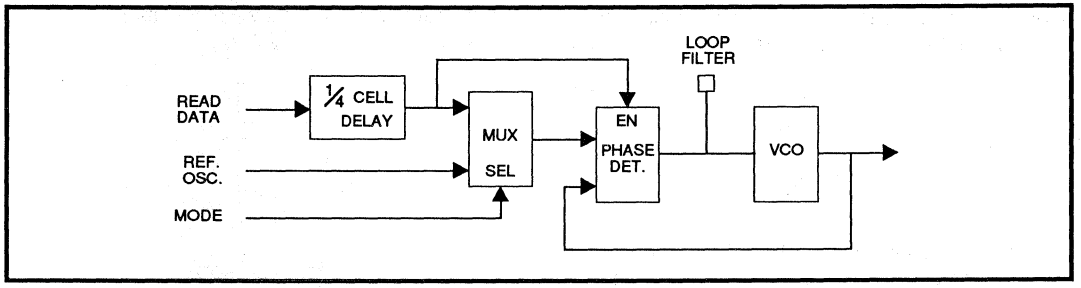


FIGURE 17A: Standard Configuration of a Data Synchronizer Phase-Locked Loop

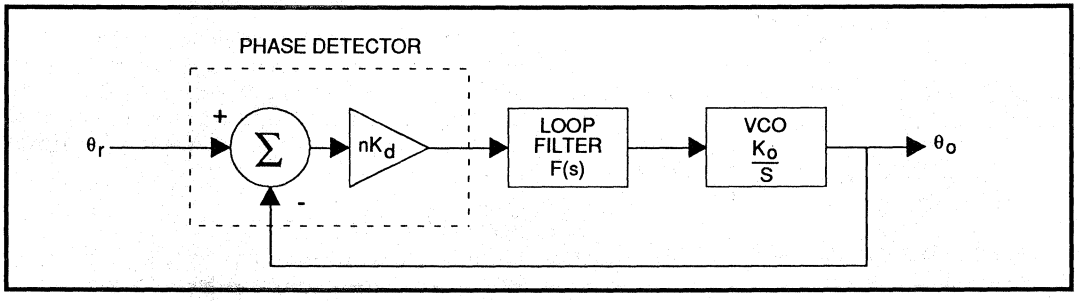


FIGURE 17B: Phase-Lock Loop System Representation

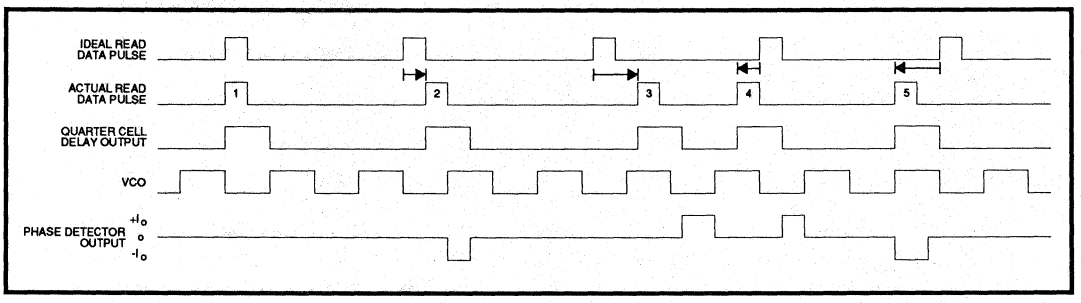


FIGURE 18A: Phase Detector Timing with Ideal Quarter Cell Delay. For an ideal pulse (1), there is no phase detector output. When a pulse is shifted late (2) or early (4) by less than the quarter cell delay time, the phase detector output is negative or positive, respectively. When the read data is shifted late (3) or early (5) by more than the quarter cell delay time, a phase detector output polarity error occurs. In this case, the output polarity becomes positive for a late shifted pulse and negative for an early shifted pulse.

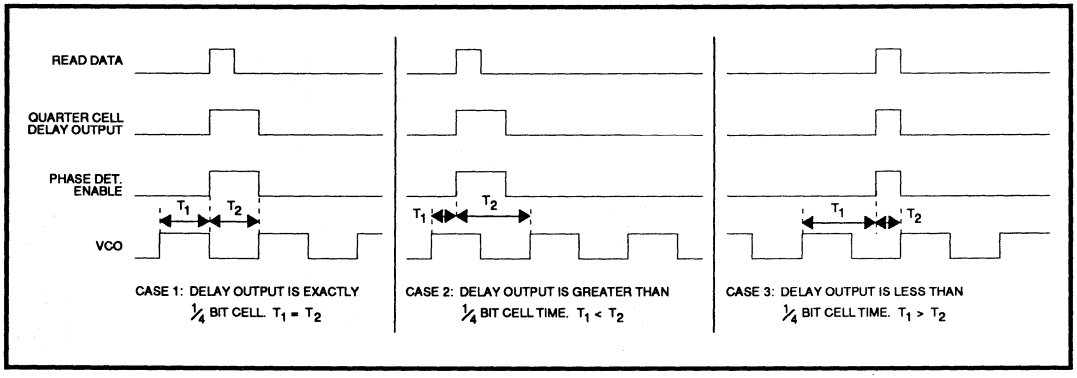


FIGURE 18B: Timing of Phase Detector Enable Logic. The read data input pulse can shift to the left by T1 and to the right by T2 before an error occurs in the phase detector output polarity, If the quarter cell delay output is not exactly 1/4 bit cell wide, then T1 ≠ T2, as shown in cases 2 and 3.

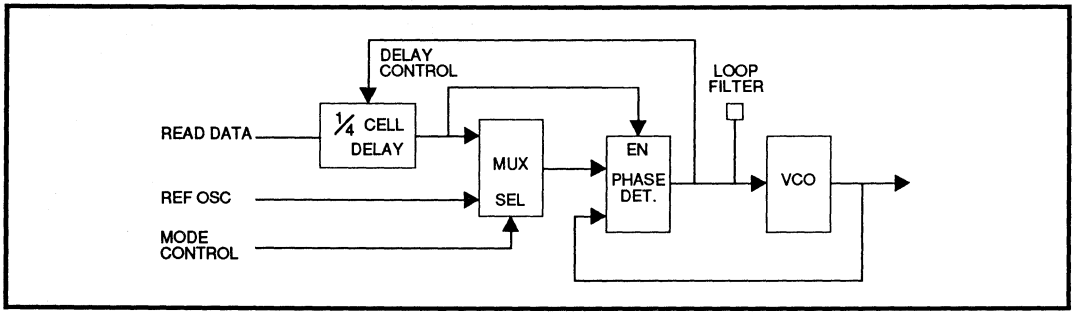


FIGURE 19A: Modified Data Synchronizer Phase-Locked-Loop with Quarter Cell Delay Control

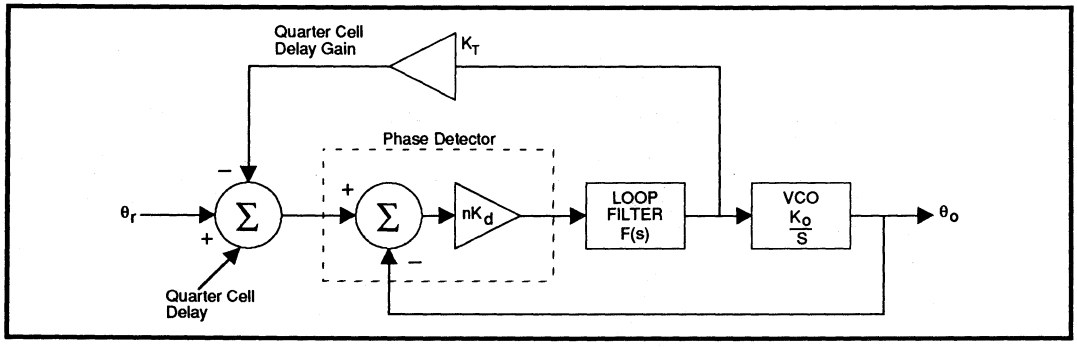
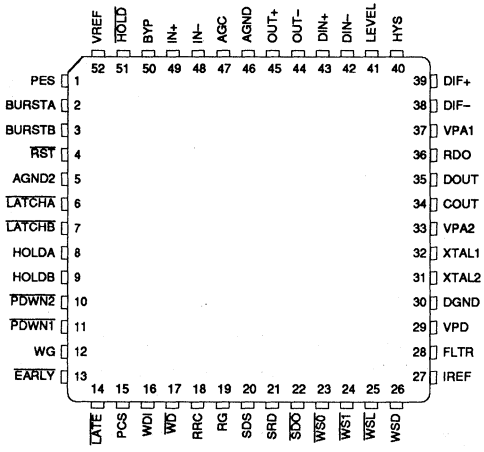


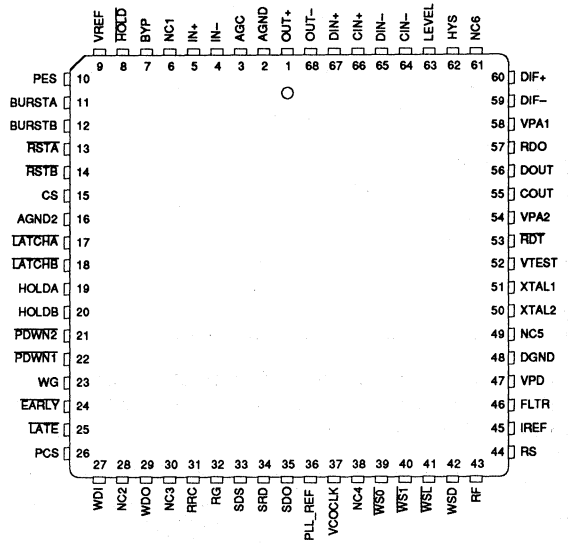
FIGURE 19B: Modified Data Synchronizer System Representation

SSI 32P548
Pulse Detector & Data Synchronizer

PACKAGE PIN DESIGNATIONS
(Top View)



52-Pin QFP



68-Pin PLCC

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32P549
Pulse Detector

Advance Information

July, 1990

2

DESCRIPTION

The SSI 32P549 is a bipolar integrated circuit that provides all data processing necessary for detection and qualification of MFM or RLL encoded read signals.

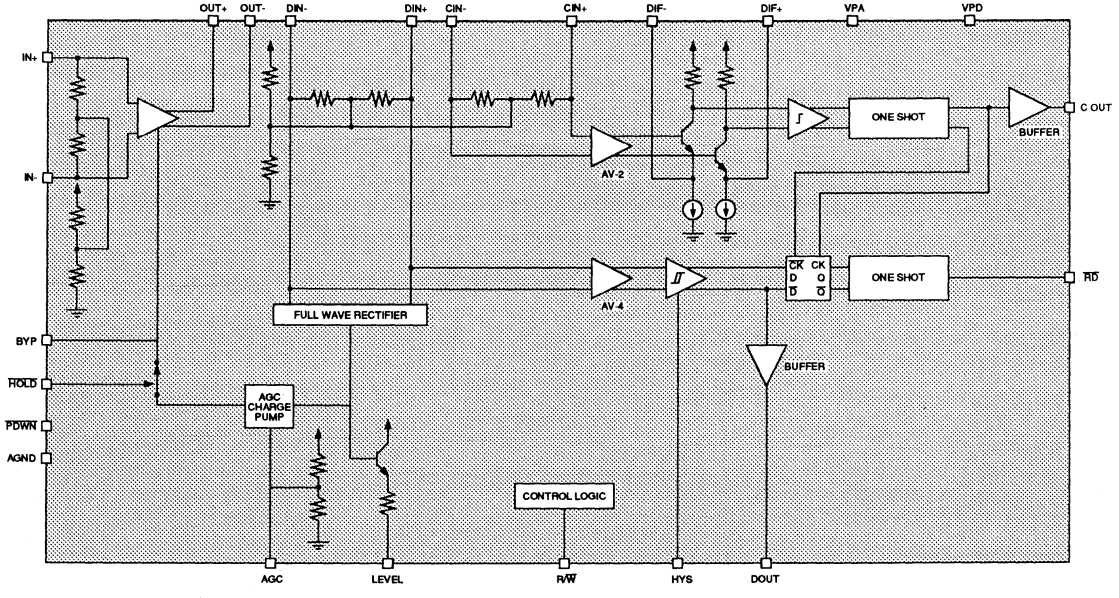
In read mode the SSI 32P549 provides amplification and qualification of head preamplifier outputs. Pulse qualification is accomplished using level qualification of differentiated input zero crossings. An AGC amplifier is used to compensate for variations in head preamp output levels, presenting a constant input level to the pulse qualification circuitry. The AGC loop can be disabled so that a constant gain can be used for embedded servo decoding or other processing needs.

In write mode the circuitry is disabled and the AGC gain stage input impedance is switched to a lower level to allow fast setting of the input coupling capacitors during a write to read transition. The SSI 32P549 requires a +5V power supply and is available in a 28-pin PLCC, 24-pin DIP and 24-pin SOL.

FEATURES

- **Level qualification supports high resolution MFM and RLL encoded data retrieval**
- **Wide bandwidth AGC input amplifier**
- **Standard +5V ± 5% supplies**
- **Write to read transient suppression**
- **Fast and slow AGC attack regions for fast transient recovery**
- **≤ ±1.0 ns pulse pairing**
- **16 Mbit/s operation**

BLOCK DIAGRAM



CIRCUIT OPERATION

READ MODE

In read mode (R/$\overline{W}$ input high or open) the input signal is amplified and qualified using an AGC amplifier and pulse level qualification of the detected signal peaks.

An amplified head output signal is AC coupled to the IN+ and IN- pins of the AGC amplifier. Gain control is accomplished by full wave rectifying and amplifying the [(DIN+)-(DIN-)] voltage level and comparing it to a reference voltage level at the AGC pin.

The 32P549 contains a dual rate attack charge pump. The value of the attack current is dependent on the instantaneous level at DIN±. For signal levels above 125% of the desired level a fast attack mode is invoked that supplies a 1.3 mA charge current to the network on the BYP pin. Between 125% and 100% of the desired level the circuit enters a slow attack mode and supplies 0.18 mA of charge current to the BYP pin.

Two decay modes are available and are automatically controlled within the device.

Upon a switch to write mode, the device will hold the gain at its previous value. When the device is then switched back to read mode the AGC holds the gain and stays in a low impedance state for 0.9 µs. It then switches into a fast/slow attack mode if the new gain required is less than the previously held gain or a fast decay mode if the gain required is more than its previous value. The fast decay current is 0.12 mA and stays on for 0.9 µs. After the 0.9 µs time period the device stays in a steady state slow attack, slow decay mode. The slow decay discharge current is 4.5 µA.

The AGC pin is internally biased so that the target differential voltage input at DIN± is 1.0 Vpp under nominal conditions. The voltage on this pin can be modified by tying a resistor between AGC and GND or VPA. A resistor to GND decreases the voltage level, while a resistor to VPA increases it. The resulting AGC voltage level is shown in Figure 1; where:

V = Voltage at AGC w/pin open (2.3V, nom)

Rint = AGC pin input impedance (2.5 kΩ, typ)

Rext = External resistor

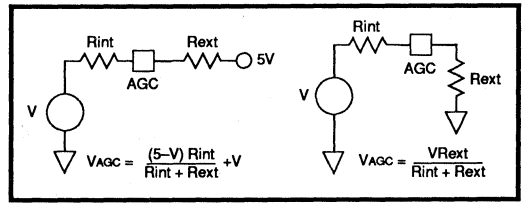


FIGURE 1: AGC Voltage

The new DIN ± input target level is nominally 0.45 Vpp/ V_{AGC}.

The maximum AGC amplifier output swing is 3.0 Vpp at OUT±, which allows for up to 6dB loss in any external filter between OUT± and DIN±.

AGC gain is a linear function of the BYP-pin voltage (VBYP) as shown in Figure 2.

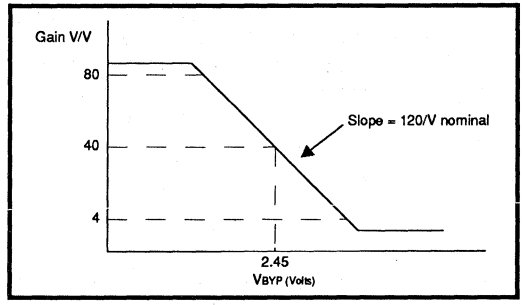


FIGURE 2: AGC Gain

In the amplitude channel the signal is sent to a hysteresis comparator. The hysteresis threshold level is set so that it will be tripped only by valid signal pulses and not by baseband noise. It can be a fixed level or a fraction of the DIN± voltage level.

The latter approach is accomplished by using an external filter/network between the LEVEL and HYS pins. This allows setting the AGC slow attack and decay times slow enough to minimize time channel distortion and setting a shorter time constant for the hysteresis level. The LEVEL pin output is a rectified and amplified version of DIN±, 1.0 Vpp at DIN± results in 1.0 Vo-p nominally, at the LEVEL pin. A voltage divider is used from LEVEL to ground to set the Hysteresis threshold at a percentage of the peak DIN± voltage. For example,

if DIN± is 1.0 Vpp, then using an equal valued resistor divider will result in 0.5 Vpk at the HYS pin. This will result in a nominal ±0.18V threshold or a 36% threshold of a ±0.500V DIN± input. The capacitor is chosen to set an appropriate time constant. This "feed forward" technique speeds up transient recovery by allowing qualification of the input pulses while the AGC is still settling. This helps in the two critical areas of write to read and head change recovery. Some care in the selection of the hysteresis level time constant must be exercised so as to not miss pattern (resolution) induced lower amplitude signals. The output of the hysteresis comparator is the "D" input of a D-type flip-flop. The DOUT pin is a comparator output signal for testing purposes only.

In the time channel the signal is differentiated to transform signal peaks to zero crossings which are detected and used to trigger a bi-directional one-shot. The one-shot output pulses are used as the clock input of the D flip-flop. The COUT pin provides the one-shot output for test purposes.

The differentiator function is accomplished by an external network between the DIF+ and DIF- pins. The transfer function from CIN± to the comparator input (not DIF±) is:

$$Av = \frac{-2000Cs}{LCs^2 + C(R+92)s + 1}$$

where: C, L, R are external passive components
$20\ pF < C < 150\ pF$
$s = j\omega = j2\pi f$

During normal operation, the time channel clocks the D flip-flop on every positive and negative peak of the CIN± input. The D input to the flip-flop only changes state when the DIN± input exceeds the hysteresis comparator threshold opposite in polarity to the previous threshold exceeding peak.

The time channel, then, determines signal peak timing and the amplitude channel determines validity by blocking signal peaks that do not exceed the hysteresis comparator threshold. The delays in each of these channels to the D flip-flop inputs are well matched.

WRITE MODE

In Write Mode the SSI 32P549 Pulse Detector section is disabled and preset for the following Read Mode. The digital circuitry is disabled, the input AGC amplifier gain is held at its previous value and the AGC amplifier input impedance is reduced.

Holding the AGC amplifier gain and reducing input impedance shortens system Write to Read recovery times.

The lowered input impedance improves settling time by reducing the time constant of the network between the SSI 32P549 and a head preamplifier such as the SSI 32R1200R. Write to read timing is controlled to maintain the reduced impedance for 0.9 µs before the AGC circuitry is activated. Coupling capacitors should be chosen with as low a value as possible consistent with adequate bandwidth to allow more rapid settling.

POWER DOWN MODE

A power down mode is provided to reduce power usage during the idle periods. Taking $\overline{PDWN}$ low causes the device to go into complete shutdown. When $\overline{PDWN}$ returns high, the device executes the normal Write to Read recovery sequence.

MODE CONTROL

The SSI 32P549 circuit mode is controlled by the $\overline{PDWN}$, $\overline{HOLD}$, and R/$\overline{W}$ pins as shown in Table 1.

R/$\overline{W}$	$\overline{HOLD}$	$\overline{PDWN}$	
1	1	1	Read Mode, AGC Active
1	0	1	Read Mode AGC gain held constant*
0	X	1	Write Mode AGC gain held constant* Input impedance reduced
X	X	0	Power Down - low current disabled mode

* AGC gain will drift at a rate determined by BYP and Hold mode discharge current.

TABLE 1: Mode Control

PIN DESCRIPTION

NAME	TYPE	DESCRIPTION
VPA	I	Analog (+5V) power supply for pulse detector
AGND	I	Analog ground pin for pulse detector block
VPD	I	Digital (+5V) power supply pin
DGND	I	Digital ground pin
IN+, IN–	I	Analog signal input pins
OUT+, OUT–	O	Read path AGC Amplifier output pins
DIN+, DIN–	I	Analog input to the hysteresis comparator
CIN+, CIN–	I	Analog input to the differentiator
DIF+, DIF–	I/O	Pins for external differentiating network
COUT	O	Test point for monitoring the flip-flop clock input
DOUT	O	Test point for monitoring the flip-flop D-input
$\overline{RD}$	O	TTL compatible read output
BYP	I/O	An AGC timing capacitor or network is tied between this pin and AGND1
AGC	I	Reference input voltage for the read data AGC loop
LEVEL	O	Output from fullwave rectifier that may be used for input to the hysteresis comparator
$\overline{HYS}$	I	Hysteresis level setting input to the hysteresis comparator
$\overline{HOLD}$	I	TTL compatible pin that holds the AGC gain when pulled low
$\overline{PDWN}$	I	Low state on this pin puts the device in a low power "off" state
R/$\overline{W}$	I	Selects Read or Write mode

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only. Do not use for final design.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32P3000
Pulse Detector with Programmable Filter

Advance Information

July, 1990

2

DESCRIPTION

The SSI 32P3000 is a bipolar integrated circuit that provides all data processing necessary for detection and qualification of encoded read signals. The circuit will handle a data rate of 48 Mbit/s.

In read mode the SSI 32P3000 provides amplification and qualification of head preamplifier outputs. Pulse qualification is accomplished using level qualification of differentiated input zero crossings. An AGC amplifier is used to compensate for variations in head preamp output levels, presenting a constant input level to the pulse qualification circuitry. The AGC loop can be disabled so that a constant gain can be used for embedded servo decoding or other processing needs.

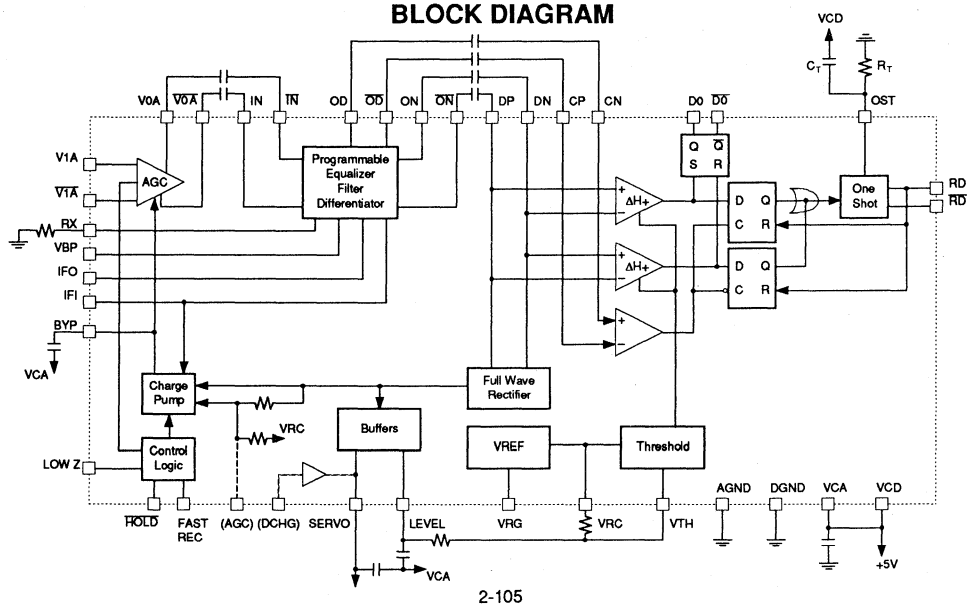
Write to read transient recovery is enhanced by providing AGC input impedance switching and a selectable Fast Recovery mode that provides a higher decay current.

Additionally, the SSI 32P3000 contains an integrated programmable electronic filter with cutoff frequencies between 9 and 27 MHz. High frequency boost (for pulse slimming) of up to +12db is also provided. The SSI 32P3000 requires only a +5V power supply and is available in a 36-pin SOM package.

FEATURES

- **Compatible with 48 Mbit/s data rate operation**
- **Fast attack/decay modes for rapid AGC recovery**
- **Low Drift AGC hold, fast AGC recovery, and low AGC input impedance control signals**
- **Includes programmable pulse slimming equalization and programmable channel filter and differentiator with no external filter components**
- **±0.5 ns filter group delay variation from 0.3 fc to fc = 26 MHz**
- **Independent positive and negative threshold qualification to supress error propagation**
- **0.5 ns max pulse pairing**
- **+5V only operation**
- **36-pin SOM package**

BLOCK DIAGRAM



SSI 32P3000
Pulse Detector with Programmable Filter

DESCRIPTION

The SSI 32P3000 Pulse Detector is designed to support a 48 Mbit/s data rate. The signal processing circuits include a wide band variable gain amplifier, a programmable electronic filter, differentiator and pulse slimming equalizer, a precision wide bandwidth fullwave rectifier, and a dual rate charge pump. A fully differential filter, differentiator, equalizer, and fullwave rectifier are provided to minimize external noise pickup. To optimize recovery for constant density recording, the AGC charge pump current tracks the programmable filter current IFI. The differentiator zero tracks the programmable filter cutoff frequency. Thus in constant density recording applications, an approximately constant differentiated signal amplitude is maintained. The desired filter response and equalization are easily programmed with the SSI 32D4661, Time Base Generator DACs. A dual rate attack charge pump and a Fast Decay mode are included for fast transient recovery. At maximum IFI current, the normal AGC attack current is .18 mA. When the signal exceeds 125% of the nominal signal level, the attack current is increased by a factor of 7. The nominal decay current is 4 µA. The decay current is increased 20 times when the FAST REC input is high. In this mode, transients that produce low gain will recover more rapidly with the Fast Decay current, while transients that produce high gain will put the circuit in the fast attack recovery mode. When LOW Z is high, the AGC amplifier input impedance is reduced to allow quick recovery of the AGC amplifier input ac coupling capacitors. When the HOLD input is low, the AGC action is stopped and the AGC amplifier gain is set by the voltage at the BYP pin. In most applications, the BYP pin voltage is stored on an external capacitor when HOLD goes low. In applications where AGC action is not desired, the BYP voltage can be set by a resistor divider network connected from VCC to VRC. If a programmable gain is desired, the resistor network could be driven by a current DAC. The precision fullwave rectifier produces an accurate Level and Servo output signal. These outputs are referenced to the reference voltage VRC. SERVO and LEVEL are buffered open emitter outputs with 100 ohm series current limiting resistors. These outputs could be further filtered with external capacitors.

Independent positive and negative threshold qualification comparators are used to suppress the error propagation of a positive and negative threshold hysterisis comparator. However, a slight amount of hysterisis is included to increase the comparator output time when a signal that just exceeds the threshold level is detected. This eases the timing with respect to the zero crossing clock comparator. A differential comparator with floating hysterisis threshold allows differential signal qualification for noise rejection. An accurate feed forward qualification level is generated by comparing the difference between Level and VRC. VRC is referenced to VCA. Thus with the VTH resistor network connected from VCA to VRC, an accurate fixed threshold can be established. A qualified signal zero crossing triggers the output one shot. The one shot period is set by an external resistor. Low level differential outputs are provided for high speed operation and to minimize noise generation.

PIN DESCRIPTION

INPUT PINS

NAME	TYPE	DESCRIPTION
VIA, $\overline{\text{VIA}}$		AGC Amplifier input pins.
IN, $\overline{\text{IN}}$		Equalizer/filter input pins.
DP, DN		Data inputs to data comparators and fullwave rectifier.
CP, CN		Differentiated data inputs to the clock comparator.
VTH		Threshold level setting input for the data comparators.
FACT REC		TTL compatible input when high puts the charge pump in the fast decay mode.
LOW Z		TTL compatible input when high reduces the AGC amplifier input resistance.
HOLD		TTL compatible input when low disables the AGC action by turning off the charge pump.
OUTPUT PINS		
VOA, $\overline{\text{VOA}}$		AGC amplifier output pins.
ON, $\overline{\text{ON}}$		Equalizer/filter normal output pins.
OD, $\overline{\text{OD}}$		Equalizer/filter differentiated output pins.
DO, $\overline{\text{DO}}$		ECL compatible data comparator latch output pins.
RD, $\overline{\text{RD}}$		ECL compatible read data output pins.
LEVEL		Open NPN emitter output that provides a fullwave rectified signal for the VTH input. The signal is referenced to VRC.
SERVO		Open NPN emitter output that provides a fullwave rectified servo signal. The signal is referenced to VRC.
ANALOG PINS		
OST		Pin for R_T C_T network to set RD output pulse width. An external C_T capacitor will not be required if an extra 15% pulse width tolerance error is acceptable.
VRC		Reference voltage pin for SERVO and LEVEL. VRC is referenced to VCA.
VRG		Reference voltage pin for the programmable filter. VRG is referenced to ground.
VBP		The equalizer high frequency boost is set by an external voltage applied to this pin. VBP must be proportional to VRG. Programmable boost is implemented by using a DAC that uses VRG as its reference. A fixed amount of boost can be set by an external resistor divide network connected from VBP to VRG and GND.
RX		Pin to set filter reference current. External resistor Rx from this pin to ground sets the filter reference current IFO.

PIN DESCRIPTION (Continued)

ANALOG PINS (Continued)

NAME	TYPE	DESCRIPTION
IFO		Reference current output pin. The reference current is normally supplied as the reference current to a current DAC which generates the programmable input current for the IFI pin.
IFI		Programmable filter input current pin. The filter cutoff frequency is proportional to the current into this pin. The current must be proportional to the reference current out of IFO. A fixed filter cutoff frequency is generated by connecting IFO to IFI and selecting Rx to set the desired frequency.
BYP		The AGC integrating capacitor C_A is connected between BYP and VCA.
VCA, VCD		Analog and Digital +5 volts.
AGND, DGND		Analog and Digital grounds.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

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SSI 32P4620/4621
Pulse Detector & Data Separator

Advance Information

June, 1990

2

DESCRIPTION

The SSI 32P4620 combines pulse detection and data synchronization electronics into a single high-performance bipolar integrated circuit. It provides advanced features like programmable data rate, and write precompensation control. Data synchronization is performed with a fully integrated high-performance PLL. The VCO frequency setting elements are incorporated into the 32P4620 for enhanced performance and reduced board space. Programmable channel filtering supports both constant density recording and pulse slimming applications. These features are programmed by two external DACs such as those provided by the 32D4660. Data rate is programmed by a single external resistor or a DAC in constant-density recording applications. The 32P4620 only requires a +5V power supply and is available in a variety of packages.

FEATURES

- **High performance pulse detector**
  - **Wide bandwidth AGC**
  - **Dual Rate charge pump**
  - **Amplitude pulse qualification**
- **High performance data synchronizer**
  - **Fast aquisition PLL, using zero phase restart**
  - **Programmable write precompensation**
  - **1, 7 ENDEC**
- **Supports Constant-Density Recording applications**
  - **Programmable data rate**
  - **Programmable channel filtering**
- **Variable width pulse slimming**
- **Servo burst output available**
- **Supports external read channel margin testing**
- **Differential (TTL option) high speed digital data paths and TTL compatible mode control interface**
- **Low power, +5 volt only operation**
- **Available in 68- and 100-pin packages**

CIRCUIT DESCRIPTION

The circuit is intended to be used as a read pulse detector and data/clock recovery circuit for 1, 7 RLL code in hard disk drive systems with a +5V supply. A circuit block diagram is shown in Figure 5.

MODE CONTROL

The circuit mode is controlled by the CHIP_EN, SERVO_EN, WG, RG, $\overline{\text{HOLD}}$, AND SHORT pins. Additionally, the chip can be configured through the PULSE DETECTOR MODE CONTROL register and the DATA/CLOCK RECOVERY MODE CONTROL register, both of which are loaded through the serial digital interface.

When reading or writing data the CHIP_EN pin should be high or open circuited. When the CHIP_EN pin is pulled low and the SERVO_EN pin is pulled high the chip data/clock recovery section is disabled. This mode is intended for monitoring servo data in a low power mode when data is not being read or written. When the CHIP_EN and SERVO_EN pins are pulled low the chip goes into a low power state. Recovering from the low power state can be slow due to the necessity of charging external capacitors.

The input AGC amplifier, pulse detector and write driver sections of the circuit are controlled by the WG pin and are placed in the read mode when the WG pin is low and in write mode when the WG pin is high or open. The write driver is active during write and inactive during read.

The RG pin controls what signal the data/clock recovery PLL locks to. When RG is high the PLL locks to the signal from the pulse detector input. Normally this is the signal from the pulse detector but the signal can be externally supplied from the $\overline{\text{RD}}$ pin for testing by setting the appropriate control register bit. When RG is low the PLL locks to an external reference supplied at the FREF pin.

CAUTION: Use handling procedures necessary for a static sensitive component.

CIRCUIT DESCRIPTION (Continued)

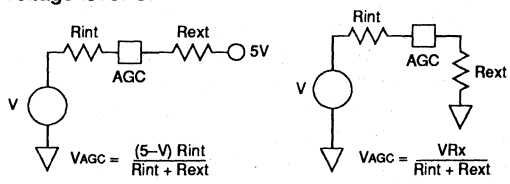
AUTOMATIC GAIN CONTROL CIRCUIT

An amplified head output signal, such as the output of the SSI 32R117, 501, 510 or 32R4610 read/write circuits, is AC coupled to the IN1+ and IN1– inputs. When WG is high or when SHORT is high the pulse detect digital circuitry is disabled and the input impedance of the input AGC stage is reduced to allow more rapid settling of the input coupling capacitors from the read/write circuit upon transition to the read mode. Transition timing to read is controlled to allow settling of the coupling capacitors between the read/write circuit and the 32P4620 before the AGC circuitry is activated when going to the read mode. Coupling capacitors should be chosen with as low a value as possible consistent with adequate bandwidth to allow more rapid settling. Also, when SHORT is high the AGC circuit enters the read mode in a maximum gain state and can rapidly attack to the desired level.

The $\overline{\text{HOLD}}$ pin controls the input AGC stage automatic gain circuit. When CHIP_EN or SERVO_EN is high, and $\overline{\text{HOLD}}$ is high and WG and SHORT are low the input AGC amplifier is controlled to keep a constant read data peak level. When the $\overline{\text{HOLD}}$ pin is pulled low the gain of the analog circuit is held at the level determined when the $\overline{\text{HOLD}}$ pin was high (the gain will slowly drift due to leakage).

In the read mode the level at the input to the DIN+, DIN- pins is controlled by full wave rectifying the level at these pins and comparing it to a reference level supplied at the AGC pin. When the input level at the DIN+, DIN- input is greater than about 125% the desired level as set by the AGC pin the circuit is in a fast attack mode and will supply about 1.7 mA of discharge current at the GAIN pin. When the circuit is not in fast attack and the input level is above 100% of the desired level the circuit enters a slower attack mode and will supply about 0.18mA of discharge current. This allows the AGC amplifier to rapidly recover when going from write to read but reduces zero crossing distortion once the AGC amplifier is in range. There is an on-chip fixed slow decay current source. When the slow attack threshold has not been reached for a specified amount of time the circuit assumes the signal is too low and goes into a fast decay mode. The fast attack and fast decay modes can be disabled with the fast attack/decay control bit in the PULSE DETECTOR MODE CONTROL register.

The AGC pin is internally biased so that the target differential voltage input at the DIN+/– pins is 1.0 Vp-p at nominal conditions. The AGC voltage can be modified by tying a resistor between AGC and ground or VPA. A resistor to ground decreases the voltage level while a resistor to VPA increases it. The resultant AGC voltage level is:



where:

V=Voltage at AGC with pin open(TBD, nom.)
Rint = AGC pin input impedance (6.7 kΩ, typ.)
Rx = External resistor

The new DIN+/– input target level is nominally 0.48 Vp-p/V_{AGC}.

Gain of the AGC amplifier is nominally:

Av = Gain of the AGC stage
= K1 x exp[K2 x V(GAIN)]

where:

Av = Gain of AGC stage
V(GAIN) = Voltage on the gain pin

READ MODE DIGITIZING SECTION

In the data path the signal is sent to a hysteresis comparator. The comparator hysteresis level can be set at a fixed level or, with the addition of an external filter network, can be set as a fraction of the signal level as shown in the circuit block diagram. The latter approach allows setting the AGC circuit decay and slow attack times slow enough to minimize distortion of the signal going into the clocking path and setting a shorter time constant for the hysteresis level. Thus when switching to a head with a different output level or when switching from write to read the circuit is properly decoding data before the AGC circuit gain has settled to its final steady state level. In addition, the hysteresis threshold level can be set from the serial data port. The output of the hysteresis comparator is sent to the "D" input of a D flip-flop. The DOUT pin provides the TTL compatible comparator output digital signal for testing purposes and, if required, for use in the servo circuit.

In the clocking path the signal is sent to a differentiator circuit whose characteristics are set by external components. The output of the differentiator circuit is sent to an edge trigger circuit which creates an output pulse on every zero crossing of the output of the differentiator. The output of the edge trigger is the clock input of the D flip flop. The COUT pin provides the edge trigger output signal for testing purposes.

During normal system operation the differentiator circuit clocks the D flip-flop on every positive and negative peak of the signal input to DIN+,DIN-. The data path D input to the flip-flop only changes state when the signal applied to the DIN+, DIN- inputs exceeds the hysteresis comparator threshold in a polarity opposite the polarity of the peak which last exceeded the threshold. Therefore, the clocking path determines signal timing and the data path blocks spurious peaks if they do not exceed the hysteresis comparator threshold. Figure 8 shows circuit operation of the digital section. The two digital signal path delays between the DIN+, DIN- inputs to the flip-flop CK input and the DIN+, DIN- inputs to flip-flop D input are well matched.

SERVO BURST CAPTURE SECTION

The circuit provides a full wave rectified output of the signal appearing at the DIN+/- inputs at the SER_OUT pin and a servo reference level at the SER_REF pin for use in embedded servo recovery.

DATA/CLOCK RECOVERY CIRCUIT

The circuit is designed to perform data recovery and data encoding in rotating memory systems which utilize a 1,7 RLL encoding format. In the read mode the circuit performs data synchronization, sync field search and detect, address mark detect, and data decoding. In the write mode, the circuit converts NRZ data into the 1,7 RLL format described in Table 3, performs write precompensation, generates the preamble field and inserts address marks as requested. The interface electronics and architecture of the circuit have been optimized for use as a companion device to the SSI 32C452, SSI 32C4640 or AIC 010 controllers.

The data rate is established by a single 1% external resistor, RR, connected from the IREF pin to VPA. This resistor establishes a reference current which sets the VCO center frequency, the phase detector gain, and the 1/3 cell delay. The value of this resistor is given by:

RR= (TBD/DR) - TBD kΩ

where: DR = data rate in Mbit/s

In a constant density recording application the IREF pin can be driven by a DAC such as contained in the SSI 32D4660. The circuit employs a dual mode phase detector; harmonic in the read mode and non-harmonic in the write and idle modes. In the read mode the harmonic phase detector updates the PLL with each occurrence of a $\overline{DRD}$ pulse. In the write and idle modes the non-harmonic phase detector is continuously enabled, thus maintaining both phase and frequency lock. By acquiring both phase and frequency lock to the input reference frequency and utilizing a zero phase restart technique, false lock to $\overline{DRD}$ is eliminated.

The phase detector incorporates a charge pump in order to drive the loop filter directly. The polarity and width of the output current pulses correspond to the direction and magnitude of the phase error. The READ GATE (RG) and WRITE GATE (WG) inputs control the mode of the data/clock recovery section of the chip.

RG is an asynchronous input and may be initiated or terminated at any position on the disk. WG is also an asynchronous input, but should not be terminated prior to the last output write data pulse. NRZ write data input to encoded write data output latency is 5 NRZ clock periods.

READ OPERATION

The data synchronizer utilizes a fully integrated fast acquisition PLL to accurately develop the decode window. Read gate, RG, initiates the PLL locking sequence and selects the PLL reference input; a high level (read mode) selects the $\overline{RD}$ (internal) input and a low level selects the external reference clock.

In the read mode the falling edge of $\overline{DRD}$ enables the phase detector while the rising edge is phase compared to the rising edge of VCO/2. As depicted in Figure 9, $\overline{DRD}$ is a 1/3 cell wide (TVCO) pulse whose leading edge is defined by the leading edge of RD. A decode window is developed from the VCO/2 clock.

In the non-read modes, the PLL is locked to the external reference clock. When the reference input to the PLL is switched, the VCO is stopped momentarily, then restarted in an accurate phase alignment with the next PLL reference input pulse, and the VCO clock divider is reset.

SOFT SECTOR OPERATION

Refer to Figure 1.

ADDRESS MARK DETECT

In soft sector read operation the circuit must first detect an address mark to be able to initiate the rest of the read lock sequence. An address mark consists of two sets each of seven "0" patterns followed by two sets each of eleven "0" patterns. To begin the read lock sequence the read gate (RG) is asserted high by the controller. The address mark detect (AMD) circuit then initiates a search of the read data (RD) for an address mark. First the address mark detect circuit looks for a set of 6 "0's" within the 7 "0's" patterns. Having detected a 6 "0's" pattern the AMD then looks for a 9 "0's" set within the 11 "0's" patterns. If AMD does not detect 9 "0's" within 5 RD bits after detecting a 6 "0's" pattern it will restart the address mark detect sequence and look for 6 "0's." When the AMD has acquired a 6 "0's," 9 "0's" sequence the $\overline{AMD}$ output transitions low.

PREAMBLE SEARCH

After the address mark (AM) has been detected, an internal counter counts negative transitions of the incoming read data (RD) looking for 3 consecutive "3T" preambles. Once the counter reaches count 3 (i.e. finds 3 consecutive "3T" preambles) the internal read gate enables, switching the phase detector from the external reference clock to the delayed read data input ($\overline{DRD}$); at the same time a zero phase restart (internal) signal restarts the VCO in phase with the read reference clock. This prepares the VCO to be synchronized to data when the bit sync circuitry is enabled after VCO lock is established.

VCO LOCK AND BIT SYNC ENABLE

When the internal counter counts sixteen more "3T" or a total of 19 negative transitions from RG enable, an internal VCO lock signal enables. The VCO lock signal activates the decoder bit synchronization circuitry to define the proper decode boundaries. Also, at count 19, the RRC source switches from the external reference clock to VCO clock signal which is phase locked to DRD. The VCO is assumed locked at this point. A maximum of 2 RRC time periods may occur for the RRC transition, however no short duration glitches will occur. After the bit sync circuitry sets the proper decode window (VCO in sync with RRC and RRC in sync with the data) NRZ is enabled and data is toggled in to be decoded for the duration of the read gate.

HARD SECTOR OPERATION

Refer to Figure 2. In hard sector operation $\overline{AMD}$ remains inactive. A hard sector read operation does not require an address mark but starts with a preamble search as with soft sector and sequences identically. In all respects, with the exception of the address mark sequence, hard sector read operation is identical to soft sector.

WRITE MODE

In the write mode the circuit converts NRZ data from the controller into 1,7 RLL formatted data for storage on the disk. The circuit can operate with a hard or soft sector hard drive.

In soft sector operation the circuit generates a 7"0's," 7"0's," 11"0's," 11"0's" address mark and a preamble ("3T"s) pattern. In hard sector operation the circuit generates a "3T" preamble pattern but no preceeding address mark.

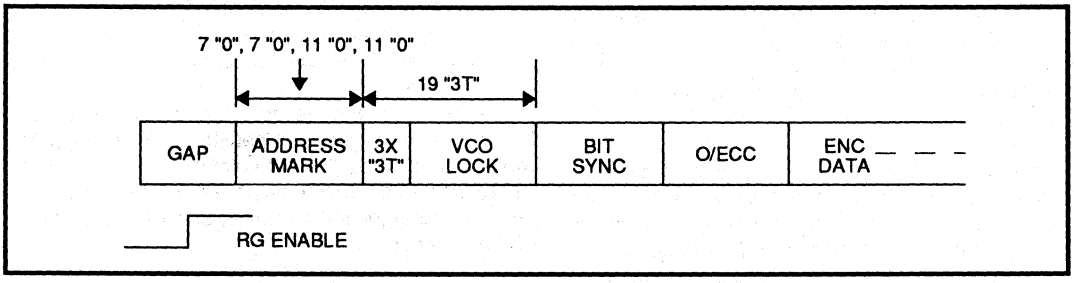


FIGURE 1: Disk Operation Lock Sequence in Read Mode Soft Sector Operation

Serial NRZ data is clocked into the circuit and latched on defined cell boundaries. The NRZ input data must be synchronous with the rising edges of the RRC.

Write precompensation circuitry is provided to compensate for media bit shift caused by intersymbol interference. The circuit recognizes specific write data patterns and can add or subtract delays in the time position of write data bits to counteract the read back shift. The magnitude of the time shift, TPC, is determined by an external RC network on the PCS pin given by:

TPC =(TBD) (Rps) (Cps + Cs),

and as programmed through the serial data port.

The circuit performs write precompensation according to the algorithm outlined in Table 3.

SOFT SECTOR

In soft sector operation, when read gate (RG) transitions low, VCO source and RRC source switch from RD and VCO/3, respectively, to the external reference clock. At the same time the VCO (internal) lock goes inactive but the VCO is locked to the external reference clock. After a delay of 1 NRZ time period (min) from RG low, the write gate (WG) can be enabled while NRZ is maintained (NRZ write data) low. The address mark enable ($\overline{WAM}$) is made active (high) a minimum of 1 NRZ time period(s) later. The address mark (consisting of 7"0's,"7"0's,"11"0's,"11"0's") and the preamble is then written to $\overline{WD}$. NRZ goes active at this point and after a delay of 5 NRZ time periods begins to toggle out $\overline{WD}$ encoded data. Finally, at the end of the write cycle, 5 NRZ of blank encoded time passes to insure the encoder is flushed of data; WG then goes low.

HARD SECTOR

In hard sector operation, when read gate (RG) transitions low, VCO source and RRC switch references and VCO lock (internal) goes inactive as with soft sector and the $\overline{WAM}$ (address mark enable) is tri-stated. The circuit then sequences from RG disable to WG enable and NRZ active as in soft sector operation.

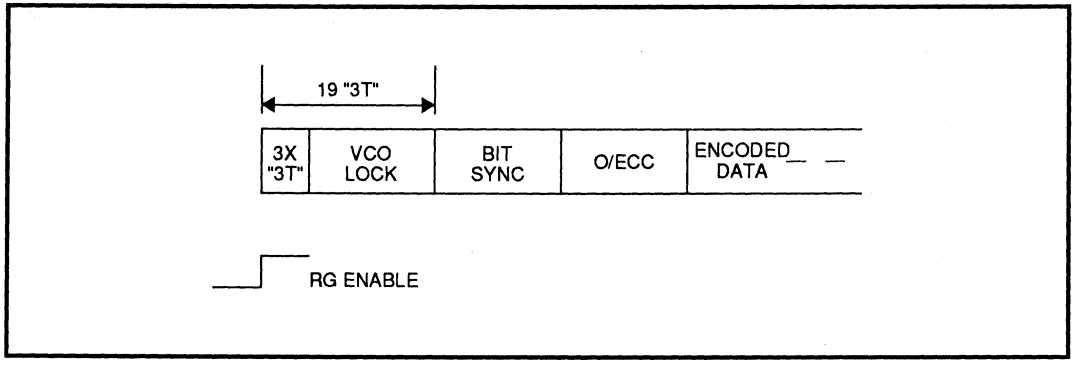


FIGURE 2: Disk Operation Lock Sequence in Read Mode Hard Sector Operation

TABLE 1: 1, 7 RLL Code Set

PREVIOUS CODE WORD LAST BIT	DATA BITS PRESENT	NEXT	CODE BITS
X0	1 0	0 X	1 0 1
X0	1 0	1 X	0 1 0
X0	1 1	0 0	0 1 0
X0	1 1	* *	1 0 0
10	0 0	0 X	0 0 1
10	0 0	1 X	0 0 0
00	0 1	0 X	0 0 1
00	0 1	1 X	0 0 0
X1	0 0	0 X	0 0 1
X1	0 0	1 X	0 1 0
X1	0 1	0 0	0 1 0
X1	0 1	* *	0 0 0
Y2, Y3	D1 D2	D3 D4	Y1 Y2 Y3

X = Don't care

* = Not all zeros

TABLE 3: Write Precompensation Algorithm

BIT n-2	BIT n-1	BIT n	BIT n+1	BIT n+2	COMP. BIT n
1	0	1	0	1	NONE
0	0	1	0	0	NONE
1	0	1	0	0	EARLY
0	0	1	0	1	LATE

LATE: Bit n is time shifted (delayed) from its normal time position towards the bit n+1 time position.

EARLY: Bit n is time shifted (advanced) from its normal time position towards the bit n-1 time position.

TABLE 2: Clock Frequency

WG	RG	VCO REF	RRC	DECCLK	ENCCLK	MODE
0	0	FREF/2	FREF/3	FREF/2	FREF/2	IDLE
0	1	RD	VCO/3	VCO/2	FREF/2	READ
1	0	FREF/2	FREF/3	FREF/2	FREF/2	WRITE
1	1	EXT. RD	FREF/3	FREF/2	FREF/2	IDLE

Note 1. Until the VCO locks to the new source, the VCO/2 entries will be XTAL/2.

2. Until the VCO locks to the new source, the VCO/3 entries will be XTAL/3.

3. WG=1 and RG=1 implement a test mode where RD is supplied externally at the $\overline{RD}$ pad.

PIN DESCRIPTIONS

POWER SUPPLY

NAME	TYPE	DESCRIPTION
VPA1, VPA2, VPA3	I	5 volt analog power supply pins
VPD1, VPD2	I	5 volt digital power supply pins
AGND1, AGND2, AGND3	I	Analog ground pins
DGND1, DGND2	I	Digital ground pins

CHIP MODE CONTROL

CHIP_EN	I	CHIP ENABLE: TTL compatible input which enables the chip during normal drive operation
SERVO_EN	I	SERVO ENABLE: TTL compatible input which enables only the portions of the chip needed to read the servo burst.
WG	I	WRITE GATE: TTL compatible read/write control pin
SDATA	I	SERIAL DATA: Serial data input
SCLK	I	SERIAL CLOCK: Serial data clock
DATA_EN	I	DATA ENABLE: Serial data enable pin
R/$\overline{W}$	O	READ/WRITE: TTL compatible output pin which is the negative of WG and which is intended to drive the R/$\overline{W}$ input of the read write chip

AGC GAIN STAGE

IN1+, IN1-	I	INPUT1+/-: AGC amplifier signal input pins
OUT1+, OUT1-	O	OUTPUT1+/-: AGC amplifier signal output pins
HP2+, HP2-, LP2+, LP2-	I	HIGH/LOW PASS INPUTS: Inputs into a summer with variable gain coefficients from external high pass and low pass filters. This configuration is intended to implement a pair of real axis variable zeros.
HP3+, HP3-, LP3+, LP3-	O	HIGH/LOW OUTPUTS: Variable gain outputs to an external filter. This configuration is intended to implement a pair of imaginary axis variable zeros.
IN4+, IN4-	I	INPUT4+/-: Fixed gain amplifier signal input pins
OUT4+, OUT4-	O	OUTPUT4+/-: Fixed gain amplifier signal output pins

AGC GAIN STAGE (Continued)

NAME	TYPE	DESCRIPTION
MULT_1, MULT_2	I	MULTIPLIER 1 & 2: Pins whose DC levels control the gain ratios of the 2 multiplier stages setting equalizer & bandwidth response.
$\overline{\text{HOLD}}$	I	HOLD: TTL compatible control pin which, when pulled low, holds the input AGC amplifier gain.
SHORT	I	SHORT: TTL compatible control pin which, when pulled high shorts the AGC input pins.
AGC	I	AUTOMATIC GAIN CONTROL REFERENCE: Reference input voltage level for the AGC circuit.
GAIN	I	GAIN CONTROL VOLTAGE: The AGC timing capacitor is tied between this pin and AGND. Also gain of the AGC amplifier can be controlled by a DC voltage on this pin.
VREF	O	REFERENCE VOLTAGE: A reference voltage for the external D/A which supplies MULT_1 and MULT_2.

PULSE DIGITIZING STAGE

DIN+, DIN-	I	DATA IN+/-: Signal input pins to the hysteresis level detect comparator.
HYS	I	HYSTERESIS: Hysteresis level setting input to the hysteresis level detect comparator.
LEVEL	O	LEVEL: Provides rectified level setting level for input into the hysteresis circuit.
DOUT, $\overline{\text{DOUT}}$	O	DATA OUT+/-: D input into D flip-flop provided as output for testing or servo use. Differential Version (32P4621): Differential Outputs TTL Version (32P4620): DOUT only TTL output, $\overline{\text{DOUT}}$ not provided
CIN+, CIN-	I	CLOCK INPUT+/-: Differential signal input pins to the clocking channel.
COUT	O	CLOCK OUTPUT: Clock input into D flip-flop provided for testing
$\overline{\text{RD}}$	I/O	READ DATA: Bidirectional test pin which provides ECL like read output from the pulse detector section when WG is low and allows a TTL compatible external read data pattern to be sent to the data/clock recovery when WG is high.

SERVO OUTPUT

NAME	TYPE	DESCRIPTION
SERV_OUT	O	SERVO OUTPUT: Servo output signal
SERV_REF	O	SERVO REFERENCE: Servo reference level

DATA/CLOCK RECOVERY SECTION

RG	I	READ GATE: Selects the PLL reference input and initiates the PLL synchronization sequence. A high level selects the RD input and enables the read mode/address detect sequences. A low level selects the FREF input.
FREF	I	REFERENCE FREQUENCY: The input can be driven by a direct coupled signal or an AC coupled ECL signal. For minimizing pulse jitter during read, FREF should be stopped by gating it externally with $\overline{VCOE}$.
NRZ1	O	NRZ DATA PORT 1: TTL Version (32P4620): When in read mode NRZ1 is a single ended TTL output for NRZ read data. When in write or idle mode NRZ1 is tristated. Differential Version (32P4621): When in read mode NRZ1 is the NRZ read data output (forms differential output with NRZ2). When in write or idle modes NRZ1 is tri stated.
NRZ2	I/O	NRZ DATA PORT 2: TTL Version (32P4620): NRZ2 is a single ended TTL input for NRZ write data. Differential Version (32P4621): When in read mode NRZ2 is the NRZ read data complementary output (forms differential output with NRZ1). When in write mode NRZ2 is a single ended TTL input for NRZ write data. When in idle mode NRZ is tri stated.
$\overline{WAM}$	I/O	WRITE ADDRESS MARK: The pin is the write address mark input when WG is high. In soft sector mode, a one bit wide low level pulse will write a 7"0," 7"0," 11"0," 11"0" address mark.
$\overline{AMD}$	O	ADDRESS MARK DETECT: The pin is the low level address mark detect output when RG is high. In hard sector mode, the pin is in a high impedance state.
$\overline{WD}$	O	WRITE DATA: Encoded write data output, active low. The data is automatically re sychronized to one edge of the FREF input clock.

DATA/CLOCK RECOVERY SECTION (Continued)

NAME	TYPE	DESCRIPTION
RRC/$\overline{\text{RRC}}$	O	READ/REFERENCE CLOCK: A multiplexed clock source used by the controller, see table 2. During a mode change, no glitches are generated and no more than two lost clock pulsed will occur. Differential Version (32P4621): RRC and $\overline{\text{RRC}}$ form a differential output. TTL Version (32P4620): RRC is a single ended TTL output; $\overline{\text{RRC}}$ is not provided.
$\overline{\text{VCOE}}$	O	VCO ENABLE: A low level selects FREF as the PLL input and a high level selects RD as the PLL input. The switching is done sychronously so that the VCO is restarted in phase with the PLL input.
VCO_CLK	O	VCO CLOCK: An open emitter ECL output test point. Two external resistors are required to use this pin. They should be removed during normal operation to reduce power dissipation. VCO_CLK and DRD can be used with a test chip to window margin test a drive.
$\overline{\text{DRD}}$	O	DELAYED READ DATA: An open emitter ECL output test point. The positive edges of this signal indicate the data bit position. Two external resistors are required to use this pin. They should be removed during normal operation to reduce power dissipation.

ANALOG PINS

IREF	I	CURRENT REFERENCE INPUT: The VCO center frequency, the 1/3 cell delay, and the phase gain are a function of the current sourced into this pin.
FLTR	I	LOOP FILTER INPUT: Input for passive PLL filter.
PCS	I	WRITE PRECOMPENSATION SET: Pin for RC network to program the write precompensation magnitude value.

ABSOLUTE MAXIMUM RATINGS

PARAMETER	MIN	NOM	MAX	UNIT
+5V supply voltage - VPA1,VPA2,VPA3,VPD1,VPD2			6	V
Storage Temperature	65		150	°C
Package Temp. PLCC, QFP (20 sec reflow solder)			215	°C
Pin Voltages: DOUT, $\overline{\text{DOUT}}$, RD, $\overline{\text{WD}}$, NRZ1, NRZ2, $\overline{\text{WAM/AMD}}$, $\overline{\text{VCOE}}$, RRC, $\overline{\text{RRC}}$, VCO_CLK, $\overline{\text{DRD}}$	–0.3		VPA/VPD+0.3 or +12	V mA
All other pins	–0.3		VPA/VPD+0.3	V

ELECTRICAL SPECIFICATIONS

(Unless otherwise specified: 4.65 ≤ VPA ≤ 5.25, 4.65 ≤ VPD ≤ 5.25, TBD ≤ Tj ≤ TBD.)

POWER SUPPLY

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
+5 V (VPA/VPD) Supply current	Outputs unloaded, CHIP_EN, SERVO_EN=High			260	mA
Power Dissipation	Outputs unloaded, Tj=145 °C,				
	CHIP_EN,SERVO_EN=High		1.0	1.3	W
	CHIP_EN=High, SERVO_EN=Low			1175	mW
	CHIP_EN,SERVO_EN=Low			925	mW

MODE CONTROL

Power Down Modes

CHIP_EN	SERVO_EN	MODE	DESCRIPTION
1	-	Enable	The entire chip is enabled.
0	1	Servo	Only the parts of the chip necessary to generate the SERV_OUT and DOUT/$\overline{\text{DOUT}}$ outputs are active.
0	0	Disable	The entire chip is in a power down mode.

Pulse Detector Mode Control
(CHIP_EN or SERVO_EN = 1)

WG	$\overline{\text{HOLD}}$	SHORT	MODE	DESCRIPTION
0	1	0	Read	Read amp on, AGC active and controlled by data.
0	0	0	Read/Hold	Read amp on, AGC level held at previous active level
1	-	0	Write	(Read amp gain set to zero) AGC level held at previous active level, AGC inputs shorted by low impedance.
-	-	1	Reset AGC	(Read amp gain set to zero) GAIN pin set for AGC maximum AGC gain, AGC inputs shorted by low impedance

Data/Clock Recovery Mode Control
(CHIP_EN = 1)

WG	RG	MODES	DESCRIPTION
0	1	RD lock	Data/clock recovery PLL locked to read data, $\overline{WD}$ is high.
0	0	FREF lock	Data/clock recovery PLL locked to external FREF reference, $\overline{WD}$ high.
1	0	Write	Data/clock recovery PLL locked to external FREF reference, $\overline{WD}$ active.
1	1	-	Undefined state.

PULSE DETECTOR TRANSITION TIMES

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
Enable <–> Disable Transition time	Settling time of external capacitors not included			20.0	µs
Read –> Write Transition Time	WG pin Low –> High			1.0	µs
Write –> Read Transition Time	WG pin High –>Low AGC settling not included	1.2		3.0	µs
Read –> Short Transition Time	SHORT pin Low –> High			1.0	µs
Short –> Read Transition Time	SHORT pin High –> Low AGC settling not included	1.2		3.0	µs
Hold On <–> Hold Off Transition time	$\overline{HOLD}$ pin High <–> Low			1.0	µs

SERIAL DIGITAL INTERFACE
(Refer to Figure 3.)

Register Addresses

A0	A1	A2	A3	DESTINATION
0	0	0	0	Pulse detector mode control
1	0	0	0	Data/clock recovery control register
0	1	0	0	Reserved

SERIAL DIGITAL INTERFACE (Continued)

Pulse Detector Mode Control Register Bit Definition

BITS		DESCRIPTION
D0		Fast attack/decay current control
0		Fast attack/decay enabled
1		Fast attack/decay disabled
D1	D2	Hysteresis level control
0	0	Level always controlled by HYS pin level
0	1	Level fixed at maximum percent of input level
1	0	Level fixed at nominal percent of input level
1	1	Level fixed at minimum percent of input level
D3		Test Mode
0		Normal mode: Read mode can be monitored on $\overline{RD}$ pin.
1		Test mode; Read data can be sent to the data/clock recovery section by driving the $\overline{RD}$ pin.

Data/Clock Recovery Mode Control Register Bit Definition

BITS		DESCRIPTION
D0		Phase detector enable control bit
0		Normal mode
1		Disables the phase detector and allows the VCO to coast (test mode only)
D1		Hard/soft sector control bit
1		Hard sector
0		Soft sector activates the 7 "0," 7 "0," 11"0," 11 "0" pattern soft sector address mark circuitry
D2	D3	Write precompensation magnitude control bits
1	1	Maximum shift
0	1	Second highest shift
1	0	Minimum shift
0	0	No shift

SERIAL DIGITAL INTERFACE (Continued)

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
TSLAT	Setup time; see Figure 3	1.5			µs
THLAT	Hold time; see Figure 3	1.0			µs
TSSDAT	Data setup time; see Figure 3	45			ns
THSDAT	Data hold time; see Figure 3	45			ns

DIGITAL INPUTS AND OUTPUTS

Two versions of the chip are supported:

Digital Inputs and Outputs Common to both versions:
WG, CHIP_EN, SERVO_EN, DATA_EN, SDATA, RG, FREF, SHORT, $\overline{\text{HOLD}}$, (These are TTL inputs)
$\overline{\text{VCOE}}$, R/$\overline{\text{W}}$, $\overline{\text{WD}}$ are TTL outputs
$\overline{\text{WAM/AMD}}$ is a bidirectional TTL pin
$\overline{\text{RD}}$ is a bidirectional pin with TTL input and ECL-like output

TTL version: (32P4620)
NRZ2 is a TTL input
DOUT, NRZ1, RRC are TTL outputs

Differential Digital Output Version: (32P4621)
DOUT, $\overline{\text{DOUT}}$, RRC, $\overline{\text{RRC}}$, NRZ1, NRZ2 are differential outputs; NRZ2 is also bidirectional and acts as a TTL input.

TTL COMPATIBLE INPUTS

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
Input Low Voltage	(VIL)	-0.3		0.8	V
Input High Voltage	(VIH)	2.0		VPD+0.3	V
Input Low Current	VIL = 0.4 V	0.0		0.4	mA
Input High Current	VIH = 2.4 V			100	µA

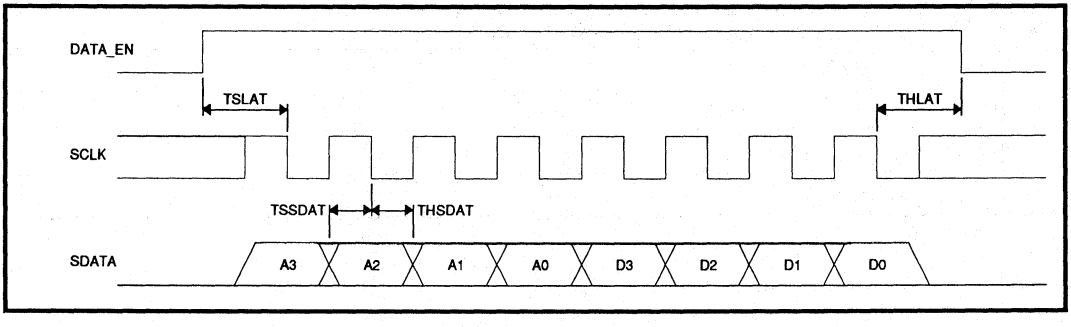


FIGURE 3: Serial Data Interface Timing

TTL COMPATIBLE OUTPUTS

Note: Outputs are loaded with a 4 kΩ resistor to 5V and 15 pF total capacitance (including stray capacitance) to GND for rise/fall time measurements.

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
Output Low voltage	Iol = 4.0 mA			0.4	V
Output High Voltage	Ioh = –400 µA	2.4			V
Output Rise Time	Voh = 2.4 V			9.0	ns
Output Fall Time	Vol = 0.4 V			9.0	ns

DIFFERENTIAL OUTPUTS

Outputs are loaded with a 10 kΩ resistor and 5 pF total capacitance (including stray capacitance) to GND for rise/fall time measurements.

PARAMETER	CONDITION		MIN	MAX	UNIT
Output Low Voltage	–0.5 mA < Iol < 0.5 mA	Tj=25°C	VPD–2.7	VPD–2.5	V
		Tj=145°C	VPD–2.2	VPD–2.0	V
Output High Voltage	–0.5 mA < Ioh < 0.5mA	Tj=25°C	VPD–1.8	VPD–1.7	V
		Tj=145°C	VPD–1.3	VPD–1.2	V
Output Rise Time	Voh = 90% final			6.0	ns
Output Fall time	Vol = 10% final			6.0	ns

ANALOG GAIN SECTION

The circuit is intended to interface with the filter structure shown in Figure 5.
The following measurements are made with the following conditions unless otherwise stated: 1. The circuit is in the read mode (CHIP_EN or SERVO_EN, and $\overline{\text{HOLD}}$ PINS high, WG and SHORT pins low) 2. The circuit is connected as in Figure 5.

Automatic Gain Control Section

The AGC circuit maintains the AC voltage level monitored across the DIN+/- pins at a level defined by the voltage on the AGC pin.

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
Stage Gain Settings					
K1	K1 = 30 V/V			±17	%
K2	K2 = –2.5 V/V			±5	%
Minimum Gain Range		0.3		20	V/V

Automatic Gain Control Section (Continued)

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
AGC Loop Level Settings					
DIN+ - DIN- Input Voltage Swing vs. V(AGC)	20mVpp≤V(IN1+–IN1-)≤240mVpp, 0.5Vpp≤V(DIN+ – DIN-)≤1.4Vpp	0.37		0.56	Vpp/V
DIN+ - DIN- Input Voltage Swing When AGC Pin is Open	20 mVpp ≤ V(IN1+ – IN1-) ≤ 240mVpp	0.85	1.0	1.12	%
DIN+ - DIN- Input Voltage Swing Variation	20 mVpp ≤ V(IN1+ – IN1-) ≤ 240mVpp			8.0	%
AGC Pin Input Impedance		4.4		10.8	kΩ
AGC Pin Voltage	V(AGC) = 2.19V, AGC pin open			±11	%
Allowable DIN+ - DIN- Input signal range				1.4	Vpp

AGC Loop Time Constants

Slow AGC Decay Capacitor Charge Current	V(DIN+ - DIN-)=0.0		4.5		µA
Fast AGC Decay Capacitor Charge Current	V(DIN+ - DIN-)=0.0		1.2		mA
Fast Decay Hold Off Time	Slow attack threshold not reached	0.7		0.3	µs
AGC Capacitor Leakage Current	Read/Hold Mode	-0.2		0.2	µA
Slow AGC Attack Capacitor Discharge Current	V(DIN+ - DIN-)=0.8Vdc Vary V(AGC) until slow charge begins.	0.14		0.22	mA
Fast AGC Attack Capacitor Discharge Current	V(DIN+ - DIN-)=0.8Vdc V(AGC)= 3.0V	-1.3		-2.0	mA
Fast –> Slow Attack Switchover Point	V(DIN+ - DIN-) - V(DIN+ - DIN-)Final		0.25		V
Gain Decay Time (Td) (see Figure 7)	Vin = 240 mVpp –> 120 mVpp @ 2.5 Mhz, Vout to 90% of final value		TBD		µs
Gain Attack Time (Ta) (see Figure 7)	WG = high –> low, Vin = 240 mV @ 2.5 Mhz Vout to 110% final value		4		µs

General Amplifier Characteristics

PARAMETER	CONDITION	MIN	NOM	MAX	UNITS
Input Voltage Range		20		240	mVpp
Differential Input Resistance	V(IN1+ - IN1-) = 100 mVpp @ 2.5 Mhz		5.0		kΩ
Differential Input Capacitance	V(IN1+ - IN1-)=100 mVpp			10.0	pF
Common Mode Input	SHORT pin = low		1.8		kΩ
Impedance (both sides)	SHORT pin = high		250		Ω
Input Noise	Gain set to Maximum			30	nV/√Hz
Differential Output Resistance OUT1+/-		16		60	Ω
Output Offset Voltage				±100	mV
Maximum Output Voltage Swing	Set by GAIN pin voltage Z(load diff) = 600Ω	0.56			Vpp
OUT1+ to OUT1- Pin current	No DC path from OUT+/- to GND	±1.1			mA
Bandwidth	Gain set to maximum, ±3 dB bandwidth	30			MHz
Common ModeRejection Ratio (Input Referred)	V(IN1+)=V(IN1-)=100 mVpp, 5 Mhz, Gain set to maximum	40			dB
Power Supply Rejection Ratio (Input Referred)	V(VPA/VPD) = 100 mVpp 5 MHz, Gain set to maximum	30			dB

Adjustable Real and Imaginary Zero Filter Section

See applications section for equations governing generation of real/imaginary axis zeros. All the following measurements are made with LP3+ tied to HP3+ and to a 180Ω resistor to VPA and with LP3- tied to HP3- and to a 180Ω resistor to VPA.

PARAMETER	CONDITION	MIN	MAX	UNITS
Stage Gain Settings				
K4	K4 = 0.0031Ω		±TBD	%
M1	M1 = [7.5 x V(MULT_1)]/V(VREF)		±TBD	%
Minimum M1 Range		0.1	7.0	V/V
M2	M2 = 0.75[V(MULT_2)–0.1]/V(VREF)		±TBD	%
Minimum M2 Range		0.01	0.5	V/V
Allowable Load Resistor Range	180Ω per side to VPA		±5	%

Adjustable Real and Imaginary Zero Filter Section (Continued)

PARAMETER	CONDITION	MIN	NOM	MAX	UNITS
General Amplifier Char.					
Output Offset Voltage				±100	mV
Differential Input Resistance	V(LP2/HP2+ - LP2/HP2-) = 100 mVpp, 2.5 MHz (LP2+ - LP2-) or (HP2+ - HP2-)		10		kΩ
Differential Input Capacitance	V(LP2/HP2+ - LP2/HP2-) = 100 mVpp, 2.5 MHz (LP2+ - LP2-) or (HP2+ - HP2-)			10.0	pF
Common Mode Input Impedance (Both sides)	(LP2+ - LP2-) or (HP2+ - HP2-)		3.3		kΩ
Bandwidth	Gain set to maximum, +3 dB bandwidth	30			MHz
LP3+, LP3, HP3+, HP3 pin current	With LP2+/- and HP3+/- shorted, (LP2+ + HP2+) or (LP2- + HP2-)	1.7			mA
Common Mode Rejection Ratio (Input referred)	V(LP2+)=V(LP2-)=100 mVpp, or V(HP2+)=V(HP2-)=100 mVpp 5 MHz, gain set to maximum	40			dB
Power Supply Rejection Ratio (Input referred)	ΔV(VPA/VPD)=100 mVpp, 5 MHz, Gain set to maximum	30			dB
Differential Output Resistance	(LP3+ - LP3-) or (HP3+ - HP3-)	10			kΩ
MULT_1 Current				±3	mA
MULT_2 Current				±10	mA

Gain Buffer to Differentiator and Matched Delay Section
See applications section for equations development. All of the following measurements are made with a 500Ω resistor tied from OUT4+ to OUT4-.

PARAMETER	CONDITION	MIN	NOM	MAX	UNITS
Gain	Av = 2.5 V/V			±15	%
Differential Input Resistance	V(IN4+ - IN4-) = 100 mVpp, 2.5 MHz		10		kΩ
Differential Input Capacitance	V(IN4+ - IN4-) = 100 mVpp, 2.5 MHz			10	pF
Common Mode Input Impedance	Both sides		3.0		kΩ

Gain Buffer to Differentiator and Matched Delay Section

PARAMETER	CONDITION	MIN	NOM	MAX	UNITS
Differential Output Resistance OUT4+/-		10		32	Ω
Maximum Output Voltage Swing	Z(load diff.) = 350 Ω	1.4			Vpp
OUT4+ to OUT4- Pin current	No DC path from OUT+/- to GND	±2.3			mA
Output Offset Voltage				±50	mV
Bandwidth	Gain set to maximum,	30			MHz
Common Mode Rejection Ratio (Input referred)	V(IN4+) = V(IN4-)=100 mVpp, 5 Mhz, Gain set to maximum	40			dB
Power Supply Rejection Ratio (Input referred)	V(VPA/VPD) = 100 mVpp, 5 Mhz, Gain set to maximum	30			dB

Voltage Reference Generator Section

An on-chip reference voltage is generated for use as a reference by the external DACs which supply the MULT_1 and MULT_2 voltages.

PARAMETER	CONDITION	MIN	NOM	MAX	UNITS
Output Voltage on VREF Pin	0.4 mA < I(VREF) < 1.1 mA	1.9	2.2	2.5	V

READ MODE DIGITIZING SECTION

All of the measurements in the read digital section are made with the following conditions unless otherwise stated:

1. In the read mode, (CHIP_EN high, WG & SHORT pins low)
2. The clock and data input (CIN+ - CIN) and (DIN+ - DIN-), receive AC coupled 2.5 MHz, 1.0 Vpp sine-wave input signals with the DIN+/- input leading CIN+/- by 90 degrees.
3. A 1.8V DC voltage is applied to HYS pin.
4. The $\overline{RD}$ and DOUT pins are loaded with a 10 kΩ resistor and 5 pF total capacitance to GND.

Hysteresis Comparator Circuit

PARAMETER	CONDITION	MIN	NOM	MAX	UNITS
Input Signal Range				1.4	Vpp
Differential Input Resistance	V(DIN+ - DIN-) = 100 mVpp, 2.5 Mhz	10		16.5	kΩ
Differential Input Capacitance	V(DIN+ - DIN-) = 100 mVpp, 2.5 Mhz			4.0	pF

Hysteresis Comparator Circuit (Continued)

PARAMETER	CONDITION	MIN	NOM	MAX	UNITS
Common Mode Input Impedance	Both sides	2.5		4.0	kΩ
LEVEL Pin Output Voltage vs DIN+ - DIN- Input voltage	0.6 < V(DIN+ - DIN-)<1.4 Vpp 10 kΩ between LEVEL & GND	1.3		2.2	V/Vpp
LEVEL Pin Output Impedance	I(LEVEL) = 0.5 mA		140		Ω
LEVEL Pin Maximum Output Current		3.0			mA
Comparator Offset Voltage	HYS pin at GND, ≤1.5 kΩ across DIN+, DIN-			±10	mV
Hysteresis Trip Voltage (at DIN+, DIN-) vs. HYS pin voltage	1V < V(HYS) < 2V	0.44	0.5	0.64	Vpp/V
Hysteresis Threshold Margin as a % of V(DIN+ - DIN-) Peak	V(HYS) = some % of V(AGC)* or V(LEVEL), 1V < V(HYS) < 3V See Figures 18 & 19	-15		+15	% Peak
HYS Pin Input Current	1V < V(HYS) < 3V	0.0		-20	µA

*In an open loop configuration where reference is V(AGC) tolerance may be slightly higher

TABLE 1: Frequency Template of Hysteresis Trip Point as Percent of Peak Input Voltage Across DIN+/– Pins

Frequency	Hysteresis			
	External	High	Medium	Low
0 to TBD MHz	TBD to TBD %	TBD to TBD %	TBD to TBD %	TBD to TBD %
TBD MHz	TBD to TBD %	TBD to TBD %	TBD to TBD %	TBD to TBD %

Note 1: Pulse detector mode control register bits D1, 2 set as follows:

00 = External hysteresis

10 = About 65% hysteresis

01 = About 50% hysteresis

11 = About 35% hysteresis

Note 2: For external hysteresis, LEVEL/HYS pin network is set up with external component values as shown in Figure 5a.

Clocking Circuit

PARAMETER	CONDITION	MIN	NOM	MAX	UNITS
Input Signal Range				1.4	Vp-p
Differential Input Resistance	V(CIN+ - CIN-) = 100 mVp-p, 2.5 Mhz	10		16.5	kΩ
Differential Input Capacitance	V(CIN+ - CIN-) = 100 mVp-p, 2.5 Mhz			4.0	pF
Common Mode Input Impedance	Both sides	2.7		3.8	kΩ
Input Offset Voltage				6.0	mV
COUT Pin Output Low Voltage	TIE 2 kΩ from COUT to GND		VPA-3.0		V
COUT Pin Output Pulse Voltage V(high) - V(low)	TIE 2 kΩ from COUT to GND		+0.8		V
COUT Pin Output Pulse Width	TIE 2 kΩ from COUT to GND		12		ns

Read Mode Digital Section as System

PARAMETER	CONDITION	MIN	NOM	MAX	UNITS
Required DFF Set up Time, (Td1 in Figure 8)	Minimum allowable time delay from V(DIN+, DIN) exceeding hysteresis point to V(CIN+,CIN) crossing zero	0			ns
Propagation Delay Td3 in Figure 8				60	ns
Pulse Pairing	|Td3-Td4| in Figure 8			1.0	ns
RD Pin Output Pulse Width	0.0 < Ioh < 0.5 mA		10		ns
RD Pin Output Low Voltage	0.0 < Iol < 0.5 mA		VPA-2.1		V
RD Pin Output Pulse Voltage V(high)-V(low)	0.0 < Ioh < 0.5 mA		+0.8		V

Servo Burst Capture Circuit
All of the measurements for the servo are made with the following conditions unless otherwise stated. The circuit is connected as shown in Figure 5.

PARAMETER	CONDITION	MIN	NOM	MAX	UNITS
SERV_REF Pin Level		VPA-2.8		VPA-2.1	V
SERV_OUT to SERV_REF Offset	DIN+ shorted to DIN-			±20	mV
SERV_OUT Level vs AGC Pin Voltage	$\frac{V(SERV\_OUT)}{V(AGC)} = 0.2\ Vp/V$			±TBD	%
Servo Frame vs. V(DIN+/-)	$\frac{V(SERV\_OUT - SERV\_REF)}{V(DIN+/-)}$ = 0.39 Vp/Vpp			TBD	Vp/Vpp
Allowable Load Impedance SERV_OUT or SERV_REF to GND	Equivalent parallel resistance	10			kΩ
	Equivalent parallel capacitance			5	pF

CLOCK/DATA RECOVERY SECTION:
See applications section for loop filter development.

DC Output levels

PARAMETER	CONDITION	MIN	NOM	MAX	UNITS
Test Point Output High Level (VOHT) $\overline{DRD}$, VCO_CLK, VCO_REF	262Ω to VPD,402Ω to GND VPA = VPD	VPD-1.02			V
Test Point Output Low Level (VOLT) $\overline{DRD}$, VCO_CLK, VCO_REF	262Ω to VPD,402Ω to GND VPA = VPD			VPD-1.625	V

Read Mode

PARAMETER	CONDITION	MIN	NOM	MAX	UNITS
Read Clock Rise Time (TRRC)	0.8V to 2.0V, C1 ≤ 15 pF			8	ns
Read Clock Fall Time (TFRC)	2.0V to 0.8V, C1 ≤ 15 pF			5	ns
NRZ (out) Set Up and Hold Time (TPNRZ)		.31 TORC			ns
$\overline{AMD}$ Propagation Delay (TPAMD)		10			ns
1/3 Cell Delay	TD = 4.92(RR + 0.53) RR = 2.0 kΩ to 7.0 kΩ	0.8TD		1.2TD	ns

Write Mode

PARAMETER	CONDITION	MIN	MAX	UNIT
Write Data Pulse Width (TWDC)	C1 < 15 pF	$\frac{2TOWC}{3}$ - 2TPC - 5	$\frac{2TOWC}{3}$ + 5	ns
Write Data Fall Time (TFWD)	2.0V to 0.8V, C1 ≤ 15 pF		8	ns
Write Data Clock Rise Time (TWRC)	0.8V to 2.0V, C1 < 15 pF		10	ns
Write Data Clock Fall Time (TWFC)	2.0 to 0.8V C1 < 15 pF		8	ns
NRZ Set Up Time (TSNRZ)		5		ns
NRZ Hold Time (THNRZ)		5		ns
Precompensation Time Shift Magnitude Accuracy (TPC)	TPCO = T x A/(B+3A) See note			
	D2 bit=1, D3 bit=1	0	0	ns
	D2 bit=0, D3 bit=1	0.8TPC-0.2	1.2TPC+0.2	ns
	D2 bit=1, D3 bit=0	2(0.8TPC)	2(1.2TPC)	ns
	D2 bit=0, D3 bit=0	3(0.8TPC)	3(1.2TPC)	ns

Note: T = FREF period, A=0.19/(Rpc+0.51)+0.0058, B=0.42/(RR+0.53)+0.0108, Rpc & RR in kΩ

Data Synchronization

PARAMETER	CONDITION	MIN	MAX	UNIT
VCO Center Frequency Period (TVCO)	VCO IN = 2.7V, TO=4.03(RR+1.33), VPA, VPD = 5.0V, RR=2.0 kΩ to 7.0 kΩ	0.8TO	1.2TO	ns
VCO Frequency Dynamic Range	1.0V≤VCO IN≤VPA-0.6V VPA, VPD = 5.0V	±25	±45	%
VCO Control Gain (KVCO)	ωo = 2 x π/TO, 1.0V≤VCO IN≤VPA-0.6V	0.14ωo	0.26ωo	$\frac{rad}{VxS}$
Phase Detector Gain (KD)	For PLL REF=FREF, KD=0.095/(RR+530) For PLL REF=RD, KD=0.19/(RR+530) VPA, VPD = 5.0V	0.83KD	1.17KD	A/rad
KVCOxKD Product Accuracy		-28	+28	%
VCO Phase Restart Error	Referred to RRC	-1	+1	rad
Decode Window Centering Accuracy			±1.0	ns
Decode Window		(2TORC/3) -1.5		ns

APPLICATIONS SECTION

ADJUSTABLE REAL AND IMAGINARY ZERO FILTER SECTION

With external components connected as in Figure 5a, this section generates a pair of symmetric real axis zeros whose position is controlled by the voltage on the MULT_1 pin.

$$H1(s) = \frac{1}{(L1a + L1b)\,C2 \cdot s^2 + (L1a + L1b/3)s + 1} - \frac{M1 \cdot L5 \frac{C4a \cdot C4b}{C4a \cdot C4b} \cdot s^2}{L5 \cdot \frac{C4a \cdot C4b}{C4a \cdot C4b} \cdot s^2 + (L5/R6)s + 1}$$

$$= \frac{1 - M1 \cdot L \cdot C \cdot s^2}{LCs^2 + (L/R)s + 1}$$

for: $L = L5 = 2 \cdot L1a = 2 \cdot L1b$
$C = C2 = 0.5 \cdot C4a = 0.5 \cdot C4b$

With the external components connected as in Figure 5a, this section also generates a pair of symmetric imaginary axis zeros whose position is controlled by the voltage on the MULT_2 pin.

$$H2(s) = K4 \cdot \frac{M2(L8a + L8b) \cdot C7 \cdot s^2 + 1}{(E \cdot s^N) + (F \cdot s^{N-1}) + \ldots + 1} \cdot (R12a + R12b)$$

With the external components connected as in Figure 6a, this section can also generate two pairs of symmetric complex zeros whose position is controlled by the voltage on the MULT_2 pin.

$$H2(s) = K4 \cdot \frac{(M2 \cdot A \cdot s^4) + (M2 \cdot B \cdot s^2) + 1}{(E \cdot s^N) + (F \cdot s^{N-1}) + \ldots + 1} \cdot (R12a + R12b)$$

where $A = Cg \cdot C7 \cdot 2L10 \cdot 2L8$
$B = (C7 \cdot 2L8) + (C7 \cdot 2L10) + (Cg \cdot 2L10)$

GAIN BUFFER TO DIFFERENTIATOR AND MATCHED DELAY SECTION

With external components conncected as in Figure 5a, this section generates the differentiated signal applied to CIN+/- and a signal with a matched delay applied to DIN+/-.

$$Hcin(s) = \frac{\frac{C16a \cdot C16b}{C16a + C16b} \cdot R17 \cdot s}{(L15a + L15b) \cdot \frac{C16a \cdot C16b}{C16a + C16b} \cdot s^2 + \frac{C16a \cdot C16b}{C16a + C16b} \cdot R17 \cdot s + 1}$$

$$= \frac{CRs}{LCs^2 + CRs + 1}$$

For: $L = 2 \cdot L15a = 2 \cdot L15b$
$C = 0.5 \cdot C16a = 0.5 \cdot C16b$
$R = R17$

$$Hdin(s) = \frac{1}{(L18a + L18b) \cdot C19 \cdot s^2 + C19 \cdot R20 \cdot s + 1}$$

$$= \frac{1}{LCs^2 + CRs + 1}$$

For: $L = 2 \cdot L18a = 2 \cdot L18b$
$C = C19$
$R = R20$

LOOP FILTER

The low pass filter attenuates high frequency components fo the phase error signal from the phase detector and modifies the dynamics of the PLL. In lock mode, the PLL can be approximated by the linear model shown in Figure 4. The transfer functions of the blocks are as follows:

KD = conversion factor for phase detector in μA/radian
KVCO = VCO gain factor in radians/volt-second
F(s) = low pass filter transfer function

Thus the closed loop transfer function is:

$$H(s) = \frac{\frac{KD \cdot Kvco \cdot F(s)}{N}}{s + \frac{KD \cdot Kvco \cdot F(s)}{N}}$$

where: N = ratio between TBD and FIN
N = 1.0 for preamble
N= 0.5 for external clock

For the low pass filter example:

$$F(s) = \frac{1 + sC1R}{sC1\left(1 + \frac{C2}{C1} + sC2R\right)}$$

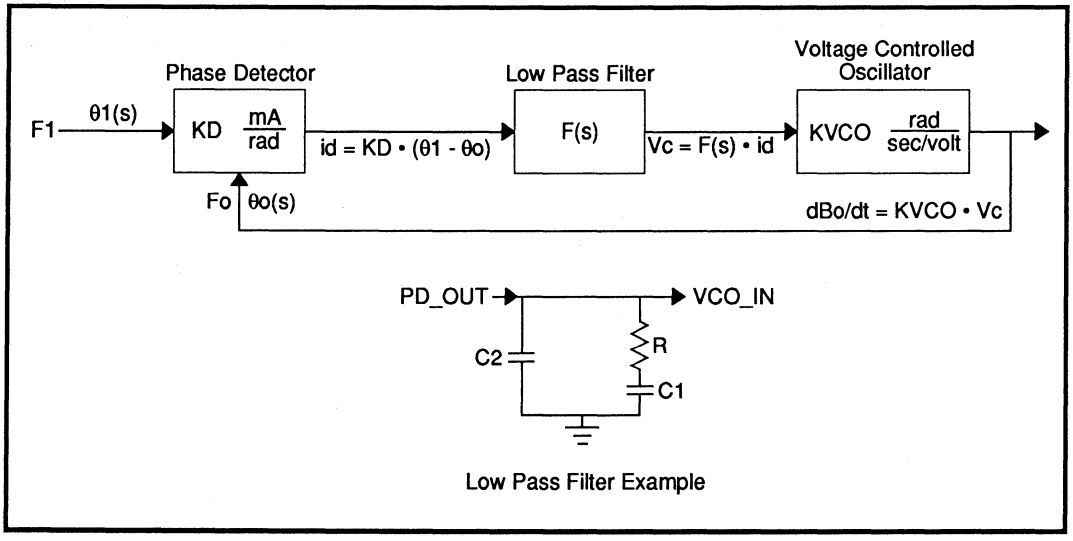


FIGURE 4: Phase Locked Loop

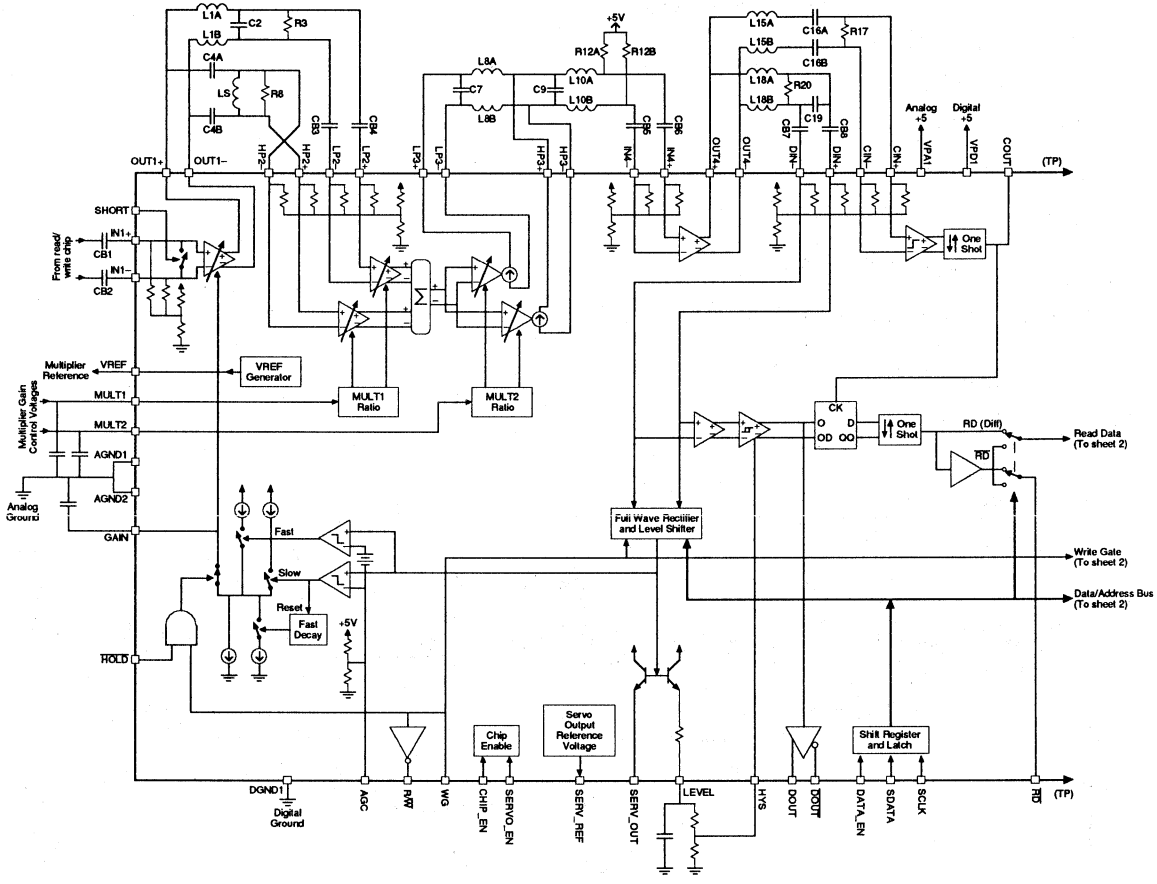


FIGURE 5a: SSI 32P4621 Circuit Block Diagram - Differential Output Data Version - Sheet 1

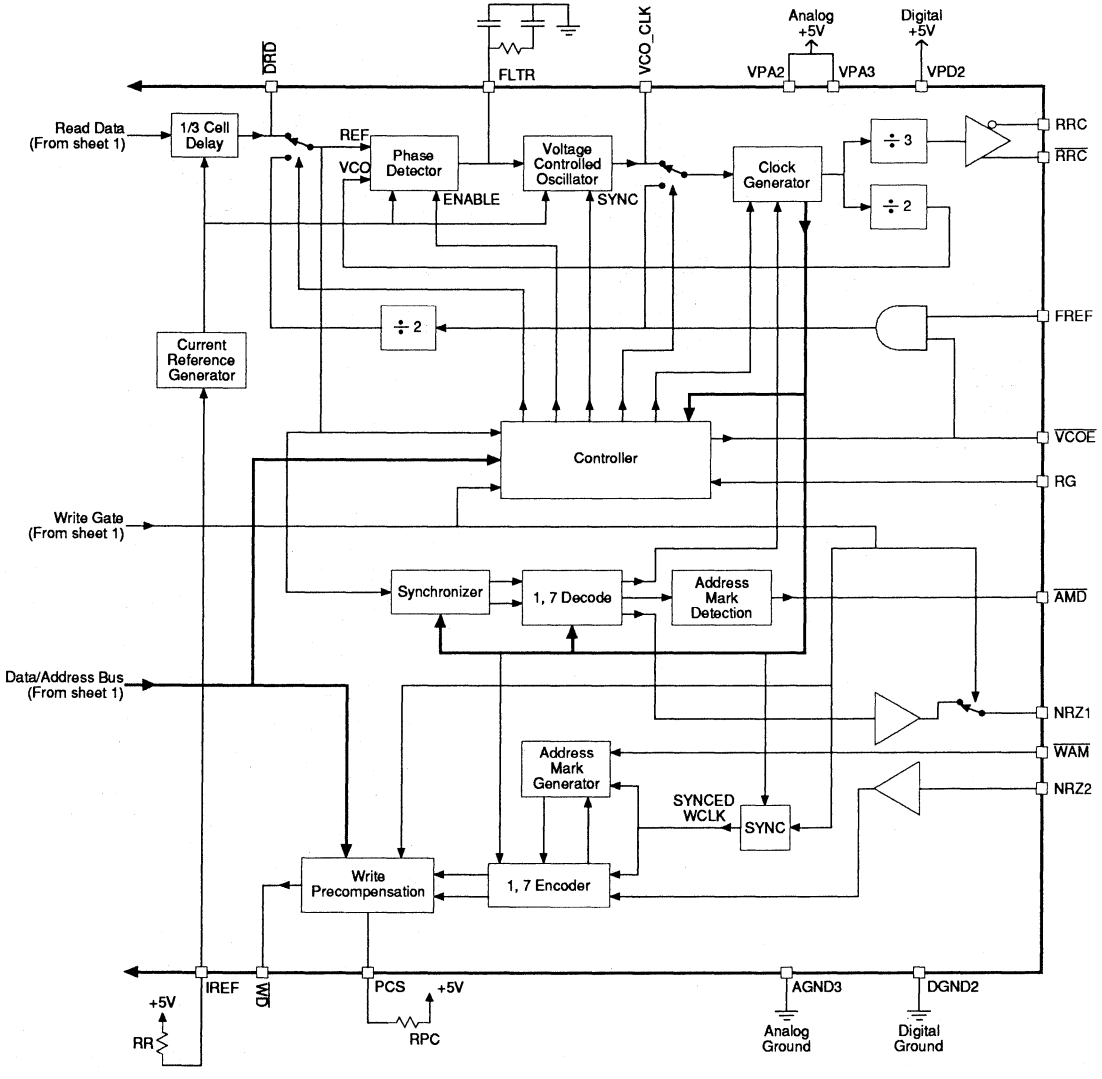


FIGURE 5b: SSI 32P4621 Circuit Block Diagram - Differential Output Data Version - Sheet 2

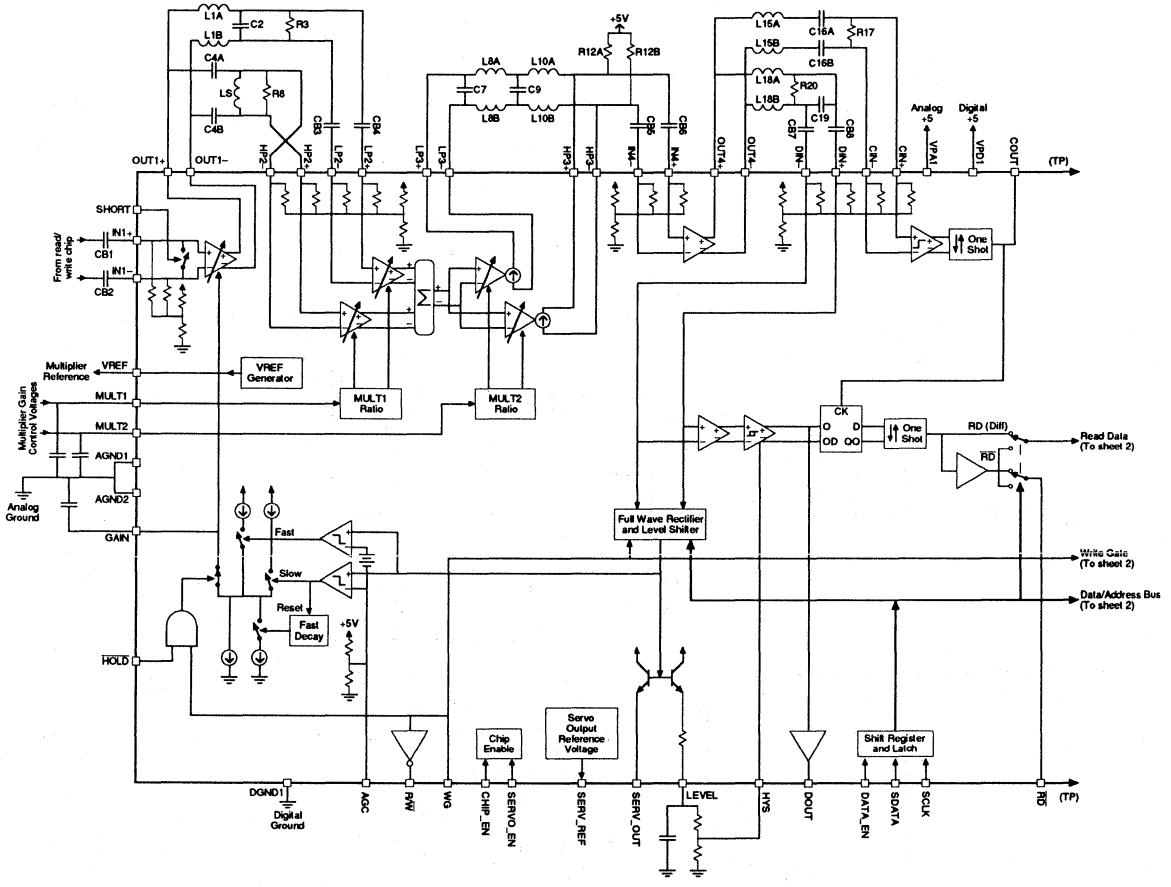


FIGURE 6a: SSI 32P4620 Circuit Block Diagram - Single Ended Output Data Version - Sheet 1

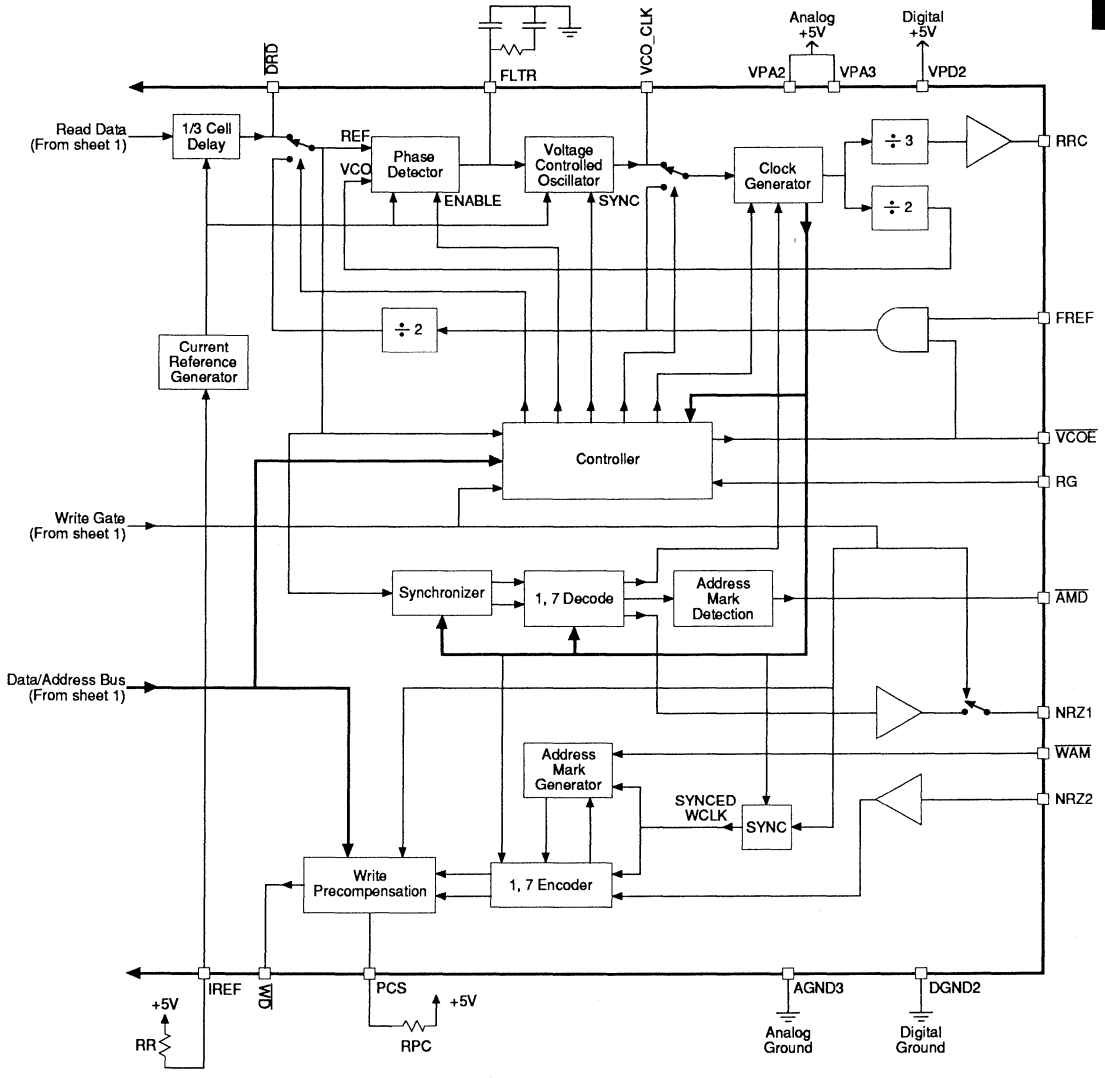


FIGURE 6b: SSI 32P4620 Circuit Block Diagram - Single Ended Output Data Version - Sheet 2

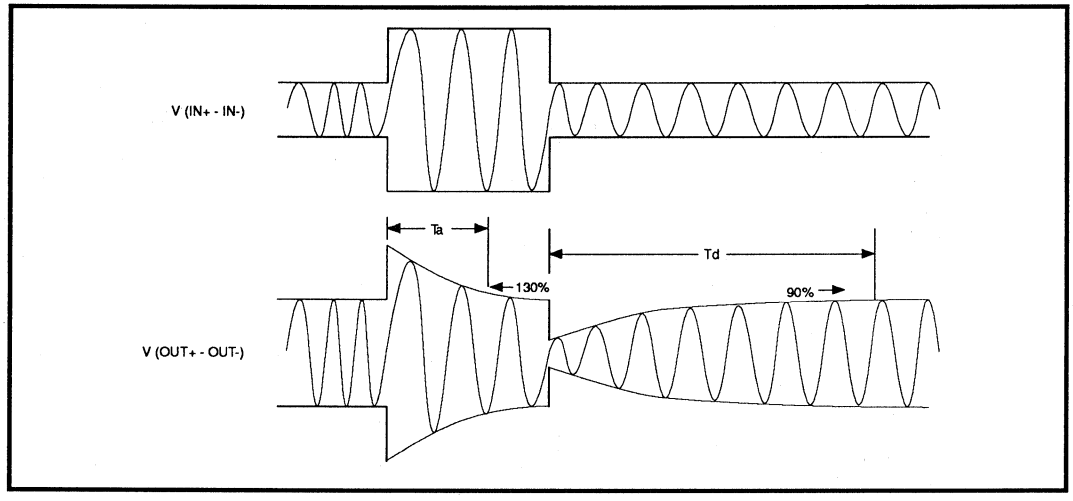


FIGURE 7: AGC Timing Diagram

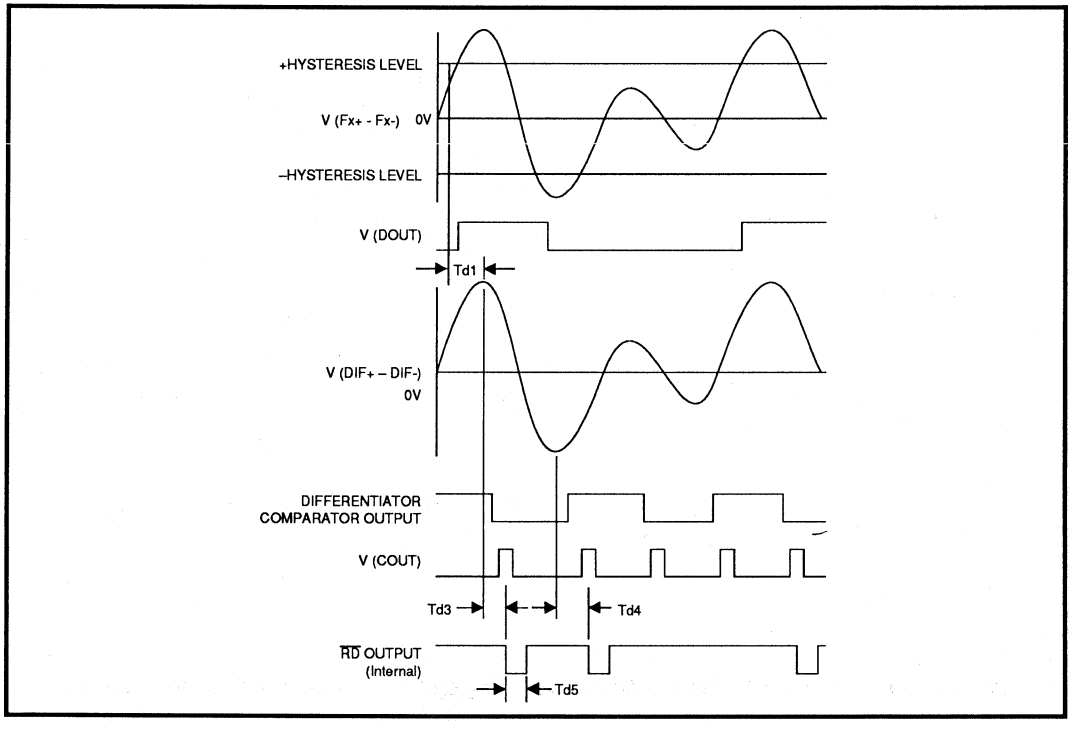


FIGURE 8: Read Mode Digital Section Timing Diagram

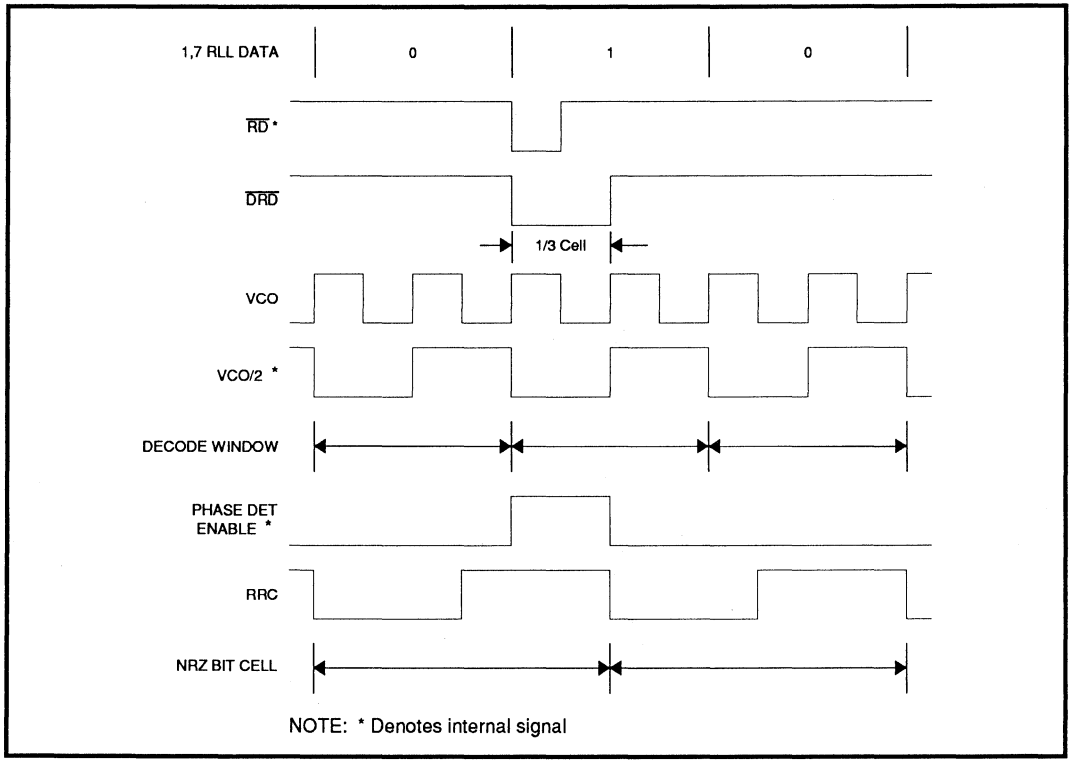


FIGURE 9: Data Synchronization Waveform

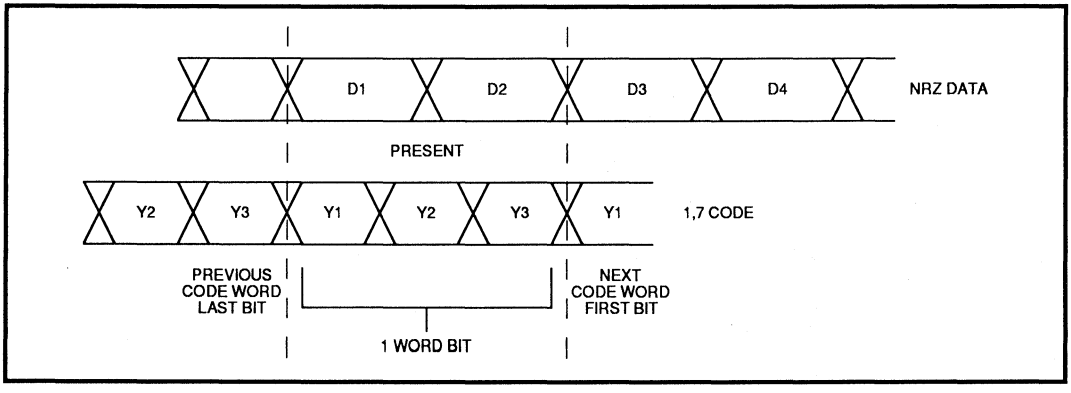


FIGURE 10: NRZ Data Word Comparison to 1, 7 Code Word Bit
(See Table 1 for decode scheme)

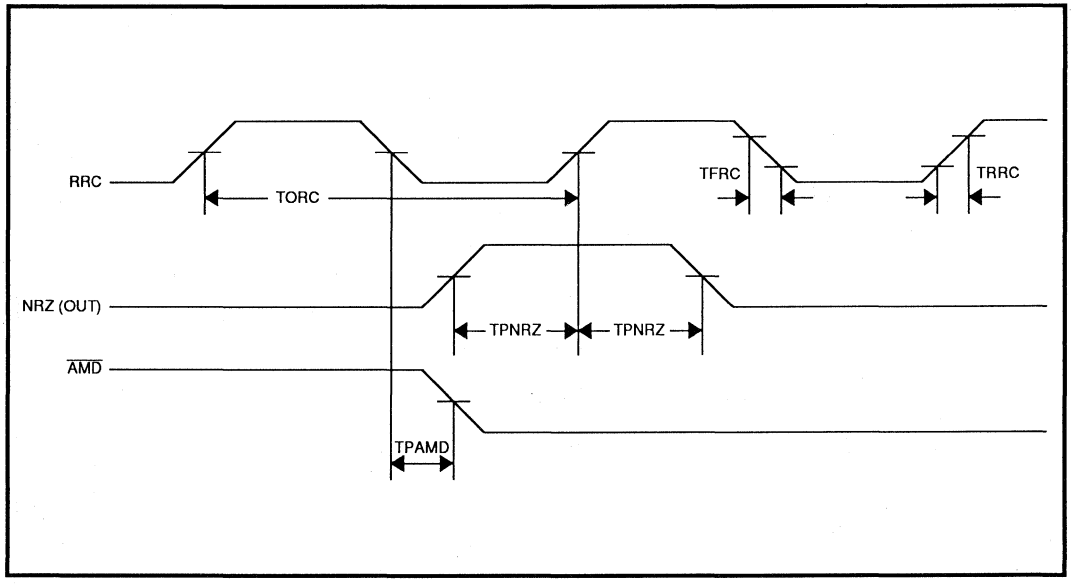


FIGURE 11: Read Timing

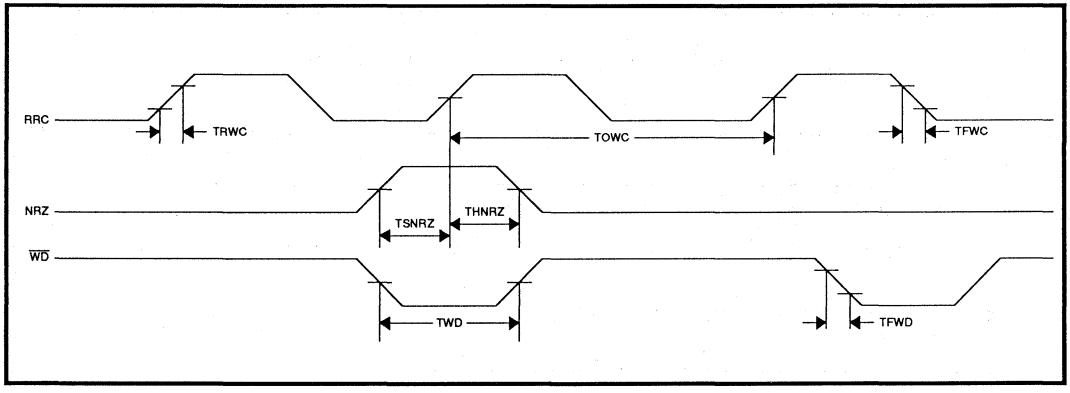
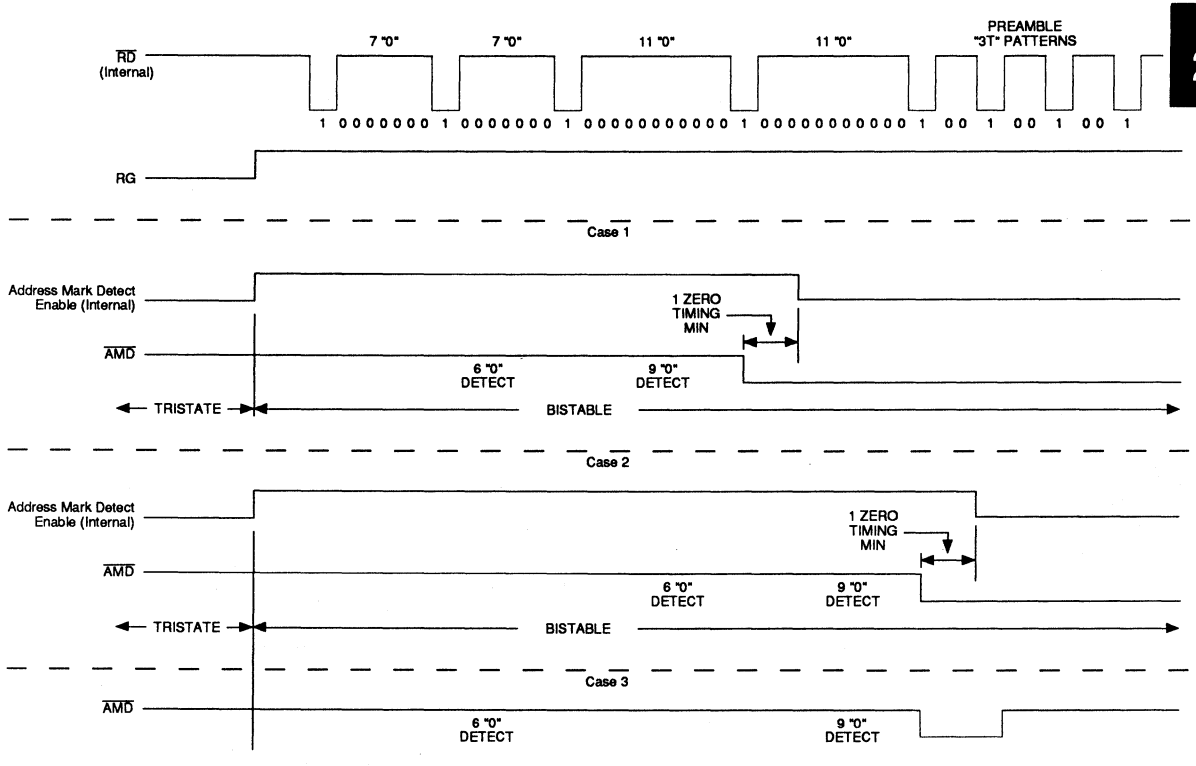


FIGURE 12: Write Timing



If 5 bits of RD are detected after 6 "0" and before 9 "0" are found, then restart and look for 6 "0."

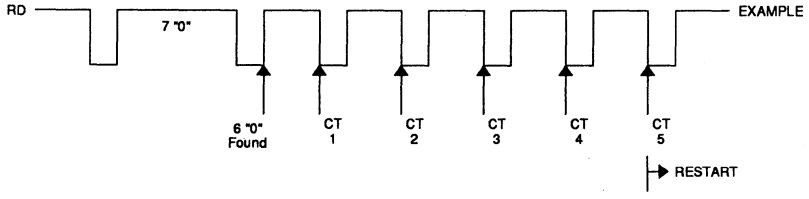
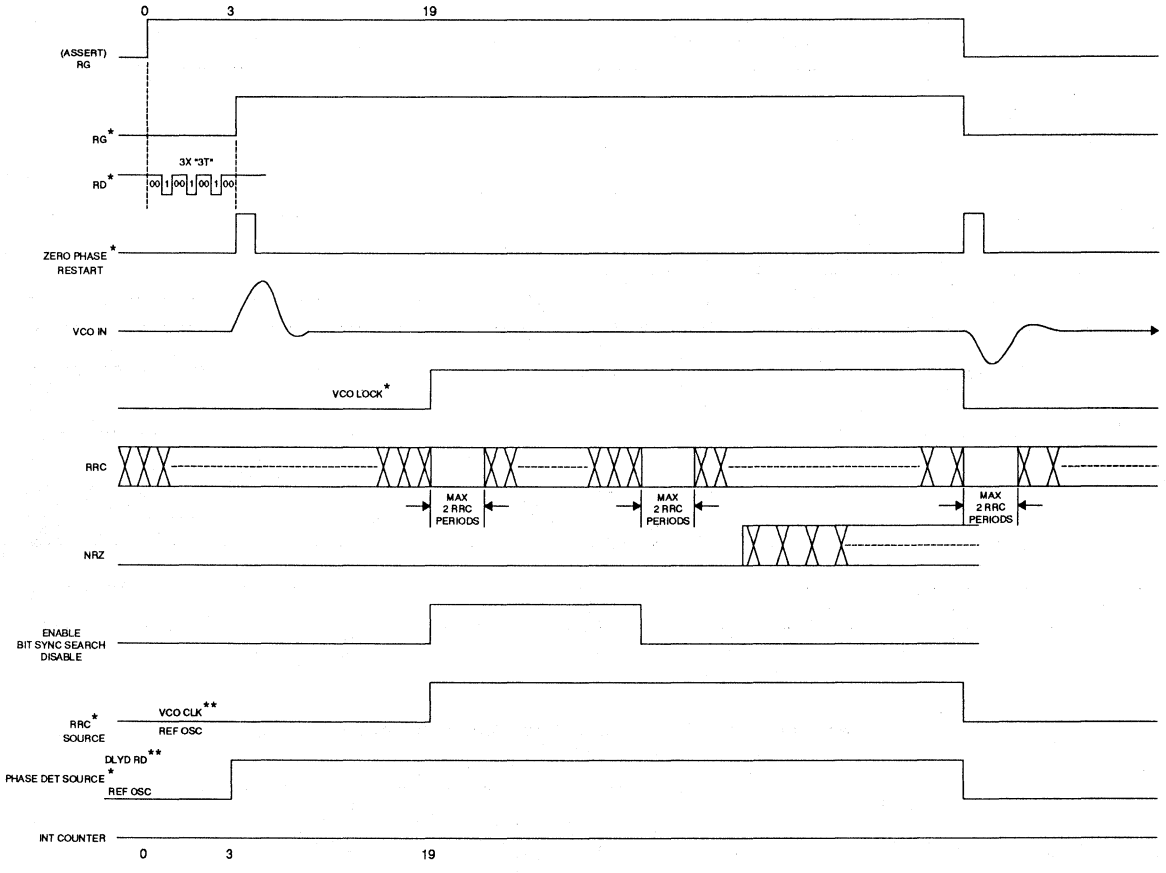


FIGURE 13: Address Mark Search



*= – Internal Source

**= – Test Point

FIGURE 14: Read Mode Locking Sequence (Soft and Hard Sector)

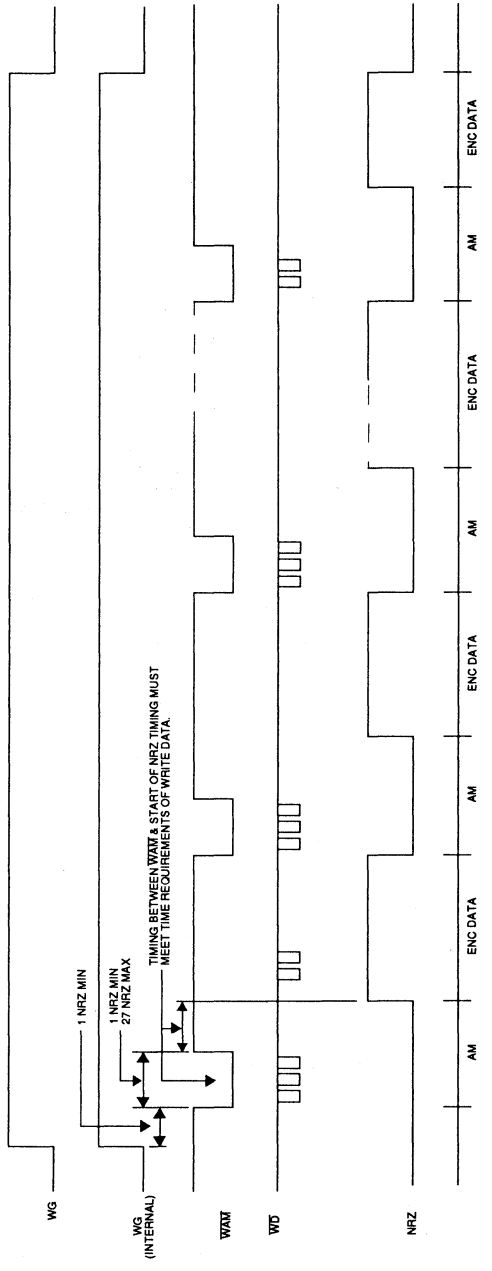


FIGURE 15: Multiple Address Mark Write

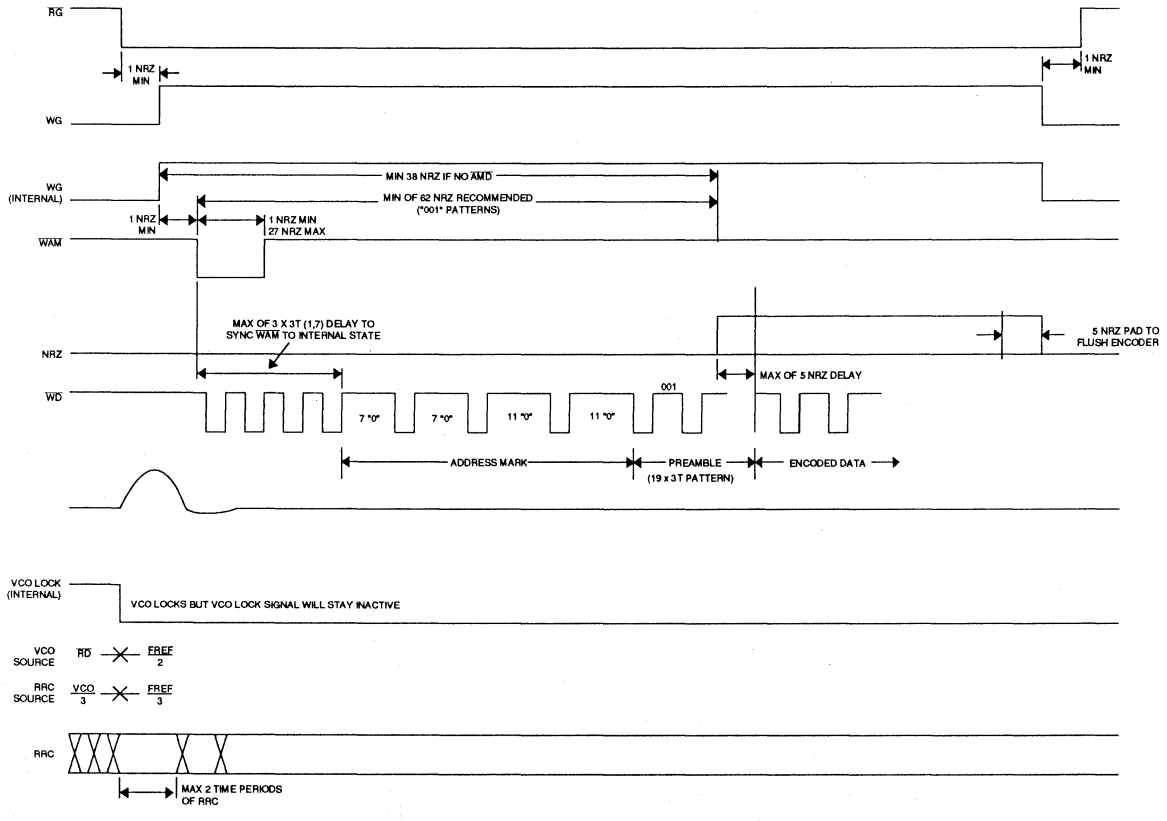


FIGURE 16: Write Data

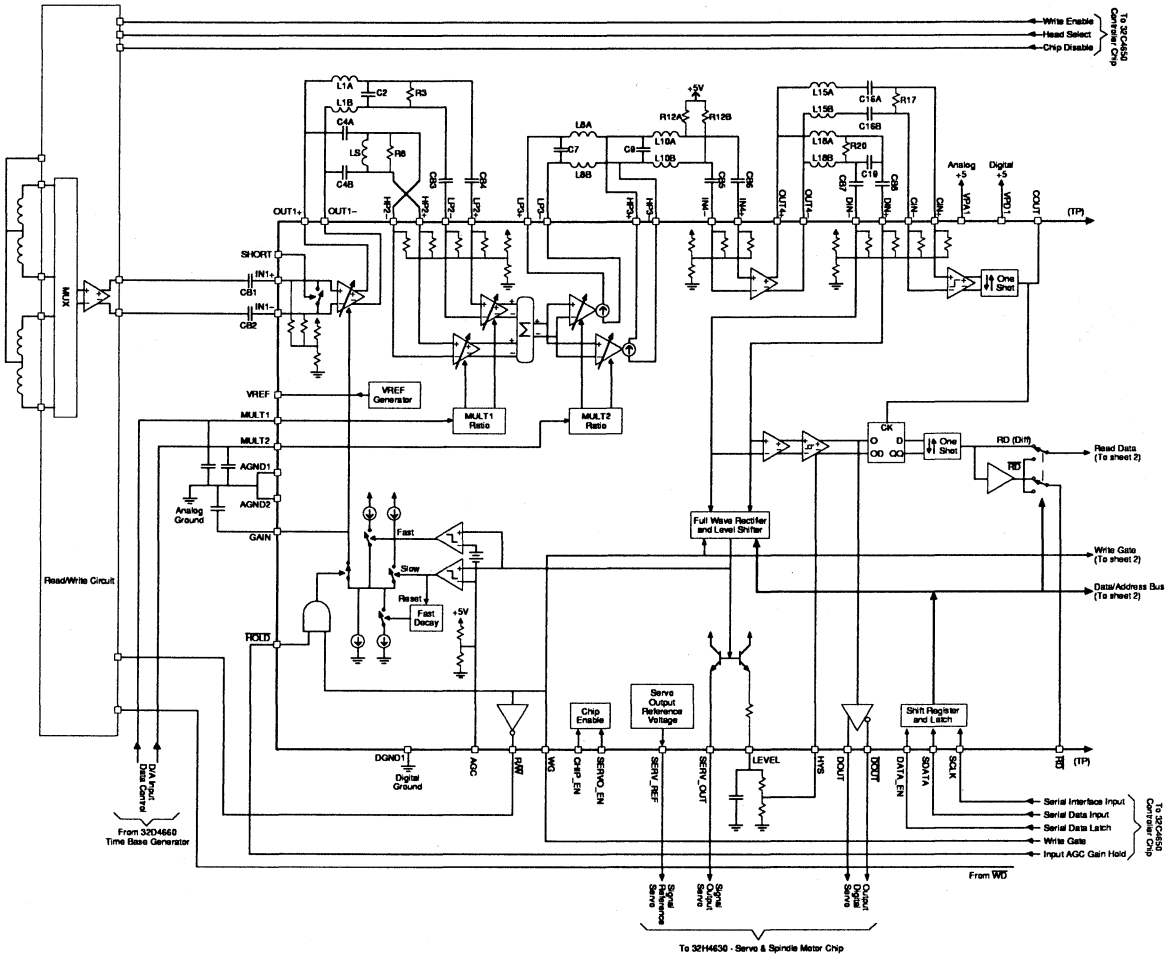


FIGURE 17a: System Configuration - Sheet 1

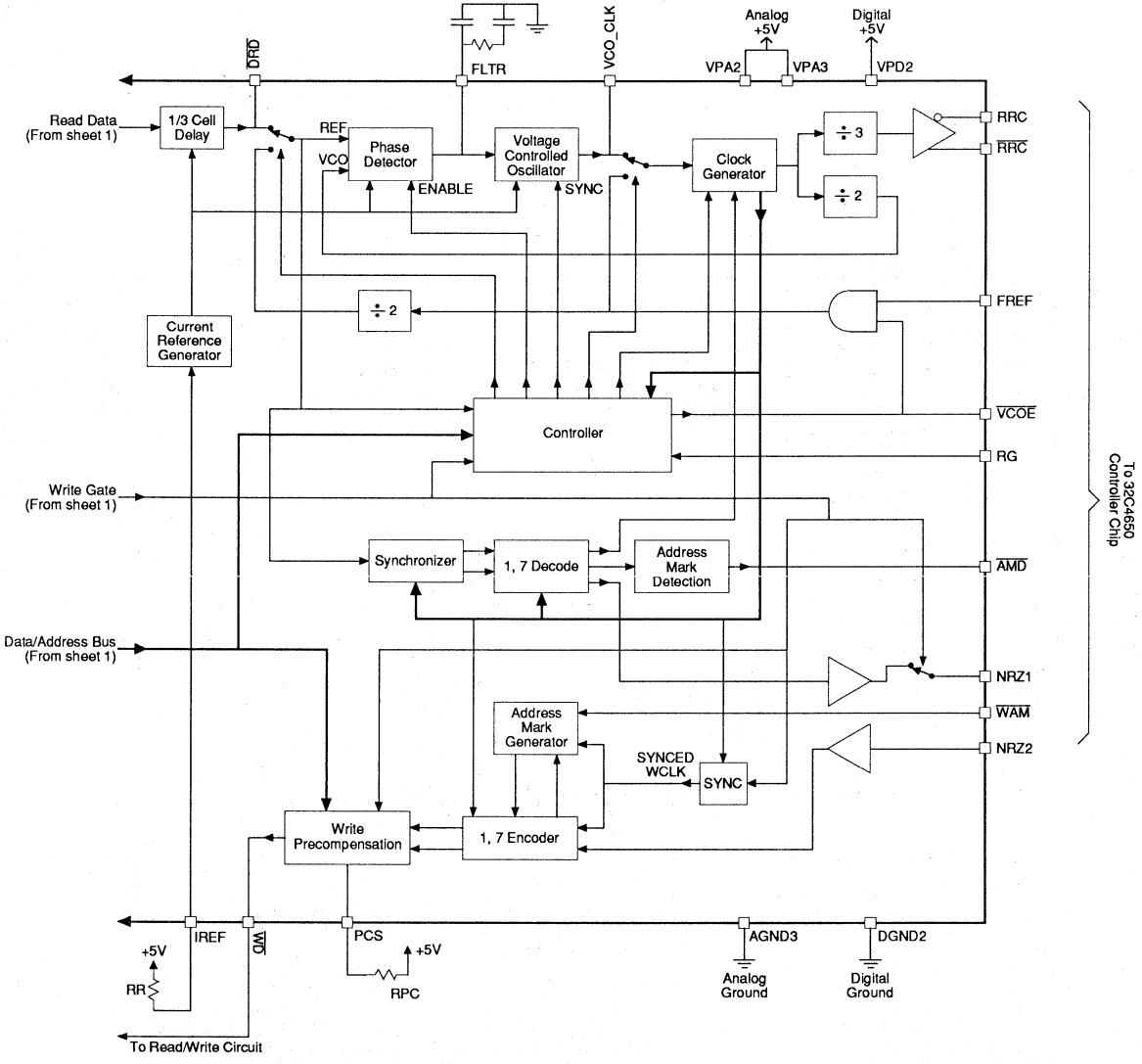


FIGURE 17b: System Configuration - Sheet 2

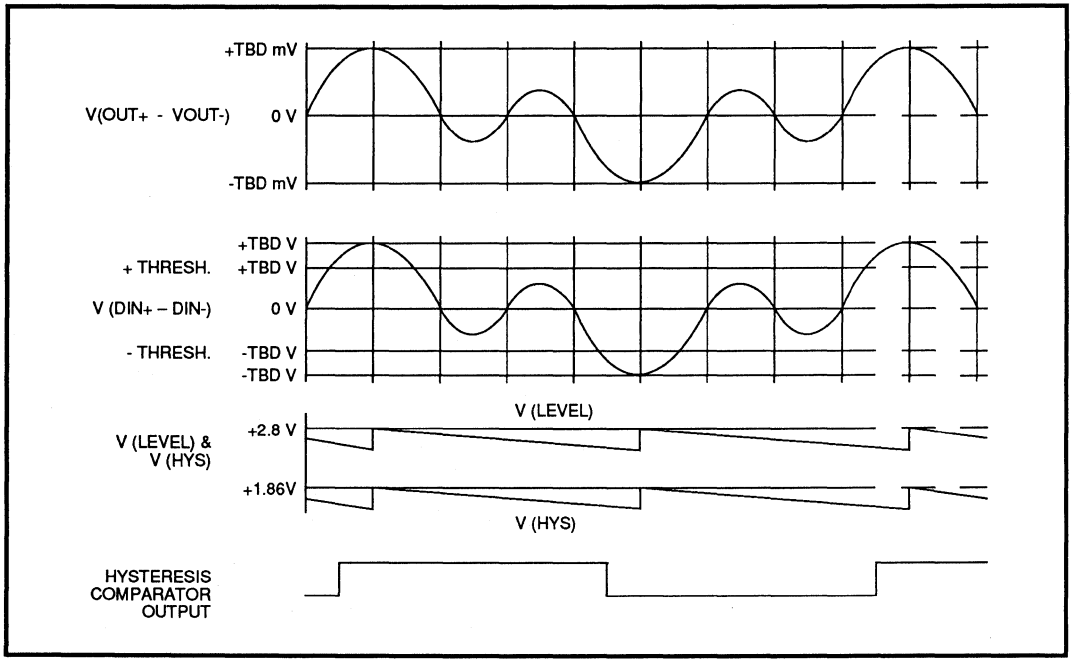


FIGURE 17c: Expected Nominal Voltage Levels

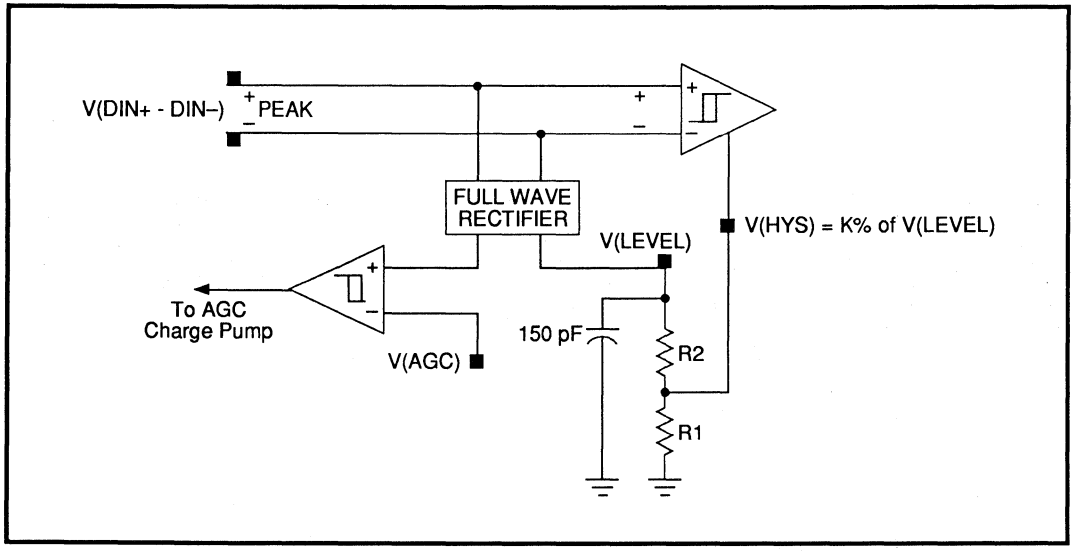


FIGURE 18: Feed forward Mode

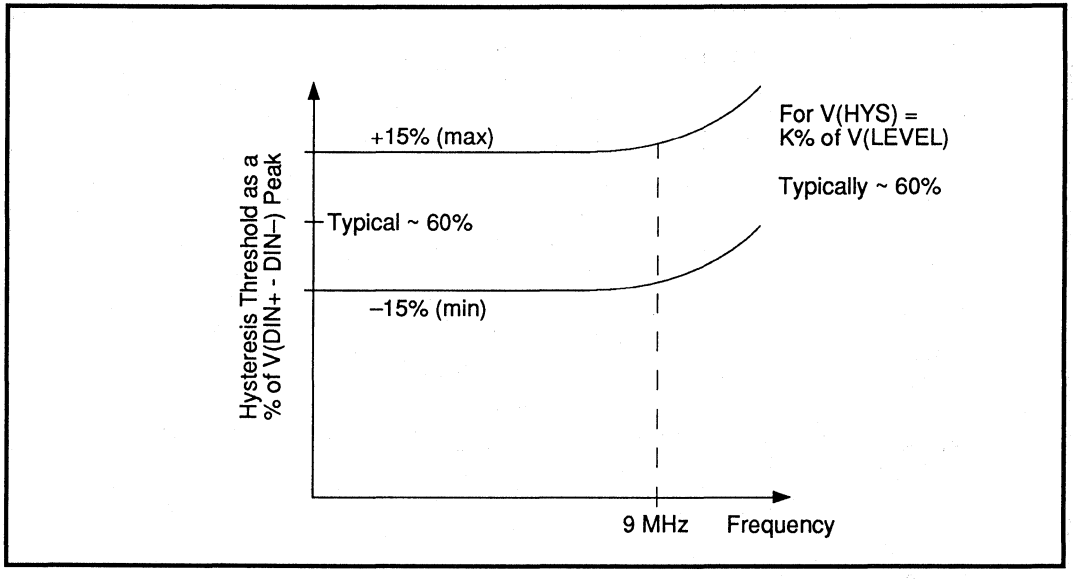


FIGURE 19: Percentage Threshold vs. Frequency

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only. Do not use for final design.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Section 3

HDD ACTIVE FILTERS

SSI 32F8011
Programmable Electronic Filter

Preliminary Data

July, 1990

3

DESCRIPTION

The SSI 32F8011 Programmable Electronic Filter provides an electronically controlled low–pass filter with a separate differentiated low–pass output. A seven–pole, Bessel–type, low–pass filter is provided along with a single-pole, single-zero differentiator. Both outputs have matched delays. The delay matching is unaffected by any amount of programmed equalization or bandwidth. This programability combined with low group delay variation makes the SSI 32F8011 ideal for use in constant density recording applications. Double differentiation pulse slimming equalization is accomplished by a two–pole, low–pass with a two–pole, high–pass feed forward section to provide complimentary real axis zeros. A variable attenuator is used to program the zero locations.

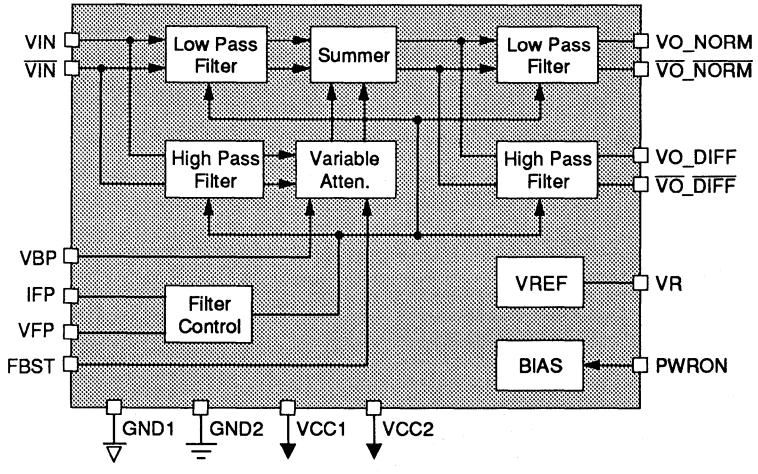
The SSI 32F8011 programmable equalization and bandwidth characteristics can be controlled by external DACs or DACs provided in the SSI 32D4661 Time Base Generator. Fixed characteristics are easily accomplished with three external resistors, in addition equalization can be switched in or out by a logic signal. The circuit is optimized to be used with the SSI 32P4620 and 54x series pulse detectors.

The SSI 32F8011 requires only a +5V supply and is available in 16-pin DIP, SON, and SOL packages.

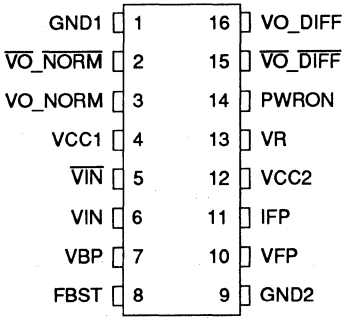
FEATURES

- **Compatible with 24 Mbit/s operation**
- **Ideal for constant density recording applications**
- **Programmable filter cutoff frequency (fc = 5 to 13 MHz)**
- **Programmable pulse slimming equalization (0 to 9 dB boost at the filter cutoff frequency)**
- **Matched normal and differentiated low-pass outputs**
- **Differential filter input and outputs**
- **±10% cutoff frequency accuracy**
- **±0.75 ns group delay variation from 0.2 fc to fc = 13 MHz**
- **Total harmonic distortion less than 1%**
- **No external filter components required**
- **+5V only operation**
- **16-pin DIP, SON, and SOL package**

BLOCK DIAGRAM



PIN DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

PIN DESCRIPTIONS

NAME	DESCRIPTION
VIN, $\overline{\text{VIN}}$	DIFFERENTIAL SIGNAL INPUTS. The input signals must be AC coupled to these pins.
VO_NORM, $\overline{\text{VO\_NORM}}$	DIFFERENTIAL NORMAL OUTPUTS. The output signals must be AC coupled to the pulse detector.
VO_DIFF, $\overline{\text{VO\_DIFF}}$	DIFFERENTIAL DIFFERENTIATED OUTPUTS. For minimum pulse pairing, these outputs should be AC coupled to the pulse detector.
IFP	FREQUENCY PROGRAM INPUT. The filter cutoff frequency FC, is set by an external current IFP, injected into this pin. IFP must be proportional to voltage VR. This current can be set with an external current generator such as a DAC. VFP should be left open when using this pin.
VFP	FREQUENCY PROGRAM INPUT. The filter cutoff frequency can be set by programming a current through a resistor from VR to this pin. IFP should be left open when using this pin.
VBP	FREQUENCY BOOST PROGRAM INPUT. The slimmer high frequency boost is set by an external voltage applied to this pin. VBP must be proportional to voltage VR. A fixed amount of boost can be set by an external resistor divider network connected from VBP to VR and GND. No boost is applied if the FBST pin is grounded, or at logic low.
FBST	FREQUENCY BOOST. A high logic level or open input enables the frequency boost circuitry.
PWRON	POWER ON. A high logic level or open circuit enables the chip. A low level puts the chip in a low power state.
VR	REFERENCE VOLTAGE. Internally generated reference voltage.
VCC1, VCC2	+5 VOLT SUPPLY.
GND1, GND2	GROUND

ABSOLUTE MAXIMUM RATINGS

Operation above maximum ratings may damage the device.

PARAMETER	RATINGS	UNIT
Storage Temperature	-65 to +150	°C
Junction Operating Temperature, Tj	+130	°C
Supply Voltage, VCC1, VCC2	-0.5 to 7	V
Voltage Applied to Inputs	-0.5 to VCC	V
IFP, VFP Inputs Maximum Current*	<1.5	mA
Maximum Power Dissipation, fc = 13 MHz	390	mW

* Exceeding this current may cause frequency programming lockup.

RECOMMENDED OPERATING CONDITIONS

Supply voltage, VCC1, VCC2	4.65 < VCC1,2 < 5.50	V
Junction Temperature, Tj	0 < Tj < 130	°C
Ambient Temperature	0 < Ta < 70	°C

ELECTRICAL CHARACTERISTICS

Power Supply Characteristics (Unless otherwise specified recommended operating conditions apply.)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
ICC	Power Supply Current	PWRON = 0.8V		10	13	mA
ICC	Power Supply Current	PWRON ≥ 2.0V		67	80	mA

DC Characteristics

VIH	High Level Input Voltage	TTL input	2.0			V
VIL	Low Level Input Voltage				0.8	V
IIH	High Level Input Current	VIH = 2.7V			20	µA
IIL	Low Level Input Current	VIL = 0.4V			–1.5	mA

Filter Characteristics

fc	Filter Cutoff Frequency	$fc = \frac{16.25\ MHz}{mA}\ (Ifp)$ Ifp = 0.31 to 0.8 mA	5		13	MHz
FCA	Filter fc Accuracy	fc = 13 MHz	–10		+10	%
AO	VO_NORM Diff Gain	F = 0.67 fc, FB = 0 dB	0.8		1.20	V/V
AD	VO_DIFF Diff Gain	F = 0.67 fc, FB = 0 dB	0.8AO		1.0AO	V/V
FB	Frequency Boost at fc	$FBdB = 20\ \log\left[1.884\left(\frac{VBP}{VR}\right)+1\right]$ VBP = VR		9.2		dB
FBA	Frequency Boost Accuracy	FB = 9.0 dB	–1		+1	dB
TGD0	Group Delay Variation Without Boost*	fc = 13 MHz, VBP = 0V F = 0.2 fc to fc	–0.75		+0.75	ns
TGDB	Group Delay Variation With Boost*	fc = 13 MHz, VBP = VR F = 0.2 fc to fc	–0.75		+0.75	ns
VIF	Filter Input Dynamic Range	THD = 1% max, F = 0.67 fc	1.5			Vpp
VOF	Filter Output Dynamic Range	THD = 1% max, F = 0.67 fc	1.5			Vpp
RIN	Filter Diff Input Resistance		3.0			kΩ
CIN	Filter Diff Input Capacitance				7	pF
EOUT	Output Noise Voltage Differentiated Output	BW = 100 MHz, Rs = 50Ω, Ifp = 0.8 mA, VBP = 0.0V		5.5		mVRms
EOUT	Output Noise Voltage Normal Output	BW = 100 MHz, Rs = 50Ω Ifp = 0.8 mA, VBP = 0.0V		2.5		mVRms
EOUT	Output Noise Voltage Differentiated Output	BW = 100 MHz, Rs = 50Ω Ifp = 0.8 mA, VBP = VR		6.0		mVRms
EOUT	Output Noise Voltage Normal Output	BW = 100 MHz, Rs = 50Ω Ifp = 0.8 mA, VBP = VR		3.25		mVRms

ELECTRICAL CHARACTERISTICS (continued)

Filter Characteristics (continued)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
IO–	Filter Output Sink Current		1.0			mA
IO+	Filter Output Source Current		2.0			mA
RO	Filter Output Resistance**				60	Ω

Filter Control Characteristics

VR	Reference Voltage		2.0		2.40	V
VBP	Frequency Boost Control Voltage Range	VR = 2.2V FBoost = 0 to 9.2dB	0		2.2	V
IFP	Frequency Program Current	VR = 2.2V	0.31		0.8	mA
VFP	Frequency Program Current Range	Ivfp = 0.33 VR / RX VR = 2.2V	0.31		0.8	mA

* Not directly testable in production, design characteristic

** Single ended

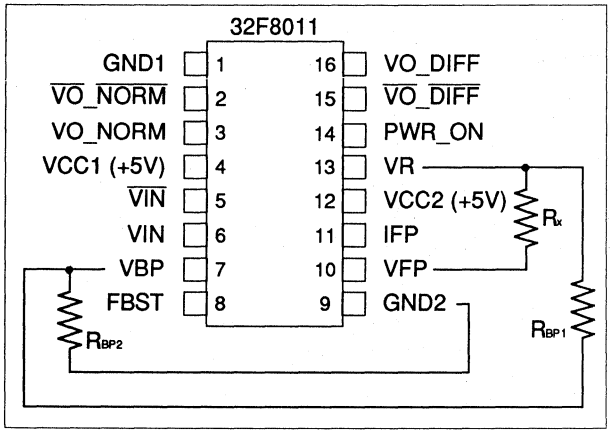


FIGURE 1: 32F8011 Applications Setup, 16-Pin SO or DIP

VR = 2.2V

VFP = .667 VR

IVfp = .33VR/Rx

IVfp range: 0.31 mA to 0.8 mA
(5 MHz to 13 MHz)

VFP is used when programming current is set with a resistor from VR. When VFP is used IFP must be left open.

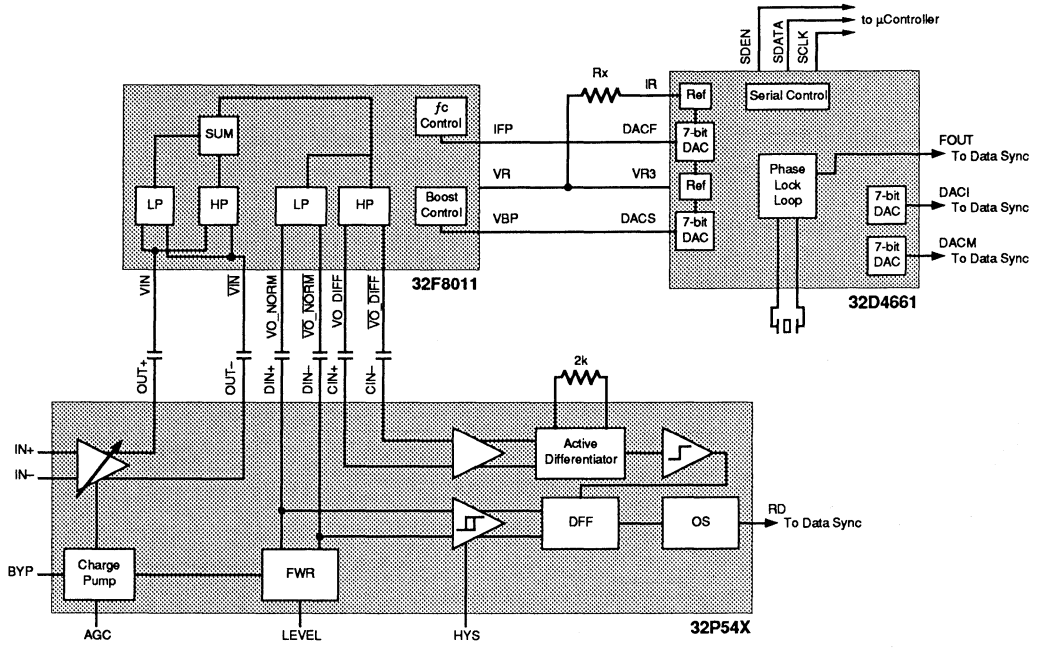


FIGURE 2: Applications Setup, Constant Density Recording 32F8011, 32P54X, 32D4661

IOF = DACF output current

IOF = (0.98F•VR)/127Rx

Rx = (0.98F•VR)/127IOF

Rx = current reference setting resistor

VR = Voltage Reference = 2.2V

F = DAC setting: 0-127

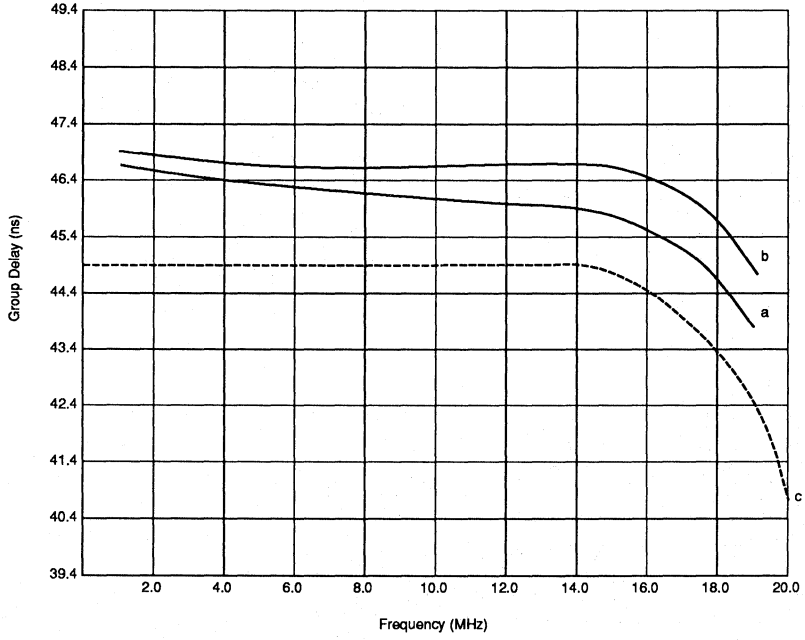
Full scale, F = 127

For range of Max fc = 13 MHz then IFP = 0.8 mA

Therefore, for Max programming current range to 0.8 mA:

Rx = (0.98)(2.2/0.8) = 2.7 kΩ

Please note that in setups such as this where IFP is used for cutoff frequency programming VFP must be left open.



fc = 10.4 MHz

a) No Pulse Equalization Boost
b) Max Pulse Equalization Boost
c) Ideal Bessel Filter

FIGURE 3: 32F8011 Typical Group Delay Variation (Differentiated Output)

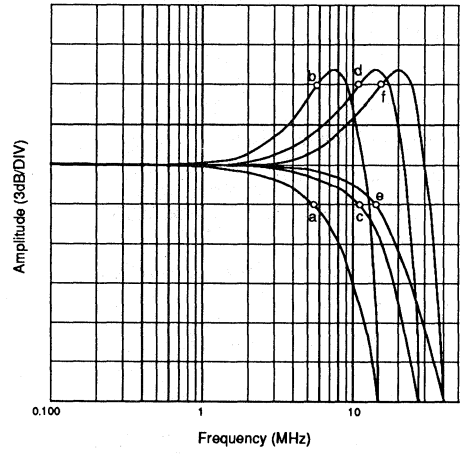


FIGURE 4: 32F8011 Normal Low Pass Output Response (VO_NORM)

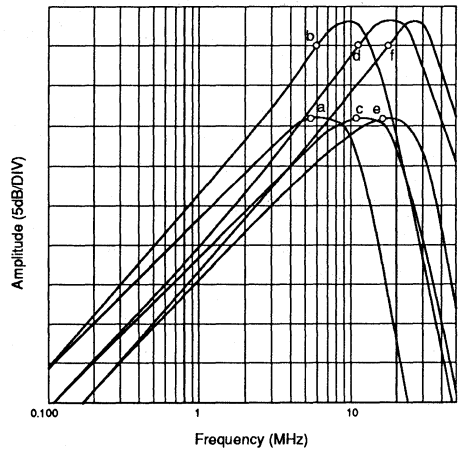
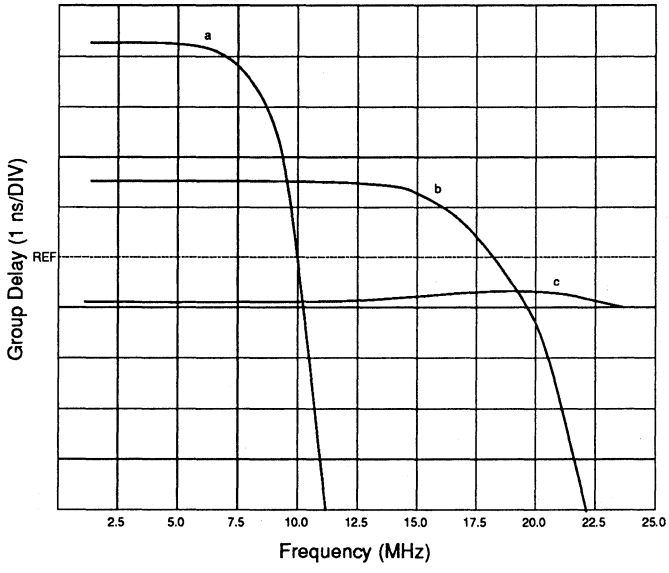


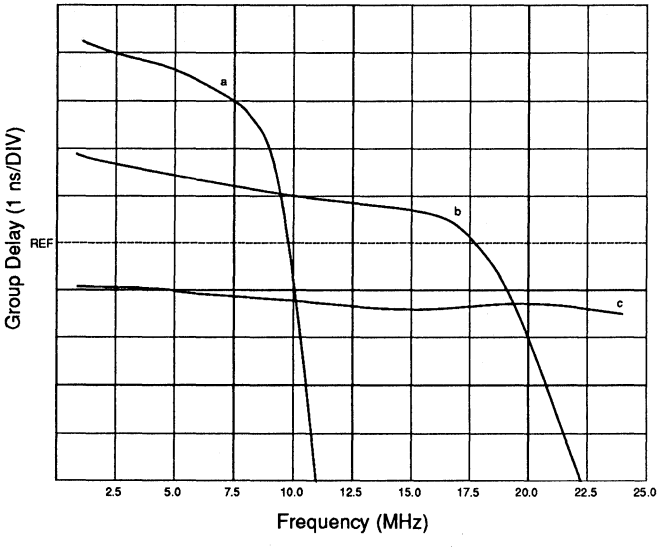
FIGURE 5: 32F8011 Differented Low Pass Output Response (VO_DIFF)

a) fc = 5 MHz No Pulse Equalization Boost
b) fc = 5 MHz Max Pulse Equalization Boost
c) fc = 10 MHz No Pulse Equalization Boost
d) fc = 10 MHz Max Pulse Equalization Boost
e) fc = 15 MHz No Pulse Equalization Boost
f) fc = 15 MHz Max Pulse Equalization Boost



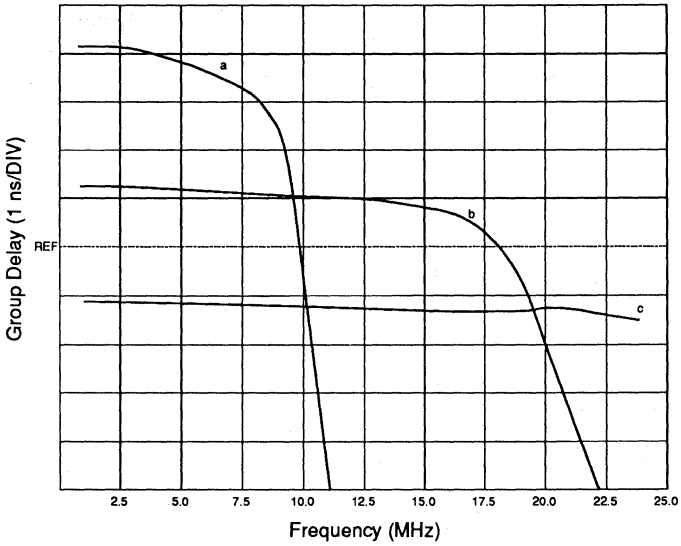
a) fc = 5 MHz (Ref = 80 ns)
b) fc = 10 MHz (Ref = 45 ns)
c) fc = 15 MHz (Ref = 35 ns)

FIGURE 6: 32F8011 Typical Group Delay Variation (Differentiated Output) Maximum Pulse Equalization Boost



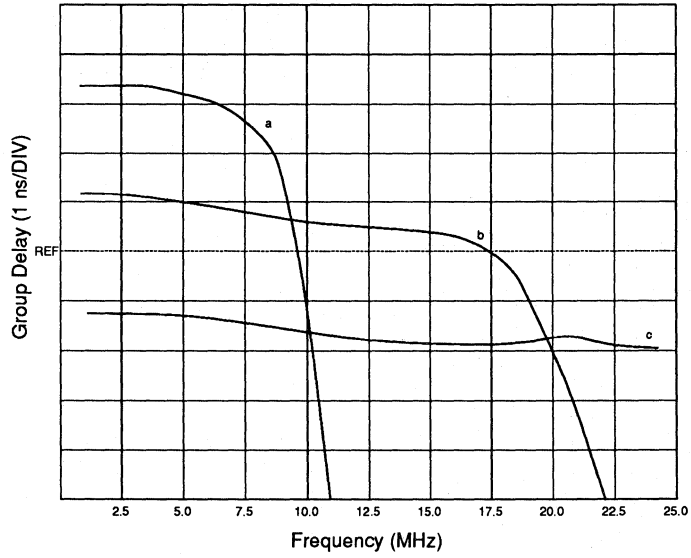
a) fc = 5 MHz (Ref = 80 ns)
b) fc = 10 MHz (Ref = 45 ns)
c) fc = 15 MHz (Ref = 35 ns)

FIGURE 7: 32F8011 Typical Group Delay Variation (Differentiated Output) No Pulse Equalization Boost



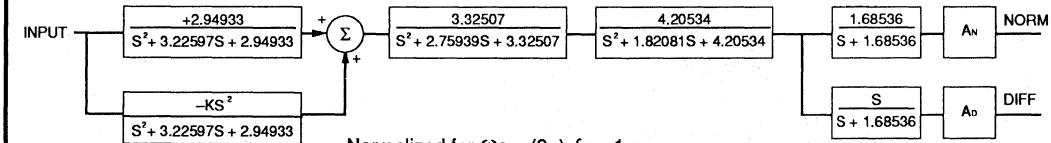
a) fc = 5 MHz (Ref = 80 ns)
b) fc = 10 MHz (Ref = 45 ns)
c) fc = 15 MHz (Ref = 35 ns)

FIGURE 8: 32F8011 Typical Group Delay Variation (Normal Low Pass Output) Maximum Pulse Equalization Boost



a) fc = 5 MHz (Ref = 80 ns)
b) fc = 10 MHz (Ref = 45 ns)
c) fc = 15 MHz (Ref = 35 ns)

FIGURE 9: 32F8011 Typical Group Delay Variation (Normal Low Pass Output) No Pulse Equalization Boost



Normalized for $\omega c = (2\pi)\ fc = 1$
AN and AD are adjusted for unity gain (0 dB) at $F = 0.67\ fc$
Denormalize the frequency by substituting $S \rightarrow (S/2\pi fc)$
Eq for fc = 13 MHz, $S = S / [(2\pi)(13 \cdot 10^6)] = S / 8.16814^7$

FIGURE 10: 32F8011 Normalized Block Diagram

TABLE 1: 32F8011 Frequency Boost Calculations

Assuming 9.2 dB boost for VBP = VR

$$\frac{VBP}{VR} \cong \frac{\left(10^{(FB/20)}\right) - 1}{1.884}$$

Boost	VBP/VR	Boost	VBP/VR
1 dB	0.065	6 dB	0.528
2 dB	0.137	7 dB	0.658
3 dB	0.219	8 dB	0.802
4 dB	0.310	9 dB	0.965
5 dB	0.413		

or,

boost in $dB \cong 20 \log \left[1.884 \left(\frac{VBP}{VR}\right) + 1\right]$

VBP/VR	Boost	VBP/VR	Boost
0.1	1.499 dB	0.6	6.569 dB
0.2	2.777 dB	0.7	7.305 dB
0.3	3.891 dB	0.8	7.984 dB
0.4	4.879 dB	0.9	8.613 dB
0.5	5.765 dB	1.0	9.200 dB

TABLE 2: Calculations

Typical change in *f*-3 dB point with boost

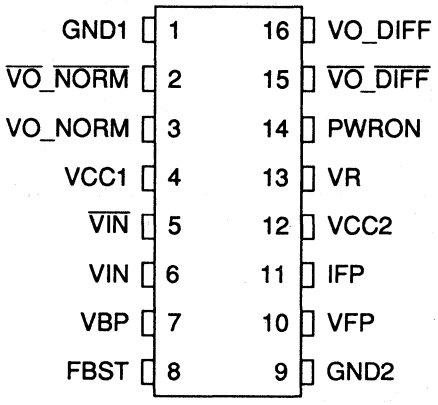
Boost at *fc*	*f*-3 dB/*fc*	Boost at *fc*	*f*-3 dB/*fc*
0 dB	1.0	5 dB	2.13
1	1.2	6	2.28
2	1.47	7	2.41
3	1.74	8	2.53
4	1.95	9	2.65

Notes: 1. *fc* is the original programmed cutoff frequency with no boost
2. *f*-3 dB is the new -3 dB value with boost implemented

i.e., *fc* = 5 MHz when boost = 0 dB
if boost is programmed to 5 dB then f-3 dB = 10.65 MHz

SSI 32F8011
Programmable
Electronic Filter

PIN DIAGRAM (Top View)



16-pin DIP, SON, SOL

Thermal Characteristics: ØjA

16-lead SON (150 mil)	105° C/W
16-lead SOL (300 mil)	100° C/W
16-lead PDIP	170° C/W

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32F8011 Programmable Electronic Filter		
16-lead SON (150 mil)	SSI 32F8011-CN	32F8011
16-lead SOL (300 mil)	SSI 32F8011-CL	32F8011
16-lead PDIP	SSI 32F8011-CP	32F8011-CP

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX: (714) 731-5457

SSI 32F8020
Low-Power Programmable Electronic Filter

Advance Information

July, 1990

3

DESCRIPTION

The SSI 32F8020 Programmable Electronic Filter provides an electronically controlled low–pass filter with a separate differentiated low–pass output. A seven–pole, .05° Equiripple-type linear phase, low–pass filter is provided along with a single-pole, single-zero differentiator. Both outputs have matched delays. The delay matching is unaffected by any amount of programmed equalization or bandwidth. This programability combined with low group delay variation makes the SSI 32F8020 ideal for use in constant density recording applications. Double differentiation pulse slimming equalization is accomplished by a two–pole, low–pass with a two–pole, high–pass feed forward section to provide complimentary real access zeros. A variable attenuator is used to program the zero locations.

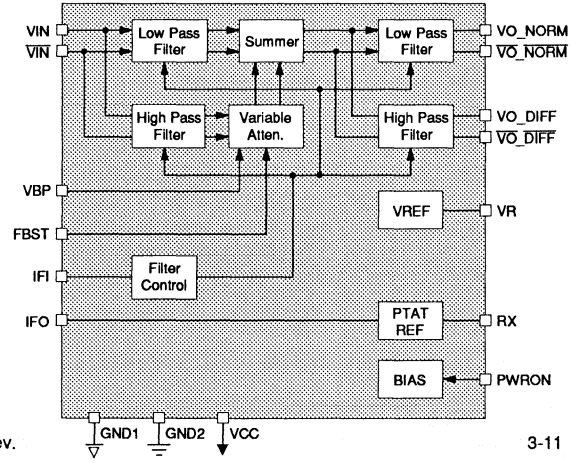
The SSI 32F8020 programmable equalization and bandwidth characteristics can be controlled by external DACs or DACs provided in the SSI 32D4661 time base generator. Fixed characteristics are easily accomplished with three external resistors, in addition equalization can be switched in or out by a logic signal. The circuit is optimized to be used with the SSI 32P4620 and 54x series pulse detectors.

The SSI 32F8020 requires only a +5V supply and is available in 16-pin DIP, SON, and SOL packages.

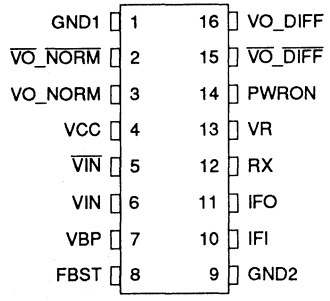
FEATURES

- **Ideal for constant density recording applications**
- **Programmable filter cutoff frequency (fc = 1.5 to 8 MHz)**
- **Programmable pulse slimming equalization (0 to 9 dB boost at the filter cutoff frequency)**
- **Matched normal and differentiated low-pass outputs**
- **Differential filter input and outputs**
- **±10% cutoff frequency accuracy**
- **±2% maximum group delay variation from 1.5 - 8 MHz**
- **Total harmonic distortion less than 1%**
- **No external filter components required**
- **+5V only operation**
- **16-pin DIP, SON, and SOL package**

BLOCK DIAGRAM



PIN DIAGRAM



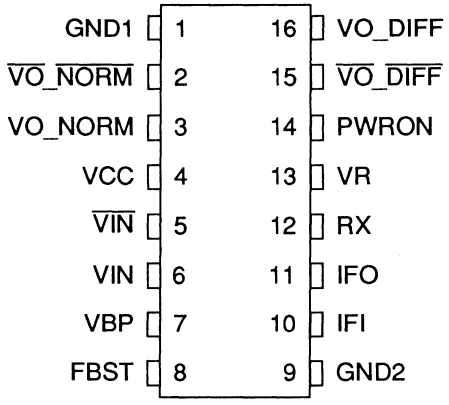
CAUTION: Use handling procedures necessary for a static sensitive component.

PIN DESCRIPTIONS

NAME	DESCRIPTION
VIN, $\overline{\text{VIN}}$	DIFFERENTIAL SIGNAL INPUTS. The input signals must be AC coupled to these pins.
VO_NORM, $\overline{\text{VO\_NORM}}$	DIFFERENTIAL NORMAL OUTPUTS. The output signals must be AC coupled to the pulse detector.
VO_DIFF $\overline{\text{VO\_DIFF}}$	DIFFERENTIAL DIFFERENTIATED OUTPUTS. For minimum pulse pairing, these outputs should be AC coupled to the pulse detector.
RX	PTAT REFERENCE CURRENT SET. PTAT (proportional to absolute temperature) reference current IFO is equivalent to the current set on this pin.
IFI	FREQUENCY PROGRAM INPUT. The filter cutoff frequency FC, is set by an external current IFI, injected into this pin. IFI must be proportional to current IFO. This current can be set with an external current generator such as a DAC, referenced to IFO.
IFO	PTAT CURRENT REFERENCE OUTPUT. This pin ouputs a PTAT reference current which is externally scaled for control input into IFI.
VBP	FREQUENCY BOOST PROGRAM INPUT. The slimmer high frequency boost is set by an external voltage applied to this pin. VBP must be proportional to voltage VR. A fixed amount of boost can be set by an external resistor divider network connected from VBP to VR and GND. No boost is applied if the FBST pin is grounded, or at logic low.
FBST	FREQUENCY BOOST. A high logic level or open input enables the frequency boost circuitry.
PWRON	POWER ON. A high logic level circuit enables the chip. A low level puts the chip in a low power state. A low or open circuit disables the chip.
VR	REFERENCE VOLTAGE. Internally generated reference voltage.
VCC	+5 VOLT SUPPLY.
GND1, GND2	GROUND

PIN DIAGRAM

(Top View)



32F8020
16-pin DIP, SON, SOL

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

Section 4

HDD DATA RECOVERY

SSI 32D5321
Data Synchronizer/ 2, 7 RLL ENDEC

June, 1990

DESCRIPTION

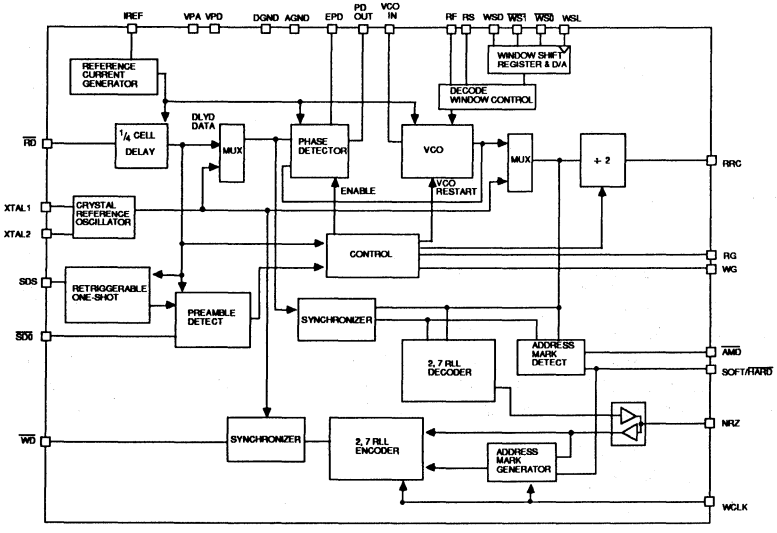
The SSI 32D5321 Data Synchronizer / 2, 7 RLL ENDEC provides data recovery and data encoding for storage systems which employ a 2, 7 RLL encoding format. Data synchronization is performed with a fully integrated high performance PLL. A zero phase restart technique is used to minimize PLL acquisition time. The SSI 32D5321 has been optimized for operation as a companion device to the SSI 32C452A and the AIC 010 controllers. The VCO frequency setting elements are incorporated within the SSI 32D5321 for enhanced performance and reduced board space. Data rate is established with a single external programming resistor. The SSI 32D5321 utilizes an advanced bipolar process technology which affords precise decode window control without the requirement of an accurate 1/4 cell delay or external devices. To enhance disk drive testability, decode window symmetry control is available through a digital µP port and/or two analog pins. This feature can facilitate defect mapping, automatic calibration, systematic error cancellation, window margin testing and error recovery. The SSI 32D5321 requires a single +5V power supply and is available in 28-pin DIP and PLCC packages.

FEATURES

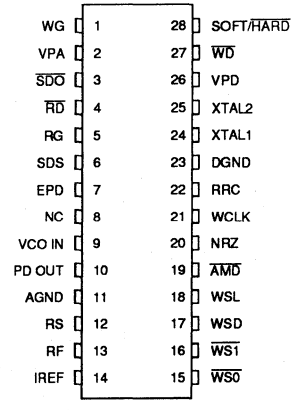
- **Data Synchronizer and 2, 7 RLL ENDEC**
- **7.5 to 10 Mbit/s Operation Programmed with a Single External Resistor**
- **Optimized for Operation with the SSI 32C452 and AIC 010 Controllers**
- **Programmable Decode Window Symmetry via a µP Port and/or Analog Pins**
- **Fast Acquisition Phase Locked Loop**
  - **Zero Phase Restart Technique**
- **Fully Integrated Data Separator**
  - **No External Delay Lines or Active Devices Required**
- **Crystal Controlled Reference Oscillator**
- **Hard/Soft Sector Operation**
- **+5V Operation**
- **28-pin DIP and PLCC Packages**

4

BLOCK DIAGRAM



PIN DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

OPERATION

The SSI 32D5322 is designed to perform data recovery and data encoding in rotating memory systems which utilize a 2, 7 RLL encoding format. In the Read Mode the SSI 32D5322 performs Data Synchronization, Sync Field Search and Detect, Address Mark Detect and Data Decoding. In the Write Mode, the SSI 32D5322 converts NRZ data into the 2,7 RLL format described in Table 1, it generates the Preamble Field, and inserts Address Marks as requested. The interface electronics and architecture of the SSI 32D5322 have been optimized for use as a companion device to the SSI 32C452 or AIC 010 controllers.

The SSI 32D5322 can operate with data rates ranging from 7.5 to 10 Mbit/s. This data rate is established by a single 1% external resistor, RR, connected from pin IREF to VPA. This resistor establishes a reference current which sets the VCO center frequency, the phase detector gain, and the 1/4 cell delay. The value of this resistor is given by:

$$RR = \frac{40.67}{DR} - 0.5\ (k\Omega)$$

where: DR = Data Rate in Mbit/s

An internal crystal reference oscillator, operating at twice the data rate, generates the standby reference for the PLL. A series resonant crystal between XTAL1 and XTAL2 should be selected at twice the Data Rate. If a crystal oscillator is not desired, then an external TTL compatible reference may be applied to XTAL1, leaving XTAL2 open.

The SSI 32D5322 employs a Dual Mode Phase Detector; Harmonic in the Read Mode and Non-Harmonic in Write and Idle Modes. In the Read Mode the Harmonic Phase Detector updates the PLL with each occurrence of a DLYD DATA pulse. In the Write and Idle Modes the Non-Harmonic Phase Detector is continuously enabled, thus maintaining both phase and frequency lock. By acquiring both phase and frequency lock to the crystal reference oscillator and utilizing a zero phase restart technique, false lock to DLYD DATA is eliminated.

The phase detector incorporates a charge pump in order to drive the loop filter directly. The polarity and width of the output current pulses correspond to the direction and magnitude of the phase error. Figure 1 depicts the average output current as a function of the input phase error (relative to the VCO period).

The READ GATE (RG), and WRITE GATE (WG), inputs control the device mode as described in Table 2. RG is an asynchronous input and may be initiated or terminated at any position on the disk. WG is also an asynchronous input, but should not be terminated prior to the last output Write Data pulse.

READ OPERATION

The Data Synchronizer utilizes a fully integrated fast acquisition PLL to accurately develop the decode window. Read Gate, RG, initiates the PLL locking sequence and selects the PLL reference input; a high level (Read Mode) selects the $\overline{RD}$ input and a low level selects the crystal reference oscillator.

In the Read Mode the rising edge of DLYD DATA enables the Phase Detector while the falling edge is phase compared to the rising edge of the VCO. As depicted in Figure 2, DLYD DATA is a 1/4 cell wide (TVCO/2) pulse whose leading edge is defined by the leading edge of $\overline{RD}$. An accurate and symmetrical decode window is developed from the VCO clock. The decode window is generated from the falling edges of the VCO clock. By utilizing a fully integrated symmetrical VCO running at twice the data rate, the decode window is insured to be accurate and centered symmetrically about the falling edges of DLYD DATA. The accuracy of the 1/4 cell delay only affects the retrace angle of the phase detector and does not influence the accuracy of the decode window.

Shifting the symmetry of the VCO clock effectively shifts the relative position of the DLYD DATA pulse within the decode window. This powerful capability easily facilitates defect mapping, automatic calibration, window margin testing, error recovery, and systematic error cancellation. For enhanced disk drive testability and error recovery, decode window control is provided via a µP port (WSL, WSD, $\overline{WS0}$, $\overline{WS1}$) as

described in Table 3. In applications not utilizing this feature, WSL should be connected to ground, while WSD, $\overline{WS0}$, and $\overline{WS1}$ can be left open.

Window shifts in the range of ±1.5% to ±7.5% of TORC are easily programmed by latching the appropriate control word into the Window Shift Register with the WSL pin. Shifts in the positive or negative directions result in early or late decode windows respectively, as depicted in Figure 3. Additionally, for small systematic error cancellation, a resistor, R, connected from either RS (Early) or RF (Late) to ground will provide analog control over the decode window. The magnitude of this shift, TSA is determined by:

$$TSA = 0.125\ TORC\left(1 - \frac{680 + R}{1180 + R}\right)$$

where: R is in ohms

Pins RF and RS are intended to be used as a trim and should be restricted to ±1.5% window shifts. They can be used in conjunction with the digital control port.

In Non-Read Modes, the PLL is locked to the crystal reference oscillator. This forces the VCO to run at a frequency which is very close to that required for tracking actual data and thus minimizes the associated frequency step during acquisition. When the reference input to the PLL is switched, the VCO is stopped momentarily, then restarted in an accurate phase alignment with the next PLL reference input pulse, and the VCO clock divider is reset. By minimizing the phase alignment in this manner (phase error ≤ 0.5 rads), the acquisition time is substantially reduced.

The SSI 32D5322 provides two sync modes for controlling the PLL locking sequence; Soft Sector and Hard Sector.

SOFT SECTOR MODE

The Soft Sector Mode activates the Preamble Search and Address Mark detection circuitry. As depicted in Figure 4, when RG transitions high, the counter is reset and the SSI 32D5322 requires 10 high to low transitions (Preamble '1' bits) before switching the reference input to the PLL, 48 high to low transitions before switching the Read Reference Clock to the VCO clock divided by two and activating the Address Mark Detect circuitry; then it must detect the Address Mark prior to 80 high to low transitions in order to enter the Read Mode. This sequence repeats after 95 input '1' bits until the read mode is successfully entered or until RG is cancelled.

When RG transitions high, the following PLL locking sequence begins:

a) PREAMBLE SEARCH:

The 3T detect circuitry initiates the PLL locking sequence once it has detected 10 consecutive '100' bit groups from the 3T preamble field. The 3T detect timing is set by the sum of the 1/4 cell delay and the retriggerable one-shot delay. The 1/4 cell timing capacitor is included on-chip and its timing is externally set by resistor RR. The retriggerable one-shot timing is externally set by resistor Rd and capacitor Cd. The sum of their delays is set to 3.5 bit cell times. Therefore, a continuous stream of input pulses with a 3T bit cell time pulse rate keeps the one-shot reset, and a 4T or longer bit cell time input period allows the one-shot to time out producing a 4T detect pulse. The 4T detect pulse resets the Input Counter and the search is started over.

b) PLL ACQUISITION:

Once 10 consecutive '100' bit groups are detected, the reference input to the PLL is switched from the crystal reference oscillator to the DLYD DATA, the VCO is phase reset to the next DLYD DATA pulse, and PLL acquistion begins. When an additional 38 '100' bit groups are detected, the Read Reference Clock output (RRC) is switched to the VCO clock divided by 2, the 4T Detect circuitry is inhibited, and the Address Mark Detection circuitry is enabled. If a 4T detect pulse occurs before 48 Preamble '1' bits are detected, then the PLL is locked back to the crystal reference oscillator, the RRC output is switched to the crystal reference oscillator divided by 2, the Input Counter reset, and the sequence is restarted. No short duration glitches will occur at the RRC output during this switching.

c) **ADDRESS MARK DETECTION:**

The circuit searches for the occurrence of the $5EAx_{16}$ Address Mark. If an Address Mark is detected prior to the Input Counter reaching count 80, the correct phase of the RRC is ensured by resetting the n/2 divider, the $\overline{AMD}$ output is latched low, the PLL training sequence is terminated, and the Read Mode is entered allowing the data field to be read. If the Input Counter reaches count 80 before the Address Mark is detected, the PLL is locked back to the crystal reference oscillator, the RRC output is switched to the crystal reference oscillator divided by 2, and the PLL training sequence is restarted when the Input Counter reaches count 96. Figure 5 depicts the Address Mark detection sequence.

HARD SECTOR MODE

In the Hard Sector mode (SOFT/$\overline{HARD}$ = 0) the SSI 32D5321 utilizes a 4T (1000) Preamble Field and disables the Preamble Search and Address Mark detection circuitry. It allows the PLL to be controlled directly by RG for Hard Sector format operation. With the absence of an Address Mark, the 4T Preamble Field is utilized to properly set the bit cell alignment boundaries for proper decoding.

When RG transitions high, as depicted in Figure 6, reference input to the PLL is switched from the crystal reference oscillator to DLYD DATA, the VCO is phase reset to the next DLYD DATA pulse, and the PLL acquisition begins. When 32 '1' Preamble bits are detected, the RRC output is switched to the VCO clock divided by 2, and the Read Mode is entered allowing the data field to be read.

In the Hard Sector mode, the NRZ output is inverted and will remain low until the data field is read, as shown in Figure 7. Since the Preamble Search circuitry is not utilized, the external one-shot timing components (Cd, Rd) are not required and the SDS pin can be left open.

WRITE OPERATION

In the Write Mode the SSI 32D5321 converts NRZ data from the controller into 2, 7 RLL formatted data for storage onto the disk. The SSI 32D5321 can operate with a soft or hard sectored disk drive. In the Soft Sector Mode, (SOFT/$\overline{HARD}$ = 1) the device generates a 3T Preamble Field and can insert a N7V Address Mark. The N7V Address Mark is a valid 2, 7 RLL pattern which is not contained in the code set. In the Hard Sector Mode, (SOFT/$\overline{HARD}$ = 0) the device generates a 4T Preamble Field and no Address Mark. Serial NRZ data is clocked into the SSI 32D5321 and latched on defined cell boundaries. The NRZ input data must be synchronous with the rising edges of the WCLK input. In a SCSI or ST506 operation, WCLK is connected directly to the RRC output.

SOFT SECTOR MODE

In the Soft Sector Mode, when WRITE GATE (WG), transitions high and the NRZ input is held low, the SSI 32D5321 automatically generates the 3T (100) Preamble Field at the WRITE DATA ($\overline{WD}$), output. The 3T Preamble Field will continue to be generated until the first low to high transition on the NRZ line. As shown in Figure 8, the first low to high transition occurs with the second bit '1' of the 5_{16} (0101) in the $5EAx_{16}$ Address Mark generation pattern. To generate the Address Mark, the SSI 32D5321 automatically changes the '1' in the eleventh position (see note 3) of the 2, 7 RLL encoded sequence, to a '0'. This generates a pattern of seven zero's followed by two zero's. This unique pattern satisfies the 2, 7 RLL constraints, but will never occur during a normal encoding sequence. The x_{16} of the $5EAx_{16}$ Address Mark generation pattern can be selected, a 'C_{16}' (1100) was utilized in this example.

HARD SECTOR MODE

In the Hard Sector Mode, when WG goes high and the NRZ input is held low, the SSI 32D5321 automatically generates the 4T (1000) Preamble Field at the WRITE DATA, $\overline{WD}$, output. Note that in the Hard Sector mode, the NRZ input is inverted, therefore a constant low is equivalent to an '11...' input which generates the 4T '1000...' Preamble Field. The 4T Preamble Field will be generated between the time WG goes high and the first low to high transition on the NRZ line. The 32D5321 requires a minimum of 32 4T (1000) bit groups prior to the data field.

PIN DESCRIPTIONS

INPUT PINS

NAME	TYPE	DESCRIPTION
$\overline{RD}$	I	READ DATA: Encoded Read Data from the disk drive read channel, active low.
RG	I	READ GATE: Selects the PLL reference input and initiates the PLL synchronization sequence. A high level selects the $\overline{RD}$ input and enables the Read Mode/ Address Mark Detection sequences. A low level selects the crystal reference oscillator. Pin RG has an internal resistor pull-up.
WG	I	WRITE GATE: Enables the write mode. Pin WG has an internal resistor pull-up.
WSL	I	WINDOW SYMMETRY LATCH: Used to latch the input window symmetry control bits WSD, $\overline{WS0}$ and $\overline{WS1}$ into the internal DAC. An active high level latches the input bits. Pin WSL has an internal resistor pull-up.
WSD	I	WINDOW SYMMETRY DIRECTION: Controls the direction of the optional window symmetry shift. Pin WSD has an internal resistor pull-up.
$\overline{WS0}$	I	WINDOW SYMMETRY CONTROL BIT: A low level introduces a window shift of 1.5% TORC (Read Reference Clock Period) in the direction established by WSD. Pin $\overline{WS0}$ has an internal resistor pull-up.
$\overline{WS1}$	I	WINDOW SYMMETRY CONTROL BIT: A low level introduces a window shift of 6% TORC (Read Reference Clock Period) in the direction established by WSD. A low level at both $\overline{WS0}$ and $\overline{WS1}$ will produce the sum of the two window shifts. Pin $\overline{WS1}$ has an internal resistor pull-up.
SOFT/$\overline{HARD}$	I	SOFT/$\overline{HARD}$ SECTOR: Selects the address mark and the Preamble field patterns. A high level (Soft Sector) selects a 3T Preamble Field pattern and a non-violating 2, 7 address mark, N7V. A low level (Hard Sector) selects a 4T Preamble Field pattern and disables the address mark circuitry. Pin SOFT/$\overline{HARD}$ has an internal resistor pull-up.
WCLK	I	WRITE CLOCK: Write Clock input. Must be synchronous with the Write Data input on the NRZ Data Port. For small cable delays, WCLK may be connected directly to pin RRC (Read/Reference Clock).
EPD	I	ENABLE PHASE DETECTOR: A low level (Coast Mode) disables the phase detector and allows the VCO to coast. Pin EPD has an internal resistor pull up.

BIDIRECTIONAL PINS

NRZ	I/O	NRZ DATA PORT: Read Data output when RG is high and Write Data input when WG is high. In the idle mode NRZ is in a high impedance state.

PIN DESCRIPTIONS (Cont.)

OUTPUT PINS

NAME	TYPE	DESCRIPTION
$\overline{WD}$	O	WRITE DATA: Encoded write data output, active low.
RRC	O	READ/REFERENCE CLOCK: A multiplexed clock source used by the controller. In the read mode, this clock is the VCO frequency divided by two (1/TORC) and in the write mode it is the crystal reference frequency divided by two (1/TORO). No short clock pulses are generated during a mode change.
$\overline{AMD}$	O	ADDRESS MARK DETECT: In the soft sector Read Mode, a latched low level output indicates that an address mark has been detected. In non-Read modes $\overline{AMD}$ is configured as a high impedance output.
$\overline{SDO}$	O	SYNC DETECT OUTPUT: An active low output that indicates successful detection of the 3T Preamble sync field. THE $\overline{SDO}$ pin is not a TTL level signal.

ANALOG PINS

IREF	I	TIMING PROGRAM PIN: The VCO center frequency and the 1/4 Cell Delay are a function of the current source into pin IREF. The current is set by an external resistor, RR, connected from IREF to VPA.
XTAL1, XTAL2	I	CRYSTAL OSCILLATOR CONNECTIONS: If a crystal oscillator is not desired, XTAL1 maybe driven by a TTL source with XTAL2 open. The frequency must be at twice the data rate.
PD OUT	O	PHASE DETECTOR OUTPUT: Drives the Loop Filter input.
VCO IN	I	VCO CONTROL INPUT: Driven by the Loop Filter output.
SDS	I	SYNC DETECT SET: Used to program the sync detect retriggerable one-shot timing with an external R-C network. Connect the capacitor, Cd, to VPA and the resistor, Rd, to AGND.
RF, RS	I	WINDOW SYMMETRY ADJUST PINS: Provides analog control over the decode window symmetry; typically used to null out any window symmetry offset. A resistor connected from either RF or RS to AGND will provide magnitude and direction control. They can be used in conjunction with the digital control port WSD, $\overline{WS0}$, $\overline{WS1}$.

POWER

DGND, AGND	I	DIGITAL AND ANALOG GROUND
VPA	I	ANALOG +5V
VPD	I	DIGITAL +5V

NRZ	2, 7 RLL
10	0100
11	1000
000	000100
010	100100
011	001000
0010	00100100
0011	00001000

TABLE 1: 2, 7 RLL Code Set

WG	RG	MODE
0	0	IDLE
0	1	READ
1	0	WRITE
1	1	ILLEGAL

TABLE 2: Mode Control

Ts, NOMINAL WINDOW SHIFT	WSD	$\overline{WS1}$	$\overline{WS0}$
+TS3	0	0	0
+TS2	0	0	1
+TS1	0	1	0
0	0	1	1
-TS3	1	0	0
-TS2	1	0	1
-TS1	1	1	0
0	1	1	1

TABLE 3 : Decode Window Symmetry Control

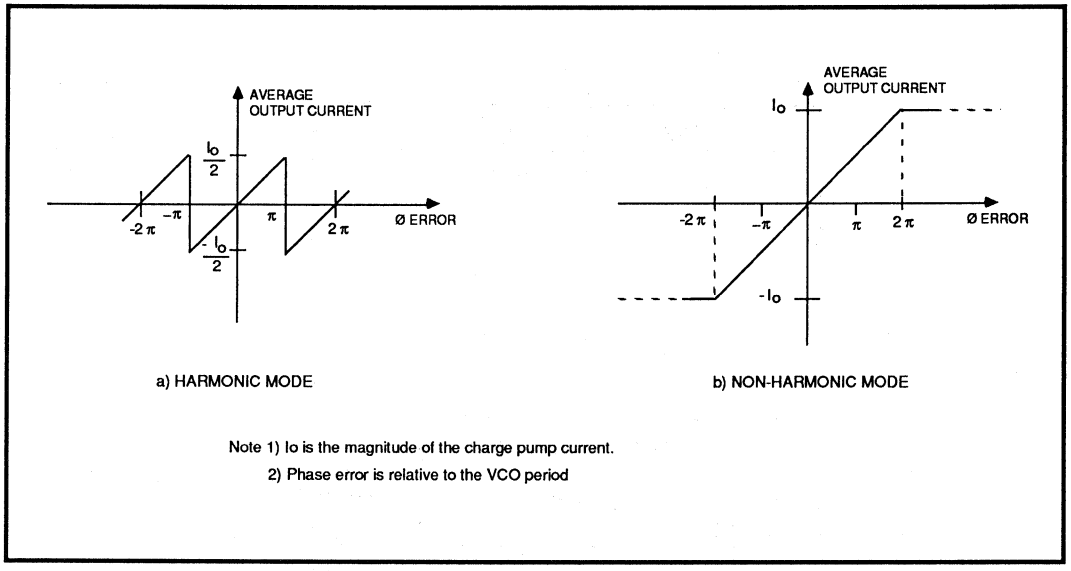


FIGURE 1: Phase Detector Transfer Function

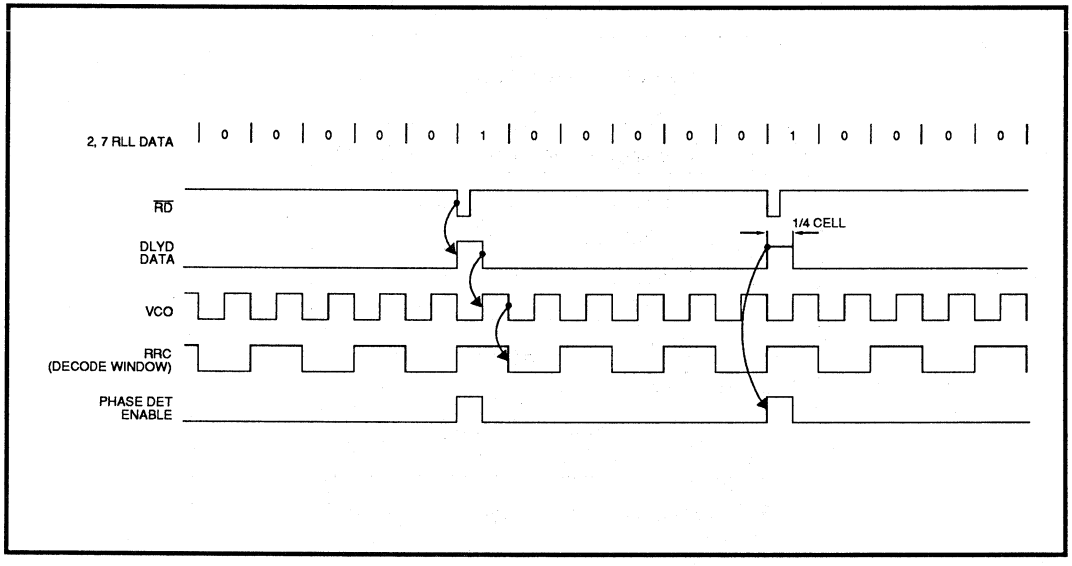


FIGURE 2: Data Synchronization Waveform Diagram

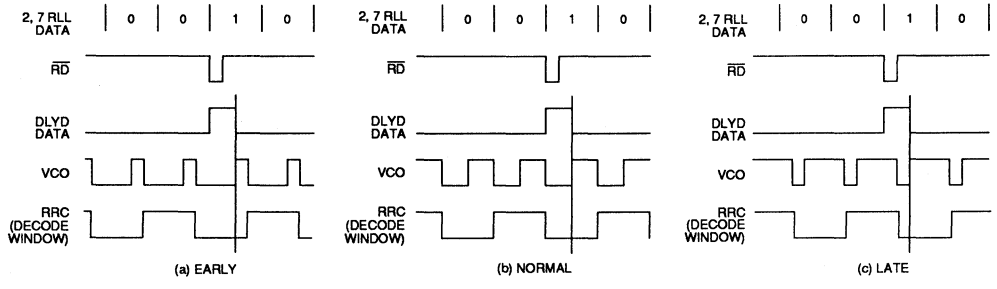
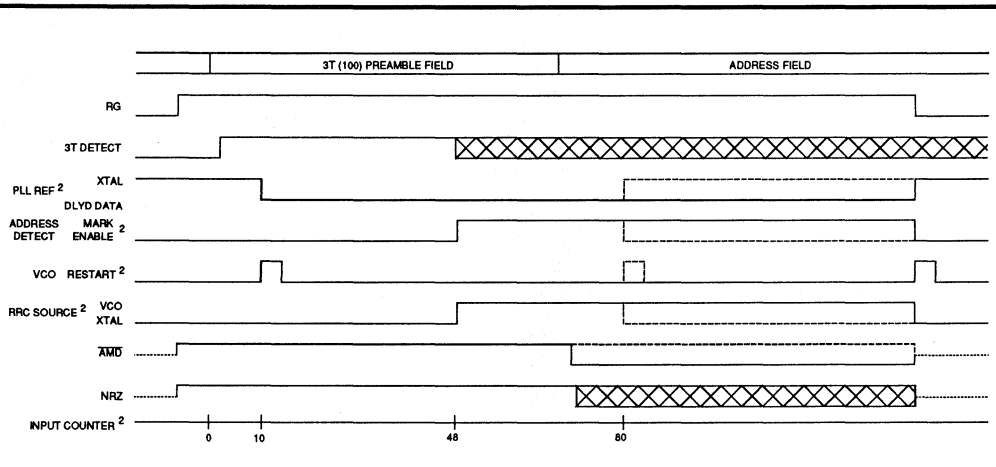


FIGURE 3: Decode Window



Notes: 1) Dashed lines represent conditions where AMD did not occur
2) Representations of internal signals
3) Dotted lines represent a high impedance output state

FIGURE 4: Soft Sector Mode Timing Diagram

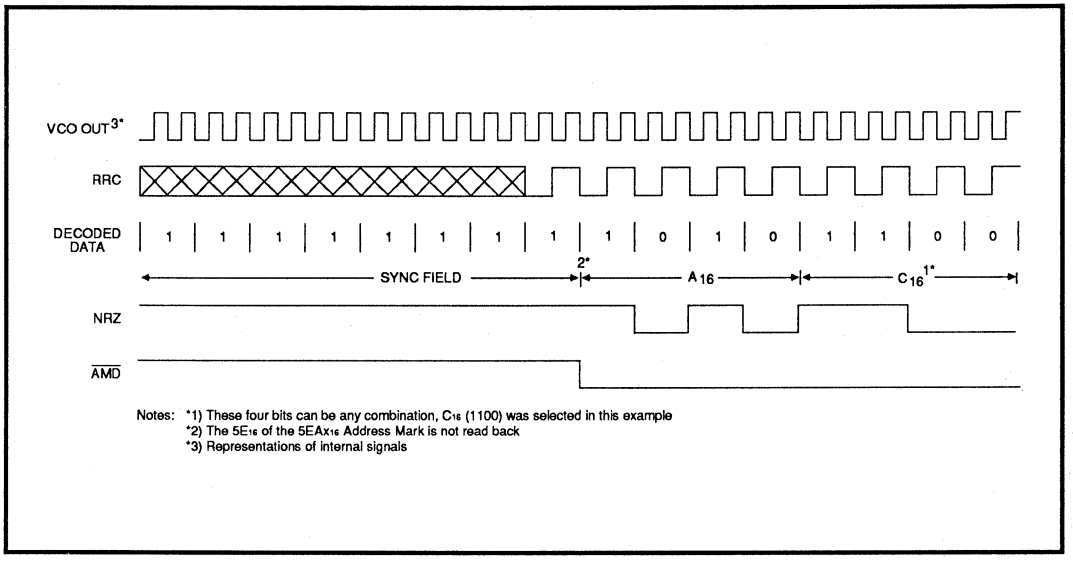


FIGURE 5: Address Mark Detection and NRZ Output Waveform

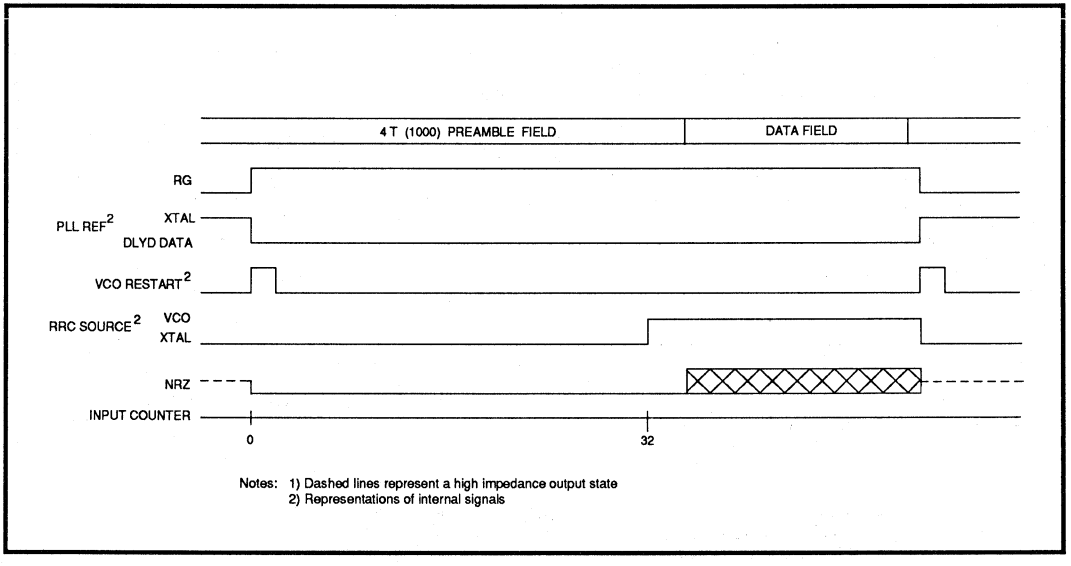


FIGURE 6: Hard Sector Mode Timing Diagram

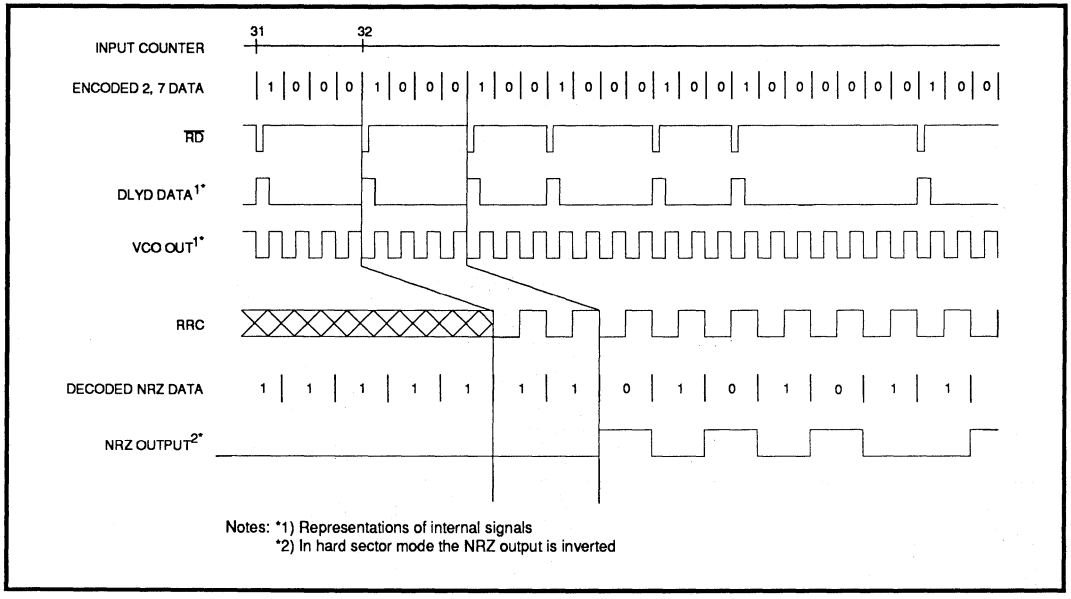


FIGURE 7: Hard Sector Mode Decode Timing

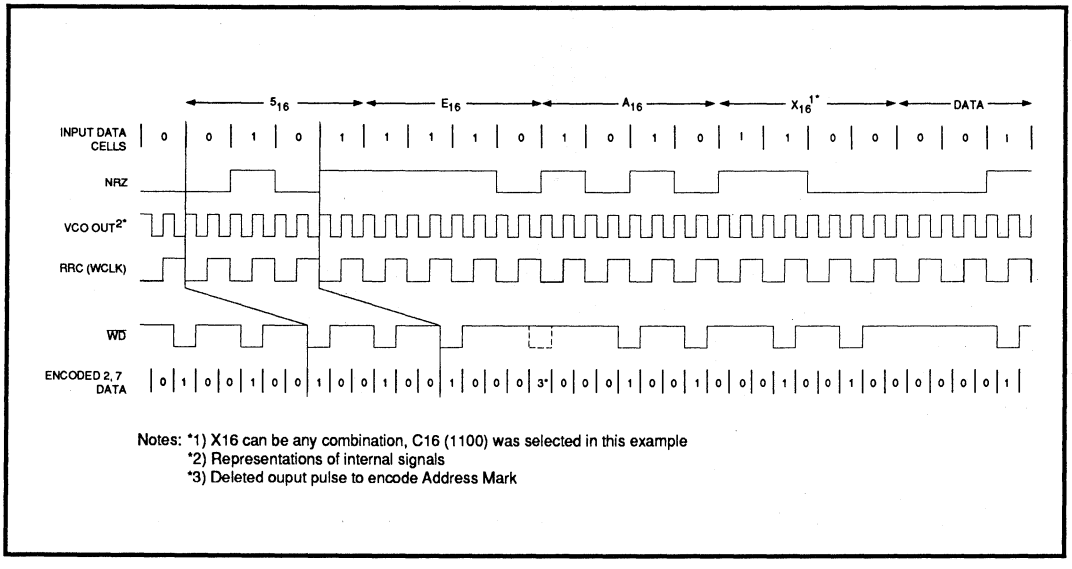


FIGURE 8: Write Address Mark Generation

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATINGS	UNIT
Storage Temperature	-65 to +150	°C
Ambient Operating Temperature, Ta	0 to +70	°C
Junction Operating Temperature	0 to +130	°C
Supply Voltage, VCC	-0.5 to 7	Vdc
Voltage Applied to Logic inputs	-0.5 to VCC +0.5	Vdc
Maximum Power Dissipation	950	mW

DC ELECTRICAL CHARACTERISTICS - unless otherwise specified, 4.75V < VCC < 5.25V, Ta = 0°C to 70°C, 7.5 MHz < 1/TORC < 10 MHz, 15 MHz < 1/TVCO < 20 MHz

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VIH, High Level Input Voltage		2.0			V
VIL, Low Level Input Voltage				0.8	V
IIH, High Level Input Current	VIH = 2.7V			20	µA
IIL, Low Level Input Current	VIL = 0.4V			-0.36	mA
VOH, High Level Output Voltage	IOH = -400 µA	2.7			V
VOL, Low Level Output Voltage	IOL = 4 mA			0.5	V
ICC, Power Supply Current	All outputs open			165	mA

DYNAMIC CHARACTERISTICS AND TIMING

READ MODE (See Figure 9)

TRD, Read Data Pulse Width		20		TORC-40	ns
TFRD, Read Data Fall Time	2.0V to 0.8V, CL ≤ 15 pF			15	ns
TRRC, Read Clock Rise Time	0.8V to 2.0V, CL ≤ 15 pF			8	ns
TFRC, Read Clock Fall Time	2.0V to 0.8V, CL ≤ 15 pF			5	ns
TPNRZ, NRZ (out) Propagation Delay		-15		15	ns
TPAMD, $\overline{AMD}$ Propagation Delay		-15		15	ns
1/4 Cell + Retriggerable One-Shot Detect Stability		-4		+4	%

READ MODE (Cont.)

PARAMETER	CONDITIONS	MIN	MAX	UNIT
1/4 Cell + Retriggerable One-Shot Delay*	TD=6.14(RR +0.5) + 0.172 Rd (Cd +11.5) RR = kΩ Rd = kΩ Cd = 68 pF to 100 pF	0.89 TD	1.11 TD	ns
Note: * = Excludes External Capacitor and Resistor Tolerances				

WRITE MODE (See Figure 10)

TWD, Write Data Pulse Width	CL ≤15 pF	(TORO/2) -12	(TORO/2) +12	ns
TFWD, Write Data Fall Time	2.0V to 0.8V, CL ≤ 15 pF		8	ns
TOWC Write Data Clock Repetition Period		TORO -12	TORO +12	ns
TRWC Write Data Clock Rise Time	0.8V to 2.0V		10	ns
TFWC Write Data Clock Fall Time	2.0V to 0.8V		8	ns
TSNRZ, NRZ (in) Set Up Time		20		ns
THNRZ, NRZ (in) Hold Time		7		ns

DATA SYNCHRONIZATION

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TVCO	VCO Center Frequency Period	VCO IN = 2.7V TO = 1.23E - 11 (RR +500) VCC = 5.0V	0.8TO		1.2 TO	sec
	VCO Frequency Dynamic Range	1.0V ≤ VCO IN ≤ VCC -0.6V VCC = 5.0V	±24		±40	%
KVCO	VCO Control Gain	ωo = 2π / TO 1.0V ≤ VCO IN ≤ VCC -0.6V	0.14ωo		0.20 ωo	rad/s V
KD	Phase Detector Gain	KD = 0.309 / (RR + 500) VCC = 5.0V	0.83KD		1.17 KD	A/rad
	KVCO x KD Product Accuracy		-28		+28	%
	VCO Phase Restart Error		-0.5		+0.5	rad
	Decode Window Centering Accuracy				± (0.01 TORC + 2)	ns
	Decode Window		(TORC/2) -2			ns

DATA SYNCHRONIZATION (Cont.)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TS1	Decode Window Time Shift Magnitude	TS1 = 0.015 TORC	0.85 TS1		1.15 TS1	sec
TS2	Decode Window Time Shift Magnitude	TS2 = 0.06 TORC	0.90 TS2		1.1 TS2	sec
TS3	Decode Window Time Shift Magnitude	TS3 = 0.075 TORC	0.90 TS3		1.1 TS3	sec
TSA	Decode Window Time Shift Magnitude	$TSA = 0.125\ TORC\left(1 - \frac{680 + R}{1180 + R}\right)$ with: R in ohms	0.65 TSA		1.35 TSA	sec

CONTROL CHARACTERISTICS (See Figure 11)

TSWS, $\overline{WS0}$, $\overline{WS1}$, WSD Set Up Time		50			ns
THWS, $\overline{WS0}$, $\overline{WS1}$, WSD Hold Time		0			ns
RG, WG, SOFT/$\overline{HARD}$ Time Delay				100	ns

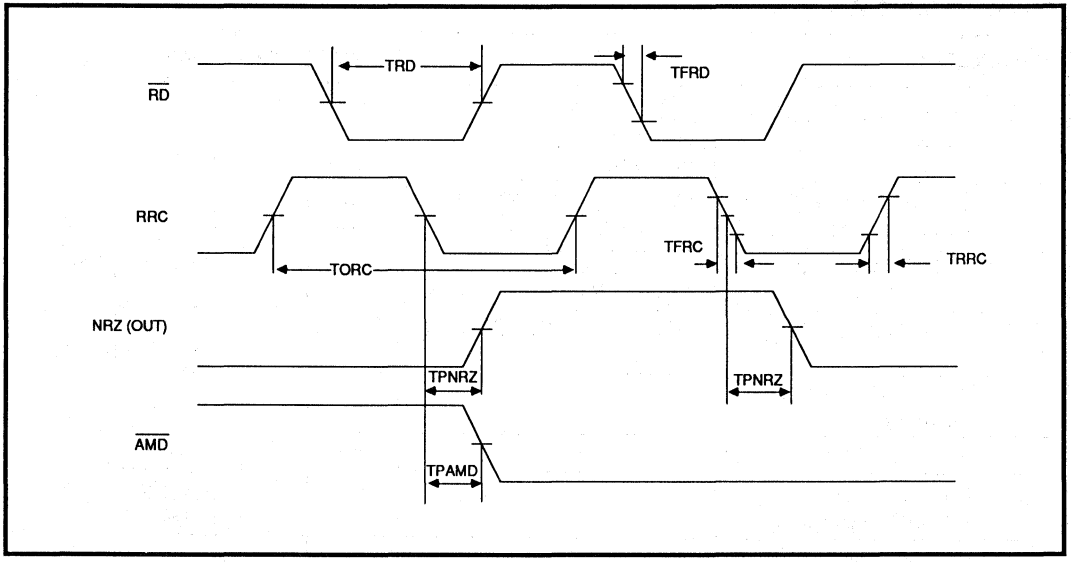


FIGURE 9: Read Timing

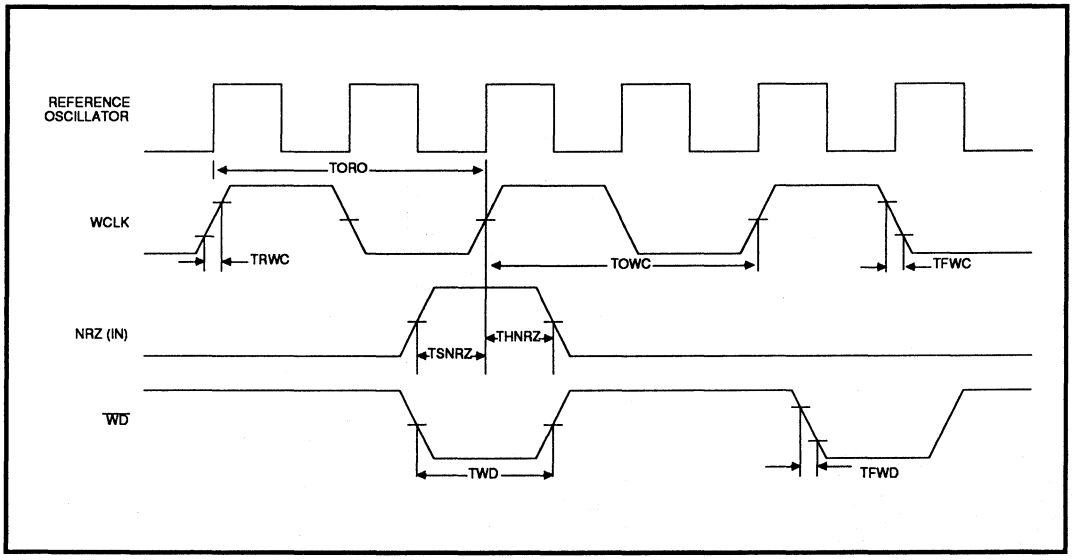


FIGURE 10: Write Timing

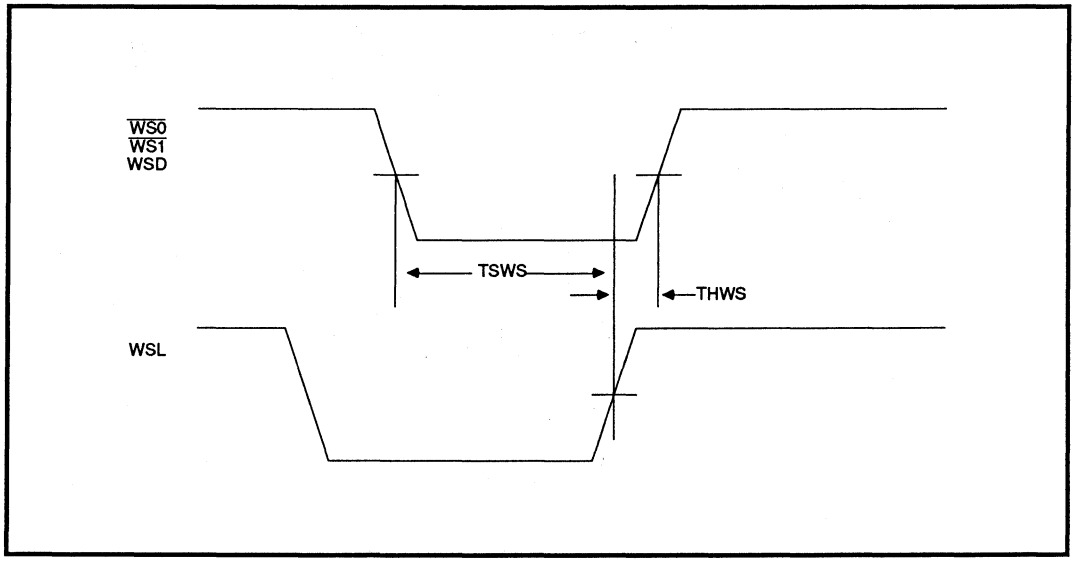
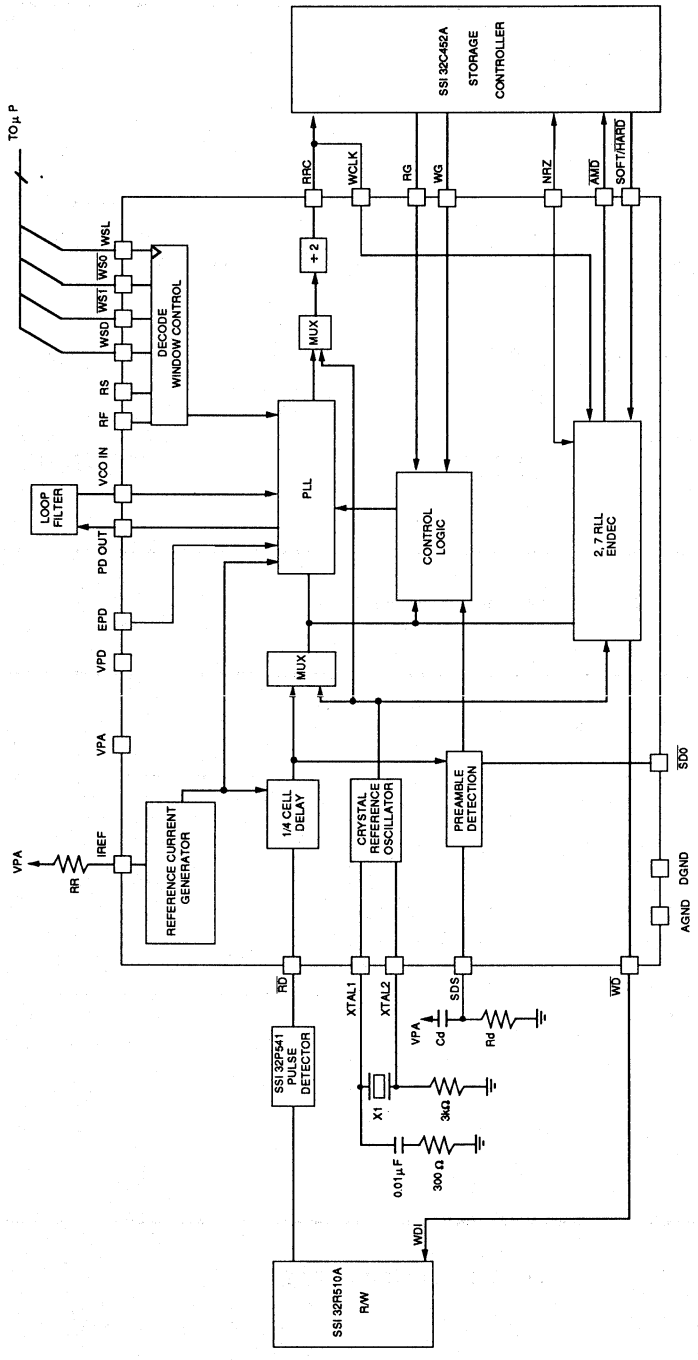
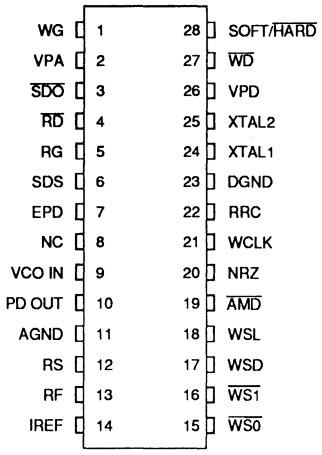


FIGURE 11: Control Timing

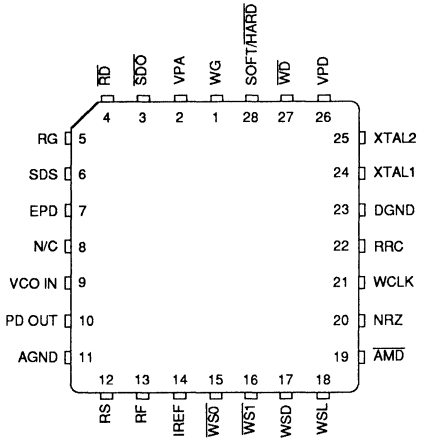


TYPICAL SSI 532 APPLICATION

PACKAGE PIN DESIGNATIONS
(TOP VIEW)



28-Pin DIP



28-Pin PLCC

4

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32D5321 28-Pin PLCC	SSI 32D5321 - C28H	32D5321 - CH
SSI 32D5321 28-Pin Plastic DIP	SSI 32D5321 - C28P	32D5321 - CP

Silicon Systems, Inc. 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32D5322
Data Synchronizer/ 2, 7 RLL ENDEC

June, 1990

DESCRIPTION

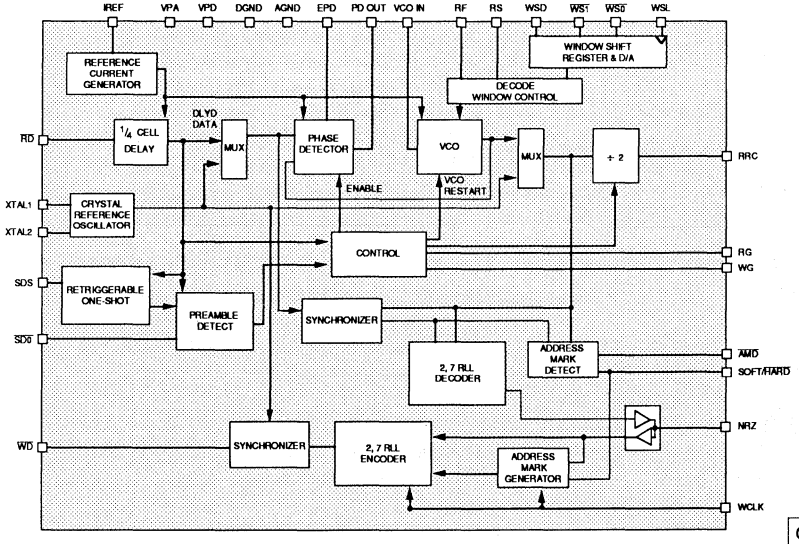
The SSI 32D5322 Data Synchronizer/2, 7 RLL ENDEC provides data recovery and data encoding for storage systems which employ a 2, 7 RLL encoding format. Data synchronization is performed with a fully integrated high performance PLL. A zero phase restart technique is used to minimize PLL acquisition time. The SSI 32D5322 has been optimized for operation as a companion device to the SSI 32C452 and the AIC 010 controllers. The VCO frequency setting elements are incorporated within the SSI 32D5322 for enhanced performance and reduced board space. Data rate is established with a single external programming resistor. The SSI 32D5322 utilizes an advanced bipolar process technology which affords precise decode window control without the requirement of an accurate 1/ 4 cell delay or external devices. To enhance disk drive testability, decode window symmetry control is available through a digital µP port and/or two analog pins. This feature can facilitate defect mapping, automatic calibration, systematic error cancellation, window margin testing and error recovery. The SSI 32D5322 requires a single +5V power supply and is available in 28-pin DIP and PLCC packages.

FEATURES

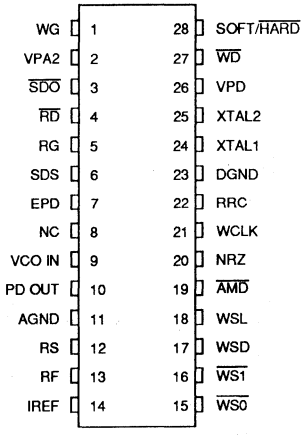
- **Data Synchronizer and 2, 7 RLL ENDEC**
- **7.5 to 15 Mbit/s Operation Programmed with a Single External Resistor**
- **Optimized for Operation with the SSI 32C452 and AIC 010 Controllers**
- **Programmable Decode Window Symmetry via a µP Port and/or Analog Pins**
- **Fast Acquisition Phase Locked Loop**
  - **Zero Phase Restart Technique**
- **Fully Integrated Data Separator**
  - **No External Delay Lines or Active Devices Required**
- **Crystal Controlled Reference Oscillator**
- **Hard/Soft Sector Operation**
- **+5V Operation**
- **28-Pin DIP and PLCC Packages**
- **ESDI (Hard Sector) Compatible**

4

BLOCK DIAGRAM



PIN DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

OPERATION

The SSI 32D5322 is designed to perform data recovery and data encoding in rotating memory systems which utilize a 2, 7 RLL encoding format. In the Read Mode the SSI 32D5322 performs Data Synchronization, Sync Field Search and Detect, Address Mark Detect and Data Decoding. In the Write Mode, the SSI 32D5322 converts NRZ data into the 2,7 RLL format described in Table 1, it generates the Preamble Field, and inserts Address Marks as requested. The interface electronics and architecture of the SSI 32D5322 have been optimized for use as a companion device to the SSI 32C452 or AIC 010 controllers.

The SSI 32D5322 can operate with data rates ranging from 7.5 to 15 Mbit/s. This data rate is established by a single 1% external resistor, RR, connected from pin IREF to VPA. This resistor establishes a reference current which sets the VCO center frequency, the phase detector gain, and the 1/4 cell delay. The value of this resistor is given by:

$$RR = \frac{43.86}{DR} - 1.2(k\Omega)$$

where: DR = Data Rate in Mbit/s.
[* Note: This equation differs from 32D5321 RR equation]

An internal crystal reference oscillator, operating at twice the data rate, generates the standby reference for the PLL. A series resonant crystal between XTAL1 and XTAL2 should be selected at twice the Data Rate. If a crystal oscillator is not desired, then an external TTL compatible reference may be applied to XTAL1, leaving XTAL2 open.

The SSI 32D5322 employs a Dual Mode Phase Detector; Harmonic in the Read Mode and Non-Harmonic in Write and Idle Modes. In the Read Mode the Harmonic Phase Detector updates the PLL with each occurrence of a DLYD DATA pulse. In the Write and Idle Modes the Non-Harmonic Phase Detector is continuously enabled, thus maintaining both phase and frequency lock. By acquiring both phase and frequency lock to the crystal reference oscillator and utilizing a zero phase restart technique, false lock to DLYD DATA is eliminated.

The phase detector incorporates a charge pump in order to drive the loop filter directly. The polarity and width of the output current pulses correspond to the direction and magnitude of the phase error. Figure 1 depicts the average output current as a function of the input phase error (relative to the VCO period).

The READ GATE (RG), and WRITE GATE (WG), inputs control the device mode as described in Table 2. RG is an asynchronous input and may be initiated or terminated at any position on the disk. WG is also an asynchronous input, but should not be terminated prior to the last output Write Data pulse.

READ OPERATION

The Data Synchronizer utilizes a fully integrated fast acquisition PLL to accurately develop the decode window. Read Gate, RG, initiates the PLL locking sequence and selects the PLL reference input; a high level (Read Mode) selects the $\overline{RD}$ input and a low level selects the crystal reference oscillator.

In the Read Mode the rising edge of DLYD DATA enables the Phase Detector while the falling edge is phase compared to the rising edge of the VCO. As depicted in Figure 2, DLYD DATA is a 1/4 cell wide (TVCO/2) pulse whose leading edge is defined by the leading edge of $\overline{RD}$. An accurate and symmetrical decode window is developed from the VCO clock. The decode window is generated from the falling edges of the VCO clock. By utilizing a fully integrated symmetrical VCO running at twice the data rate, the decode window is insured to be accurate and centered symmetrically about the falling edges of DLYD DATA. The accuracy of the 1/4 cell delay only affects the retrace angle of the phase detector and does not influence the accuracy of the decode window.

Shifting the symmetry of the VCO clock effectively shifts the relative position of the DLYD DATA pulse within the decode window. This powerful capability easily facilitates defect mapping, automatic calibration, window margin testing, error recovery, and systematic error cancellation. For enhanced disk drive testability and error recovery, decode window control is provided via a µP port (WSL, WSD, $\overline{WS0}$, $\overline{WS1}$) as described in Table 3. In applications not utilizing this feature, WSL should be connected to ground, while WSD, $\overline{WS0}$, and $\overline{WS1}$ can be left open.

Window shifts in the range of ±1.5% to ±7.5% of TORC are easily programmed by latching the appropriate control word into the Window Shift Register with the WSL pin. Shifts in the positive or negative directions result in early or late decode windows respectively, as depicted in Figure 3. Additionally, for small systematic error cancellation, a resistor, R, connected from either RS (Early) or RF (Late) to ground will provide analog control over the decode window. The magnitude of this shift, TSA is determined by:

$$TSA = 0.125\ TORC\left(1 - \frac{680 + R}{1180 + R}\right)$$

where: R is in ohms

Pins RF and RS are intended to be used as a trim and should be restricted to ±1.5% window shifts. They can be used in conjunction with the digital control port.

In Non-Read Modes, the PLL is locked to the crystal reference oscillator. This forces the VCO to run at a frequency which is very close to that required for tracking actual data and thus minimizes the associated frequency step during acquisition. When the reference input to the PLL is switched, the VCO is stopped momentarily, then restarted in an accurate phase alignment with the next PLL reference input pulse, and the VCO clock divider is reset. By minimizing the phase alignment in this manner (phase error ≤ 0.5 rads), the acquisition time is substantially reduced.

The SSI 32D5322 provides two sync modes for controlling the PLL locking sequence; Soft Sector and Hard Sector.

SOFT SECTOR MODE

The Soft Sector Mode activates the Preamble Search and Address Mark detection circuitry. As depicted in Figure 4, when RG transitions high, the counter is reset and the SSI 32D5322 requires 10 high to low transitions (Preamble '1' bits) before switching the reference input to the PLL, 48 high to low transitions before switching the Read Reference Clock to the VCO clock divided by two and activating the Address Mark Detect circuitry; then it must detect the Address Mark prior to 80 high to low transitions in order to enter the Read Mode. This sequence repeats after 95 input '1' bits until the read mode is successfully entered or until RG is cancelled.

When RG transitions high, the following PLL locking sequence begins:

a) PREAMBLE SEARCH:

The 3T detect circuitry initiates the PLL locking sequence once it has detected 10 consecutive '100' bit groups from the 3T preamble field. The 3T detect timing is set by the sum of the 1/4 cell delay and the retriggerable one-shot delay. The 1/4 cell timing capacitor is included on-chip and its timing is externally set by resistor RR. The retriggerable one-shot timing is externally set by resistor Rd and capacitor Cd. The sum of their delays is set to 3.5 bit cell times. Therefore, a continuous stream of input pulses with a 3T bit cell time pulse rate keeps the one-shot reset, and a 4T or longer bit cell time input period allows the one-shot to time out producing a 4T detect pulse. The 4T detect pulse resets the Input Counter and the search is started over.

b) PLL ACQUISITION:

Once 10 consecutive '100' bit groups are detected, the reference input to the PLL is switched from the crystal reference oscillator to the DLYD DATA, the VCO is phase reset to the next DLYD DATA pulse, and PLL acquisition begins. When an additional 38 '100' bit groups are detected, the Read Reference Clock output (RRC) is switched to the VCO clock divided by 2, the 4T Detect circuitry is inhibited, and the Address Mark Detection circuitry is enabled. If a 4T detect pulse occurs before 48 Preamble '1' bits are detected, then the PLL is locked back to the crystal reference oscillator, the RRC output is switched to the crystal reference oscillator divided by 2, the Input Counter reset, and the sequence is restarted. No short duration glitches will occur at the RRC output during this switching.

c) ADDRESS MARK DETECTION:

The circuit searches for the occurrence of the $5EAx_{16}$ Address Mark. The 4T detect circuitry remains active, so that, during the search, once a 4T or longer bit cell time input period is detected, the address mark must be found within the next five counts of the read input pulses. If an Address Mark is detected prior to

c) **ADDRESS MARK DETECTION** (Continued)

the Input Counter reaching count 80, the correct phase of the RRC is ensured by resetting the n/2 divider, the $\overline{AMD}$ output is latched low, the PLL training sequence is terminated, and the Read Mode is entered allowing the data field to be read. If the Input Counter reaches count 80 before the Address Mark is detected, the PLL is locked back to the crystal reference oscillator, the RRC output is switched to the crystal reference oscillator divided by 2, and the PLL training sequence is restarted when the Input Counter reaches count 96. Figure 5 depicts the Address Mark detection sequence.

HARD SECTOR MODE

In the Hard Sector mode (SOFT/$\overline{HARD}$ = 0) the SSI 32D5322 utilizes a 4T (1000) Preamble Field and disables the Preamble Search and Address Mark detection circuitry. It allows the PLL to be controlled directly by RG for Hard Sector format operation. With the absence of an Address Mark, the 4T Preamble Field is utilized to properly set the bit cell alignment boundaries for proper decoding.

When RG transitions high, as depicted in Figure 6, reference input to the PLL is switched from the crystal reference oscillator to DLYD DATA, the VCO is phase reset to the next DLYD DATA pulse, and the PLL acquisition begins. When 32 '1' Preamble bits are detected, the RRC output is switched to the VCO clock divided by 2, and the Read Mode is entered allowing the data field to be read.

In the Hard Sector mode, the NRZ output is inverted and will remain low until the data field is read, as shown in Figure 7. Since the Preamble Search circuitry is not utilized, the external one-shot timing components (Cd, Rd) are not required and the SDS pin can be left open.

WRITE OPERATION

In the Write Mode the SSI 32D5322 converts NRZ data from the controller into 2, 7 RLL formatted data for storage onto the disk. The SSI 32D5322 can operate with a soft or hard sectored disk drive. In the Soft Sector Mode, (SOFT/$\overline{HARD}$ = 1) the device generates a 3T Preamble Field and can insert a N7V Address Mark. The N7V Address Mark is a valid 2, 7 RLL pattern which is not contained in the code set. In the Hard Sector Mode, (SOFT/$\overline{HARD}$ = 0) the device generates a 4T Preamble Field and no Address Mark. Serial NRZ data is clocked into the SSI 32D5322 and latched on defined cell boundaries. The NRZ input data must be synchronous with the rising edges of the WCLK input. In a SCSI or ST506 operation, WCLK is connected directly to the RRC output.

SOFT SECTOR MODE

In the Soft Sector Mode, when WRITE GATE (WG), transitions high and the NRZ input is held low, the SSI 32D5322 automatically generates the 3T (100) Preamble Field at the WRITE DATA ($\overline{WD}$), output. The 3T Preamble Field will continue to be generated until the first low to high transition on the NRZ line. As shown in Figure 8, the first low to high transition occurs with the second bit '1' of the 5_{16} (0101) in the $5EAx_{16}$ Address Mark generation pattern. To generate the Address Mark, the SSI 32D5322 automatically changes the '1' in the eleventh position (see note 3) of the 2, 7 RLL encoded sequence, to a '0'. This generates a pattern of seven zero's followed by two zero's. This unique pattern satisfies the 2, 7 RLL constraints, but will never occur during a normal encoding sequence. The x_{16} of the $5EAx_{16}$ Address Mark generation pattern can be selected, a 'C_{16}' (1100) was utilized in this example.

HARD SECTOR MODE

In the Hard Sector Mode, when WG goes high and the NRZ input is held low, the SSI 32D5322 automatically generates the 4T (1000) Preamble Field at the WRITE DATA, $\overline{WD}$, output. Note that in the Hard Sector mode, the NRZ input is inverted, therefore a constant low is equivalent to an '11 . . . ' input which generates the 4T '1000 . . . ' Preamble Field. The 4T Preamble Field will be generated between the time WG goes high and the first low to high transition on the NRZ line. The SSI 32D5322 requires a minimum of 32 4T (1000) bit groups prior to the data field.

PIN DESCRIPTIONS

INPUT PINS

NAME	TYPE	DESCRIPTION
$\overline{RD}$	I	READ DATA: Encoded Read Data from the disk drive read channel, active low.
RG	I	READ GATE: Selects the PLL reference input and initiates the PLL synchronization sequence. A high level selects the $\overline{RD}$ input and enables the Read Mode/Address Mark Detection sequences. A low level selects the crystal reference oscillator. Pin RG has an internal resistor pull-up.
WG	I	WRITE GATE: Enables the write mode. Pin WG has an internal resistor pull-up.
WSL	I	WINDOW SYMMETRY LATCH: Used to latch the input window symmetry control bits WSD, $\overline{WS0}$ and $\overline{WS1}$ into the internal DAC. An active high level latches the input bits. Pin WSL has an internal resistor pull-up. If unused, connect this pin to ground.
WSD	I	WINDOW SYMMETRY DIRECTION: Controls the direction of the optional window symmetry shift. Pin WSD has an internal resistor pull-up. If unused, this pin can be left open.
$\overline{WS0}$	I	WINDOW SYMMETRY CONTROL BIT: A low level introduces a window shift of 1.5% TORC (Read Reference Clock Period) in the direction established by WSD. Pin $\overline{WS0}$ has an internal resistor pull-up. If unused, this pin can be left open.
$\overline{WS1}$	I	WINDOW SYMMETRY CONTROL BIT: A low level introduces a window shift of 6% TORC (Read Reference Clock Period) in the direction established by WSD. A low level at both $\overline{WS0}$ and $\overline{WS1}$ will produce the sum of the two window shifts. Pin $\overline{WS1}$ has an internal resistor pull-up. If unused, this pin can be left open.
SOFT/$\overline{HARD}$	I	SOFT/$\overline{HARD}$ SECTOR: Selects the address mark and the Preamble field patterns. A high level (Soft Sector) selects a 3T Preamble Field pattern and a non-violating 2, 7 address mark, N7V. A low level (Hard Sector) selects a 4T Preamble Field pattern and disables the address mark circuitry. Pin SOFT/$\overline{HARD}$ has an internal resistor pull-up.
WCLK	I	WRITE CLOCK: Write Clock input. Must be synchronous with the Write Data input on the NRZ Data Port. For small cable delays, WCLK may be connected directly to pin RRC (Read/Reference Clock).
EPD	I	ENABLE PHASE DETECTOR: A low level (Coast Mode) disables the phase detector and allows the VCO to coast. Pin EPD has an internal resistor pull up.

BIDIRECTIONAL PINS

NRZ	I/O	NRZ DATA PORT: Read Data output when RG is high and Write Data input when WG is high. In the idle mode NRZ is in a high impedance state.

PIN DESCRIPTIONS (Cont.)

OUTPUT PINS

NAME	TYPE	DESCRIPTION
$\overline{WD}$	O	WRITE DATA: Encoded write data output, active low.
RRC	O	READ/REFERENCE CLOCK: A multiplexed clock source used by the controller. In the read mode, this clock is the VCO frequency divided by two (1/TORC) and in the write mode it is the crystal reference frequency divided by two (1/TORO). No short clock pulses are generated during a mode change.
$\overline{AMD}$	O	ADDRESS MARK DETECT: In the soft sector Read Mode, a latched low level output indicates that an address mark has been detected. In non-Read modes $\overline{AMD}$ is configured as a high impedance output.
$\overline{SDO}$	O	SYNC DETECT OUTPUT: An active low output that indicates successful detection of the 3T Preamble sync field. THE $\overline{SDO}$ pin is not a TTL level signal.

ANALOG PINS

IREF	I	TIMING PROGRAM PIN: The VCO center frequency and the 1/4 Cell Delay are a function of the current source into pin IREF. The current is set by an external resistor, RR, connected from IREF to VPA.
XTAL1, XTAL2	I	CRYSTAL OSCILLATOR CONNECTIONS: If a crystal oscillator is not desired, XTAL1 maybe driven by a TTL source with XTAL2 open. The frequency must be at twice the data rate.
PD OUT	O	PHASE DETECTOR OUTPUT: Drives the Loop Filter input.
VCO IN	I	VCO CONTROL INPUT: Driven by the Loop Filter output.
SDS	I	SYNC DETECT SET: Used to program the sync detect retriggerable one-shot timing with an external R-C network. Connect the capacitor, Cd, to VPA and the resistor, Rd, to AGND.
RF, RS	I	WINDOW SYMMETRY ADJUST PINS: Provides analog control over the decode window symmetry; typically used to null out any window symmetry offset. A resistor connected from either RF or RS to AGND will provide magnitude and direction control. They can be used in conjunction with the digital control port WSD, $\overline{WS0}$, $\overline{WS1}$.

POWER

DGND,AGND	I	DIGITAL AND ANALOG GROUND
VPA	I	ANALOG +5V
VPD	I	DIGITAL +5V

NRZ	2, 7 RLL
10	0100
11	1000
000	000100
010	100100
011	001000
0010	00100100
0011	00001000

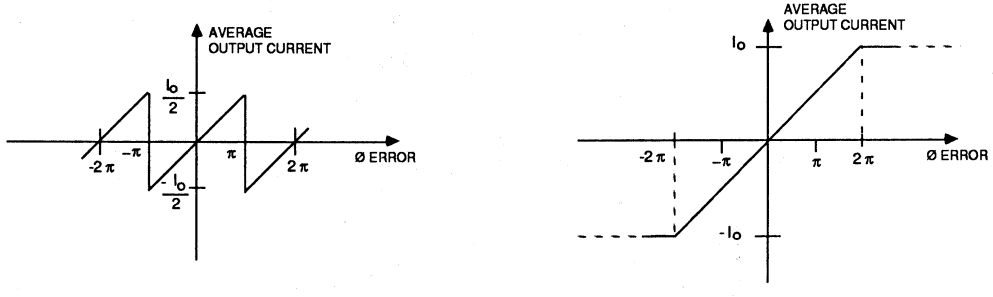
TABLE 1: 2, 7 RLL Code Set

WG	RG	MODE
0	0	IDLE
0	1	READ
1	0	WRITE
1	1	ILLEGAL

TABLE 2: Mode Control

Ts, NOMINAL WINDOW SHIFT	WSD	$\overline{WS1}$	$\overline{WS0}$
+TS3	0	0	0
+TS2	0	0	1
+TS1	0	1	0
0	0	1	1
-TS3	1	0	0
-TS2	1	0	1
-TS1	1	1	0
0	1	1	1

TABLE 3: Decode Window Symmetry Control



Note 1) Io is the magnitude of the charge pump current.
2) Phase error is relative to the VCO period

FIGURE 1: Phase Detector Transfer Function

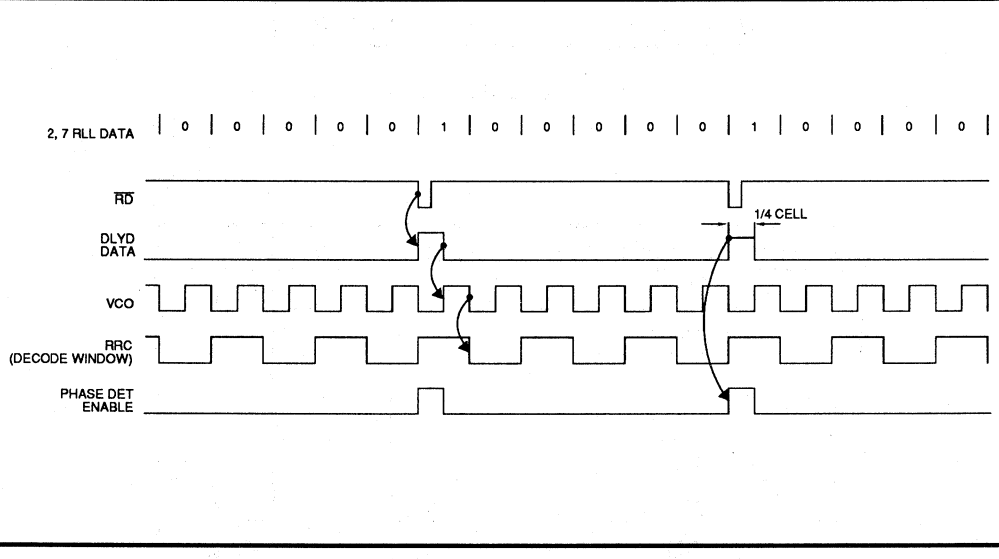


FIGURE 2: Data Synchronization Waveform Diagram

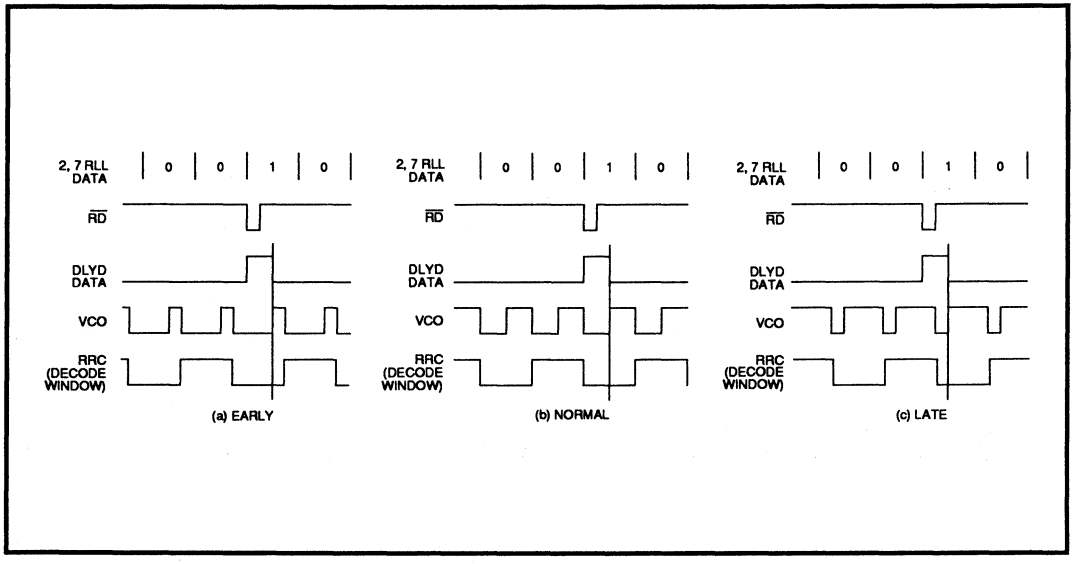
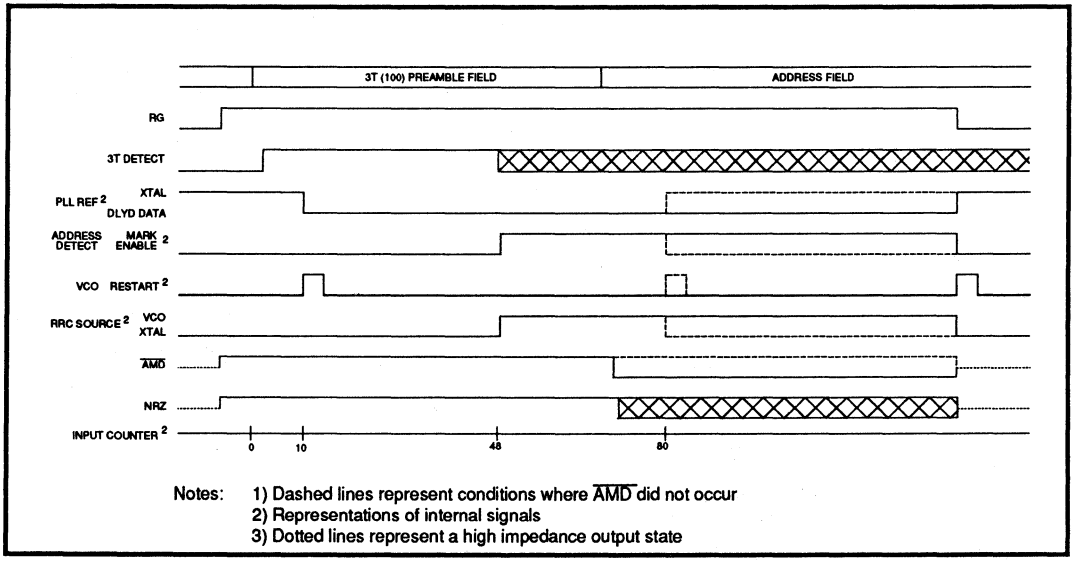
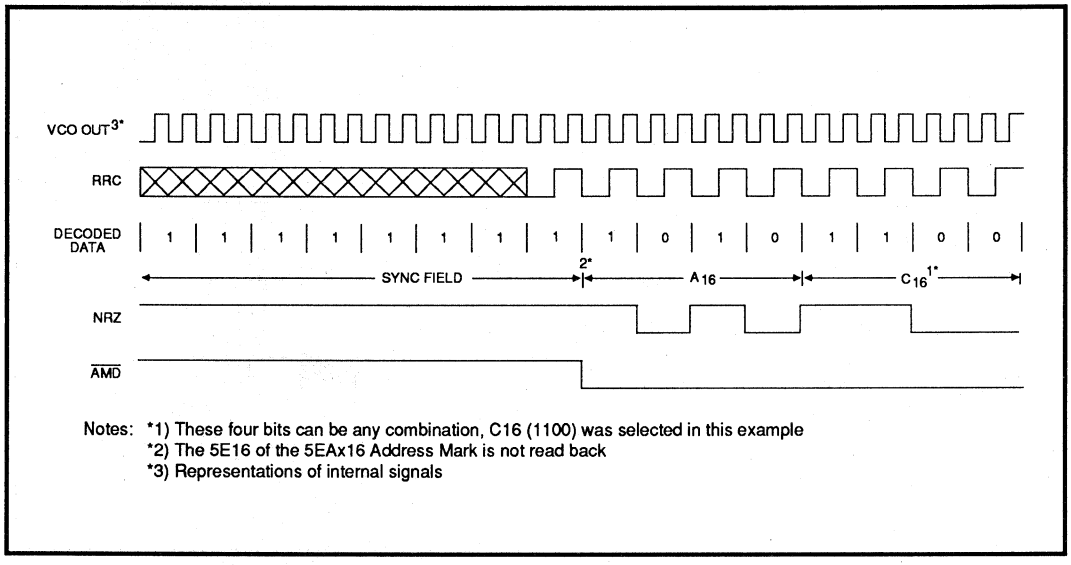


FIGURE 3: Decode Window



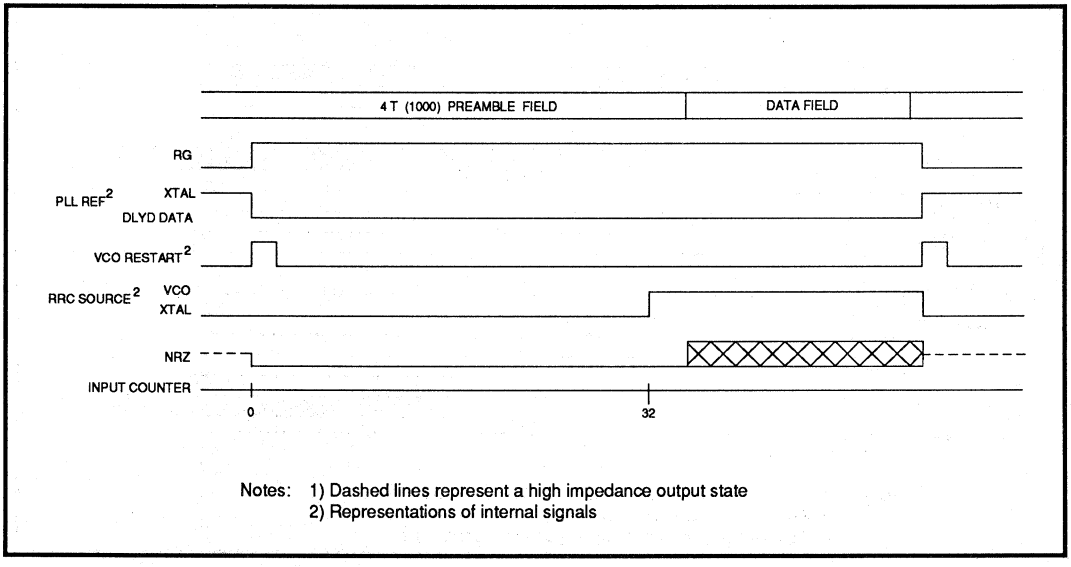
Notes: 1) Dashed lines represent conditions where $\overline{AMD}$ did not occur
2) Representations of internal signals
3) Dotted lines represent a high impedance output state

FIGURE 4: Soft Sector Mode Timing Diagram



Notes: *1) These four bits can be any combination, C16 (1100) was selected in this example
*2) The 5E16 of the 5EAx16 Address Mark is not read back
*3) Representations of internal signals

FIGURE 5: Address Mark Detection and NRZ Output Waveform



Notes: 1) Dashed lines represent a high impedance output state
2) Representations of internal signals

FIGURE 6: Hard Sector Mode Timing Diagram

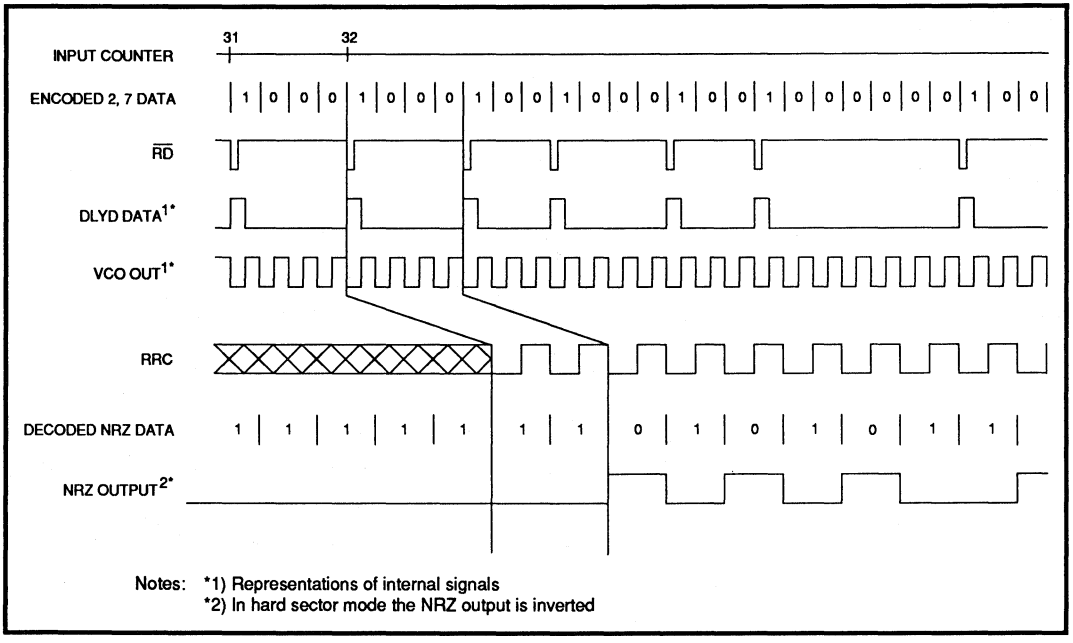


FIGURE 7: Hard Sector Mode Decode Timing

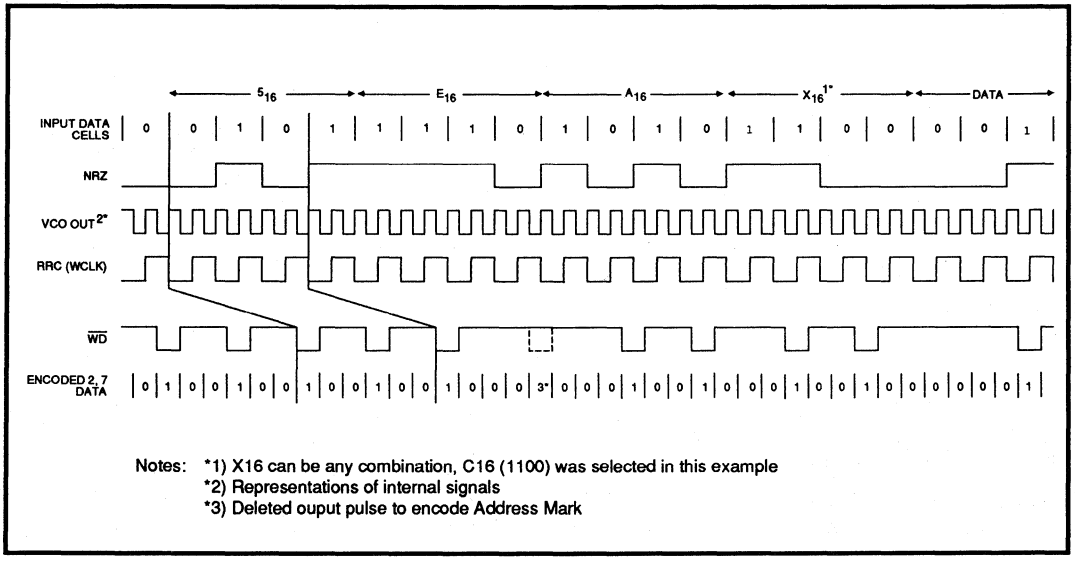


FIGURE 8: Write Address Mark Generation

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATINGS	UNIT
Storage Temperature	-65 to +150	°C
Ambient Operating Temperature, TA	0 to +70	°C
Junction Operating Temperature	0 to +130	°C
Supply Voltage, VCC	-0.5 to 7	Vdc
Voltage Applied to Logic inputs	-0.5 to VCC +0.5	Vdc
Maximum Power Dissipation	950	mW

DC ELECTRICAL CHARACTERISTICS - unless otherwise specified, 4.75V < VCC < 5.25V, TA = 0°C to 70°C, 7.5 MHz < 1/TORC < 15 MHz , 15 MHz < 1/TVCO < 30 MHz

PARAMETER	CONDITIONS	MIN	MAX	UNIT
VIH, High Level Input Voltage		2.0		V
VIL, Low Level Input Voltage			0.8	V
IIH, High Level Input Current	VIH = 2.7V		20	µA
IIL, Low Level Input Current	VIL = 0.4V		-0.36	mA
VOH, High Level Output Voltage	IOH = -400 µA	2.4		V
VOL, Low Level Output Voltage	IOL = 4 mA		0.5	V
ICC, Power Supply Current	All outputs open		165	mA

DYNAMIC CHARACTERISTICS AND TIMING

READ MODE (See Figure 9)

TRD, Read Data Pulse Width		20	TORC-40	ns
TFRD, Read Data Fall Time	2.0V to 0.8V, CL ≤ 15 pF		15	ns
TRRC, Read Clock Rise Time	0.8V to 2.0V, CL ≤ 15 pF		8	ns
TFRC, Read Clock Fall Time	2.0V to 0.8V, CL ≤ 15 pF		5	ns
TPNRZ, NRZ (out) Propagation Delay		-15	15	ns
TPAMD, $\overline{\text{AMD}}$ Propagation Delay		-15	15	ns
1/4 Cell + Retriggerable One-Shot Detect Stability		-4	+4	%
1/4 Cell + Retriggerable One-Shot Delay (see note)	TD=10.5(RR+0.5)+0.12Rd(Cd+Cs) Cs=Stray capacitance, RR = kΩ Rd = kΩ, Cd = 68 pF to 100 pF	0.89TD	1.11TD	ns
Note: Excludes External Capacitor and Resistor Tolerances				

WRITE MODE (See figure 10)

PARAMETER		CONDITIONS	MIN	MAX	UNIT
TWD	Write Data Pulse Width	CL ≤15 pF	(TORO/2) -12	(TORO/2) +12	ns
TFWD	Write Data Fall Time	2.0V to 0.8V, CL ≤ 15 pF		8	ns
TOWC	Write Data Clock Repetition Period		TORO -12	TORO +12	ns
TRWC	Write Data Clock Rise Time	0.8V to 2.0V		10	ns
TFWC	Write Data Clock Fall Time	2.0V to 0.8V		8	ns
TSNRZ	NRZ (in) Set Up Time		20		ns
THNRZ	NRZ (in) Hold Time		7		ns

DATA SYNCHRONIZATION

PARAMETER		CONDITIONS	MIN	MAX	UNIT
TVCO	VCO Center Frequency Period	VCO IN = 2.7V TO = 1.14 E-11 (RR + 1200) VCC = 5.0V	0.8TO	1.2TO	sec
	VCO Frequency Dynamic Range	1.0V ≤ VCO IN ≤ VCC -0.6V VCC = 5.0V	±24	±40	%
KVCO	VCO Control Gain	ωo = 2π / TO 1.0V ≤ VCO IN ≤ VCC -0.6V	0.14 ωo	0.20 ωo	rad/s V
KD	Phase Detector Gain	KD = 0.309 / (RR + 500) VCC = 5.0V	0.83 KD	1.17 KD	A/rad
	KVCO x KD Product Accuracy		-28	+28	%
	VCO Phase Restart Error		-0.5	+0.5	rad
	Decode Window Centering Accuracy			± (0.01 TORC+2)	ns
	Decode Window		(TORC/2)-2		ns
TS1	Decode Window Time Shift Magnitude	TS1 = 0.015 TORC	0.85 TS1	1.15 TS1	sec
TS2	Decode Window Time Shift Magnitude	TS2 = 0.06 TORC	0.90 TS2	1.1 TS2	sec

DATA SYNCHRONIZATION (Continued)

PARAMETER		CONDITIONS	MIN	MAX	UNIT
TS3	Decode Window Time Shift Magnitude	TS3 = 0.075 TORC	0.90 TS3	1.1TS3	sec
TSA	Decode Window Time Shift Magnitude	$TSA = 0.125\ TORC\left(1 - \frac{680+R}{1180+R}\right)$ with: R in ohms	0.65 TSA	1.35TSA	sec

CONTROL CHARACTERISTICS (See figure 11)

PARAMETER	CONDITIONS	MIN	MAX	UNIT
TSWS, $\overline{WS0}$, $\overline{WS1}$, WSD Set Up Time		50		ns
THWS, $\overline{WS0}$, $\overline{WS1}$, WSD Hold Time		0		ns
RG, WG, SOFT/$\overline{HARD}$ Time Delay			100	ns

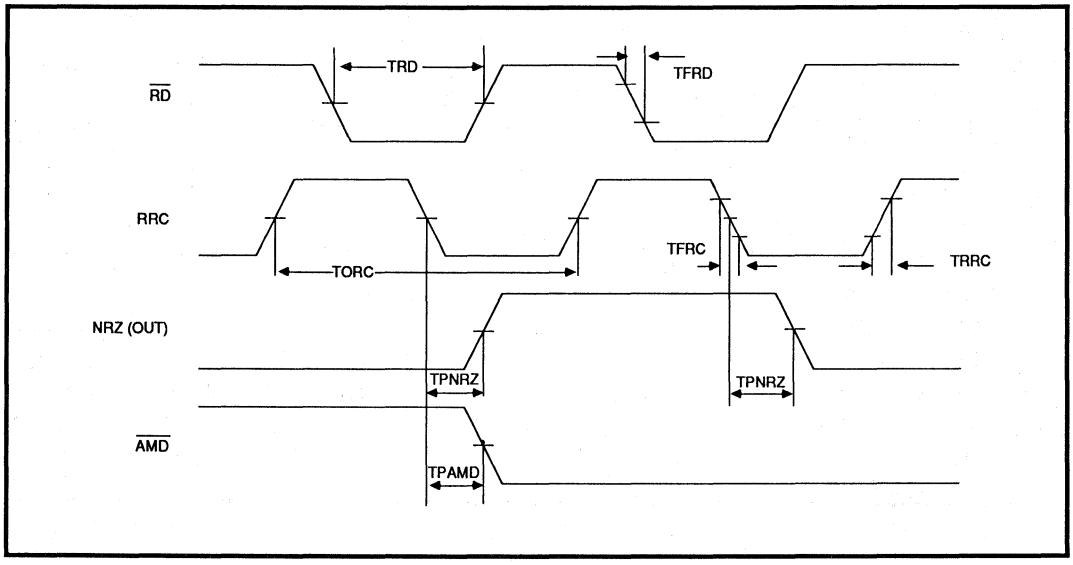


FIGURE 9: Read Timing

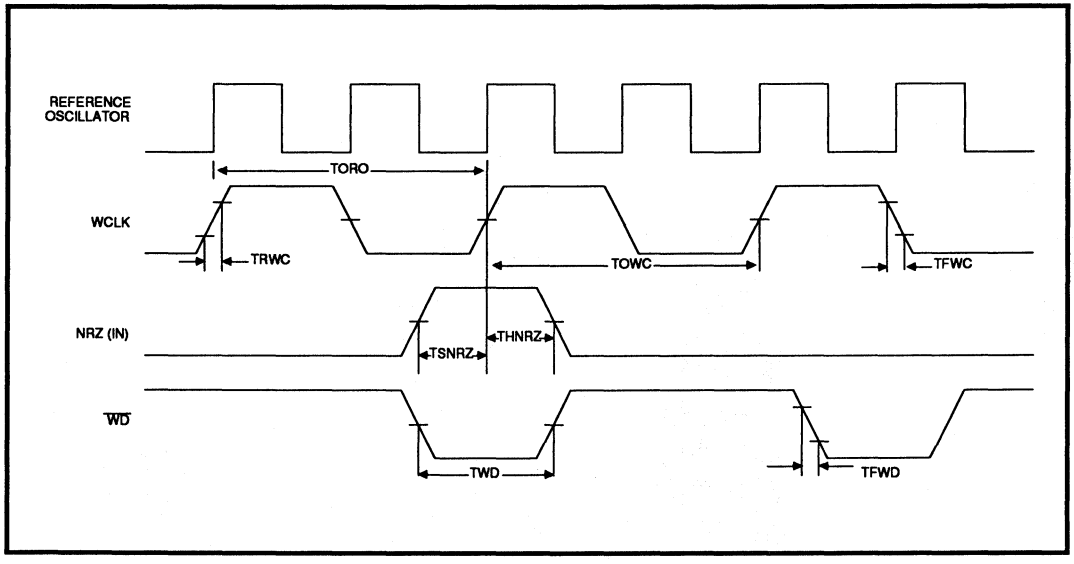


FIGURE 10: Write Timing

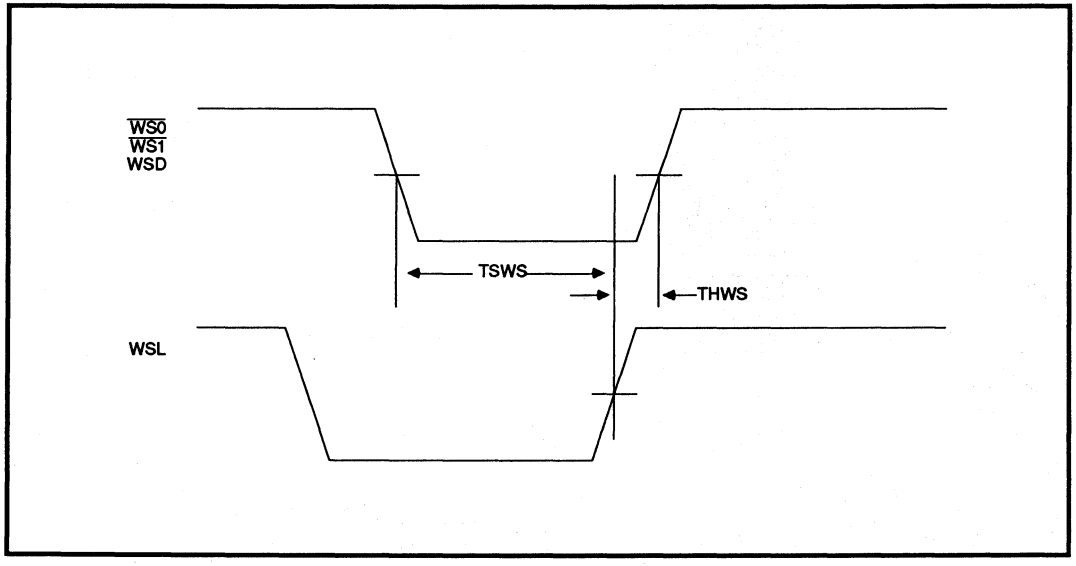


FIGURE 11: Control Timing

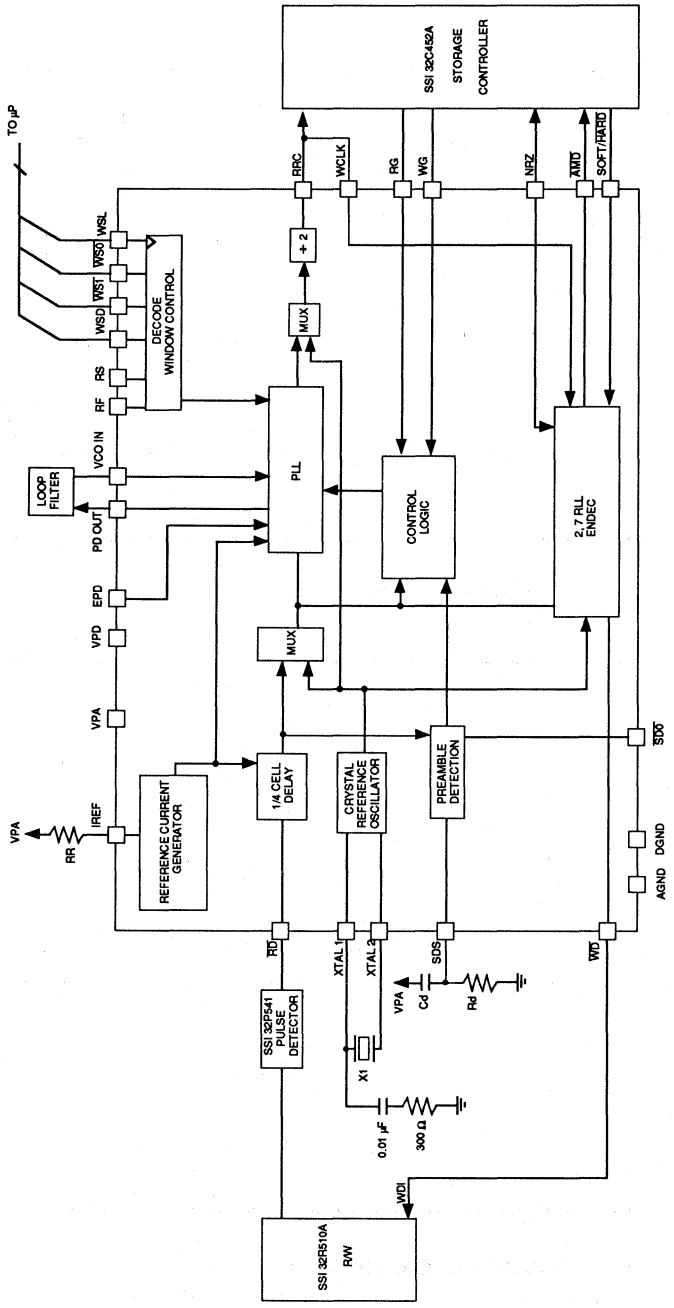
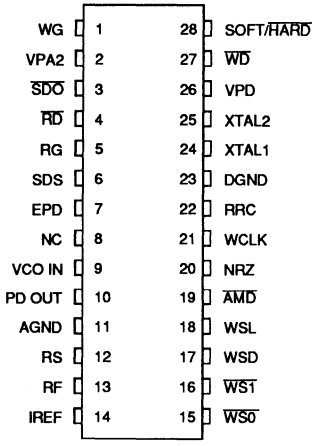
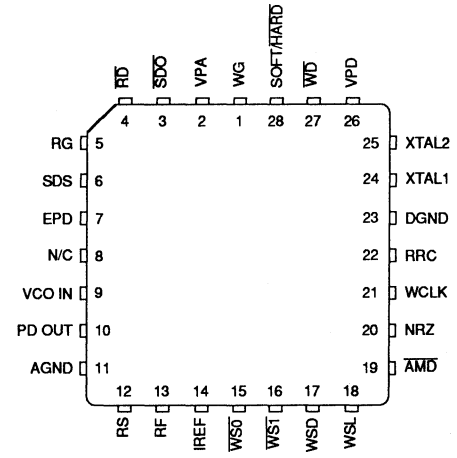


FIGURE 12: SSI 32D5322 Typical Application

PACKAGE PIN DESIGNATIONS
(Top View)



28-pin DIP



28-pin PLCC

4

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32D5322 28-pin PLCC	SSI 32D5322-CH	32D5322-CH
SSI 32D5322 28-pin Plastic DIP	SSI 32D5322-CP	32D5322-CP

Silicon Systems, Inc. 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32D534A
Data Synchronizer/ MFM ENDEC

Preliminary Data

July, 1990

DESCRIPTION

The SSI 32D534A Data Synchronizer/MFM ENDEC is intended to provide data recovery and data encoding in storage systems which employ an MFM encoding format. Data synchronization is performed with a fully integrated high performance PLL and encoding is performed in soft/hard sector formats with optional write precompensation through the internal delay line. The SSI 32D534A has been optimized for operation as a companion device to the SSI 32C452 and the AIC 010 family of controllers. The frequency setting elements are incorporated within the SSI 32D534A for enhanced performance and reduced board space. Data rate, adjustable from 5 to 10 Mbit/s, is established with a single external programming resistor for Direct Sync operation or with two external resistors for Auto Sync operation.

The SSI 32D534A utilizes an advanced bipolar process technology that affords precise decode window control without the requirement of an accurate 1/4 cell

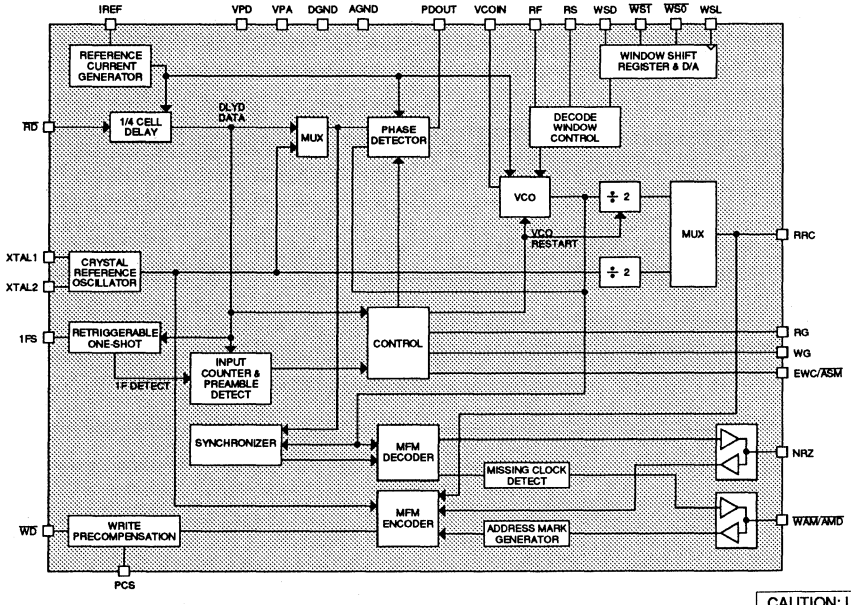
(Continued)

FEATURES

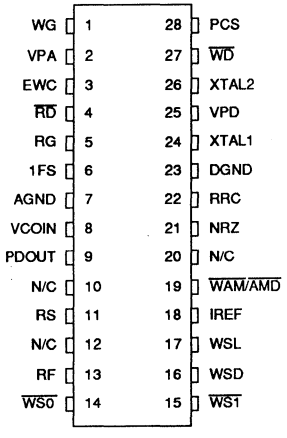
- **Data Synchronizer and MFM ENDEC**
- **5 to 10 Mbit/s operation programmed with a single external resistor**
- **Optimized for operation with the SSI 32C452 and AIC 010 family of controllers**
- **Programmable decode window symmetry via a µP port and/or analog pins**
- **Programmable write precompensation**
- **Fast acquisition phase locked loop - zero phase restart technique**
- **Fully integrated data separator - no external delay lines or active devices required**
- **+5V operation**
- **28-pin DIP and PLCC packages**

4

BLOCK DIAGRAM



PIN DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

DESCRIPTION (Continued)

delay or external devices. To enhance disk drive testability, decode window symmetry control is available through a digital microprocessor port and/or two analog pins. This feature can facilitate automatic calibration, systematic error cancellation, and window margin testing. A zero phase restart technique is used to minimize PLL acquisition time. The SSI 32D534A requires a single +5V power supply and is available in 28-pin DIP and PLCC packages.

PIN DESCRIPTION

INPUT PINS

NAME	DESCRIPTION
$\overline{RD}$	READ DATA. MFM encoded Read Data from the disk drive read channel, active low.
RG	READ GATE. Selects the PLL reference input and initiates the PLL synchronization sequence. A high level selects the $\overline{RD}$ input and enables the Read Mode/Address Mark Detection sequences. A low level selects the crystal reference oscillator. Pin RG has an internal resistor pull up.
WG	WRITE GATE. Enables the write mode. Pin WG has an internal resistor pull up. If unused, tie pin low.
WSL	WINDOW SYMMETRY LATCH. Used to latch the input window symmetry control bits WSD, $\overline{WS0}$ and $\overline{WS1}$ into an internal DAC. An active high level latches the input bits. Pin WSL has an internal resistor pull up. If unused, tie pin low.
WSD	WINDOW SYMMETRY DIRECTION. Controls the direction of the optional window symmetry shift. Pin WSD has an internal resistor pull up.
$\overline{WS0}$	WINDOW SYMMETRY CONTROL BIT. A low level introduces a window shift of 1.5% of TORC (Read Reference Clock Period) in the direction established by WSD. Pin $\overline{WS0}$ has an internal resistor pull up. If unused, leave pin open or tie high.
$\overline{WS1}$	WINDOW SYMMETRY CONTROL BIT. A low level introduces a window shift of 6% of TORC (Read Reference Clock Period) in the direction established by WSD. A low level at both $\overline{WS0}$ and $\overline{WS1}$ will produce the sum of the two window shifts. Pin $\overline{WS1}$ has an internal resistor pull up. If unused, leave pin open or tie pin high.
EWC/$\overline{ASM}$	ENABLE WRITE PRECOMP/AUTO SYNC MODE. Selects the synchronization sequence required in order to enter Read Mode, a low level selects the Auto Sync Mode. In the Write Mode, a high level enables write precompensation. Pin EWC/$\overline{ASM}$ has an internal resistor pull up.

PIN DESCRIPTION (Continued)

OUTPUT PINS

NAME	DESCRIPTION
$\overline{WD}$	WRITE DATA. MFM encoded write data output, active low. Precompensation is enabled with the EWC/$\overline{ASM}$ input pin.
RRC	READ/REFERENCE CLOCK. A multiplexed clock source used by the controller. In the read mode, this clock is the VCO frequency divided by two (1/TORC) and in the write mode it is the crystal reference frequency divided by two (1/TORO). No short clock pulses are generated during a mode change.

BIDIRECTIONAL PINS

NRZ	NRZ DATA PORT. Read data output when RG is high and write data input when WG is high. In the idle mode, NRZ is in a high impedance state.
$\overline{WAM/AMD}$	WRITE ADDRESS MARK/ADDRESS MARK DETECT. In the Write Mode, used to delete clock/data pulses in the MFM encoded output stream, $\overline{WD}$, active low. In the Read Mode, a latched low level output indicates that an address mark has been detected. In idle mode, $\overline{WAM/AMD}$ is in a high impedance state.

ANALOG PINS

IREF	TIMING PROGRAM PIN. The VCO center frequency and the 1/4 cell delay are a function of the current sourced into pin IREF. The current is set by an external resistor, RR, connected from IREF to VCC.
XTAL1, XTAL2	CRYSTAL OSCILLATOR CONNECTIONS. If a crystal oscillator is not desired, XTAL1 may be driven by a TTL signal with XTAL2 open. The frequency must be at twice the data rate.
PD OUT	PHASE DETECTOR OUTPUT. Drives the Loop Filter input.
VCO IN	VCO CONTROL INPUT. Driven by the Loop Filter output.
1FS	1F DETECT SET. Used to program the 1F detect timing with an external resistor, RT, connected from pin 1FS to ground. The 1F Detect period is the sum of the 1/4 cell delay, TQC, plus the Retriggerable One-Shot delay, TOS, which is normally set to 1 1/4 bit cell times.
RF, RS	WINDOW SYMMETRY ADJUST PINS. Provides analog control over the decode window symmetry; typically used to null out any window symmetry offset. A resistor connected from either RF or RS to ground will provide magnitude and direction control. They can be used in conjunction with the digital control port WSD, WS0, and WS1.
PCS	PRECOMP SET. Pin for R-C network to program write precompensation early and late times. Connect the capacitor, CPC, to VPA and the resistor, RPC, to either ground.
VPD, VPA	DIGITAL and ANALOG +5V.
DGND, AGND	DIGITAL and ANALOG GROUND.

SSI 32D534A
Data Synchronizer/
MFM ENDEC

FUNCTIONAL DESCRIPTION

The SSI 32D534A, a high performance data synchronizer and MFM ENDEC, performs data separation, data encoding with optional write precompensation, Preamble detection, and Write Address Mark/Address Mark detection. The interface electronics and the architecture of the SSI 32D534A has been optimized for use as a companion device to the SSI 32C452 or AIC 010 type Storage Controllers. It includes a zero phase restart PLL for fast acquisition, a crystal reference oscillator, the write precompensation delay line, a multiplexed Read/Reference clock output, and a bidirectional NRZ data interface.

Data rate is programmed with a single 1% external resistor, RR, connected from pin IREF to VCC, given by:

$$RR = \frac{30.67}{DR} - 0.5\ (k\Omega)$$

Where: DR = Data Rate in Mbit/s
RR = kΩ

Resistor RR establishes a reference current which controls the VCO center frequency, the phase detector gain, the 1/4 cell delay and, indirectly, the decode window shift (RF, RS).

The internal crystal reference oscillator, operating at twice the data rate, generates the standby reference input to the PLL. This minimizes the frequency step and the associated acquisition time encountered when locking the PLL onto Encoded Read Data. Additionally, in non-Read modes the RRC (Read Reference Clock) output is generated from the reference oscillator divided by two. A series resonant crystal at twice the data rate should be used. If a crystal oscillator is not desired, an external TTL compatible reference may be applied to XTAL1 with XTAL2 open.

READ OPERATION

The Data Synchronizer utilizes a fully integrated fast acquisition PLL to accurately develop the decode window. Read Gate, RG, initiates the PLL locking sequence and selects the PLL reference input, a high level (Read Mode) selects the $\overline{RD}$ input and a low level selects the crystal reference oscillator.

The SSI 32D534A provides two sync modes for controlling the PLL locking sequence, Auto Sync and Direct Sync. The Auto Sync mode provides preamble search and address mark detection while the Direct Sync mode provides direct control over the input to the PLL. These modes extend the applicability of the SSI 32D534A to a variety of controller and interface requirements. The appropriate mode should be selected for the given application, see Table 1.

TABLE 1: Mode Control

MODE	WG	RG	EWC/$\overline{ASM}$
Idle	0	0	X
Read (Auto Sync)	0	1	0
Read (Direct Sync)	0	1	1
Write (Disable Precomp)	1	0	0
Write (Enable Precomp)	1	0	1
Illegal	1	1	X

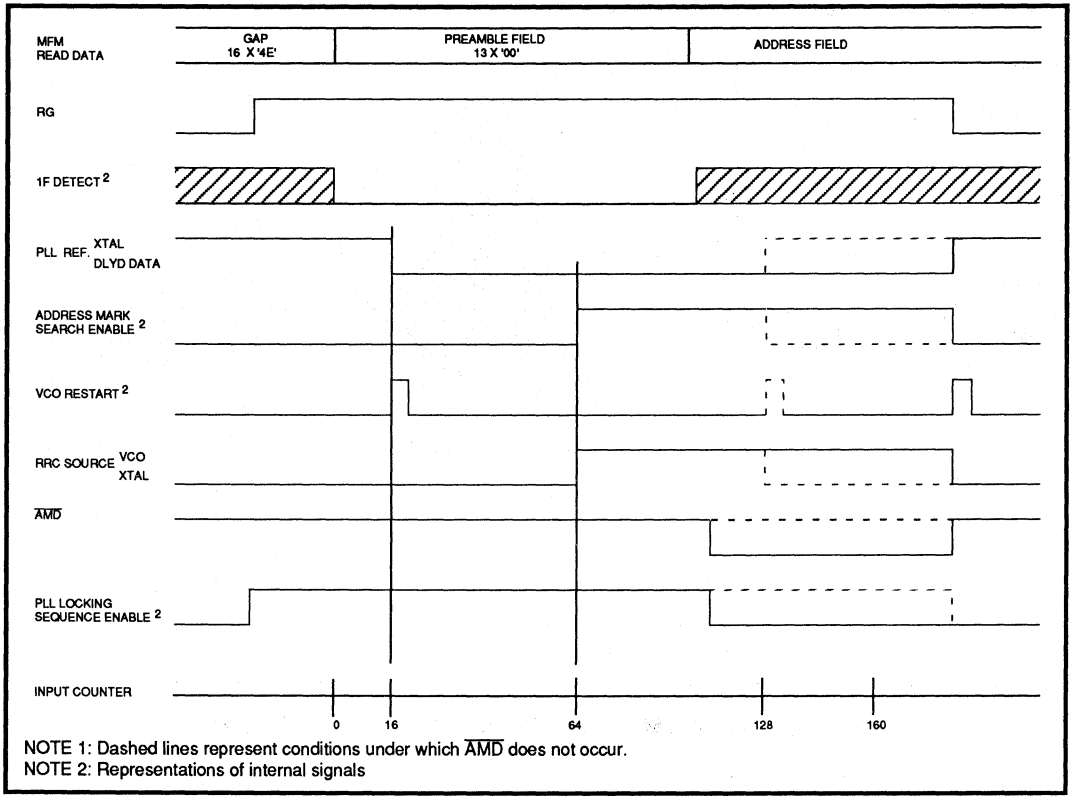
(X = Don't Care)

AUTO SYNC MODE

The Auto Sync mode, typically used for Soft Sector formats, activates the preamble search and address mark detection circuitry. As depicted in Figure 1, the SSI 32D534A requires16 continuous preamble bits before switching the reference input to the PLL, 64 preamble bits before switching the Read Reference Clock to the VCO clock divided by two, and a detected address mark prior to an additional 64 input bits in order to enter the Read Mode. This sequence repeats after 160 input bits until Read mode is successfully entered or until RG is cancelled.

When RG transitions high, the following PLL locking sequence begins:

a) PREAMBLE SEARCH: The SSI 32D534A searches for 16 continous preamble bits. The Preamble fields consist of a stream of MFM encoded 0's. The sum of the delays from the Re-



NOTE 1: Dashed lines represent conditions under which $\overline{AMD}$ does not occur.
NOTE 2: Representations of internal signals

FIGURE 1: Auto Sync Mode Waveform Diagram

triggerable One Shot, TOS, and the 1/4 Cell Delay, TQC, is set to 1 1/2 bit cell times with the external programming resistor, RT. The Preamble stream has a pulse rate of 1 bit cell time (2F frequency) which continuously resets the one-shot while a 2 bit cell period (1F frequency) allows the one-shot to time out producing a 1F detect pulse. The 1F detect pulse resets the Input counter and the search is started over.

b) PLL ACQUISITION: When 16 continuous preamble '0' bits are detected, the reference input to the PLL is switched from the crystal reference oscillator to the DLYD DATA, the VCO is phase reset to the next DLYD DATA pulse, PLL acquisition begins, and the VCO clock divider is reset. When 64 '0' preamble bits are detected, the Read Reference Clock output (RRC) is switched to the VCO clock divided by 2, and the Address Mark Detection circuitry is enabled. If a 1F detect pulse occurs before 64 preamble bits are detected, the PLL is locked back to the crystal reference oscillator, the RRC output is switched to the crystal reference oscillator divided by 2, the Input Counter is reset, and the sequence is restarted. No short duration glitches will occur during this switching.

c) ADDRESS MARK DETECTION: The circuit searches for the occurrence of the Address Mark. The 1F detect circuitry remains active so that, during the search, once a 1F is detected, the Address Mark must be found within the next five counts of the Read Data input pulses. If an Address Mark is detected, prior to the Input Counter reaching count 128, the $\overline{WAM}/\overline{AMD}$ output is latched low, the PLL training sequence is terminated, and the Read Mode is entered allowing the

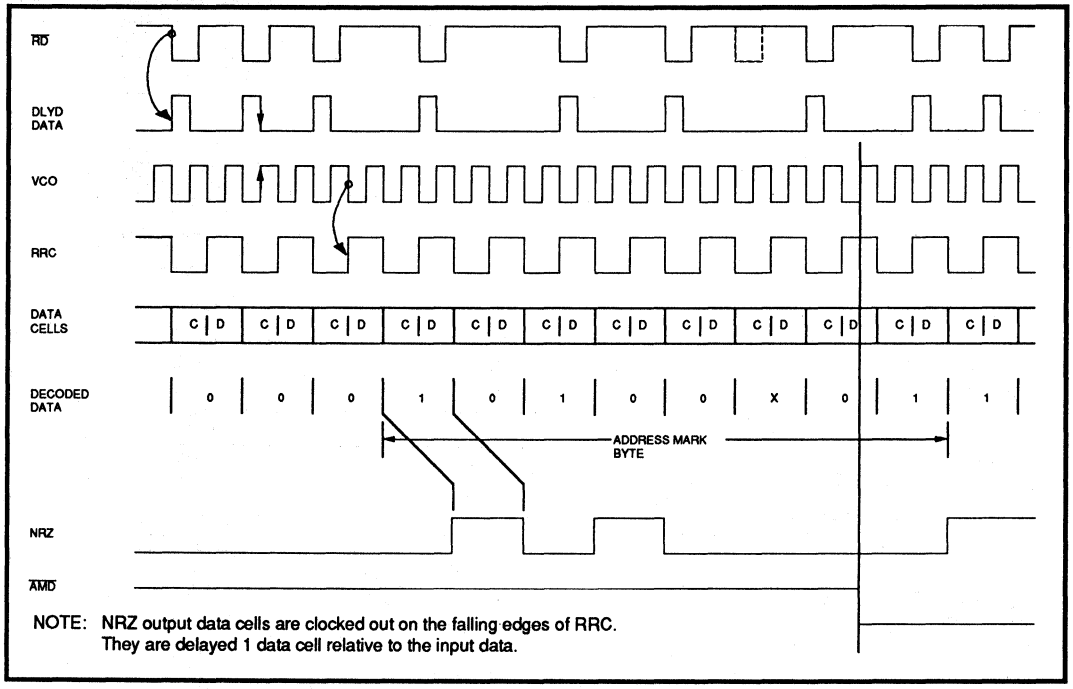


FIGURE 2: Address Mark Detection and NRZ Waveform Diagram

AUTO SYNC MODE (Continued)

data field to be read. If the input counter reaches count 128 before the Address Mark is detected, the PLL is locked back to the crystal reference oscillator, the RRC output is switched to the crystal reference oscillator divided by 2, and the PLL training sequence is restarted when the Input Counter reaches count 160. Figure 2 depicts the Address Mark detection sequence.

DIRECT SYNC MODE

Direct Sync Mode disables the preamble search and address mark detection circuitry. It allows the PLL to be controlled directly by RG, for Hard Sector format operation.

When RG transitions high, the reference input to the PLL is switched from the crystal reference oscillator to DLYD DATA, the VCO is phase reset to the next DLYD DATA pulse, PLL acquisition begins, the VCO clock divider is reset, and the RRC output is switched to the VCO clock divided by 2.

Read Gate, RG, is an asynchronous input and may be initiated or terminated at any position on the disk. Terminating RG locks the PLL to the crystal reference oscillator and switches the RRC output to the crystal reference oscillator divided by 2.

In non-Read modes the PLL is locked to the crystal reference oscillator. This forces the VCO to run at a frequency that is very close to that required for tracking actual data and thus minimizes the associated frequency step during acquisition. When the reference input to the PLL is switched, the VCO is stopped momentarily and then restarted in an accurate phase alignment with the next PLL reference input pulse and the VCO clock divider is reset. By minimizing the phase misalignment in this manner (phase error $\leq \pm 0.5$ rads), the acquisition time is substantially reduced.

The SSI 32D534A employs a dual mode phase detector; harmonic in Read mode and non-harmonic in Idle/Write modes. The harmonic phase detector only up-

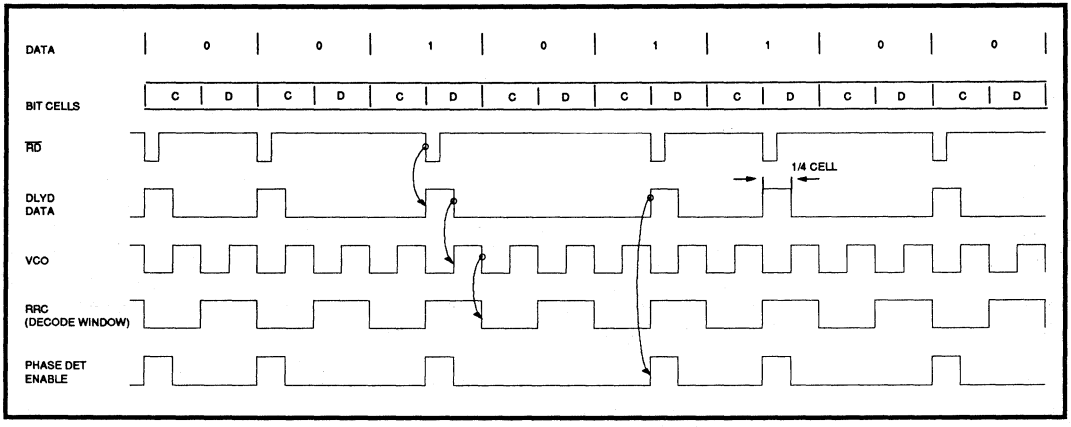
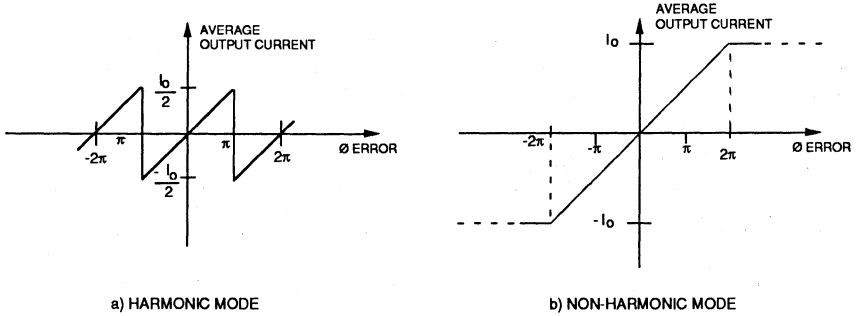


FIGURE 3: Data Synchronization Waveform Diagram

DIRECT SYNC MODE (Continued)

dates the PLL with each occurrence of a DLYD DATA pulse. This allows the PLL to remain phase locked to actual Read Data. The rising edge of DLYD DATA enables the phase detector and the falling edge is phase compared to the rising edge of the VCO. As depicted in Figure 3, DLYD DATA is a 1/4 cell wide (TVCO/2) pulse whose leading edge is defined by the leading edge of $\overline{RD}$. In Idle/Write modes, both phase and frequency lock (non-harmonic) to the crystal reference oscillator is accomplished by continuously enabling the phase detector. With both phase and frequency lock to the crystal reference oscillator and the zero phase restart acquisition technique, false lock to DLYD DATA is eliminated.

The phase detector incorporates a charge pump in order to drive the loop filter directly. The polarity and width of the output current pulses correspond to the direction and magnitude of the phase error. Figure 4 depicts the average output current as a function of the input phase error (relative to the VCO period).



a) HARMONIC MODE

b) NON-HARMONIC MODE

NOTE 1: Io is the magnitude of the charge pump current.
NOTE 2: Phase error is relative to the VCO period.

FIGURE 4: Phase Detector Transfer Function

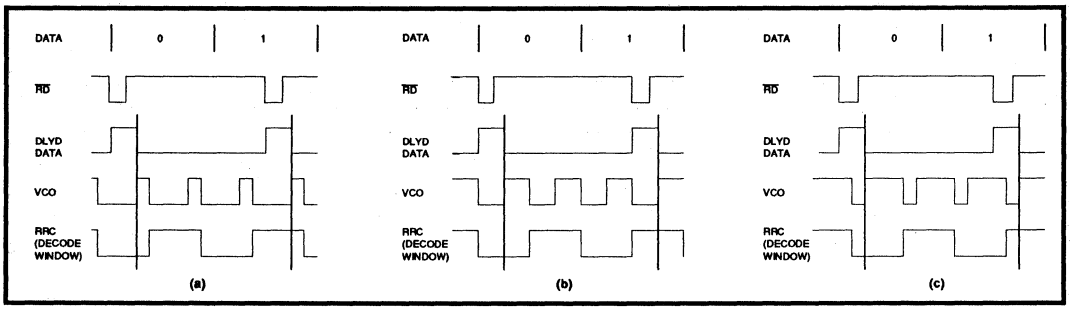


FIGURE 5: Decode Window a) Early, b) Normal, c) Late

DIRECT SYNC MODE (Continued)

An accurate and symmetrical decode window is developed from the VCO clock. The rising edges of the VCO clock are phase locked to the falling edges of DLYD DATA as shown in Figure 3. The decode window is then generated from the falling edges of the VCO clock. By utilizing a fully integrated symmetrical VCO running at twice the data rate, the decode window is ensured to be accurate and centered symmetrically about the falling edges of DLYD DATA. The accuracy of the 1/4 cell delay only affects the retrace angle of the phase detector and does not influence the accuracy of the decode window.

Shifting the symmetry of the VCO clock effectively shifts the relative position of the DLYD DATA pulse within the decode window. This powerful capability easily facilitates automatic calibration, window margin testing, error recovery, and systematic error cancellation. For enhanced disk drive testability and error recovery, decode window control is provided via a µP port (WSL, WSD, $\overline{WS0}$, $\overline{WS1}$) as described in Table 2.

Window shifts in the range of ±1.5% to ±7.5% of TORC are easily programmed by latching the appropriate control word into the Window Shift Register with the WSL pin. Shifts in the positive or negative directions result in early or late decode windows respectively, as depicted in Figure 5. For applications not utilizing this feature, WSL should be tied to ground, while WSD, $\overline{WS0}$ & $\overline{WS1}$ should be left floating. Additionally, for small systematic error cancellation a resistor, R, connected from either RS (Early) or RF (Late) to ground will provide analog control over the decode window. The magnitude of this shift, Tsa, is determined by :

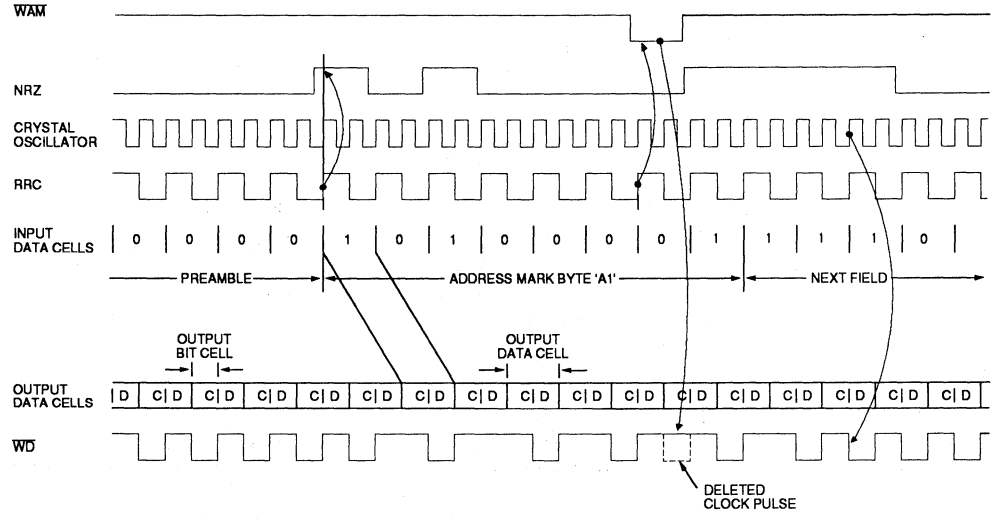
$$Tsa = \frac{(0.25)TORC}{R + 0.7}$$

Where: R is in kΩ.

Pins RF and RS are intended to be used as a trim and should be restricted to ± 1.5% window shifts. They can be used in conjunction with the digital control port.

TABLE 2: Decode Window Symetry Control

Ts, NOMINAL WINDOW SHIFT	WSD	$\overline{WS1}$	$\overline{WS0}$
0	0	1	1
+TS1	0	1	0
+TS2	0	0	1
+TS3	0	0	0
0	1	1	1
–TS1	1	1	0
–TS2	1	0	1
–TS3	1	0	0



NOTE 1: NRZ and WAM inputs are clocked in on the rising edges of RRC (input data cell boundaries).
NOTE 2: WD output data cells are defined in terms of the falling edges of RRC. They are delayed 1 1/2 data cells relative to the input data cells.

FIGURE 6: Write Address Mark /Address Write Data Waveform Diagram

WRITE OPERATION

In the Write Mode, the SSI 32D534A converts NRZ data (from the Controller) into MFM data, for storage onto the disk. It performs write precompensation, if enabled, and inserts Address Marks as requested. Serial NRZ data is clocked into the SSI 32D534A and latched on defined data cell boundaries. NRZ data must be synchronous with the rising edges of the RRC clock output. During a Write Data Operation, the SSI 32D534A processes data and ECC fields and in a Write Format Operation, Address Marks, Preamble, ECC, Gaps, and ID fields are processed. Write Gate is an asynchronous input and may be initiated or terminated at any position on the disk. MFM encoded output write data, $\overline{WD}$, is delayed from input NRZ data by 1.5 Data Cells. For the successful completion of a write operation, Write Gate, WG, should not be terminated prior to the last output Write Data pulse.

Address Marks can be inserted into the MFM encoded data stream, $\overline{WD}$, with the pin $\overline{WAM}$ (Write Address Mark). When $\overline{WAM}$ is asserted, the data/ clock pulse in the corresponding bit cell of the MFM encoded data stream is deleted. This allows specially encoded sequences (illegal MFM patterns) to be encoded using the SSI 32D534A. $\overline{WAM}$ is synchronous with the RRC clock and is internally delayed by 0.5 data cells. To generate the missing clock A1 Address Mark pattern, $\overline{WAM}$ is asserted during the sixth data cell of the NRZ A1 data pattern. Figure 6 depicts the Address Mark generation sequence.

Write Precompensation reduces the effect of intersymbol interference caused by the proximity of magnetic transitions on the disk media. The interference is caused by specific data patterns where flux reversals are positioned closely together. Compensation consists of shifting write data pulses in time to counteract for the shifting normally exhibited in the corresponding Read Back signal. When Precompensation is enabled, see Table1, the SSI 32D534A recognizes these data patterns and appropriately shifts the write data pulses. Table 3 describes the Precompensation Algorithm relative to the current data bit, n, to be written.

WRITE OPERATION (Continued)

The SSI 32D534A utilizes an internal analog delay line to time shift the encoded write data pulses. The magnitude of the time shift, TPC, is determined by the external RC network (RPC, CPC) at pin PCS (Precomp Set) and is given by:

$$TPC = 0.15 \times RPC \times (CPC + C_s),$$
with RPC in kΩ & CPC in pF
C_s = Stray capacitance

An Early/Late compensated bit results in a pulse shifted TPC seconds before/after the nominal unshifted pulse position.

TABLE 3: Write Precompensation Algorithm

BIT n-2	BIT n-1	BIT n	BIT n+1	COMPENSATION Bit n
X	0	1	1	LATE
X	1	1	0	EARLY
1	0	0	0	LATE
0	0	0	1	EARLY

ABSOLUTE MAXIMUM RATINGS

Operation above absolute maximum ratings may permanently damage the device.

PARAMETER	RATING	UNIT
Storage Temperature	-65 to +150	°C
Junction Operating Temperature	0 to +130	°C
Supply Voltage, VCC	-0.5 to 7	Vdc
Voltage Applied to Logic inputs	-0.5 to VCC + 0.5	Vdc

ELECTRICAL CHARACTERISTICS

Unless otherwise specified 4.75 ≤ VCC ≤ 5.25V, 0°C ≤ TA ≤ 70°C, 5 MHz ≤ 1/TORC ≤ 10 MHz; 10 MHz ≤ 1/TVCO ≤ 20 MHz.

PARAMETER		CONDITIONS	MIN	MAX	UNIT
VIH	High Level Input Voltage		2.0		V
VIL	Low Level Input Voltage			0.8	V
IIH	High Level Input Current	VIH = 2.7V		20	µA
IIL	Low Level Input Current	VIL = 0.4V		-0.36	mA
VOH	High level Output Voltage	IOH = -400µA	2.7		V
VOL	Low Level Output Voltage	IOL = 4mA		0.5	V
ICC	Power Supply Current	All outputs open		180	mA
	Power Dissipation	Tj = 130°C		850	mW

CONTROL CHARACTERISTICS (Refer to Figure 7)

PARAMETER		CONDITIONS	MIN	MAX	UNIT
TSWS	$\overline{WS0}$, $\overline{WS1}$, WSD Set Up Time		15		ns
THWS	$\overline{WS0}$, $\overline{WS1}$, WSD Hold Time		5		ns
TSERG	Set up time EWC to RG		10		ns
THERG	Hold time EWC from RG		0		ns
TSEWG	Set up time EWC to WG		0		ns
THEWG	Hold time EWC from WG		0		ns

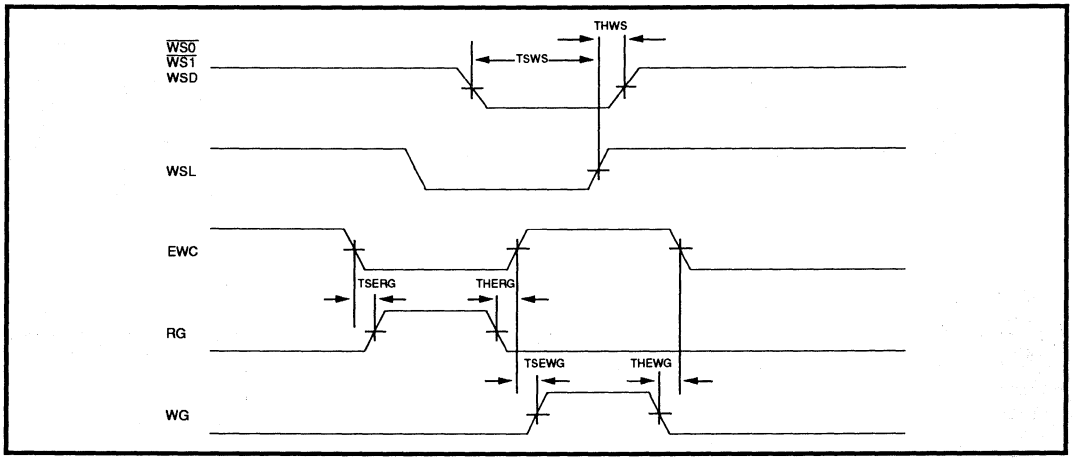


FIGURE 7: Control Timing

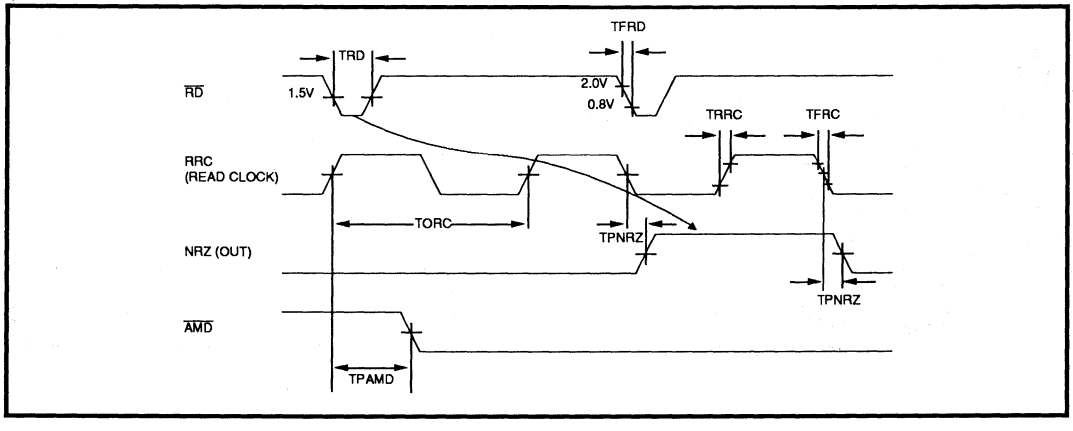


FIGURE 8: Read Timing

ENDEC CHARACTERISTICS

READ MODE (Refer to Figure 8)

PARAMETERS		CONDITIONS	MIN	MAX	UNIT
TRD	Read Data Pulse Width		20	TORC - 40	ns
TFRD	Read Data Fall Time	2.0 to 0.8V		20	ns
TRRC	Read ClockRise Time	0.8 to 2.0V; $C_L \leq 15$ pF		10	ns
TFRC	Read Clock Fall Time	2.0V to 0.8V; $C_L \leq 15$ pF		8	ns
TPNRZ	NRZ (out) Propagation Delay		-15	+15	ns
TPAMD	AMD Propagation Delay		$\frac{TVCO}{2} - 15$	$\frac{TVCO}{2} + 15$	ns
TQC	1/4 Cell Delay Accuracy	TQC = 0.25 TORO	0.8TQC	1.2TQC	sec
TOS	Retriggerable One-shot Delay Accuracy	TOS = RT (8.96 E-12) 12K ≤ RT ≤ 36K*	0.84TOS	1.16TOS	sec
TORC	Read Clock Period		0.8TORO	1.2TORO	ns

* Where: TOS = 1.25/Data Rate; Data Rate = Mbit/s

WRITE MODE (Refer to Figure 9)

PARAMETERS		CONDITIONS	MIN	MAX	UNIT
TWD	Write Data Pulse Width	$C_L \leq 15$ pF	$\frac{TORO}{2} - 2.4TPC - 12$	$\frac{TORO}{2} + 12$	ns
TPC	PrecompensationTime Shift Magnitude Accuracy	TPC = 0.15 (RPC)(CPC+Cs) 2K ≤ RPC ≤ 6K 15 pF ≤ CPC ≤ 36 pF Cs = Stray Capacitance	0.8TPC	1.2 TPC	sec
TFWD	Write Data Fall Time	2.0V to 0.8V; $C_L \leq 15$ pF		8	ns
TRRO	Reference Clock RiseTime	0.8 to 2.0V; $C_L \leq 15$ pF		10	ns
TFRO	Reference Clock Fall Time	2.0V to 0.8V; $C_L \leq 15$ pF		8	ns
TSNRZ	NRZ(in) Set Up Time		20		ns
THNRZ	NRZ(in) Hold Time		7		ns
TSWAM	$\overline{WAM}$ Set-up Time		20		ns
THWAM	$\overline{WAM}$ Hold Time		7		ns

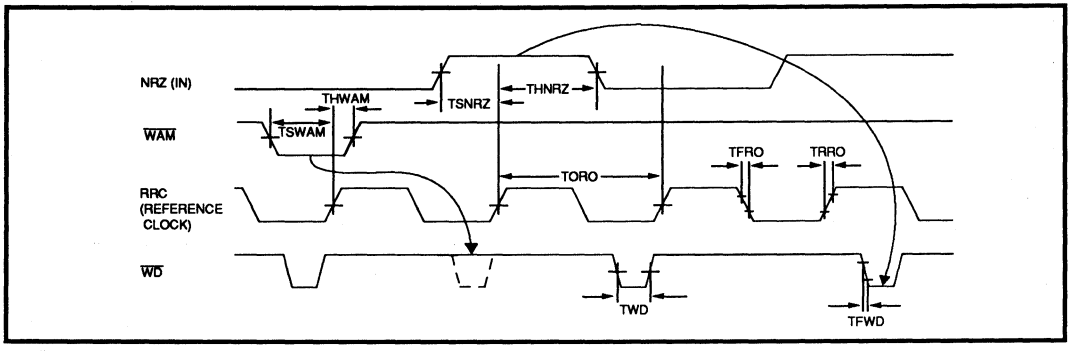


FIGURE 9: Write Timing

DATA SYNCHRONIZATION CHARACTERISTICS

PARAMETERS		CONDITIONS	MIN	NOM	MAX	UNIT
TVCO	VCO Center Frequency Period	VCOIN = 2.7V, TO = 1.63E - 11(RR+500) VCC = 5.0V, 2400 ≤ RR ≤ 6000Ω	0.78TO		1.22TO	sec
	VCO Frequency Dynamic Range	VCC = 5.0V, 1V≤VCOIN ≤ VCC-0.6V	±27		±40	%
KVCO	VCO Control Gain	1V ≤ VCOIN ≤ VCC-0.6 V, $\omega_0 = 2\pi/TO$	$0.14\omega_0$		$0.20\omega_0$	rad/s-V
KD	Phase Detector Gain	KD = 0.308/(RR+500); VCC = 5.0 V, 2400 ≤ RR ≤ 6000Ω	0.83KD		1.17KD	$\frac{A}{rad}$
*	KVCO x KD Product Accuracy	2400 ≤ RR ≤ 6000Ω, VCC = 5.0V	-28		+28	%
*	VCO Phase Restart Error			6		ns
	Decode Window Centering Accuracy				See Note	ns
	Decode Window		$\frac{TORC}{2} - 4$			ns
TS1	Decode Window Time Shift Magnitude	TS1 = 0.015TORC		TS1		ns
TS2	Decode Window Time Shift Magnitude	TS2 = 0.06TORC		TS2		ns
TS3	Decode Window Time Shift Magnitude	TS3 = 0.075TORC		TS3		ns
TSA	Decode Window Time Shift Magnitude	$TSA = \frac{(0.25)TORC}{R+0.7}$; (R in kΩ)		TSA		ns

Note: ±(0.015TORC+3)
*Not directly testable - Design Characteristic

APPLICATION

LOOP FILTER

The element in the phase lock loop which controls the loop dynamics is known as the loop filter. Acquisition time, data margin, and data tracking can be optimized by the loop filter selection. One possible loop filter configuration is shown in Figure 10, where the function of C_1 is as an integrating element. The larger the capacitance of C_1, the longer will be the lock time. If the capacitance is too small, the loop will tend to track high frequency jitter. The role of the resistor R is to reduce the phase shift induced by C_1. This is necessary since the loop will oscillate at the frequency where the gain is unity. The capacitor C_2 will suppress high frequency transients when switching occurs. This capacitor will have a minimal effect of the loop response if it is small compared to C_1 (typically, $C_2 = C_1/10$).

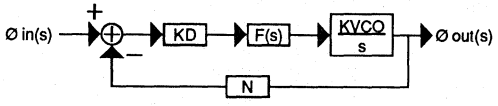
The loop filter transfer function is:

$$F(s) = \frac{Vout}{Iin} = \frac{1 + sRC_1}{sC_1\left(1 + sC_2R + \frac{C_2}{C_1}\right)}$$

if $C_2 << C_1$
then,

$$F(s) = \frac{Vout}{Iin} = \frac{1 + sRC_1}{sC_1}$$

The phase lock loop can be described as:



where:

KD = phase detector gain [A/rad]
F(s) = Filter impedance [V/A]
$\frac{KVCO}{s}$ = oscillator transfer function [rad/s V]
N = ratio of reference input frequency to the VCO output frequency.

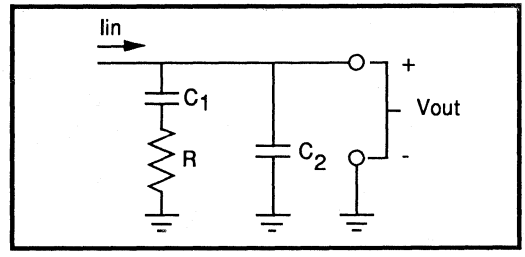


FIGURE 10: Loop Filter

Therefore, the closed loop transfer function is now:

$$T(s) = \frac{Ø\,out(s)}{Ø\,in(s)} = \frac{G(s)}{1 + G(s)H(s)} = \frac{KD \times KVCO\left(\frac{1 + sRC_1}{C_1}\right)}{s^2 + s(N \times KD \times KVCO \times R) + \frac{N \times KD \times KVCO}{C_1}}$$

now we can put the characteristic equation (denominator) in the form:

$$S^2 + 2s\zeta\omega_n + \omega_n^2$$

$$\therefore \omega_n^2 = \frac{NxKDxKVCO}{C1} \text{ and } \zeta = \frac{NxKDxKVCOxR}{2\omega_n}$$

which results in:

$$C_1 = \frac{NxKDxKVCO}{\omega_n^2}$$

$$R = \frac{2\zeta\omega_n}{N \times KD \times KVCO} \text{ and } C_2 = \frac{C_1}{10}$$

For a $\zeta = 0.8$, the relationship between ω_n and lock time is:

$$\omega_n = \frac{4.5}{\text{lock time}}$$

Therefore, the loop filter components C_1, C_2, and R can be evaluated for a required lock time and coding scheme (N) frequency relationship to the VCO frequency.

With MFM coding:

N = 1, for Øin = reference oscillator
N = 0.5, for Øin = maximum data frequency
N = 0.25 for Øin = minimum data frequency

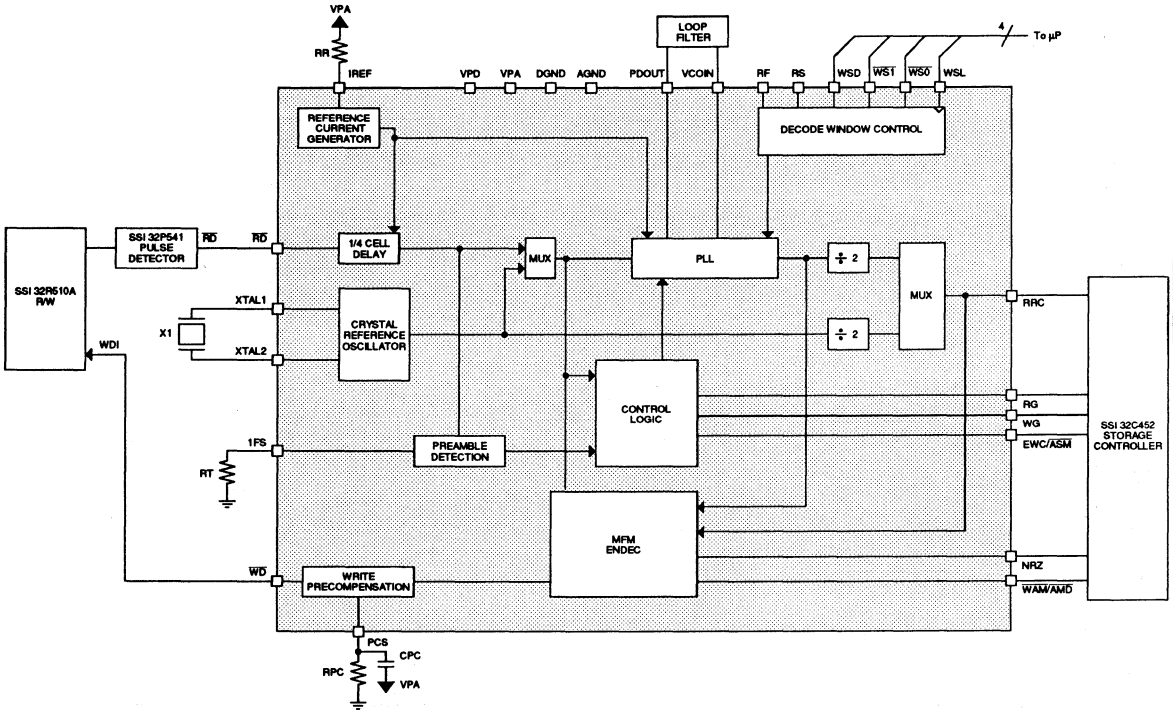


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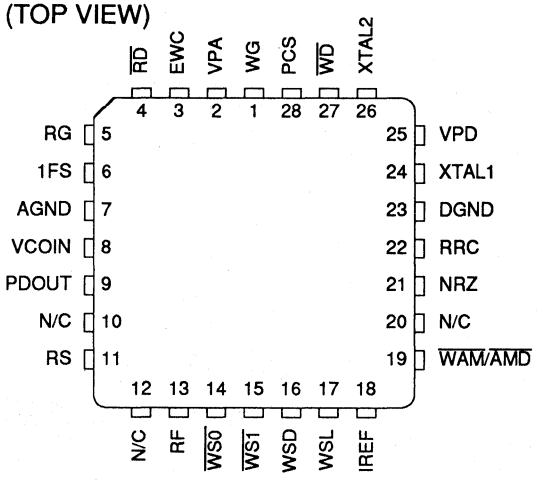
FIGURE 11: Typical Application

Typical External Component Values for a 5 Mbit/s MFM Application:

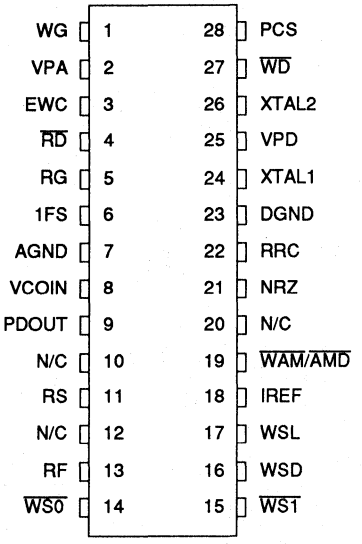
COMPONENT	CONDITIONS	VALUE	UNITS
X1	Series resonant crystal	10	MHz
RR		5.62	kΩ
RT		27.9	kΩ
RPC		2	kΩ
CPC		15	pF
Loop Filter			
R		2.8	kΩ
C_1		1200	pF
C_2		120	pF

SSI 32D534A
Data Synchronizer/
MFM ENDEC

PACKAGE PIN DESIGNATIONS
(TOP VIEW)



28-pin PLCC



28-pin DIP

THERMAL CHARACTERISTICS: Øja

28-pin PLCC	65°C/W
28-pin PDIP	55°C/W

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32D534A 28-pin PLCC	SSI 32D534A-CH	32D534A-CH
SSI 32D534A 28-pin PDIP	SSI 32D534A-CP	32D534A-CP

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32D535
Data Synchronizer/ 2, 7 RLL ENDEC with Write Precompensation

May, 1990

DESCRIPTION

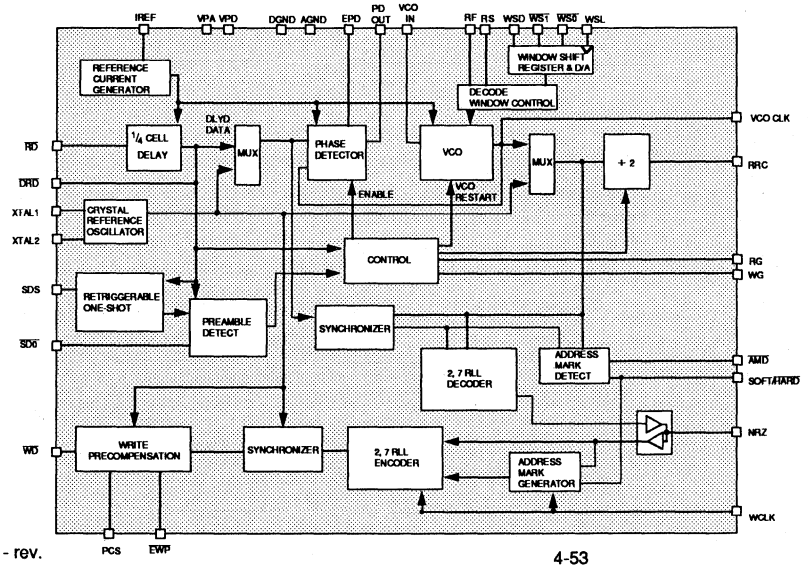
The SSI 32D535 Data Separator provides data recovery, data encoding, and write precompensation for storage systems which employ a 2, 7 RLL encoding format. Data synchronization is performed with a fully integrated high performance PLL. A zero phase restart technique is used to minimize PLL acquisition time. The SSI 32D535 has been optimized for operation at a single data rate between 7.5 to 10 Mbit/s operation utilizing a crystal reference oscillator. The VCO frequency setting elements are incorporated within the SSI 32D535 for enhanced performance and reduced board space. Data rate is established with a single external programming resistor. The SSI 32D535 utilizes an advanced bipolar process technology which affords precise decode window control without requiring an accurate 1/4 cell delay or external devices. To enhance disk drive testability, decode window symmetry control is available through a digital µP port and/or two analog pins. This feature can facilitate defect mapping, automatic calibration, systematic error cancellation, window margin testing, and error recovery. The SSI 32D535 requires a single +5V power supply and is available in a 32-pin SOW, DIP & 28-pin PLCC package.

FEATURES

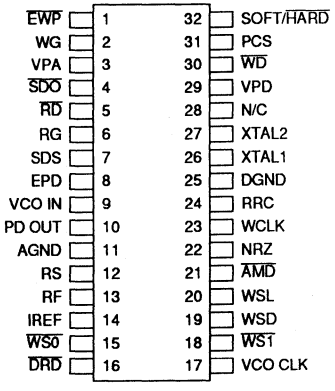
- **Data Synchronizer and 2, 7 RLL ENDEC**
- **Write Precompensation**
- **7.5 to 10 Mbit/s Programmed with a Single External Resistor**
- **Optimized for Operation with the SSI 32C452A and AIC 010 Controllers**
- **ESDI compatible**
- **Programmable Decode Window Symmetry via a µP Port and/or Analog Pins**
- **Fast Acquisition Phase Locked Loop – Zero Phase Restart Technique**
- **Input Clock Circuitry Optimized for use with Crystal Controlled Reference Oscillator**
- **Hard/Soft Sector Operation**
- **+5V Operation**
- **32-Pin DIP, SOW & 28-Pin PLCC**

4

BLOCK DIAGRAM



PIN DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

PIN DESCRIPTIONS

INPUT PINS

NAME	TYPE	DESCRIPTION
$\overline{RD}$	I	READ DATA: Encoded Read Data from the disk drive read channel, active low.
RG	I	READ GATE: Selects the PLL reference input and initiates the PLL synchronization sequence. A high level selects the $\overline{RD}$ input and enables the Read Mode/Address Mark Detection sequences. A low level selects the crystal reference oscillator. Pin RG has an internal resistor pull-up.
WG	I	WRITE GATE: Enables the write mode. Pin WG has an internal resistor pull-up. If unused, tie pin low.
WSL	I	WINDOW SYMMETRY LATCH: Used to latch the input window symmetry control bits WSD, $\overline{WS0}$ and $\overline{WS1}$ into the internal DAC. An active high level latches the input bits. Pin WSL has an internal resistor pull-up. If unused, tie pin low.
WSD	I	WINDOW SYMMETRY DIRECTION: Controls the direction of the optional window symmetry shift. Pin WSD has an internal resistor pull-up.
$\overline{WS0}$	I	WINDOW SYMMETRY CONTROL BIT: A low level introduces a window shift of 1.5% TORC (Read Reference Clock Period) in the direction established by WSD. Pin $\overline{WS0}$ has an internal resistor pull-up. If unused, leave open or tie high.
$\overline{WS1}$	I	WINDOW SYMMETRY CONTROL BIT: A low level introduces a window shift of 6% TORC (Read Reference Clock Period) in the direction established by WSD. A low level at both $\overline{WS0}$ and $\overline{WS1}$ will produce the sum of the two window shifts. Pin $\overline{WS1}$ has an internal resistor pull-up. If unused, leave open or tie high.
SOFT/$\overline{HARD}$	I	SOFT/$\overline{HARD}$ SECTOR: Selects the address mark and the Preamble field patterns. A high level (Soft Sector) selects a 3T Preamble Field pattern and a non-violating 2, 7 address mark, N7V. A low level (Hard Sector) selects a 4T Preamble Field pattern and disables the address mark circuitry. Pin SOFT/$\overline{HARD}$ has an internal resistor pull-up.
WCLK	I	WRITE CLOCK: Write Clock input. Must be synchronous with the Write Data input on the NRZ Data Port. For small cable delays, WCLK may be connected directly to pin RRC (Read/Reference Clock).
EPD	I	ENABLE PHASE DETECTOR: A low level (Coast Mode) disables the phase detector and allows the VCO to coast. Pin EPD has an internal resistor pull up.
$\overline{EWP}$	I	ENABLE WRITE PRECOMPENSATION: A low level enables Write Precompensation. Pin $\overline{EWP}$ has an internal resistor pull-up.

PIN DESCRIPTIONS (Continued)

OUTPUT PINS

NAME	TYPE	DESCRIPTION
$\overline{WD}$	O	WRITE DATA: Encoded write data output, active low.
RRC	O	READ/REFERENCE CLOCK: A multiplexed clock source used by the controller. In the read mode, this clock is the VCO frequency divided by two (1/TORC) and in the write mode it is the crystal reference frequency divided by two (1/TORO). No short clock pulses are generated during a mode change.
$\overline{AMD}$	O	ADDRESS MARK DETECT: In the soft sector Read Mode, a latched low level output indicates that an address mark has been detected. In non-Read modes $\overline{AMD}$ is configured as a high impedance output.
$\overline{SDO}$	O	SYNC DETECT OUTPUT: An active low output that indicates successful detection of the 3T Preamble sync field. THE $\overline{SDO}$ pin is not a TTL level signal.
VCO CLK	O	VCO CLK: An open emitter VCO clock test point. Two external resistors are required to utilize this output, they can be removed during normal operaton for reduced power dissipation.
$\overline{DRD}$	O	DELAYED READ DATA: Test point. The positive edges of this open emitter output signal indicate the data bit position. The positive edges of the $\overline{DRD}$ and the VCO CLK signals can be used to estimate window centering. The time jitter of $\overline{DRD}$'s positive edge is an indication of media bit shift. Two external resistors are required to perform this test, they can be removed during normal operation for reduced power dissipation.

BIDIRECTIONAL PINS

NRZ	I/O	NRZ DATA PORT: Read Data output when RG is high and Write Data input when WG is high. In the idle mode NRZ is in a high impedance state.

ANALOG PINS

IREF	I	TIMING PROGRAM PIN: The VCO center frequency and the 1/4 Cell Delay are a function of the current sourced into pin IREF. The current is set by an external resistor, RR, connected from IREF to VPA.
PCS	I	PRECOMP SET: Used to set the magnitude of the Write Precompensation time shift via an external capacitor, Cp to VPA and an external resistor, Rp to AGND.
XTAL1, XTAL2	I	CRYSTAL OSCILLATOR CONNECTIONS: The frequency must be at twice the data rate.
PD OUT	O	PHASE DETECTOR OUTPUT: Drives the Loop Filter input.
VCO IN	I	VCO CONTROL INPUT: Driven by the Loop Filter output.

PIN DESCRIPTIONS (Continued)

OUTPUT PINS (Continued)

NAME	TYPE	DESCRIPTION
SDS	I	SYNC DETECT SET: Used to program the sync detect retriggerable one-shot timing with an external R-C network. Connect the capacitor, Cd, to VPA and the resistor, Rd, to AGND.
RF, RS	I	WINDOW SYMMETRY ADJUST PINS: Provides analog control over the decode window symmetry; typically used to null out any window symmetry offset. A resistor connected from either RF or RS to AGND will provide magnitude and direction control. They can be used in conjunction with the digital control port WSD, $\overline{WS0}$, $\overline{WS1}$.

POWER

DGND, AGND	I	DIGITAL AND ANALOG GROUND
VPA	I	ANALOG +5V
VPD	I	DIGITAL +5V

OPERATION

The SSI 32D535 is designed to perform data recovery and data encoding in rotating memory systems which utilize a 2, 7 RLL encoding format. In the Read Mode the SSI 32D535 performs Data Synchronization, Sync Field Search and Detect, Address Mark Detect and Data Decoding. In the Write Mode, the SSI 32D535 converts NRZ data into the 2,7 RLL format described in Table 1, performs write precompensation, generates the Preamble Field, and inserts Address Marks as requested. The interface electronics and architecture of the SSI 32D535 have been optimized for use as a companion device to the SSI 32C452 or AIC 010 controllers.

The SSI 32D535 can operate with data rates ranging from 7.5 to 10 Mbit/s operation. This data rate is established by a single 1% external resistor, RR, connected from pin IREF to VPA. This resistor establishes a reference current which sets the VCO center frequency, the phase detector gain, and the 1/4 cell delay. The value of this resistor is given by:

$$RR = \frac{40.67}{DR} - 0.5\ (k\Omega)$$

where: DR = Data Rate in Mbit/s.

An internal crystal reference oscillator, operating at twice the data rate, generates the standby reference for the PLL. A series resonant crystal between XTAL1 and XTAL2 should be selected at twice the Data Rate.

The SSI 32D535 employs a Dual Mode Phase Detector; Harmonic in the Read Mode and Non-Harmonic in Write and Idle Modes. In the Read Mode the Harmonic Phase Detector updates the PLL with each occurrence of a DLYD DATA pulse. In the Write and Idle Modes the Non-Harmonic Phase Detector is continuously enabled, thus maintaining both phase and frequency lock. By acquiring both phase and frequency lock to the crystal reference oscillator and utilizing a zero phase restart technique, false lock to DLYD DATA is eliminated.

The phase detector incorporates a charge pump in order to drive the loop filter directly. The polarity and width of the output current pulses correspond to the direction and magnitude of the phase error. Figure 1 depicts the average output current as a function of the input phase error (relative to the VCO period).

The READ GATE (RG), and WRITE GATE (WG), inputs control the device mode as described in Table 2. RG is an asynchronous input and may be initiated or terminated at any position on the disk. WG is also an asynchronous input, but should not be terminated prior to the last output Write Data pulse.

READ OPERATION

The Data Synchronizer utilizes a fully integrated fast acquisition PLL to accurately develop the decode window. Read Gate, RG, initiates the PLL locking sequence and selects the PLL reference input; a high level (Read Mode) selects the $\overline{RD}$ input and a low level selects the crystal reference oscillator.

In the Read Mode the rising edge of DLYD DATA enables the Phase Detector while the falling edge is phase compared to the rising edge of the VCO. As depicted in Figure 2, DLYD DATA is a 1/4 cell wide (TVCO/2) pulse whose leading edge is defined by the leading edge of $\overline{RD}$. An accurate and symmetrical decode window is developed from the VCO clock. The decode window is generated from the falling edges of the VCO clock. By utilizing a fully integrated symmetrical VCO running at twice the data rate, the decode window is insured to be accurate and centered symmetrically about the falling edges of DLYD DATA. The accuracy of the 1/4 cell delay only affects the retrace angle of the phase detector and does not influence the accuracy of the decode window.

Shifting the symmetry of the VCO clock effectively shifts the relative position of the DLYD DATA pulse within the decode window. This powerful capability easily facilitates defect mappings, automatic calibration, window margin testing, error recovery, and systematic error cancellation. For enhanced disk drive testability and error recovery, decode window control is provided via a µP port (WSL, WSD, $\overline{WS0}$, $\overline{WS1}$) as described in Table 3. In applications not utilizing this feature, WSL must be connected to ground, while WSD, $\overline{WS0}$, and $\overline{WS1}$ must be left open.

Window shifts in the range of ±1.5% to ±7.5% of TORC are easily programmed by latching the appropriate control word into the Window Shift Register with the WSL pin. Shifts in the positive or negative directions result in early or late decode windows respectively, as depicted in Figure 3. Additionally, for small systematic error cancellation, a resistor, R, connected from either RS (Early) or RF (Late) to ground will provide analog control over the decode window. The magnitude of this shift, TSA is determined by:

$$TSA = 0.125\ TORC\left(1 - \frac{680 + R}{1180 + R}\right)$$

where: R is in ohms

Pins RF and RS are intended to be used as a trim and should be restricted to ±1.5% window shifts. They can be used in conjunction with the digital control port.

The VCO CLK and $\overline{DRD}$ outputs can be used to estimate window centering and data bit shift. The rising edges of VCO CLK indicate the data detection window edges. The rising edge of $\overline{DRD}$ indicates the data bit position relative to the decode window. Two external resistors are required during such testing. A pull-up resistor of 130Ω should be connected to VPD, while a pull-down resistor of 200Ω should be connected to DGND. The resistors can be removed during normal operation to reduce power dissipation.

In Non-Read Modes, the PLL is locked to the crystal reference oscillator. This forces the VCO to run at a frequency which is very close to that required for tracking actual data and thus minimizes the associated frequency step during acquisition. When the reference input to the PLL is switched, the VCO is stopped momentarily, then restarted in an accurate phase alignment with the next PLL reference input pulse, and the VCO clock divider is reset. By minimizing the phase alignment in this manner (phase error ≤ 0.5 rads), the acquisition time is substantially reduced.

The SSI 32D535 provides two sync modes for controlling the PLL locking sequence; Soft Sector and Hard Sector.

SOFT SECTOR MODE

The Soft Sector Mode activates the Preamble Search and Address Mark detection circuitry. As depicted in Figure 4, when RG transitions high, the counter is reset and the SSI 32D535 requires 10 high to low transitions (Preamble '1' bits) before switching the reference input to the PLL, 48 high to low transitions before switching the Read Reference Clock to the VCO clock divided by two and activating the Address Mark Detect circuitry; then it must detect the Address Mark prior to 80 high to low transitions in order to enter the Read Mode. This sequence repeats after 95 input '1' bits until the read mode is successfully entered or until RG is cancelled.

When RG transitions high, the following PLL locking sequence begins:

a) **PREAMBLE SEARCH:**

The 3T detect circuitry initiates the PLL locking sequence once it has detected 10 consecutive '100' bit groups from the 3T preamble field. The 3T detect timing is set by the sum of the 1/4 cell delay and the retriggerable one-shot delay. The 1/4 cell timing capacitor is included on-chip and its timing is externally set by resistor RR. The retriggerable one-shot timing is externally set by resistor Rd and capacitor Cd. The sum of their delays is set to 3.5 bit cell times. Therefore, a continuous stream of input pulses with a 3T bit cell time pulse rate keeps the one-shot reset, and a 4T or longer bit cell time input period allows the one-shot to time out producing a 4T detect pulse. The 4T detect pulse resets the Input Counter and the search is started over.

b) **PLL ACQUISITION:**

Once 10 consecutive '100' bit groups are detected, the reference input to the PLL is switched from the crystal reference oscillator to the DLYD DATA, the VCO is phase reset to the next DLYD DATA pulse, and PLL acquistion begins. When an additional 38 '100' bit groups are detected, the Read Reference Clock output (RRC) is switched to the VCO clock divided by 2, the 4T Detect circuitry is inhibited, and the Address Mark Detection circuitry is enabled. If a 4T detect pulse occurs before 48 Preamble '1' bits are detected, then the PLL is locked back to the crystal reference oscillator, the RRC output is switched to the crystal reference oscillator divided by 2, the

Input Counter reset, and the sequence is re-started. No short duration glitches will occur at the RRC output during this switching.

c) **ADDRESS MARK DETECTION:**

The circuit searches for the occurrence of the $5EAx_{16}$ Address Mark. If an Address Mark is detected prior to the Input Counter reaching count 80, the correct phase of the RRC is ensured by resetting the n/2 divider, the $\overline{AMD}$ output is latched low, the PLL training sequence is terminated, and the Read Mode is entered allowing the data field to be read. If the Input Counter reaches count 80 before the Address Mark is detected, the PLL is locked back to the crystal reference oscillator, the RRC output is switched to the crystal reference oscillator divided by 2, and the PLL training sequence is restarted when the Input Counter reaches count 96. Figure 5 depicts the Address Mark detection sequence.

HARD SECTOR MODE

In the Hard Sector mode (SOFT/$\overline{HARD}$ = 0) the SSI 32D535 utilizes a 4T (1000) Preamble Field and disables the Preamble Search and Address Mark detection circuitry. It allows the PLL to be controlled directly by RG for Hard Sector format operation. With the absence of an Address Mark, the 4T Preamble Field is utilized to properly set the bit cell alignment boundaries for proper decoding.

When RG transitions high, as depicted in Figure 6, reference input to the PLL is switched from the crystal reference oscillator to DLYD DATA, the VCO is phase reset to the next DLYD DATA pulse, and the PLL acquisition begins. When 32 '1' Preamble bits are detected, the RRC output is switched to the VCO clock divided by 2, and the Read Mode is entered allowing the data field to be read.

In the Hard Sector mode, the NRZ output is inverted and will remain low until the data field is read, as shown in Figure 7. Since the Preamble Search circuitry is not utilized, the external one-shot timing components (Cd, Rd) are not required and the SDS pin can be left open.

WRITE OPERATION

In the Write Mode the SSI 32D535 converts NRZ data from the controller into 2, 7 RLL formatted data for storage onto the disk. The SSI 32D535 can operate with a soft or hard sectored disk drive. In the Soft Sector Mode, (SOFT/$\overline{HARD}$ = 1) the device generates a 3T Preamble Field and can insert a N7V Address Mark. The N7V Address Mark is a valid 2, 7 RLL pattern which is not contained in the code set. In the Hard Sector Mode, (SOFT/$\overline{HARD}$ = 0) the device generates a 4T Preamble Field and no Address Mark. Serial NRZ data is clocked into the SSI 32D535 and latched on defined cell boundaries. The NRZ input data must be synchronous with the rising edges of the WCLK input. The WCLK input is a feature provided for operation in an ESDI application to compensate for large cable delays. In a SCSI or ST506 operation, WCLK is connected directly to the RRC output.

Write precompensation circuitry is provided to compensate for media bit shift caused by intersymbol interference. The SSI 32D535 recognizes specific write data patterns and can add or subtract delays in the time position of write data bits to counteract the read back bit shift. The magnitude of the time shift, TC, is determined by an external R-C network on the PCS pin given by:

$$TC = 0.15\ (Rp)(Cp + Cs)$$
with $RP \geq 2.0\ k\Omega$, Cs = stray capacitance

When the ENABLE WRITE PRECOMP, $\overline{EWP}$, input is low the SSI 32D535 performs write precompensation according to the algorithm outlined in Table 4.

SOFT SECTOR MODE

In the Soft Sector Mode, when WRITE GATE (WG), transitions high and the NRZ input is held low, the SSI 32D535 automatically generates the 3T (100) Preamble Field at the WRITE DATA ($\overline{WD}$), output. The 3T Preamble Field will continue to be generated until the first low to high transition on the NRZ line. As shown in Figure 8, the first low to high transition occurs with the second bit '1' of the 5_{16} (0101) in the $5EAx_{16}$ Address Mark generation pattern. To generate the Address Mark, the SSI 32D535 automatically changes the '1' in the eleventh position (see note 3) of the 2, 7 RLL encoded sequence, to a '0'. This generates a pattern of seven zeros followed by two zeros. This unique pattern satisfies the 2, 7 RLL constraints, but will never occur during a normal encoding sequence. The x_{16} of the $5EAx_{16}$ Address Mark generation pattern can be selected, a 'C_{16}' (1100) was utilized in this example.

HARD SECTOR MODE

In the Hard Sector Mode, when WG goes high and the NRZ input is held low, the SSI 32D535 automatically generates the 4T (1000) Preamble Field at the WRITE DATA, $\overline{WD}$, output. Note that in the Hard Sector mode, the NRZ input is inverted, therefore a constant low is equivalent to an '11 . . .' input which generates the 4T '1000 . . . ' Preamble Field. The 4T Preamble Field will be generated between the time WG goes high and the first low to high transition on the NRZ line. The 32D535 requires a minimum of 32 4T (1000) bit groups prior to the data field.

NRZ	2, 7 RLL
10	0100
11	1000
000	000100
010	100100
011	001000
0010	00100100
0011	00001000

TABLE 1: 2, 7 RLL Code Set

WG	RG	MODE
0	0	IDLE
0	1	READ
1	0	WRITE
1	1	ILLEGAL

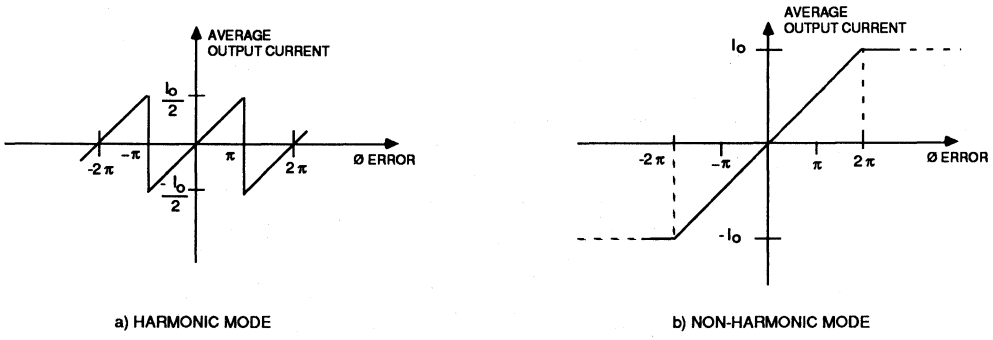
TABLE 2: Mode Control

Ts, NOMINAL WINDOW SHIFT	WSD	$\overline{WS1}$	$\overline{WS0}$
+TS3	0	0	0
+TS2	0	0	1
+TS1	0	1	0
0	0	1	1
-TS3	1	0	0
-TS2	1	0	1
-TS1	1	1	0
0	1	1	1

TABLE 3 : Decode Window Symmetry Control

ENCODED 2, 7 RLL DATA PATTERN							
BIT n - 3	BIT n - 2	BIT n - 1	BIT n	BIT n + 1	BIT n + 2	BIT n + 3	COMPENSATION BIT n
0	0	0	1	0	0	0	none
1	0	0	1	0	0	1	none
1	0	0	1	0	0	0	early
0	0	0	1	0	0	1	late

TABLE 4 : Write Precompensation Algorithm



a) HARMONIC MODE

b) NON-HARMONIC MODE

Notes: 1) Io is the magnitude of the charge pump current
2) Phase error is relative to the VCO period

FIGURE 1: Phase Detector Transfer Function

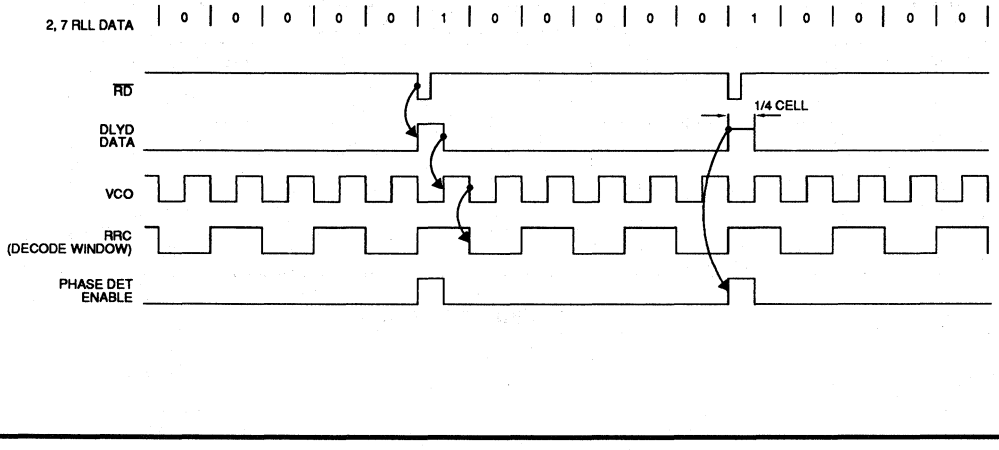


FIGURE 2: Data Synchronization Waveform Diagram

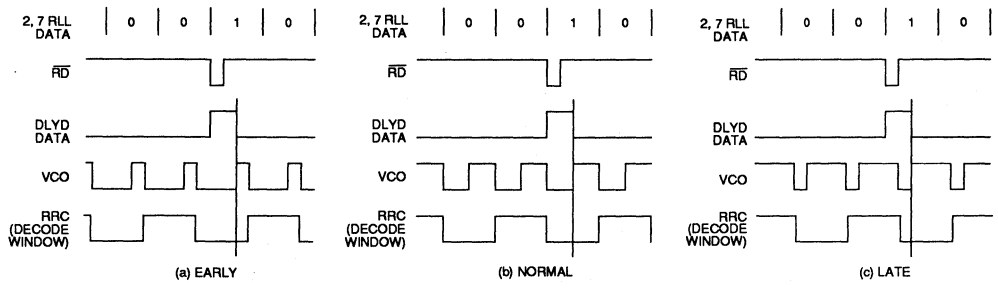
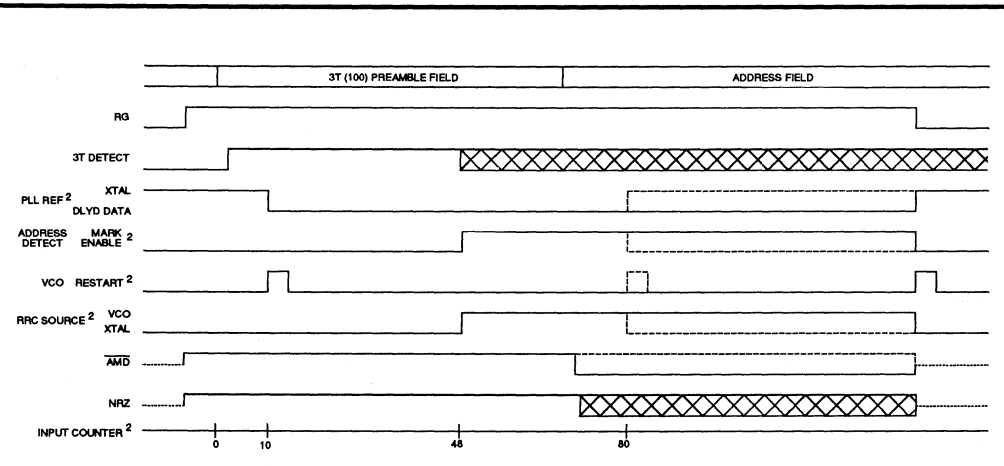


FIGURE 3: Decode Window



Notes: 1) Dashed lines represent conditions where $\overline{AMD}$ did not occur
2) Representations of internal signals
3) Dotted lines represent a high impedance output state

FIGURE 4: Soft Sector Mode Timing Diagram

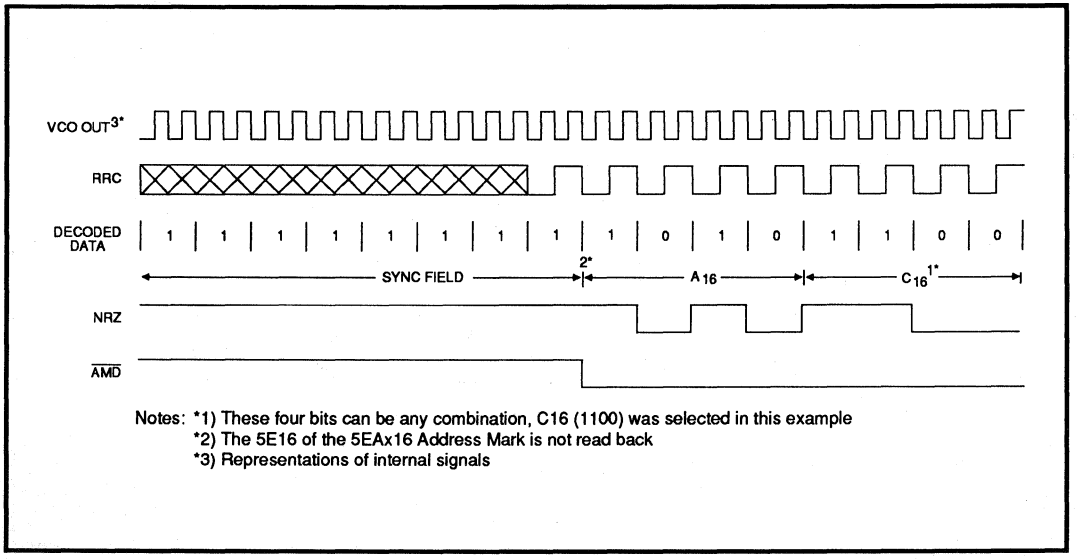


FIGURE 5: Address Mark Detection and NRZ Output Waveform

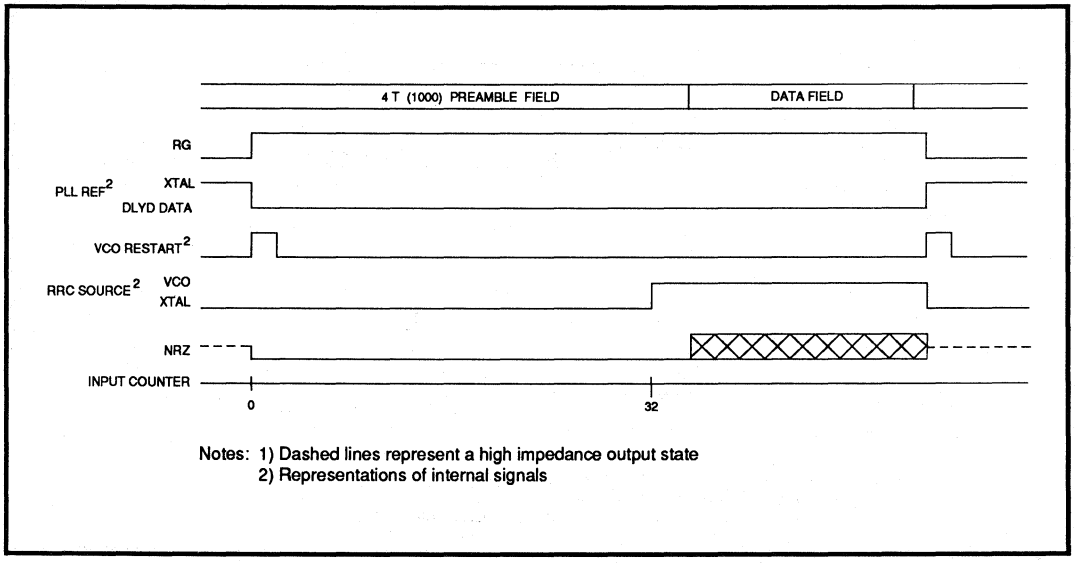


FIGURE 6: Hard Sector Mode Timing Diagram

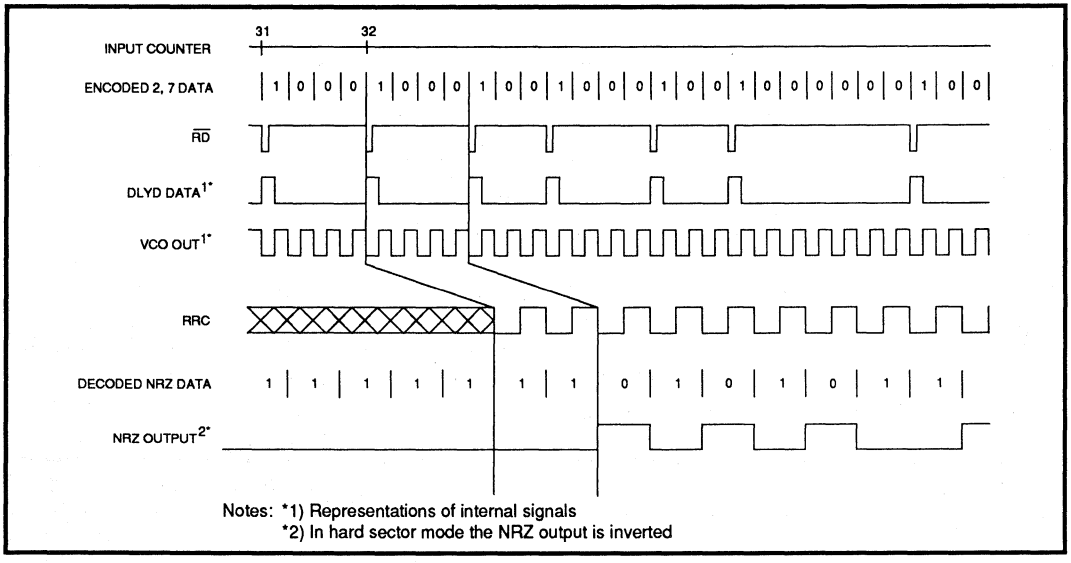


FIGURE 7: Hard Sector Mode Decode Timing

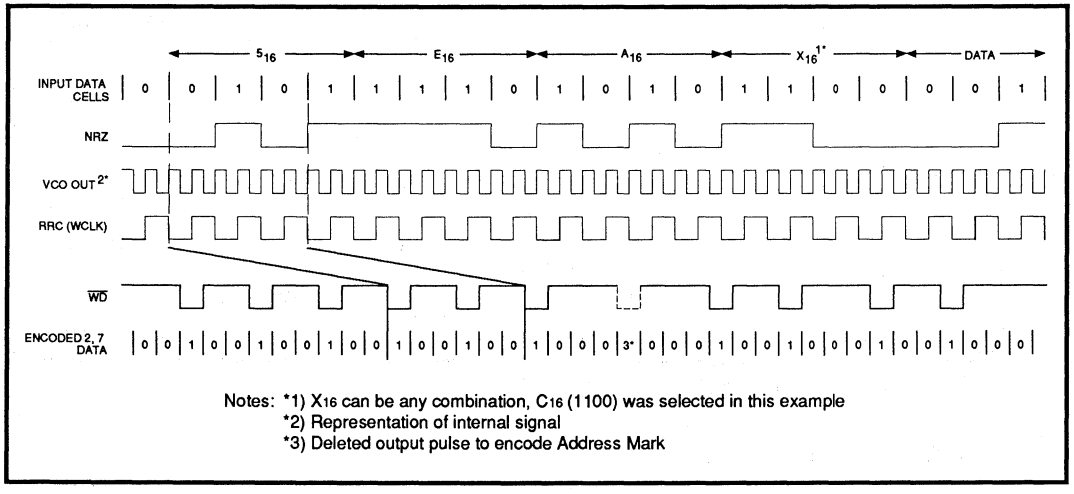


FIGURE 8: Write Address Mark Generation

ABSOLUTE MAXIMUM RATINGS

Operation above maximum ratings may permanently damage the device.

PARAMETER	RATINGS	UNIT
Storage Temperature	-65 to +150	° C
Ambient Operating Temperature, Ta	0 to +70	° C
Junction Operating Temperature, Tj	0 to +130	° C
Supply Voltage, VCC	-0.5 to 7	Vdc
Voltage Applied to Logic inputs	-0.5 to VCC +0.5	Vdc
Maximum Power Dissipation	950	mW

DC ELECTRICAL CHARACTERISTICS - unless otherwise specified, 4.75V < VCC < 5.25V, Ta = 0°C to 70°C, 7.5 MHz < 1/TORC < 10 MHz, 15 MHz < 1/TVCO < 20 MHz

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
TTL Inputs:					
VIH, High Level Input Voltage		2.0			V
VIL, Low Level Input Voltage				0.8	V
IIH, High Level Input Current	VIH = 2.7V			20	µA
IIL, Low Level Input Current	VIL = 0.4V			-0.36	mA
TTL Outputs:					
VOH, High Level Output Voltage	IOH = -400 µA	2.4			V
VOL, Low Level Output Voltage	IOL = 4 mA			0.5	V
Test Point Outputs: $\overline{DRD}$, VCO CLK (See Figure 12)					
VOH, High Level Ouput Voltage	RL= 130Ω to VPD, 200Ω to DGND		VPD-1.0		V
VOL, Low Level Output Voltage	RL= 130Ω to VPD, 200Ω to DGND		VPD-1.75		V
ICC, Power Supply Current	All outputs open			180	mA

DYNAMIC CHARACTERISTICS AND TIMING

READ MODE (See Figure 9)

TRD, Read Data Pulse Width		20		TORC-40	ns
TFRD, Read Data Fall Time	2.0V to 0.8V, CL ≤ 15 pF			15	ns
TRRC, Read Clock Rise Time	0.8V to 2.0V, CL ≤ 15 pF			8	ns
TFRC, Read Clock Fall Time	2.0V to 0.8V, CL ≤ 15 pF			5	ns

READ MODE (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
TPNRZ, NRZ (out) Propagation Delay		-15		15	ns
TPAMD, $\overline{AMD}$ Propagation Delay		-15		15	ns
1/4 Cell + Retriggerable One-Shot Delay Stability	4.5V < VCC < 5.5V	-4		+4	%
1/4 Cell + Retriggerable One-Shot Delay*	TD = 6.14(RR +0.5) + 0.172Rd (Cd +Cs)** RR = kΩ Rd = kΩ Cd = 68 pF to 100 pF	0.89TD		1.11TD	ns
* Excludes External Capacitor and Resistor Tolerances		**Cs = Stray Capacitance			

WRITE MODE (See Figure 10)

PARAMETER	CONDITIONS	MIN	MAX	UNIT
TWD, Write Data Pulse Width	CL ≤15 pF	(TOWC/2)-12-1.4TC	(TOWC/2) +12	ns
TFWD, Write Data Fall Time	2.0V to 0.8V, CL ≤ 15 pF		8	ns
TRWC Write Data Clock Rise Time	0.8V to 2.0V		10	ns
TFWC Write Data Clock Fall Time	2.0V to 0.8V		8	ns
TSNRZ, NRZ (in) Set Up Time		20		ns
THNRZ, NRZ (in) Hold Time		7		ns
TWDC Compensated Write Data Pulse Width	CL ≤ 15 pF	(TOWC/2)-2.4TC-12		ns
TE, TL Write Data Compensation Accuracy	TC = 0.15(Rp)(Cp + Cs) 2 kΩ ≤ Rp ≤ 3 kΩ, Cs = Stray Capacitance Cp = 15pF to 36pF	0.8TC	1.2TC	ns

DATA SYNCHRONIZATION

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
TVCO VCO Center Frequency Period	VCO IN = 2.7V TO = 1.23E - 11(RR +500) VCC = 5.0V	0.8TO		1.2TO	sec

DATA SYNCHRONIZATION (Cont.)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
VCO Frequency Dynamic Range		1.0V ≤ VCO IN ≤ VCC -0.6V VCC = 5.0V	±24		±40	%
KVCO	VCO Control Gain	ωo = 2π / TO 1.0V ≤ VCO IN ≤ VCC -0.6V	0.14ωo		0.20ωo	rad/s-V
KD	Phase Detector Gain	KD = 0.309 / (RR + 500) VCC = 5.0V	0.83 KD		1.17 KD	A/rad
*	KVCO x KD Product Accuracy		-28		+28	%
*	VCO Phase Restart Error			6		ns
	Decode Window Centering Accuracy				± (0.01 TORC + 2)	ns
	Decode Window		(TORC/2) -2			ns
TS1	Decode Window Time Shift Magnitude	TS1 = 0.015 TORC		TS1		sec
TS2	Decode Window Time Shift Magnitude	TS2 = 0.06 TORC		TS2		sec
TS3	Decode Window Time Shift Magnitude	TS3 = 0.075 TORC		TS3		sec
TSA	Decode Window Time Shift Magnitude	$TSA = 0.125\ TORC\left(1 - \frac{680 + R}{1180 + R}\right)$ with: R in ohms		TSA		sec

* Not directlly testable – Design Characteristics

CONTROL CHARACTERISTICS (See Figure 11)

TSWS, $\overline{WS0}$, $\overline{WS1}$, WSD Set Up Time		50			ns
THWS, $\overline{WS0}$, $\overline{WS1}$, WSD Hold Time		0			ns
RG, WG, SOFT/$\overline{HARD}$ Time Delay				100	ns

REFERENCE CLOCK CHARACTERISTICS

TXPW, Crystal Input Pulse Width	Min. Negative Pulse Width	19.23			ns
(Reference Oscillator See Figure 10)	Min. Positive Pulse Width	16			ns

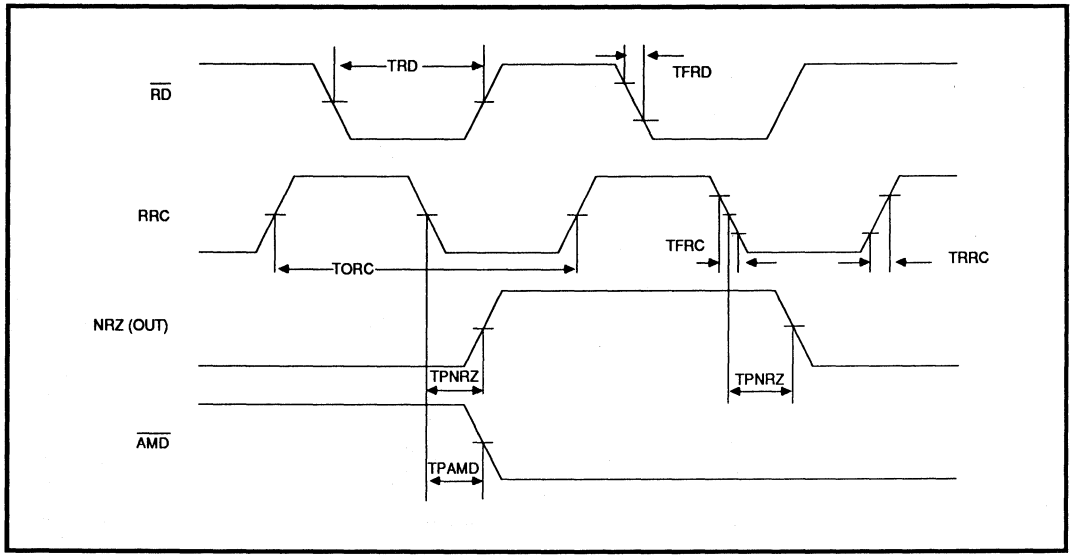


FIGURE 9: Read Timing

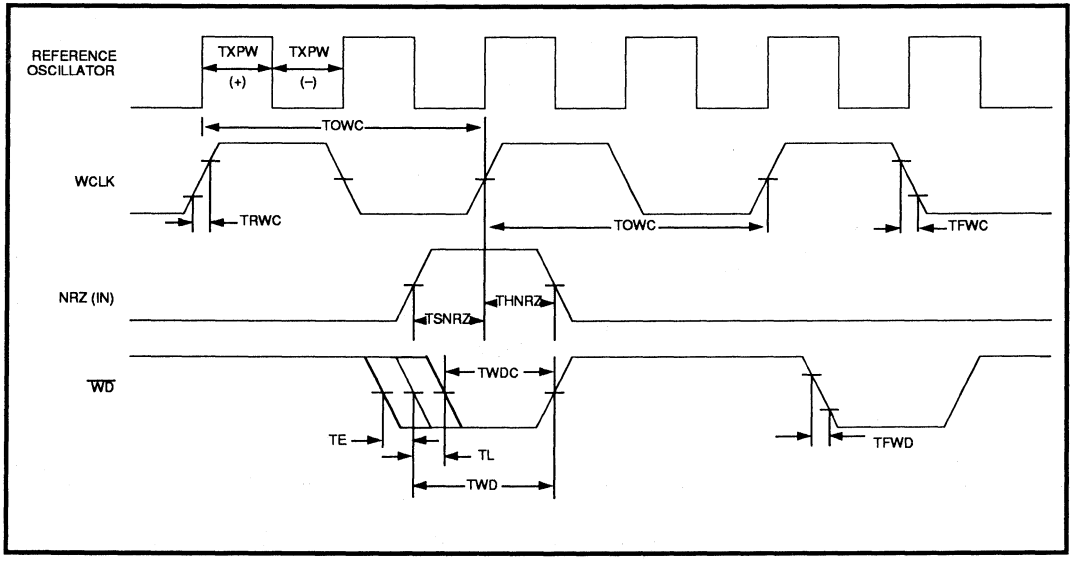


FIGURE 10: Write Timing

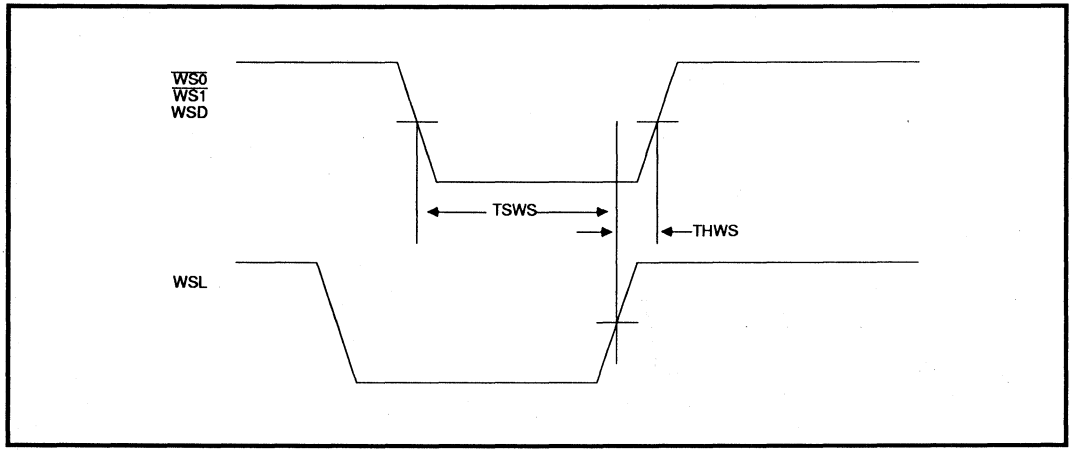


FIGURE 11: Control Timing

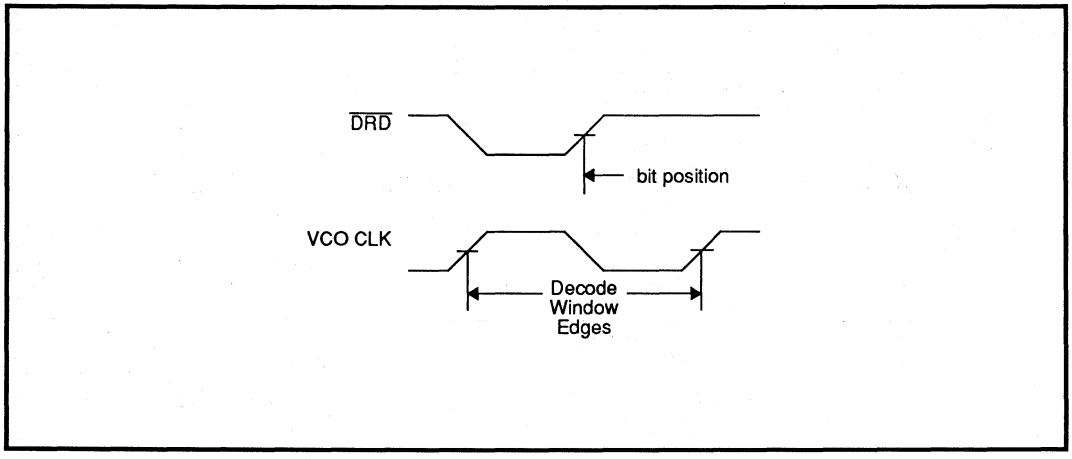


FIGURE 12: Test Point Timing

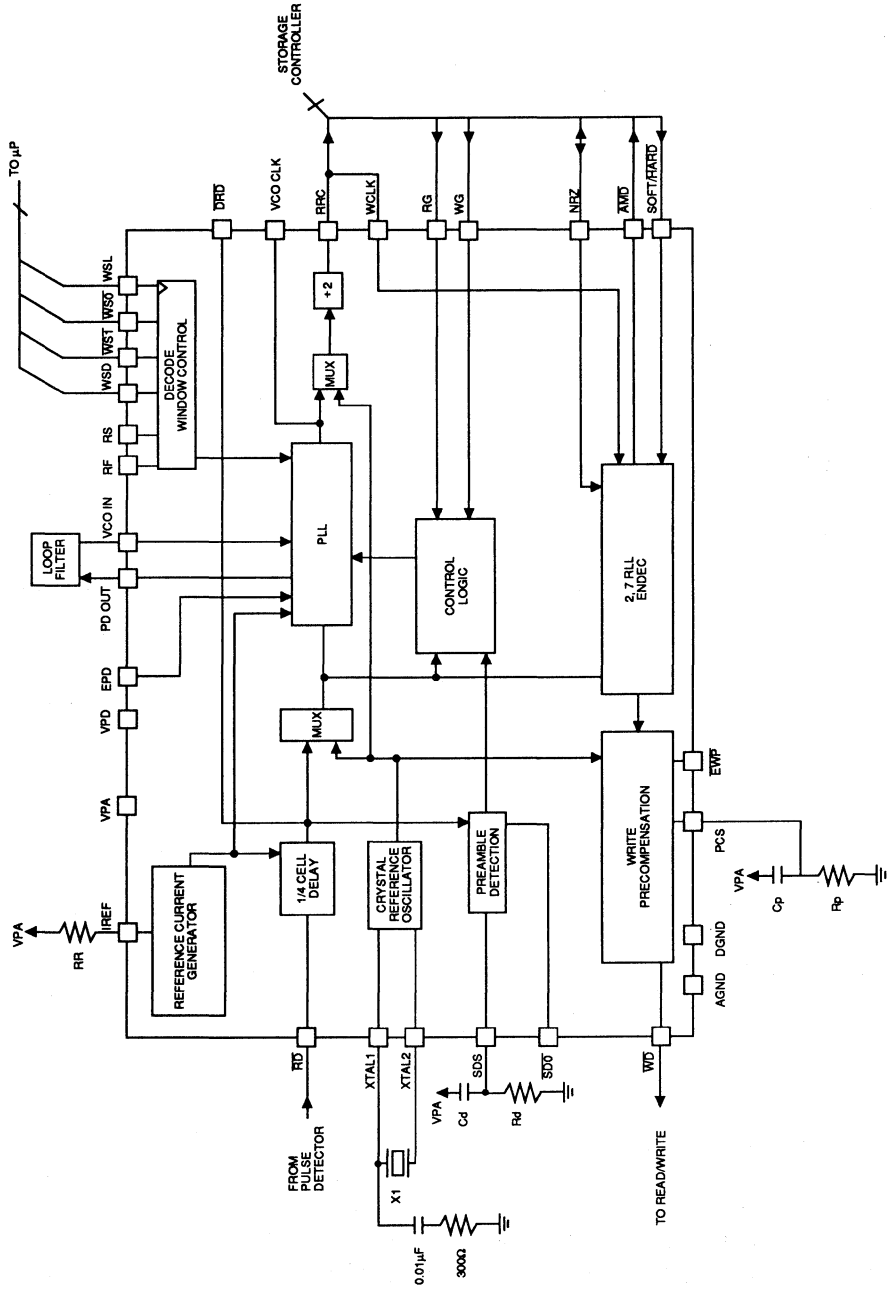
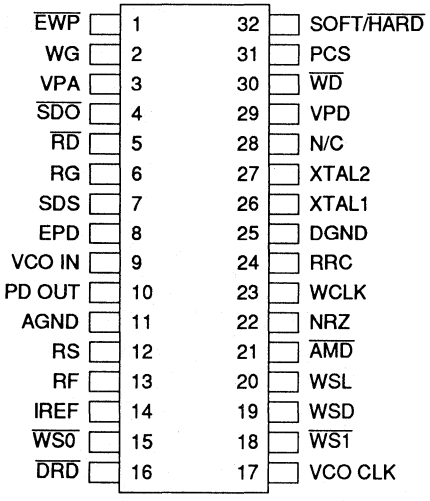


FIGURE 13: Typical SSI 32D535 Application

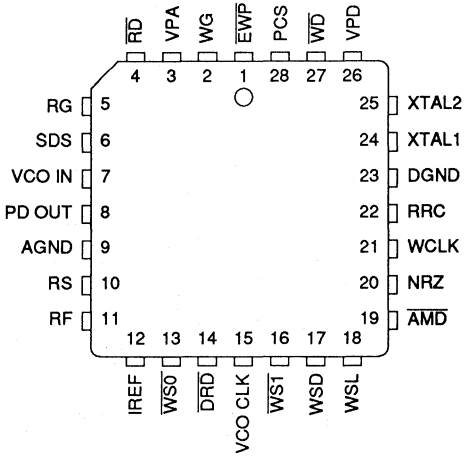
SSI 32D535
Data Synchronizer/
2, 7 RLL ENDEC
with Write Precompensation

PACKAGE PIN DESIGNATIONS

(Top View)



32-Lead SOW, DIP



28-Pin PLCC

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32D535 32-Pin Small Outline - Wide	SSI 32D535 - CW	32D535 - CW
SSI 32D535 32-Pin Plastic DIP	SSI 32D535 - CP	32D535 - CP
SSI 32D535 28-Pin PLCC	SSI 32D535 - CH	32D535 - CH

Silicon Systems, Inc. 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX (714) 731-5457

SSI 32D5351

Data Synchronizer/2, 7 RLL ENDEC w/ Write Precompensation

Preliminary Data

July, 1990

DESCRIPTION

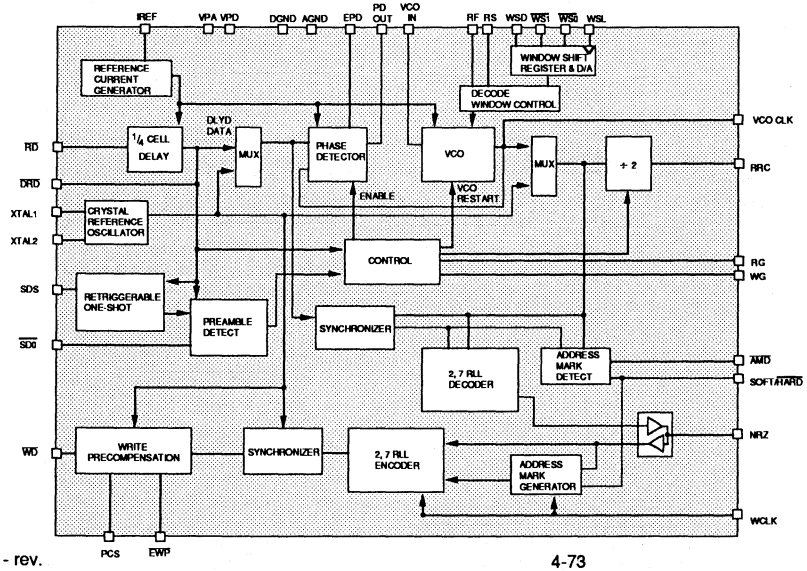
The SSI 32D5351 Data Separator provides data recovery, data encoding, and write precompensation for storage systems which employ a 2, 7 RLL encoding format. Data synchronization is performed with a fully integrated high performance PLL. A zero phase restart technique is used to minimize PLL acquisition time. The SSI 32D5351 has been optimized for operation at multiple data rates between 8 to 16 Mbit/s with multiple TTL clock schemes or the new 32D4660 Time Base Generator. The VCO frequency setting elements are incorporated within the SSI 32D5351 for enhanced performance and reduced board space. Data rate is established with a single external programming resistor. The SSI 32D5351 utilizes an advanced bipolar process technology which affords precise decode window control without the requirement of an accurate 1/4 cell delay or external devices. To enhance disk drive testability, decode window symmetry control is available through a digital µP port and/or two analog pins. This feature can facilitate defect mapping, automatic calibration, systematic error cancellation, window margin testing, and error recovery. The SSI 32D5351 requires a single +5V power supply and is available in 32-pin DIP and SOW packages.

FEATURES

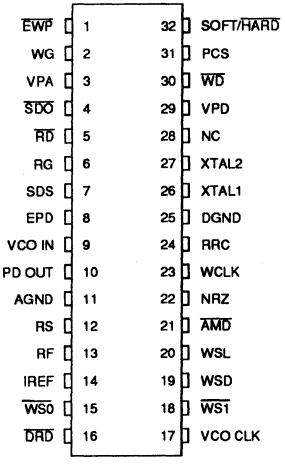
- **Data Synchronizer and 2, 7 RLL ENDEC**
- **Write Precompensation**
- **8 - 16 Mbit/s Operation Programmed with a Single External Resistor**
- **Input Reference Clock Circuitry Optimized for use with Constant Density Recording Applications**
- **ESDI compatible (Hard Sector)**
- **Programmable Decode Window Symmetry via a µP Port and/or Analog Pins**
- **Fast Acquisition Phase Locked Loop**
  - **Zero Phase Restart Technique**
- **Fully Integrated Data Separator**
  - **No External Delay Lines or Active Devices Required**
- **Crystal Controlled Reference Oscillator**
- **Hard/Soft Sector Operation**
- **+5V Operation**
- **32-Pin DIP, SOW, 28-Pin PLCC Packages**

4

BLOCK DIAGRAM



PIN DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

PIN DESCRIPTIONS

INPUT PINS

NAME	TYPE	DESCRIPTION
$\overline{RD}$	I	READ DATA: Encoded Read Data from the disk drive read channel, active low.
RG	I	READ GATE: Selects the PLL reference input and initiates the PLL synchronization sequence. A high level selects the $\overline{RD}$ input and enables the Read Mode/Address Mark Detection sequences. A low level selects the crystal reference oscillator. Pin RG has an internal resistor pull-up.
WG	I	WRITE GATE: Enables the write mode. Pin WG has an internal resistor pull-up.
WSL	I	WINDOW SYMMETRY LATCH: Used to latch the input window symmetry control bits WSD, $\overline{WS0}$ and $\overline{WS1}$ into the internal DAC. An active high level latches the input bits. Pin WSL has an internal resistor pull-up. If unused, connect this pin to ground.
WSD	I	WINDOW SYMMETRY DIRECTION: Controls the direction of the optional window symmetry shift. Pin WSD has an internal resistor pull-up. If unused, this pin can be left open.
$\overline{WS0}$	I	WINDOW SYMMETRY CONTROL BIT: A low level introduces a window shift of 1.5 % TORC (Read Reference Clock Period) in the direction established by WSD. Pin $\overline{WS0}$ has an internal resistor pull-up. If unused, this pin can be left open.
$\overline{WS1}$	I	WINDOW SYMMETRY CONTROL BIT: A low level introduces a window shift of 6% TORC (Read Reference Clock Period) in the direction established by WSD. A low level at both $\overline{WS0}$ and $\overline{WS1}$ will produce the sum of the two window shifts. Pin WS1 has an internal resistor pull-up. If unused, this pin can be left open.
SOFT/$\overline{HARD}$	I	SOFT/$\overline{HARD}$ SECTOR: Selects the address mark and the Preamble field patterns. A high level (Soft Sector) selects a 3T Preamble Field pattern and a non-violating 2, 7 address mark, N7V. A low level (Hard Sector) selects a 4T Preamble Field pattern and disables the address mark circuitry. Pin SOFT/$\overline{HARD}$ has an internal resistor pull-up.
WCLK	I	WRITE CLOCK: Write Clock input. Must be synchronous with the Write Data input on the NRZ Data Port. For small cable delays, WCLK may be connected directly to pin RRC (Read/Reference Clock).
EPD	I	ENABLE PHASE DETECTOR: A low level (Coast Mode) disables the phase detector and allows the VCO to coast. Pin EPD has an internal resistor pull up.
$\overline{EWP}$	I	ENABLE WRITE PRECOMPENSATION: A low level enables Write Precompensation. Pin $\overline{EWP}$ has an internal resistor pull-up.

PIN DESCRIPTIONS (Cont.)

OUTPUT PINS

NAME	TYPE	DESCRIPTION
$\overline{WD}$	O	WRITE DATA: Encoded write data output, active low.
RRC	O	READ/REFERENCE CLOCK: A multiplexed clock source used by the controller. In the read mode, this clock is the VCO frequency divided by two (1/TORC) and in the write mode it is the crystal reference frequency divided by two (1/TORO). No short clock pulses are generated during a mode change.
$\overline{AMD}$	O	ADDRESS MARK DETECT: In the soft sector Read Mode, a latched low level output indicates that an address mark has been detected. In non-Read modes $\overline{AMD}$ is configured as a high impedance output.
$\overline{SDO}$	O	SYNC DETECT OUTPUT: An active low output that indicates successful detection of the 3T Preamble sync field. THE SD0 pin is not a TTL level signal.
VCO CLK	O	VCO CLK: An open emitter VCO clock test point. Two external resistors are required to utilize this output, they can be removed during normal operaton for reduced power dissipation.
$\overline{DRD}$	O	DELAYED READ DATA: Test point. The positive edges of this open emitter output signal indicate the data bit position. The positive edges of the $\overline{DRD}$ and the VCO CLK signals can be used to estimate window centering. The time jitter of $\overline{DRD}$'s positive edge is an indication of media bit shift. Two external resistors are required to perform this test, they can be removed during normal operation for reduced power dissipation.

BIDIRECTIONAL PINS

NRZ	I/O	NRZ DATA PORT: Read Data output when RG is high and Write Data input when WG is high. In the idle mode NRZ is in a high impedance state.

ANALOG PINS

IREF	I	TIMING PROGRAM PIN: The VCO center frequency and the 1/4 Cell Delay are a function of the current sourced into pin IREF. The current is set by an external resistor, RR, connected from IREF to VPA.
PCS	I	PRECOMP SET: Used to set the magnitude of the Write Precompensation time shift via an external capacitor, Cp to VPA and an external resistor, Rp to AGND.
XTAL1, XTAL2	I	CRYSTAL OSCILLATOR CONNECTIONS: If a crystal oscillator is not desired, XTAL1 maybe driven by a TTL source* with XTAL2 open. The frequency must be at twice the data rate.
PD OUT	O	PHASE DETECTOR OUTPUT: Drives the Loop Filter input.
VCO IN	I	VCO CONTROL INPUT: Driven by the Loop Filter output.

* See Clock Characteristics

PIN DESCRIPTIONS (Cont.)

ANALOG PINS (Cont.)

NAME	TYPE	DESCRIPTION
SDS	I	SYNC DETECT SET: Used to program the sync detect retriggerable one-shot timing with an external R-C network. Connect the capacitor, Cd, to VPA and the resistor, Rd, to AGND.
RF, RS	I	WINDOW SYMMETRY ADJUST PINS: Provides analog control over the decode window symmetry; typically used to null out any window symmetry offset. A resistor connected from either RF or RS to AGND will provide magnitude and direction control. They can be used in conjunction with the digital control port WSD, $\overline{WS0}$, $\overline{WS1}$.

POWER

DGND, AGND	I	DIGITAL AND ANALOG GROUND
VPA	I	ANALOG +5V
VPD	I	DIGITAL +5V

OPERATION

The SSI 32D5351 is designed to perform data recovery and data encoding in rotating memory systems which utilize a 2, 7 RLL encoding format. In the Read Mode the SSI 32D5351 performs Data Synchronization, Sync Field Search and Detect, Address Mark Detect and Data Decoding. In the Write Mode, the SSI 32D5351 converts NRZ data into the 2,7 RLL format described in Table 1, performs write precompensation, generates the Preamble Field, and inserts Address Marks as requested. The interface electronics and architecture of the SSI 32D5351 have been optimized for use as a companion device to the SSI 32C452A or AIC 010 controllers.

The SSI 32D5351 can operate with data rates ranging from 8 to 16 Mbit/s. This data rate is established by a single 1% external resistor, RR, connected from pin IREF to VPA. This resistor establishes a reference current which sets the VCO center frequency, the phase detector gain, and the 1/4 cell delay. The value of this resistor is given by:

$$RR = \frac{76}{DR} - 1.75\ (k\Omega)$$

where: DR = Data Rate in Mbit/s.
$3\ k < RR < 8\ k\Omega$

An internal crystal reference oscillator, operating at twice the data rate, generates the standby reference for the PLL. A series resonant crystal between XTAL1 and XTAL2 should be selected at twice the Data Rate. If a crystal oscillator is not desired, then an external TTL compatible reference may be applied to XTAL1, leaving XTAL2 open.

The SSI 32D5351 employs a Dual Mode Phase Detector; Harmonic in the Read Mode and Non-Harmonic in Write and Idle Modes. In the Read Mode the Harmonic Phase Detector updates the PLL with each occurrence of a DLYD DATA pulse. In the Write and Idle Modes the Non-Harmonic Phase Detector is continuously enabled, thus maintaining both phase and frequency lock. By acquiring both phase and frequency lock to the crystal reference oscillator and utilizing a zero phase restart technique, false lock to DLYD DATA is eliminated.

The phase detector incorporates a charge pump in order to drive the loop filter directly. The polarity and width of the output current pulses correspond to the direction and magnitude of the phase error. Figure 1 depicts the average output current as a function of the input phase error (relative to the VCO period).

The READ GATE (RG), and WRITE GATE (WG), inputs control the device mode as described in Table 2. RG is an asynchronous input and may be initiated or terminated at any position on the disk. WG is also an asynchronous input, but should not be terminated prior to the last output Write Data pulse.

4

READ OPERATION

The Data Synchronizer utilizes a fully integrated fast acquisition PLL to accurately develop the decode window. Read Gate, RG, initiates the PLL locking sequence and selects the PLL reference input; a high level (Read Mode) selects the $\overline{RD}$ input and a low level selects the crystal reference oscillator.

In the Read Mode the rising edge of DLYD DATA enables the Phase Detector while the falling edge is phase compared to the rising edge of the VCO. As depicted in Figure 2, DLYD DATA is a 1/4 cell wide (TVCO/2) pulse whose leading edge is defined by the leading edge of $\overline{RD}$. An accurate and symmetrical decode window is developed from the VCO clock. The decode window is generated from the falling edges of the VCO clock. By utilizing a fully integrated symmetrical VCO running at twice the data rate, the decode window is insured to be accurate and centered symmetrically about the falling edges of DLYD DATA. The accuracy of the 1/4 cell delay only affects the retrace angle of the phase detector and does not influence the accuracy of the decode window.

Shifting the symmetry of the VCO clock effectively shifts the relative position of the DLYD DATA pulse within the decode window. This powerful capability easily facilitates defect mappings, automatic calibration, window margin testing, error recovery, and systematic error cancellation. For enhanced disk drive testability and error recovery, decode window control is provided via a µP port (WSL, WSD, $\overline{WS0}$, $\overline{WS1}$) as described in Table 3. In applications not utilizing this feature, WSL should be connected to ground, while WSD, $\overline{WS0}$, and $\overline{WS1}$ can be left open.

Window shifts in the range of ±1.5% to ±7.5% of TORC are easily programmed by latching the appropriate control word into the Window Shift Register with the WSL pin. Shifts in the positive or negative directions result in early or late decode windows respectively, as depicted in Figure 3. Additionally, for small systematic error cancellation, a resistor, R, connected from either RS (Early) or RF (Late) to ground will provide analog control over the decode window. The magnitude of this shift, TSA is determined by:

$$TSA = 0.125\ TORC\left(1 - \frac{680 + R}{1180 + R}\right)$$

where: R is in ohms

Pins RF and RS are intended to be used as a trim and should be restricted to ±1.5% window shifts. They can be used in conjunction with the digital control port.

The VCO CLK and $\overline{DRD}$ outputs can be used to estimate window centering and data bit shift. The rising edges of VCO CLK indicate the data detection window edges. The rising edge of $\overline{DRD}$ indicates the data bit position relative to the decode window. Two external resistors are required during such testing. A pull-up resistor of 130Ω should be connected to VPD, while a pull-down resistor of 200Ω should be connected to DGND. The resistors can be removed during normal operation to reduce power dissipation.

In Non-Read Modes, the PLL is locked to the crystal reference oscillator. This forces the VCO to run at a frequency which is very close to that required for tracking actual data and thus minimizes the associated frequency step during acquisition. When the reference input to the PLL is switched, the VCO is stopped momentarily, then restarted in an accurate phase alignment with the next PLL reference input pulse, and the VCO clock divider is reset. By minimizing the phase alignment in this manner (phase error ≤ 0.5 rads), the acquisition time is substantially reduced.

The SSI 32D5351 provides two sync modes for controlling the PLL locking sequence; Soft Sector and Hard Sector.

SOFT SECTOR MODE

The Soft Sector Mode activates the Preamble Search and Address Mark detection circuitry. As depicted in Figure 4, when RG transitions high, the counter is reset and the SSI 32D5351 requires 10 high to low transitions (Preamble '1' bits) before switching the reference input to the PLL, 48 high to low transitions before switching the Read Reference Clock to the VCO clock divided by two and activating the Address Mark Detect circuitry; then it must detect the Address Mark prior to 80 high to low transitions in order to enter the Read Mode. This sequence repeats after 95 input '1' bits until the read mode is successfully entered or until RG is cancelled.

When RG transitions high, the following PLL locking sequence begins:

a) PREAMBLE SEARCH:

The 3T detect circuitry initiates the PLL locking sequence once it has detected 10 consecutive '100' bit groups from the 3T preamble field. The 3T detect timing is set by the sum of the 1/4 cell delay and the retriggerable one-shot delay. The 1/4 cell timing capacitor is included on-chip and its timing is externally set by resistor RR. The retriggerable one-shot timing is externally set by resistor Rd and capacitor Cd. The sum of their delays is set to 3.5 bit cell times. Therefore, a continuous stream of input pulses with a 3T bit cell time pulse rate keeps the one-shot reset, and a 4T or longer bit cell time input period allows the one-shot to time out producing a 4T detect pulse. The 4T detect pulse resets the Input Counter and the search is started over.

b) PLL ACQUISITION:

Once 10 consecutive '100' bit groups are detected, the reference input to the PLL is switched from the crystal reference oscillator to the DLYD DATA, the VCO is phase reset to the next DLYD DATA pulse, and PLL acquistion begins. When an additional 38 '100' bit groups are detected, the Read Reference Clock output (RRC) is switched to the VCO clock divided by 2, the 4T Detect circuitry is inhibited, and the Address Mark Detection

circuitry is enabled. If a 4T detect pulse occurs before 48 Preamble '1' bits are detected, then the PLL is locked back to the crystal reference oscillator, the RRC output is switched to the crystal reference oscillator divided by 2, the Input Counter reset, and the sequence is re-started. No short duration glitches will occur at the RRC output during this switching.

c) **ADDRESS MARK DETECTION:**

The circuit searches for the occurrence of the $5EAx_{16}$ Address Mark. If an Address Mark is detected prior to the Input Counter reaching count 80, the correct phase of the RRC is ensured by resetting the n/2 divider, the $\overline{AMD}$ output is latched low, the PLL training sequence is terminated, and the Read Mode is entered allowing the data field to be read. If the Input Counter reaches count 80 before the Address Mark is detected, the PLL is locked back to the crystal reference oscillator, the RRC output is switched to the crystal reference oscillator divided by 2, and the PLL training sequence is restarted when the Input Counter reaches count 96. Figure 5 depicts the Address Mark detection sequence.

HARD SECTOR MODE

In the Hard Sector mode (SOFT/$\overline{HARD}$ = 0) the SSI 32D5351 utilizes a 4T (1000) Preamble Field and disables the Preamble Search and Address Mark detection circuitry. It allows the PLL to be controlled directly by RG for Hard Sector format operation. With the absence of an Address Mark, the 4T Preamble Field is utilized to properly set the bit cell alignment boundaries for proper decoding.

When RG transitions high, as depicted in Figure 6, reference input to the PLL is switched from the crystal reference oscillator to DLYD DATA, the VCO is phase reset to the next DLYD DATA pulse, and the PLL acquisition begins. When 32 '1' Preamble bits are detected, the RRC output is switched to the VCO clock divided by 2, and the Read Mode is entered allowing the data field to be read.

In the Hard Sector mode, the NRZ output is inverted and will remain low until the data field is read, as shown in Figure 7. Since the Preamble Search circuitry is not utilized, the external one-shot timing components (Cd, Rd) are not required and the SDS pin can be left open.

WRITE OPERATION

In the Write Mode the SSI 32D5351 converts NRZ data from the controller into 2, 7 RLL formatted data for storage onto the disk. The SSI 32D5351 can operate with a soft or hard sectored disk drive. In the Soft Sector Mode, (SOFT/$\overline{HARD}$ = 1) the device generates a 3T Preamble Field and can insert a N7V Address Mark. The N7V Address Mark is a valid 2, 7 RLL pattern which is not contained in the code set. In the Hard Sector Mode, (SOFT/$\overline{HARD}$ = 0) the device generates a 4T Preamble Field and no Address Mark. Serial NRZ data is clocked into the SSI 32D5351 and latched on defined cell boundaries. The NRZ input data must be synchronous with the rising edges of the WCLK input. The WCLK input is a feature provided for operation in an ESDI application to compensate for large cable delays. In a SCSI or ST506 operation, WCLK is connected directly to the RRC output.

Write precompensation circuitry is provided to compensate for media bit shift caused by intersymbol interference. The SSI 32D5351 recognizes specific write data patterns and can add or subtract delays in the time position of write data bits to counteract the read back bit shift. The magnitude of the time shift, TPC, is determined by an external R-C network on the PCS pin given by:

$$TPC = 0.15\ (Rp)(Cp + Cs)$$
$$Cp = 15 \text{ to } 36 \text{ pF}$$
$$Rp = 1k \text{ to } 3\ k\Omega$$
$$Cs = \text{stray capacitance}$$

When the ENABLE WRITE PRECOMP, $\overline{EWP}$, input is low the SSI 32D5351 performs write precompensation according to the algorithm outlined in Table 4.

SOFT SECTOR MODE

In the Soft Sector Mode, when WRITE GATE (WG), transitions high and the NRZ input is held low, the SSI 32D5351 automatically generates the 3T (100) Preamble Field at the WRITE DATA ($\overline{WD}$), output. The 3T Preamble Field will continue to be generated until the first low to high transition on the NRZ line. As shown in Figure 8, the first low to high transition occurs with the second bit '1' of the 5_{16} (0101) in the $5EAx_{16}$ Address Mark generation pattern. To generate the Address Mark, the SSI 32D5351 automatically changes the '1' in the eleventh position (see note 3) of the 2, 7 RLL encoded sequence, to a '0'. This generates a pattern of seven zero's followed by two zero's. This unique pattern satisfies the 2, 7 RLL constraints, but will never occur during a normal encoding sequence. The x_{16} of the $5EAx_{16}$ Address Mark generation pattern can be selected, a 'C_{16}' (1100) was utilized in this example.

HARD SECTOR MODE

In the Hard Sector Mode, when WG goes high and the NRZ input is held low, the SSI 32D5351 automatically generates the 4T (1000) Preamble Field at the WRITE DATA, $\overline{WD}$, output. Note that in the Hard Sector mode, the NRZ input is inverted, therefore a constant low is equivalent to an '11 . . .' input which generates the 4T '1000 . . . ' Preamble Field. The 4T Preamble Field will be generated between the time WG goes high and the first low to high transition on the NRZ line. The 32D5351 requires a minimum of 32 4T (1000) bit groups prior to the data field.

NRZ	2, 7 RLL
10	0100
11	1000
000	000100
010	100100
011	001000
0010	00100100
0011	00001000

TABLE 1: 2, 7 RLL Code Set

WG	RG	MODE
0	0	IDLE
0	1	READ
1	0	WRITE
1	1	ILLEGAL

TABLE 2: Mode Control

Ts, NOMINAL WINDOW SHIFT	WSD	$\overline{WS1}$	$\overline{WS0}$
+TS3	0	0	0
+TS2	0	0	1
+TS1	0	1	0
0	0	1	1
-TS3	1	0	0
-TS2	1	0	1
-TS1	1	1	0
0	1	1	1

TABLE 3 : Decode Window Symmetry Control

ENCODED 2, 7 RLL DATA PATTERN							
BIT n - 3	BIT n - 2	BIT n - 1	BIT n	BIT n + 1	BIT n + 2	BIT n + 3	COMPENSATION BIT n
0	0	0	1	0	0	0	none
1	0	0	1	0	0	1	none
1	0	0	1	0	0	0	early
0	0	0	1	0	0	1	late

TABLE 4 : Write Precompensatiom Algorithm

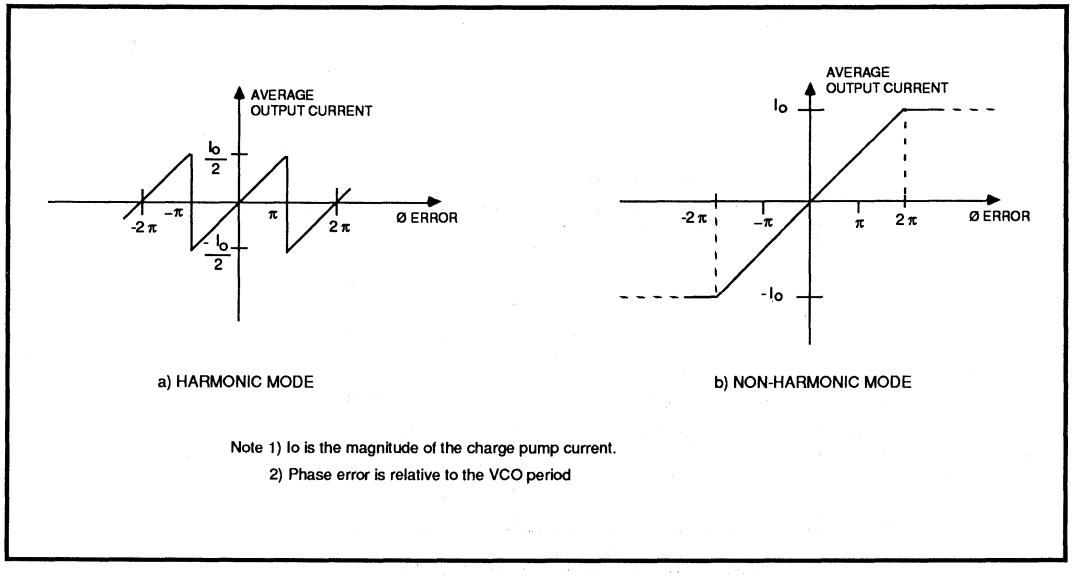


FIGURE 1: Phase Detector Transfer Funtion

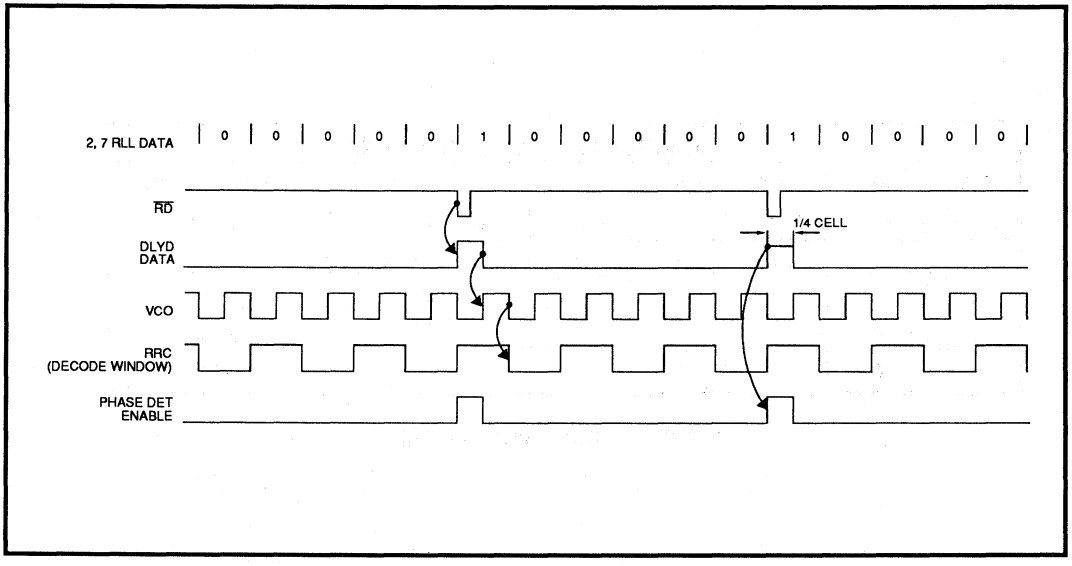


FIGURE 2: Data Synchronization Waveform Diagram

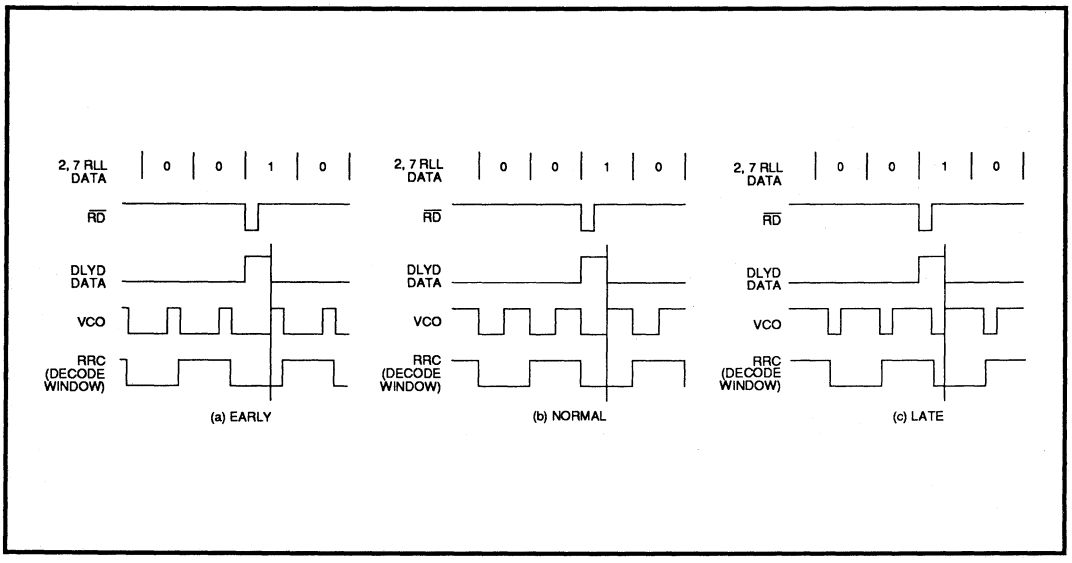


FIGURE 3: Decode Window

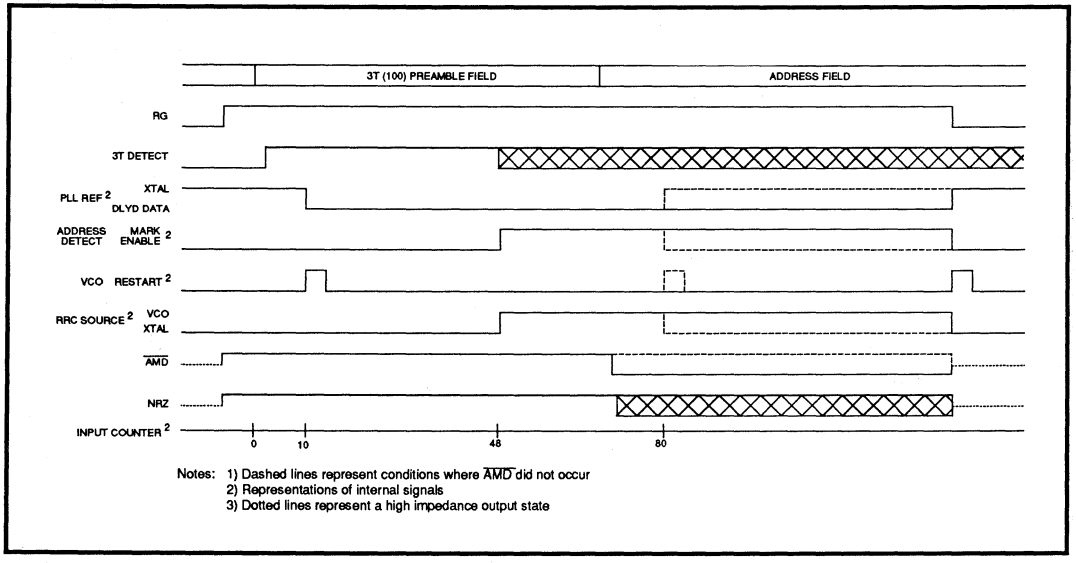


FIGURE 4: Soft Sector Mode Timing Diagram

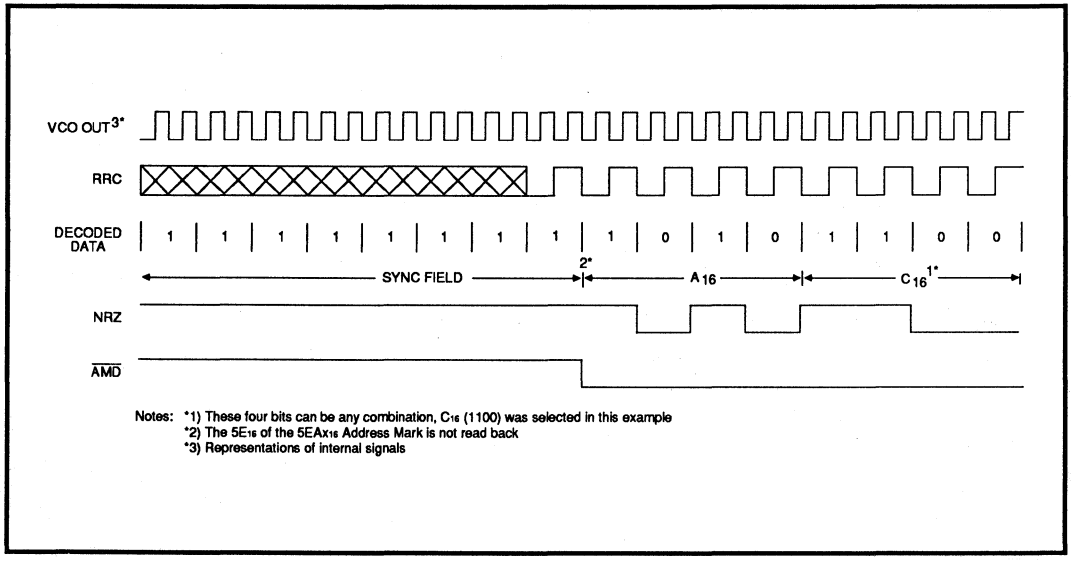


FIGURE 5: Address Mark Detection and NRZ Output Waveform

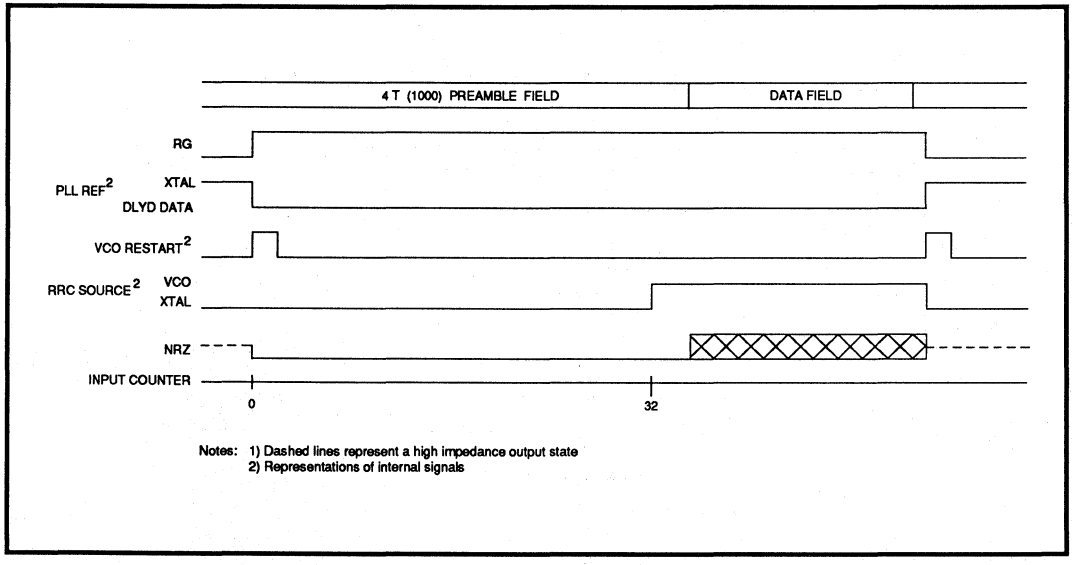


FIGURE 6: Hard Sector Mode Timing Diagram

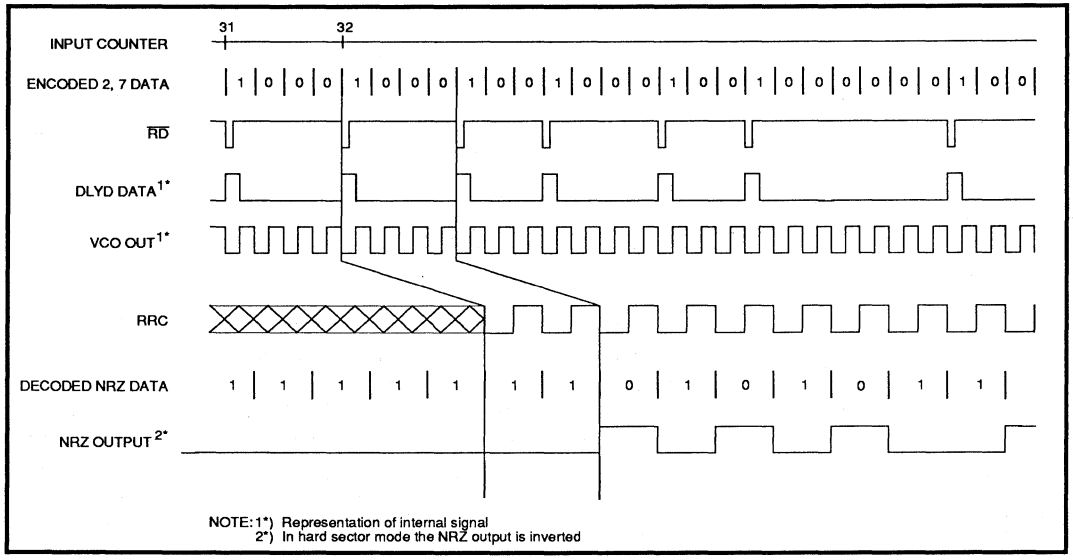


FIGURE 7: Hard Sector Mode Decode Timing

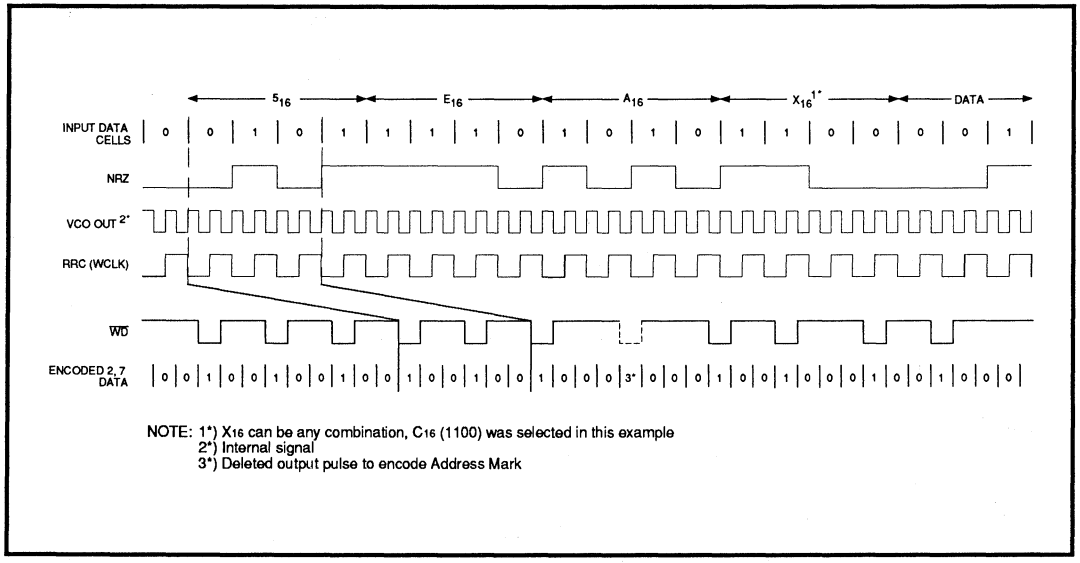


FIGURE 8: Write Address Mark Generation

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATINGS	UNIT
Storage Temperature	-65 to +150	° C
Ambient Operating Temperature, Ta	0 to +70	° C
Junction Operating Temperature, Tj	0 to +130	° C
Supply Voltage, VCC	-0.5 to 7	Vdc
Voltage Applied to Logic inputs	-0.5 to VCC +0.5	Vdc
Maximum Power Dissipation	950	mW

DC ELECTRICAL CHARACTERISTICS - unless otherwise specified, 4.75V < VCC < 5.25V, Ta = 0°C to 70°C, 8 MHz < 1/TORC < 16 MHz, 16 MHz < 1/TVCO < 32 MHz

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
TTL Inputs:					
VIH, High Level Input Voltage		2.0			V
VIHX, XTAL1 High Level Input Voltage	External Reference Clock	2.4			V
VIL, Low Level Input Voltage				0.8	V
IIH, High Level Input Current	VIH = 2.7V			20	µA
IIL, Low Level Input Current	VIL = 0.4V			-0.36	mA
TTL Outputs:					
VOH, High Level Output Voltage	IOH = -400 µA	2.4			V
VOL, Low Level Output Voltage	IOL = 4 mA			0.5	V
Test Point Outputs: $\overline{DRD}$, VCO CLK (See Figure 12)					
VOH, High Level Ouput Voltage	RL= 130Ω to VPD, 200Ω to DGND		VPD-1.00		V
VOL, Low Level Output Voltage	RL= 130Ω to VPD, 200Ω to DGND		VPD-1.75		V
ICC, Power Supply Current	All outputs open			180	mA

DYNAMIC CHARACTERISTICS AND TIMING

READ MODE (See Figure 9)

TRD, Read Data Pulse Width*		20		TORC-40	ns
TFRD, Read Data Fall Time*	2.0V to 0.8V, CL ≤ 15 pF			15	ns
TRRC, Read Clock Rise Time	0.8V to 2.0V, CL ≤ 15 pF			8	ns
TFRC, Read Clock Fall Time	2.0V to 0.8V, CL ≤ 15 pF			5	ns
TPNRZ, NRZ (out) Propagation Delay		-15		15	ns

* Input requirements for pulse detector

READ MODE (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
TPAMD, $\overline{AMD}$ Propagation Delay		-15		15	ns
1/4 Cell + Retriggerable One-Shot Delay Stability	4.75V < VCC < 5.25V	-4		+4	%
1/4 Cell + Retriggerable One-Shot Delay*	TD = 4.37 (RR +0.80) + 0.155 (Cd +Cs)** RR = kΩ Rd = kΩ Cd = 68 pF to 100 pF	0.89TD		1.11TD	ns
*Excludes External Capacitor and Resistor Tolerances, Tested Indirectly. ** Cs = Stray Capacitance [minimized]					

WRITE MODE (See Figure 10)

PARAMETER	CONDITIONS	MIN	MAX	UNIT
TWD, Write Data Pulse Width	CL ≤ 15 pF	(TOWC/2) -1.4 TPC - 12	(TOWC/2) +12	ns
TFWD, Write Data Fall Time	2.0V to 0.8V, CL ≤ 15 pF		8	ns
TRWC, Write Data* Clock Rise Time	0.8V to 2.0V		10	ns
TFWC Write Data* Clock Fall Time	2.0V to 0.8V		8	ns
TSNRZ, NRZ (in) Set Up Time		20		ns
THNRZ, NRZ (in) Hold Time		7		ns
TWDC, Compensated Write Data Pulse Width	CL ≤ 15 pF	(TOWC/2) -2.4 TPC-12		ns
TE, TL, Write Data Compensation Accuracy	TPC = 0.15(Rp)(Cp + Cs) Cp = 15 pF to 36 pF Cs = Stray Capacitance Rp = 1k to 3 kΩ	0.8TPC	1.2TPC	ns

DATA SYNCHRONIZATION

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
TVCO VCO Center Frequency Period	VCO IN = 2.7V TO = 6.59 (RR + 0.53) + 8 VCC = 5.0V 3 kΩ ≤ RR ≤ 8 kΩ	0.8TO		1.2TO	sec
VCO Frequency Dynamic Range	1.0V ≤ VCO IN ≤ VCC -0.6V VCC = 5.0V	±24		±40	%

* Input requirements for write clock

DATA SYNCHRONIZATION (Continued)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
KVCO	VCO Control Gain	$\omega o = 2\pi / TO$ 1.0V ≤ VCO IN ≤ VCC -0.6V	0.14ωo		0.22ωo	rad/s V
KD	Phase Detector Gain	KD = 0.34 / (RR + 900) VCC = 5.0V	0.83KD	1.0 KD	1.17 KD	A/rad
	*KVCO x KD Product Accuracy		-32		+32	%
	*VCO Phase Restart Error			6		ns
	Decode Window Centering Accuracy				± (0.01 TORC + 2)	ns
	Decode Window Size		(TORC/2) -2			ns
TS1	Decode Window Time Shift Magnitude			0.015 TORC		ns
TS2	Decode Window Time Shift Magnitude			0.06 TORC		ns
TS3	Decode Window Time Shift Magnitude			0.075 TORC		ns
TSA	Decode Window Time Shift Magnitude	$TSA = 0.125\,TORC\left(1 - \frac{680+R}{1180+R}\right)$ with: R in ohms				ns

CONTROL CHARACTERISTICS (See Figure 11)

TSWS $\overline{WS0}$, $\overline{WS1}$, WSD Set Up Time		50			ns
THWS $\overline{WS0}$, $\overline{WS1}$, WSD Hold Time		0			ns
RG, WG, SOFT/$\overline{HARD}$ Time Delay				100	ns

REFERENCE CLOCK CHARACTERISTICS

TXPW, Reference Oscillator Pulse Width	Positive pulse width**	12			ns
	Negative pulse width**	12			ns

*not directly testable – design characteristics
**measured at 50% point

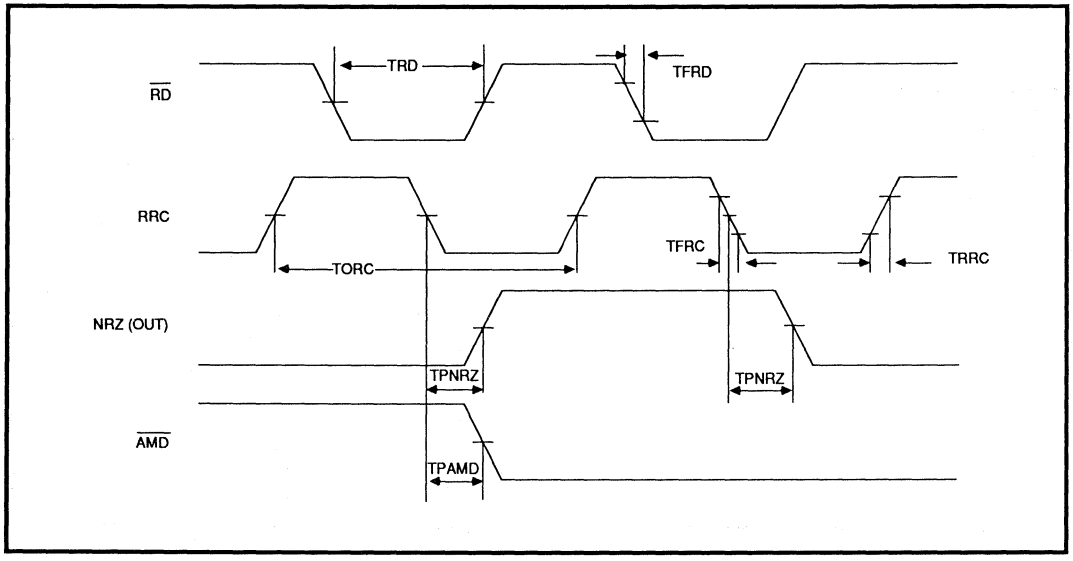


FIGURE 9: Read Timing

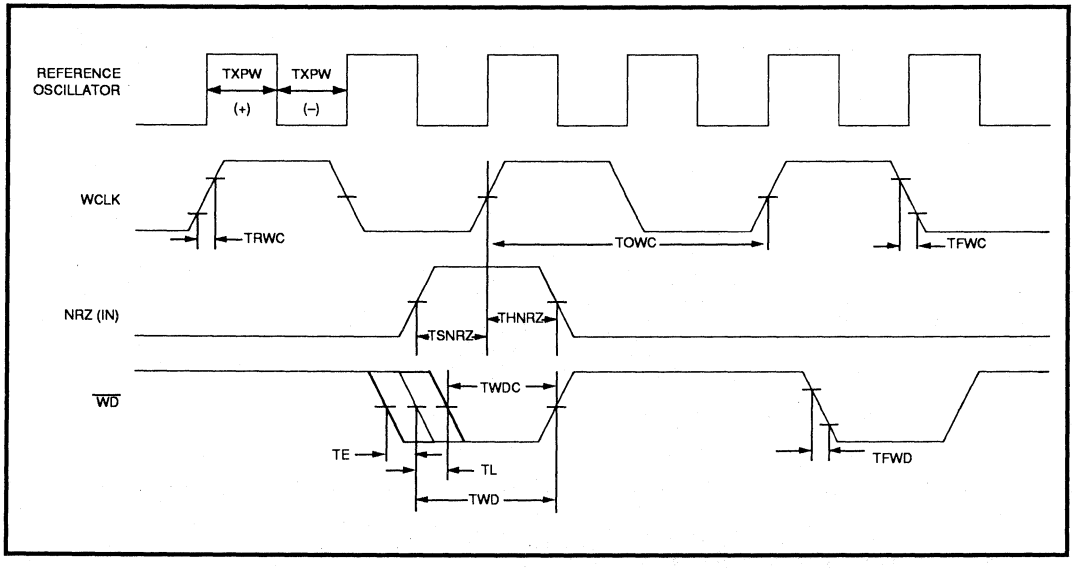


FIGURE 10: Write Timing

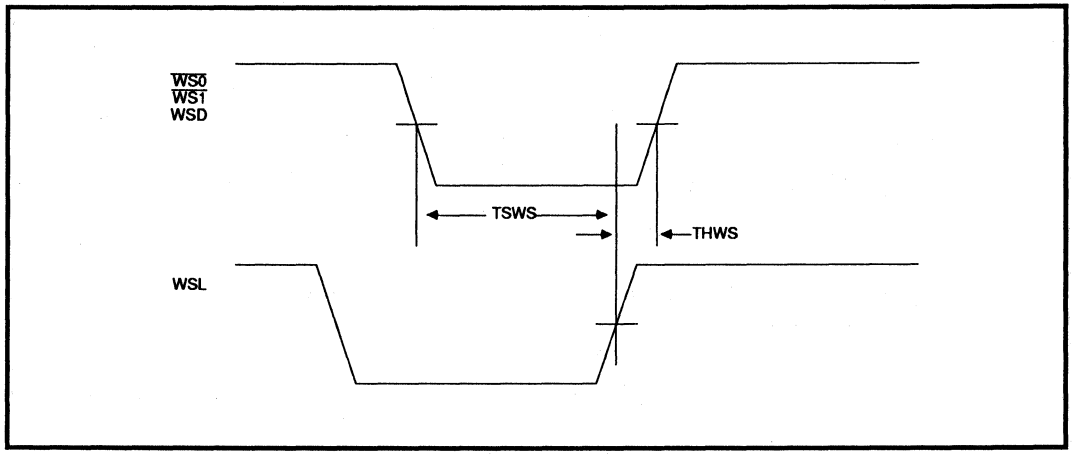


FIGURE 11: Control Timing

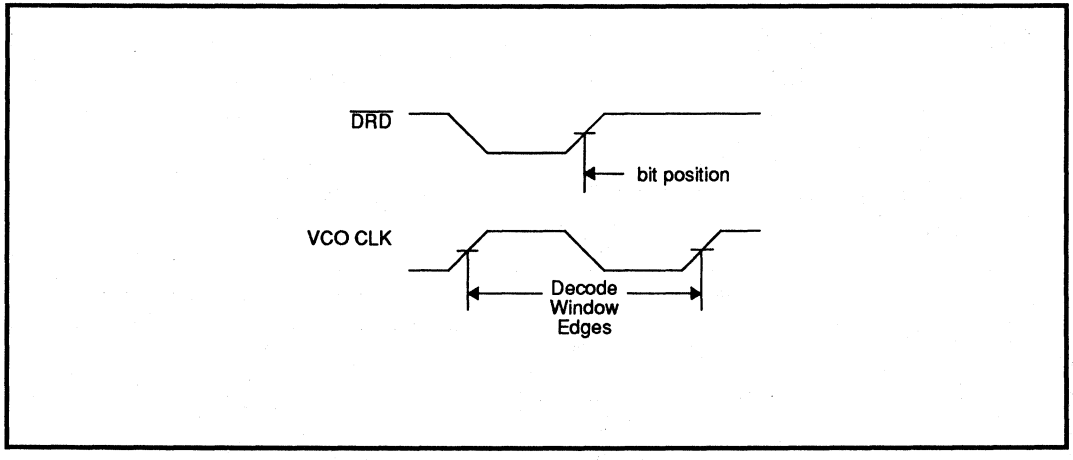


FIGURE 12: Test Point Timing

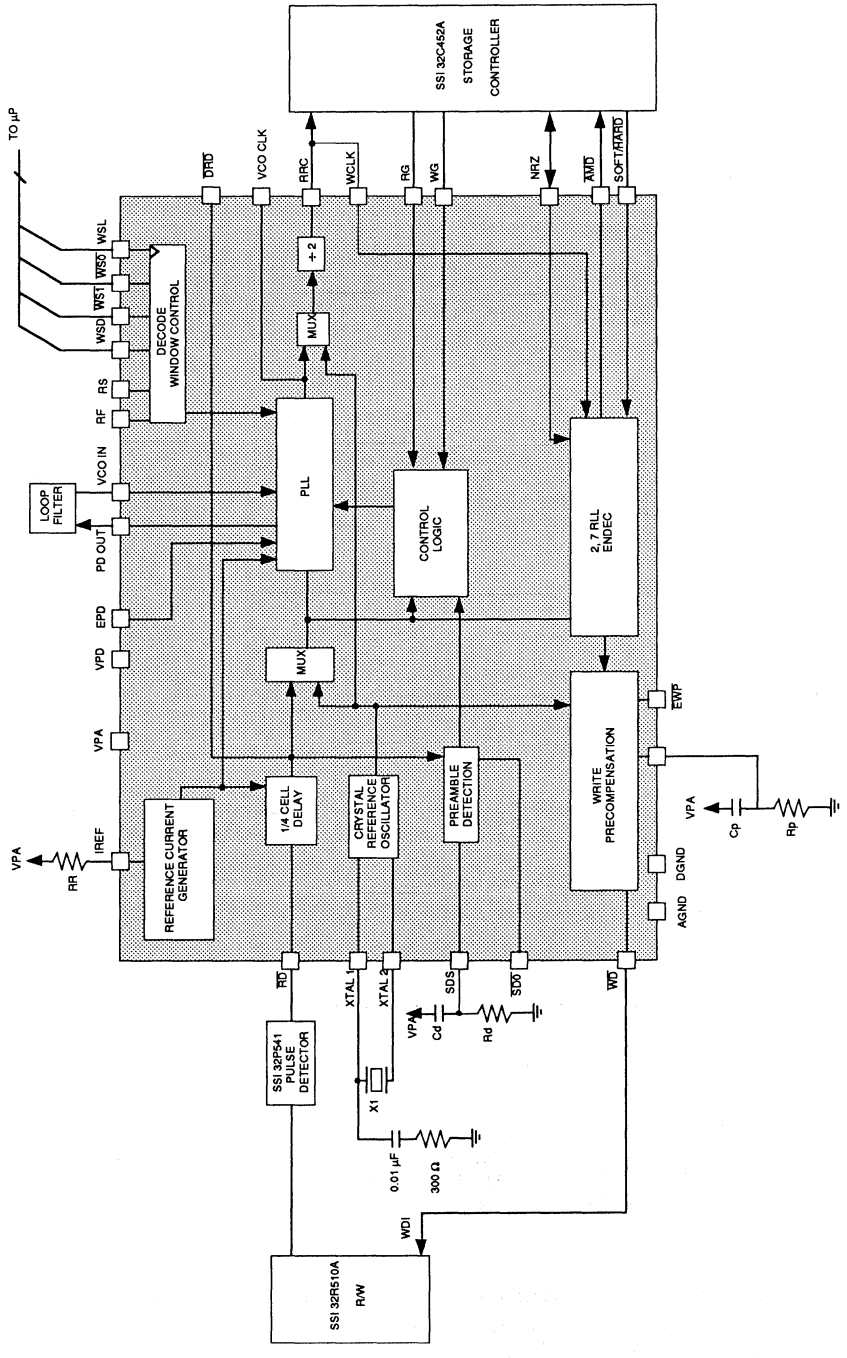
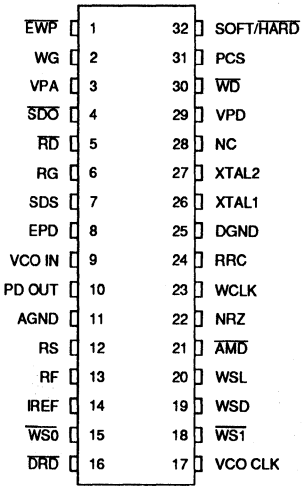


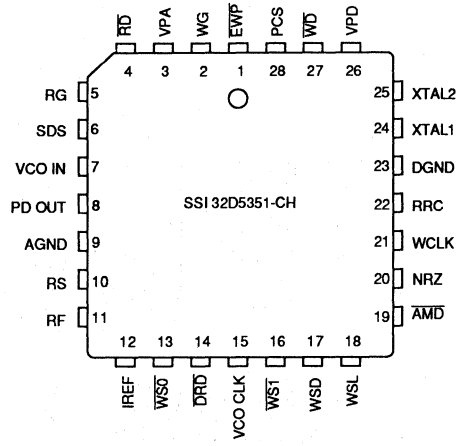
FIGURE 13: Typical SSI 32D5351 Application

SSI 32D5351
Data Synchronizer/ 2, 7 RLL ENDEC with Write Precompensation

PACKAGE PIN DESIGNATIONS
(TOP VIEW)



32-Lead SOW, DIP



28-Pin PLCC

NOTE: Does not include the following pins which are available on the 32-Pin Packages
- SDO
- EPD
- SOFT/HARD (internally pulled up high)

So must be used in soft sector applications only.

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32D5351 32-Pin Small Outline - Wide	SSI 32D5351 - CW	32D5351 - CW
SSI 32D5351 32-Pin Plastic - DIP	SSI 32D5351 - CP	32D5351 - CP
SSI 32D5351 28-Pin Plastic - Quad	SSI 32D5351 - CH	32D5351 - CH

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32D5362A

Data Synchronization/1, 7 RLL ENDEC with Write Precompensation

Preliminary Data

July, 1990

DESCRIPTION

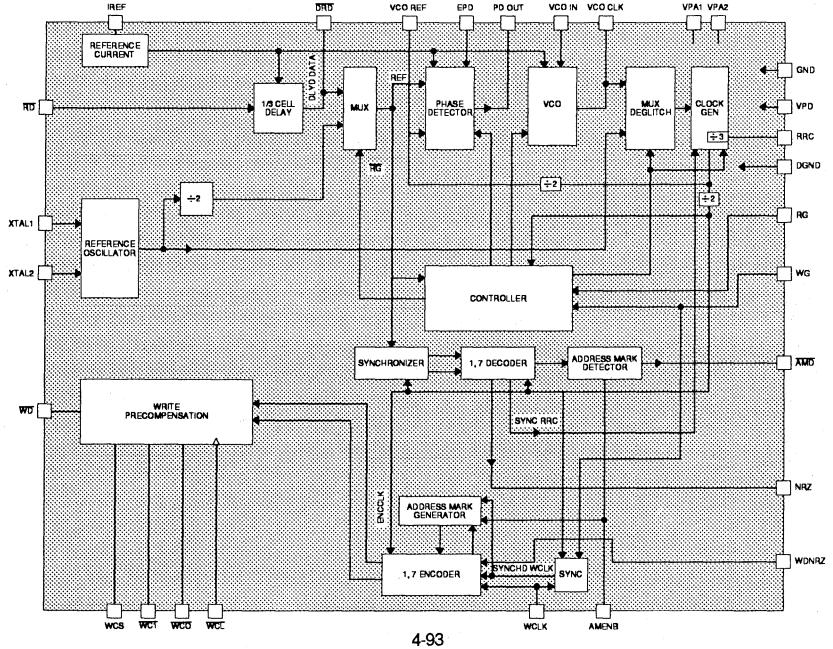
The SSI 32D5362A Data Synchronizer/1, 7 RLL ENDEC provides data recovery and data encoding for storage systems which employ a 1, 7 RLL encoding format. Data synchronization is performed with a fully integrated high performance PLL. A zero phase restart technique is used to minimize PLL acquisition time. The SSI 32D5362A has been optimized for operation as a companion device to the SSI 32C452 and AIC 010 controllers. The VCO frequency setting elements are incorporated within the SSI 32D5362A for enhanced performance and reduced board space. Data rate is established with a single external programming resistor. The SSI 32D5362A utilizes an advanced bipolar process technology which affords precise decode window control without the requirement of an accurate 1/3 cell delay or external devices. The SSI 32D5362A requires a single +5V supply.

FEATURES

- **Data Synchronizer and 1, 7 RLL ENDEC**
- **10 to 20 Mbit/s operation**
  - **Data Rate programmed with a single external resistor**
- **Optimized for operation with the SSI 32C452 and AIC 010 controllers.**
- **Fast acquisition phase lock loop**
  - **Zero phase restart technique**
- **Fully integrated data separator**
  - **No external delay lines or active devices required**
- **Programmable write precompensation**
- **Hard and soft sector operation**
- **Crystal controlled reference oscillator**
- **+5V operation**
- **28-pin PLCC & 28-pin DIP packages**
- **Test outputs - Allow drive margin testing with available test chip**

4

BLOCK DIAGRAM



SSI 32D5362A
Data Synchronization/1, 7 RLL ENDEC with Write Precompensation

OPERATION

The SSI 32D5362A is designed to perform data recovery and data encoding in rotating memory systems which utilize a 1,7 RLL encoding format. In the Read Mode the SSI32D5362A performs Data Synchronization, Sync Field Search and Detect, Address Mark Detect, and Data Decoding. In the Write Mode, the SSI 32D5362A converts NRZ data into the 1,7 RLL format described in Table 1, performs Write Precompensation, generates the Preamble Field, and inserts Address Marks as requested. The interface electronics and architecture of the SSI 32D5362A have been optimized for use as a companion device to the SSI 32C452 or AIC 010 controllers.

The SSI 32D5362A can operate with data rates ranging from 10 to 20 Mbit/s. This data rate is established by a single 1% external resistor, RR, connected from pin IREF to VPA. This resistor establishes a reference current which sets the VCO center frequency, the phase detector gain, and the 1/3 cell delay. The value of this resistor is given by:

$$RR=\frac{92.6}{DR}-2.3(k\Omega)$$

where: DR = Data Rate in Mbit/s.

An internal crystal reference oscillator, operating at three times the data rate, generates the standby reference for the PLL. A series resonant crystal between XTAL1 and XTAL2 should be selected at three times the Data Rate. If a crystal oscillator is not desired, then an external TTL compatible reference may be applied to XTAL1, leaving XTAL2 open.

The SSI 32D5362A employs a Dual Mode Phase Detector; Harmonic in the Read Mode and Non Harmonic in Write and Idle Modes. In the Read Mode the Harmonic Phase Detector updates the PLL with each occurrence of a DYLD DATA pulse. In the Write and Idle modes the Non-Harmonic Phase Detector is continuously enabled, thus maintaining both phase and frequency lock. By acquiring both phase and frequency lock to the crystal reference oscillator and utilizing a zero phase restart technique, false lock to DLYD DATA is eliminated.

The phase detector incorporates a charge pump in order to drive the loop filter directly. The polarity and width of the output current pulses correspond to the direction and magnitude of the phase error.

The READ GATE (RG), and WRITE GATE (WG) inputs control the device mode.

RG is an asynchronous input and may be initiated or terminated at any position on the disk. WG is also an asynchronous input, but should not be terminated prior to the last output Write Data pulse.

READ OPERATION

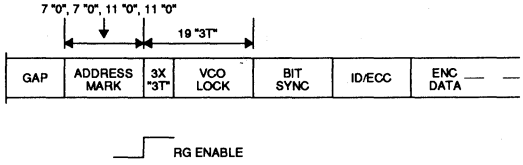
The Data Synchronizer utilizes a fully integrated fast acquisition PLL to accurately develop the decode window. Read Gate, RG, initiates the PLL locking sequence and selects the PLL reference input; a high level (Read Mode) selects the $\overline{RD}$ input and a low level selects the crystal reference oscillator.

In the Read Mode the falling edge of $\overline{DRD}$ enables the Phase Detector while the rising edge is phase compared to the rising edge of the VCO/2. As depicted in Figure 1, $\overline{DRD}$ is a 1/3 cell wide (TVCO) pulse whose leading edge is defined by the leading edge of $\overline{RD}$. An accurate and symmetrical decode window is developed from the VCO/2 clock. By utilizing a fully integrated symmetrical VCO running at three times the data rate, the decode window is insured to be accurate and centered symmetrically about the rising edges of $\overline{DRD}$. The accuracy of the 1/3 cell delay only affects the retrace angle of the phase detector and does not influence the accuracy of the decode window.

In Non-Read Modes, the PLL is locked to the crystal reference oscillator. This forces the VCO to run at a frequency which is very close to that required for tracking actual data and thus minimizes the associated frequency step during acquisition. When the reference input to the PLL is switched, the VCO is stopped momentarily, then restarted in an accurate phase alignment with the next PLL reference input pulse, and the VCO clock divider is reset. By minimizing the phase alignment in this manner (phase error $\leq$ 1 rads), the acquisition time is substantially reduced.

SOFT SECTOR OPERATION

Disk Operation Lock Sequence in Read Mode Soft Sector Operation



ADDRESS MARK DETECT

In Soft Sector Read Operation the SSI 32D5362A must first detect an address mark to be able to initiate the rest of the read lock sequence. An address mark for the SSI 32D5362A consists of two (2) 7 "0" patterns followed by two 11 "0" patterns. To begin the read lock sequence the Address Mark Enable (AMENB) is asserted high by the controller. The SSI 32D536 Address Mark Detect ($\overline{AMD}$) circuitry then initiates a search of the read data ($\overline{RD}$) for an address mark. First the $\overline{AMD}$ looks for a set of 6 "0's" within the 7 "0" patterns. Having detected a 6 "0" the $\overline{AMD}$ then looks for a 9 "0" set within the 11 "0's." If $\overline{AMD}$ does not detect 9 "0's" within 5 $\overline{RD}$ bits after detecting 6 "0's" it will restart the Address Mark Detect sequence and look for 6 "0's." When the $\overline{AMD}$ has acquired a 6 "0," 9 "0" sequence the $\overline{AMD}$ transitions low disabling AMENB input. When AMENB is released, $\overline{AMD}$ will be released by the SSI 32D536.

PREAMBLE SEARCH

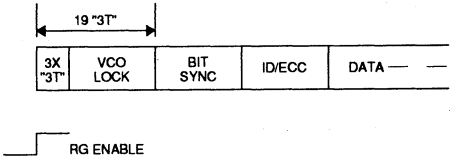
After the Address Mark (AM) has been detected a Read Gate (RG) can be asserted initiating the remainder of the read lock sequence. When RG is asserted an internal counter counts negative transitions of the incoming Read Data ($\overline{RD}$) looking for (3) consecutive 3T preamble. Once the counter reaches count 3 (finds (3) consecutive 3T preamble) the internal read gate enables switching the phase detector from the reference oscillator to the delayed Read Data input ($\overline{DRD}$); at the same time a zero phase (internal) restart signal restarts the VCO in phase with the read reference clock. This prepares the VCO to be synchronized to data when the bit sync circuitry is enabled after VCO lock is established.

VCO LOCK & BIT SYNC ENABLE

When the internal counter counts 16 more "3T" or a total of 19 negative transitions from RG enable, an internal VCO lock signal enables. The VCO lock signal activates the decoder bit synchronization circuitry to define the proper decode boundaries. Also, at count 19, the RRC source switches from the reference oscillator to VCO clock signal which is phase locked to $\overline{DRD}$. The VCO is assumed locked at this point. A maximum of 2 RRC time periods may occur for the RRC transition, however, no short duration glitches will occur. After the bit sync circuitry sets the proper decode window (VCO in sync with RRC and RRC in sync with data) NRZ is enabled and data is toggled in to be decoded for the duration of the read gate.

HARD SECTOR OPERATION

Disk Operation Lock Sequence in Read Mode Hard Sector Operation



In hard sector operation a low AMENB disables the SSI 32D5362A's Address Mark Detection circuitry and $\overline{AMD}$ remains inactive. A hard sector read operation does not require an address mark search but starts with a preamble search as with soft sector and sequences identically. In all respects, with exception to the address mark search sequence, hard sector read operation is the same as soft sector read.

WRITE MODE

In the write mode the SSI 32D5362A converts NRZ data from the controller into 1,7 RLL formatted data for storage on the disk. The SSI 32D5362A can operate with a soft or hard sector hard drive.

In soft sector operation the device generates a "7, 7, 11, 11" Address Mark, and a preamble pattern.

In the hard sector operation the device generates a 3 x "3T" preamble pattern but no preceding Address Mark. Serial NRZ data is clocked into the SSI 32D5362A and latched on defined cell boundaries. The NRZ input data must be synchronous with the

rising edges of the WCLK input. The WCLK input is a feature provided for operation in an ESDI application to compensate for large cable delays. In SCSI or ST506 operation, WCLK is connected directly to the RRC output.

Write precompensation circuitry is provided to compensate for media bit shift caused by intersymbol interference. The SSI 32D5362A recognizes specific write data patterns and can add or subtract delays in the time position of write data bits to counteract the read back bit shift. The magnitude of the time shift, TPC, is determined by an external R C network on the WCS pin given by:

$$TPC = 0.053(Rc)(Cc + Cs)$$

When the write precompensation control latch, $\overline{WCL}$ is low, the SSI 32D5362A performs write precompensation according to the algorithm outlined in Table 3.

SOFT SECTOR

In soft sector operation, when Read Gate (RG) transitions low, VCO source and RRC source switch from $\overline{RD}$ and VCO/3, respectively, to the reference crystal. At the same time the VCO (internal) lock goes inactive but the VCO is locked to the reference crystal. After a delay of 1 NRZ time period (min) from RG low, the Write Gate (WG) can be enabled while WDNRZ is maintained (NRZ write data) low. The Address Mark Enable (AMENB) is made active (high) a minimum of 1 NRZ time period later. The Address Mark (consisting of 7 "0's," 7 "0's," 11 "0's, "11 "0's") and the 3 x "3T" Preamble is then written by $\overline{WDO}$. WDNRZ goes active at this point and after a delay of 5 NRZ time periods begins to toggle out $\overline{WDO}$ encoded data. Finally, at the end of the write cycle, 5 NRZ of blank encoded time passes to insure the encoder is flushed of data; WG then goes low.

HARD SECTOR

In hard sector operation, when read gate (RG) transitions low, VCO source and RRC switch references and VCO lock (internal) goes inactive as with soft sector but the AMENB (address mark enable) is low.

The SSI 32D5362A then sequences from RG disable to WG enable and WDNRZ active as in soft sector operation.

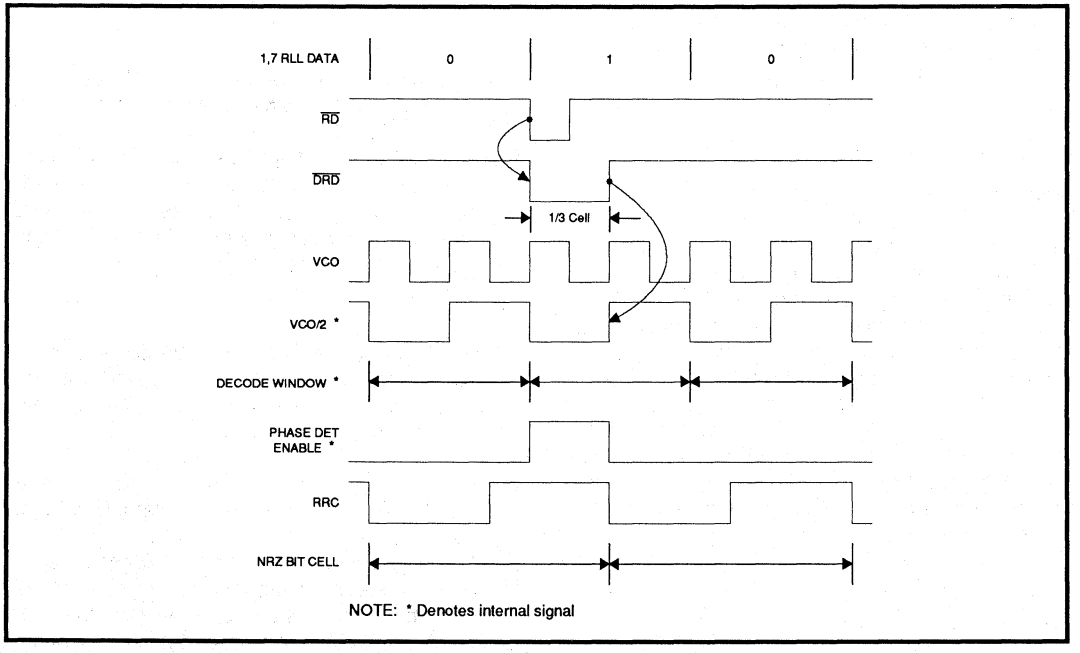


FIGURE 1: Data Synchronization Waveform

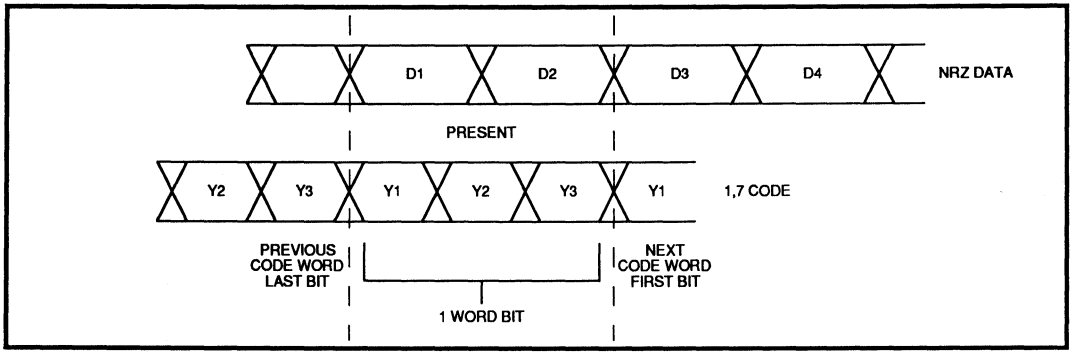


FIGURE 2: NRZ Data Word Comparision to 1, 7 Code Word Bit (See Table 1, for Decode Scheme)

TABLE 1: 1,7 RLL Code Set

PREVIOUS CODE WORD LAST BIT	DATA BITS PRESENT		NEXT		CODE BITS		
X 0	1	0	0	X	1	0	1
X 0	1	0	1	X	0	1	0
X 0	1	1	0	0	0	1	0
X 0	1	1	*	*	1	0	0
1 0	0	0	0	X	0	0	1
1 0	0	0	1	X	0	0	0
0 0	0	1	0	X	0	0	1
0 0	0	1	1	X	0	0	0
X 1	0	0	0	X	0	0	1
X 1	0	0	1	X	0	1	0
X 1	0	1	0	0	0	1	0
X 1	0	1	*	*	0	0	0
Y2 Y3	D1	D2	D3	D4	Y1	Y2	Y3

X = Don't care

* = Not all zeros

TABLE 2: Clock Frequency

WG	RG	VCO REF	RRC	DECCLK	ENCCLK	MODE
0	0	XTAL/2	XTAL/3	XTAL/2	XTAL/2	IDLE
0	1	$\overline{RD}$	VCO/3	VCO/2	XTAL/2	READ
1	0	XTAL/2	XTAL/3	XTAL/2	XTAL/2	WRITE
1	1	XTAL/2	XTAL/3	XTAL/2	XTAL/2	ILLEGAL

Note 1: Until the VCO locks to the new source, the VCO/2 entries will be XTAL/2.

2: Until the VCO locks to the new source, the VCO/3 entries will be XTAL/3.

TABLE 3: Write Precompensation Algorithm

BIT	BIT	BIT	BIT	BIT	COMPENSATION
n-2	n-1	n	n+1	n+2	BIT n
1	0	1	0	1	NONE
0	0	1	0	0	NONE
1	0	1	0	0	EARLY
0	0	1	0	1	LATE

LATE: Bit n is time shifted (delayed) from its nominal time position towards the bit n+1 time position.

EARLY: Bit n is time shifted (advanced) from its nominal time position towards the bit n-1 time position.

TABLE 4: Write Precompensation Magnitude

$\overline{WCI}$	$\overline{WCO}$	MAGNITUDE.WP
0	0	3
0	1	2
1	0	1
1	1	0

The nominal magnitude,
(TPC = WP x 0.053 (Rc) (Cc+Cs), is externally set with an R-C network on pin WCS.

PIN DESCRIPTION

INPUT PINS

NAME	TYPE	DESCRIPTION
$\overline{RD}$	I	READ DATA: Encoded Read Data from the disk drive read channel, active low.
RG	I	READ GATE: Selects the PLL reference input (REF), see Table 1. A change in state on RG initiates the PLL synchronization sequence.
WG	I	WRITE GATE: Enables the write mode, see Table 2.
WCLK	I	WRITE CLOCK: Write Clock input. Must be synchronous with the NRZ Write Data input. For small cable delays, WCLK may be connected directly to pin RRC.
EPD	I	ENABLE PHASE DETECTOR: A low level (Coast Mode) disables the phase detector. This opens the PLL and the VCO will run at the frequency commanded by the voltage on pin VCO IN. Pin EPD has an internal resistor pull up.
AMENB	I	ADDRESS MARK ENABLE: Used to enable the address mark detection and address mark generation circuitry, active high.
$\overline{WC0}$, $\overline{WC1}$	I	WRITE PRECOMPENSATION CONTROL BITS: Pins $\overline{WC1}$, and $\overline{WC0}$ control the magnitude of the write precompensation, see Table 4. Internal resistor pull ups are provided.
$\overline{WCL}$	I	WRITE PRECOMPENSATION CONTROL LATCH: Used to latch the write precompensation control bits $\overline{WC1}$ and $\overline{WC0}$ into the internal DAC. An active low level latches the input bits. Pin $\overline{WCL}$ has an internal resistor pull up.
WDNRZ	I	NRZ WRITE DATA INPUT PIN: This pin can be connected to the NRZ pin to form a bidirectional data port.

OUTPUT PINS

NAME	TYPE	DESCRIPTION
$\overline{WD}$	O	WRITE DATA: Encoded write data output, active low. The data is automatically resynchronized (independent of the delay between RRC and WCLK) to one edge of the XTAL 1 input clock.
RRC	O	READ/REFERENCE CLOCK: A multiplexed clock source used by the controller, see Table 2. During a mode change, no glitches are generated and no more than two lost clock pulses will occur. When RG goes high, RRC is synchronized to the NRZ Read Data after 19 read data pulses.
$\overline{AMD}$	O	ADDRESS MARK DETECT: Tristate output pin that is in its high impedance state when WG is high or AMENB is low. A latched low level output indicates that an address mark has been detected. A low level on pin AMENB resets pin $\overline{AMD}$.

OUTPUT PINS (Continued)

NAME	TYPE	DESCRIPTION
VCO REF	O	VCO REFERENCE: An open emitter ECL output test point. The VCO reference input to the phase detector, the negative edges are phase locked to DLYD DATA. The positive edges of this open emitter output signal indicate the edges of the decode window. Two external resistors are required to perform this test, they should be removed during normal operation for reduced power dissipation.
VCO CLK	O	VCO CLOCK: An open emitter ECL output test point. Two external resistors are required to perform this test. They should be removed during normal operation for reduced power dissipation.
$\overline{\text{DRD}}$	O	DELAYED READ DATA: An open emitter ECL output test point. The positive edges of this open emitter output signal indicates the data bit position. The positive edges of the $\overline{\text{DRD}}$ and the VCO REF signals can be used to estimate window centering. The time jitter of DRD's positive edge is an indication of media bit shift. Two external resistors are required to perform this test. They should be removed during normal operation for reduced power dissipation.
NRZ	O	NRZ READ DATA OUTPUT: Tristate output pin that is enabled when read gate is high. This pin can be connected to the WDNRZ pin to form a bidirectional data port.

ANALOG PINS

NAME	TYPE	DESCRIPTION
IREF	I	TIMING PROGRAM PIN: The VCO center frequency and the 1/3 cell delay are a function of the current sourced into pin IREF.
XTAL1, 2	I	CRYSTAL OSCILLATOR CONNECTIONS: The pin frequency is at three times the data rate. If the crystal oscillator is used, an AC coupled parallel LC circuit must be connected from XTAL1 to ground. If the crystal oscillator is not desired, XTAL1 may be driven by a TTL source with XTAL2 open. The source duty cycle should be close to 50% as possible since its duty cycle will affect the RRC clock duty cycle when XTAL is its source. The additional RRC duty cycle error will be one third the source duty cycle error.
PD OUT	O	PHASE DETECTOR OUTPUT: Drives the loop filter input.
VCO IN	I	VCO CONTROL INPUT: Driven by the loop filter output.
WCS	I	WRITE PRECOMPENSATION SET: Pin for RC network to program write precompensation magnitude value.
DGND, AGND	I	Digital and Analog Ground
VPA1, VPA2	I	Analog +5V Supplies
VPD	I	Digital +5V Supply

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

Operation above maximum ratings may damage the device.

PARAMETER	RATING	UNIT
Storage Temperature	-65 to + 150	°C
Junction Operating Temperature, Tj	0 to +130	°C
Supply Voltage, VPA1, VPA2, VPD	-0.5 to 7	V
Voltage Applied to Logic Inputs	-0.5 to VPD + 0.5	V
Maximum Power Dissipation	1.1	W

RECOMMENDED OPERATING CONDITIONS

PARAMETER	RATING	UNIT
Supply Voltage, VPA1 = VPA2 = VPD = VCC	4.75 < VCC < 5.25	V
Ambient Operating Temperature, TA	0 < TA < +70	°C

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, 4.75V< VCC <5.25V, 10 MHz< 1/TORC <20 MHz, 30 MHz< 1/TVCO <60 MHz, TA = 0°C to 70°C

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
VIH	High Level Input Voltage		2.0			V
VIL	Low Level Input Voltage				0.8	V
IIH	High Level Input Current	VIH = 2.7V			2.0	µA
IIL	Low Level Input Current	VIL = 0.4V			-1.5	mA
VOH	High Level Output Voltage	IOH = 400 µA	2.4			V
VOL	Low Level Output Voltage	IOL = 4 mA			0.5	V
ICC	Power Supply Current	All outputs open,* TA = 70 °C			240	mA
PWR	Power Dissipation	TA = 70 °C, test point* pins open			1.1	W

* WG, RG ***CANNOT*** both be high

ELECTRICAL CHARACTERISTICS (Continued)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
VOHT*	Test Point Output High Level $\overline{DRD}$, VCO CLK, VCO REF	262Ω to VPD 402Ω to GND VPD = 5.0V VOHT - VPD		-0.85		V
VOLT*	Test Point Output Low Level $\overline{DRD}$, VCO CLK, VCO REF	262Ω to VPD 402Ω to GND VPD = 5.0V VOLT - VPD		-1.75		V

* Monitor points only - Not tested

DYNAMIC CHARACTERISTICS AND TIMING

READ MODE (See Figure 3)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TRD	Read Data Pulse Width		15		TORC-20	ns
TFRD	Read Data Fall Time	2.0V to 0.8V, $C_L \leq 15$ pF			15	ns
TRRC	Read Clock Rise Time	0.8V to 2.0V, $C_L \leq 15$ pF			8	ns
TFRC	Read Clock Fall Time	2.0V to 0.8V, $C_L \leq 15$ pF			5	ns
TPNRZ	NRZ (out) Set Up/Hold Time		0.31 TORC			ns
	1/3 Cell Delay	TD = 5.05E - 12(RR + 530)	0.8TD		1.2TD	ns

WRITE MODE (See Figure 4)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TWD	Write Data Pulse Width	$C_L \leq 15$ pF	See Note 1		See Note 2	ns
TFWD	Write Data Fall Time	2.0V to 0.8V, $C_L \leq 15$ pF			8	ns
TRWC**	Write Data Clock Rise Time	0.8V to 2.0V			10	ns
TFWC**	Write Data Clock Fall Time	2.0V to 0.8V			8	ns
TSNRZ	WDNRZ Set up Time		5			ns
THNRZ	WDNRZ Hold Time		5			ns

Note 1: $\frac{2}{3}TOWC - 5 - 4.76TPCO - TPC$

Note 2: $\frac{2}{3}TOWC + 10 - 4.76TPCO - TPC$

** **INPUT** requirement - Not tested

WRITE MODE (Continued)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TPC	Precompensation Time Shift Magnitude Accuracy	TPCO=0.053 (Cc+Cs) (Rc) Rc=1k to 2k Cs=stray capacity $\overline{WC0}$ = 1 $\overline{WC1}$ = 1				ns
		$\overline{WC0}$ = 0 $\overline{WC1}$ = 1		TPCO		ns
		$\overline{WC0}$ = 1 $\overline{WC1}$ = 0		(2)TPCO		ns
		$\overline{WC0}$ = 0 $\overline{WC1}$ = 0		(3)TPCO		ns

DATA SYNCHRONIZATION

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TVCO	VCO Center Frequency Period	VCO IN = 2.7V TO = 3.6E -12(RR + 2300) VCC = 5.0V RR = 3.5k to 5.7k	0.8 TO		1.2 TO	ns
	VCO Frequency Dynamic Range	1V ≤ VCO IN ≤ VCC-0.6V VCC = 5.0	±25		±45	%
KVCO	VCO Control Gain	ωo = 2π/TO 1V ≤ VCO IN ≤ VCC 0.6V	0.14 ωo		0.26 ωo	rad/s-V
KD**	Phase Detector Gain	KD = 0.19/(RR + 530) VCC = 5.0V, PLL REF = $\overline{RD}$ 3T ("100") pattern	0.83 KD		1.17 KD	A/rad
*KVCO	*KD Product Accuracy		-28		-28	%
*VCO	Phase Restart Error			6		ns
Decode Window Centering Accuracy					±2	ns
Decode Window			(2TORC/3) - 3			ns

CONTROL CHARACTERISTICS (See Figure 5)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TSWS	$\overline{WC0}$, $\overline{WC1}$ SET UP TIME		50			ns
THWS	$\overline{WC0}$, $\overline{WC1}$ HOLD TIME		0			ns

*Not directly testable - Design characteristic

** Indirectly tested

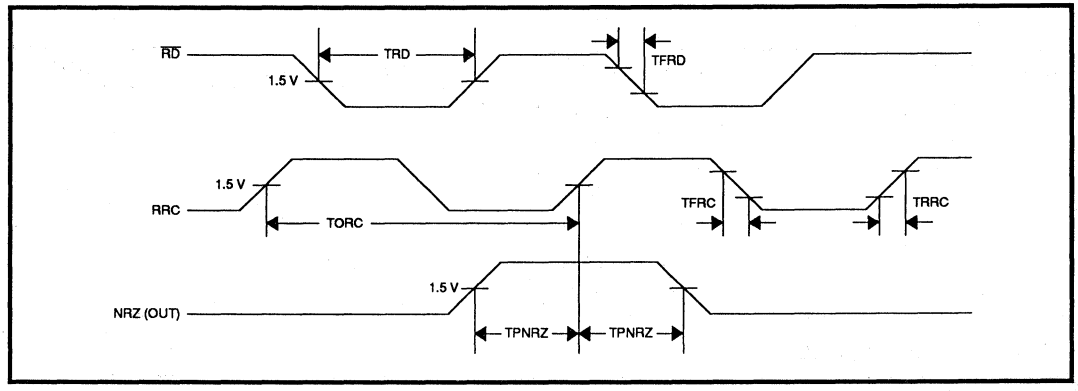


FIGURE 3: Read Timing

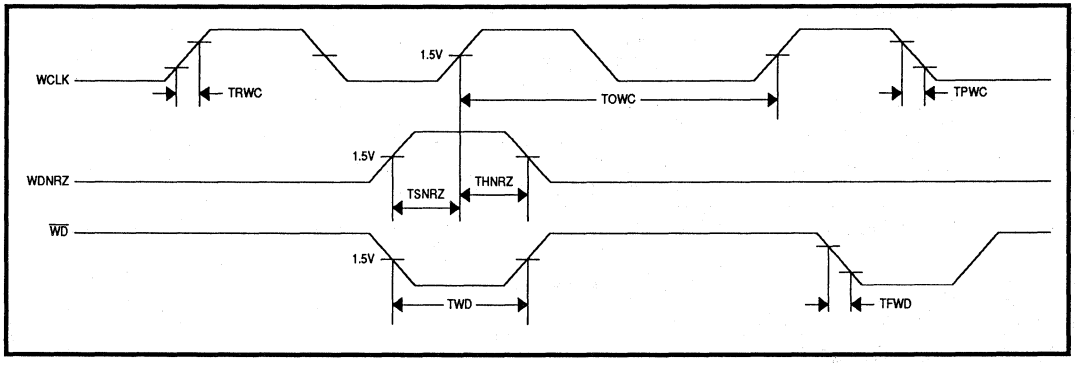


FIGURE 4: Write Timing

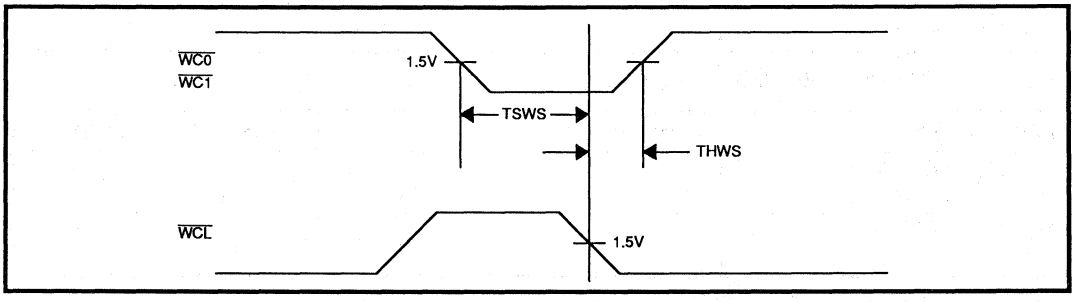


FIGURE 5: Control Timing

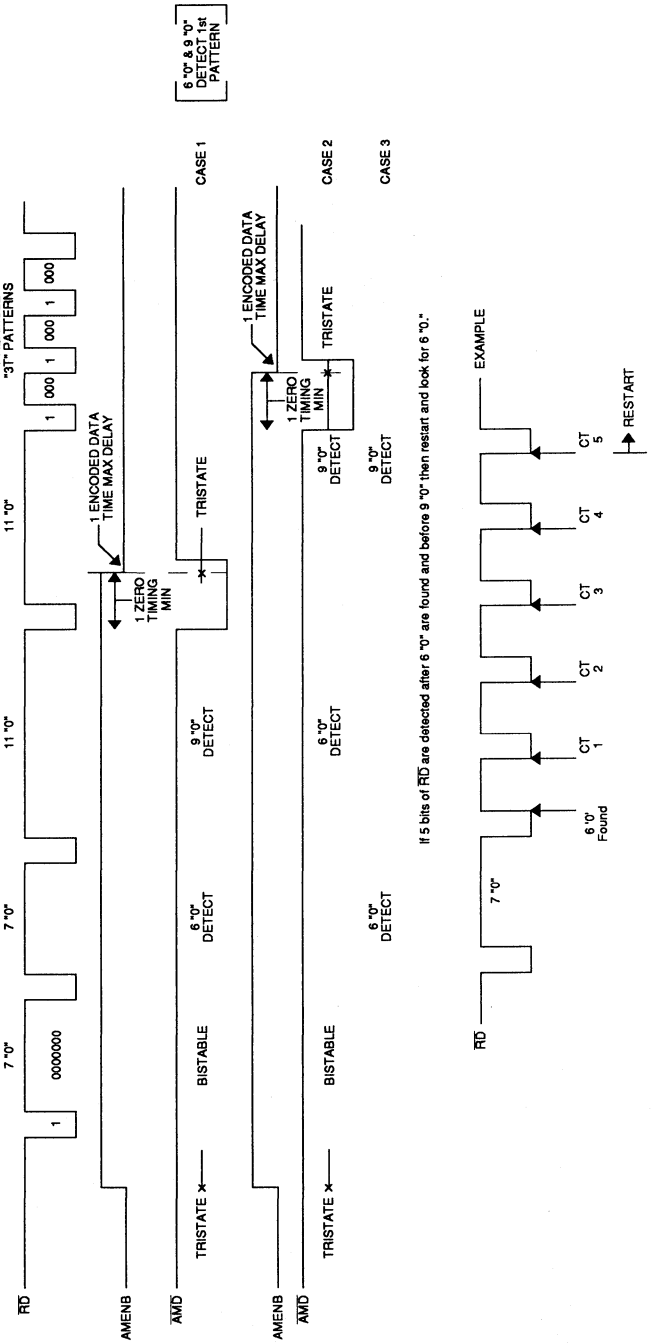


FIGURE 6: Address Mark Search

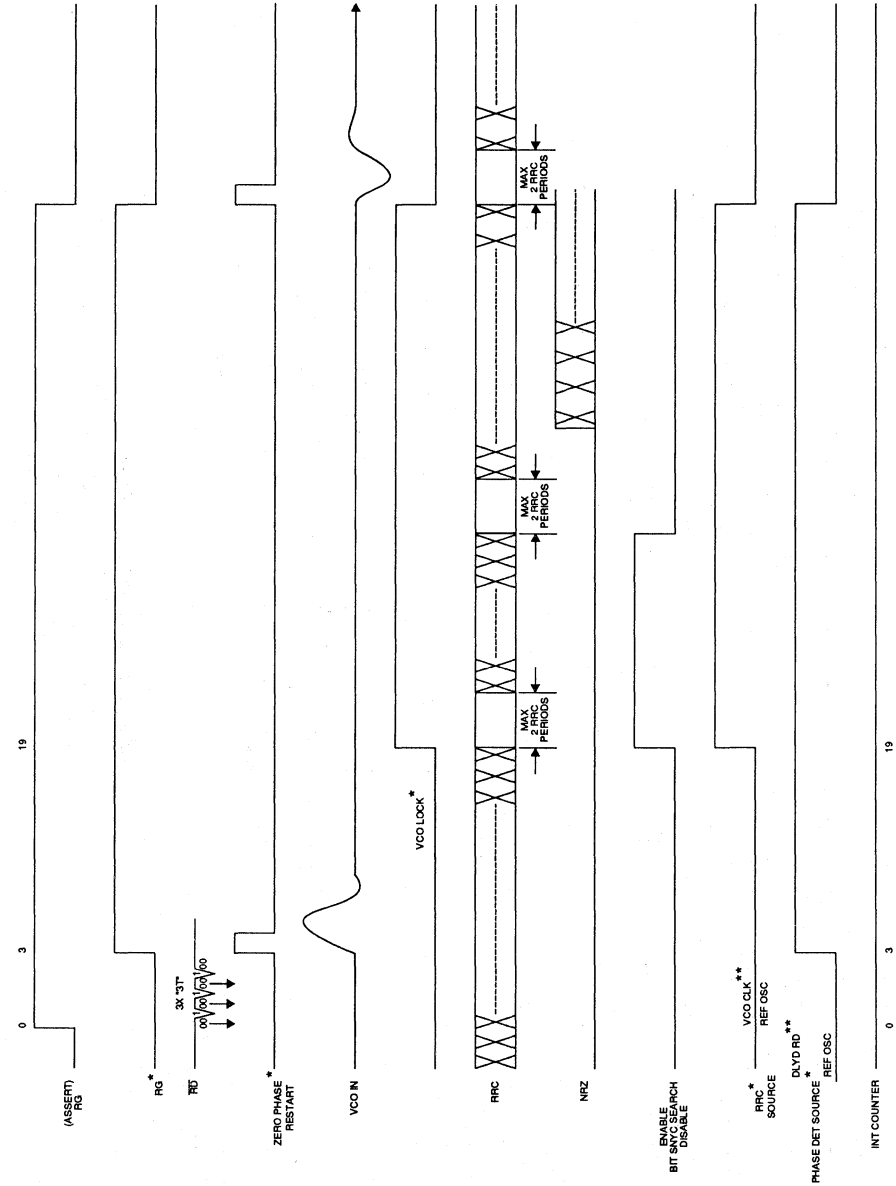


FIGURE 7: Read Mode Locking Sequence (Soft and Hard Sector)

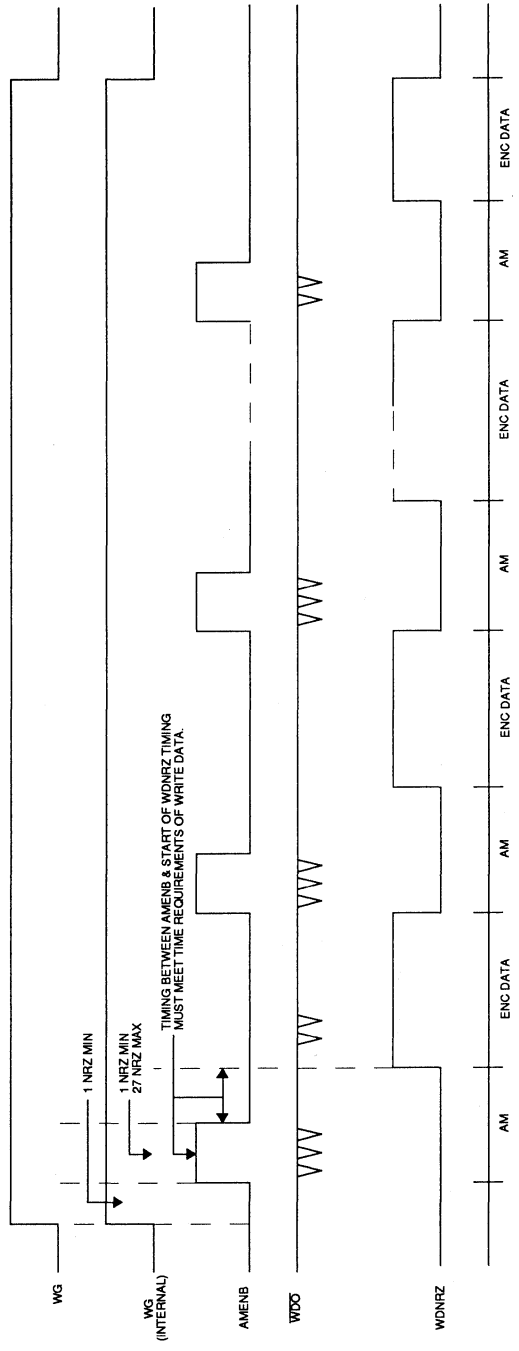


FIGURE 8: Multiple Address Mark Write

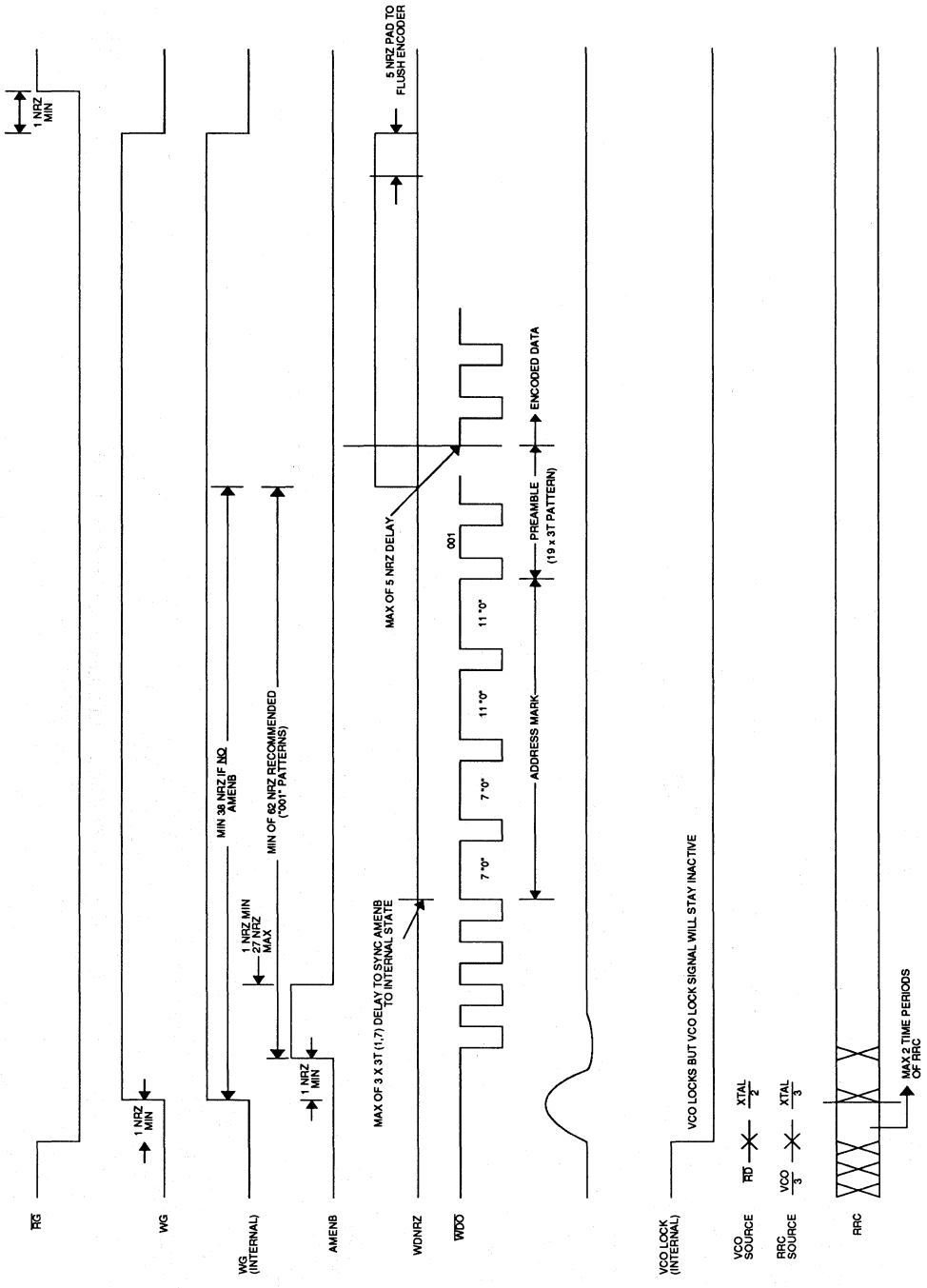
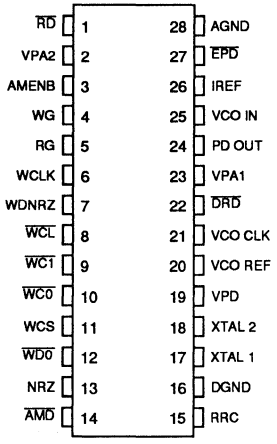


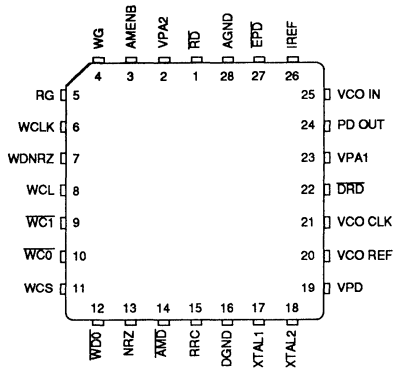
FIGURE 9: Write Data

PACKAGE PIN DESIGNATIONS
(TOP VIEW)

CAUTION: Use handling procedures necessary for a static sensitive component.



28-Pin DIP



28-Pin PLCC

4

ORDERING INFORMATION

PART DESCRIPTION	ORDERING NUMBER	PACKAGE MARK
SSI 32D5362A		
28-Pin DIP	SSI 32D5362A-CP	SSI 32D5362A-CP
28-Pin PLCC	SSI 32D5362A-CH	SSI 32D5362A-CH

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32D5371/5372

Data Synchronization/1, 7 RLL ENDEC with Write Precompensation

Advance Information

July, 1990

DESCRIPTION

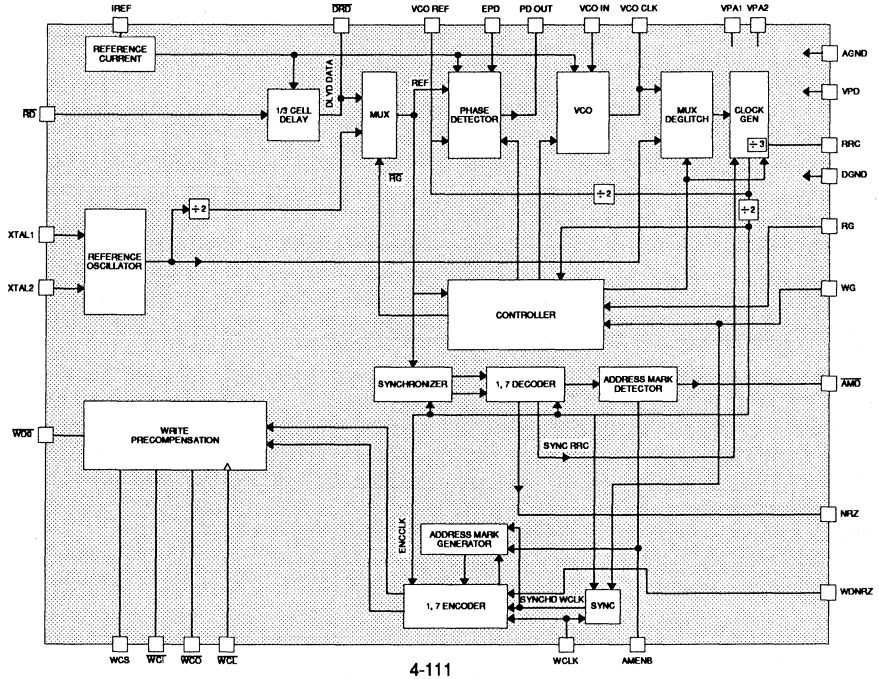
The SSI 32D5371/5372 Data Synchronizer/1, 7 RLL ENDEC provides data recovery and data encoding for storage systems which employ a 1, 7 RLL encoding format. Data synchronization is performed with a fully integrated high performance PLL. A zero phase restart technique is used to minimize PLL acquisition time. The SSI 32D5371/5372 has been optimized for operation as a companion device to the SSI 32C452 and AIC 010 controllers. The VCO frequency setting elements are incorporated within the SSI 32D5371/5372 for enhanced performance and reduced board space. Data rate is established with a single external programming resistor. The SSI 32D5371/5372 utilizes an advanced bipolar process technology which affords precise decode window control without the requirement of an accurate 1/3 cell delay or external devices. The SSI 32D5371/5372 requires a single +5V supply.

FEATURES

- **32D5371 – ECL RD Input Option**
- **32D5372 – TTL $\overline{RD}$ Input Option**
- **Data Synchronizer and 1, 7 RLL ENDEC**
- **10 to 24 Mbit/s operation - Data Rate programmed with a single external resistor**
- **Optimized for operation with the SSI 32C452 and AIC 010 controllers.**
- **Fast acquisition phase lock loop**
  - **Zero phase restart technique**
- **Fully integrated data separator**
  - **No external delay lines or active devices required**
- **Programmable write precompensation**
- **Hard and soft sector operation**
- **Crystal controlled reference oscillator**
- **+5V operation**
- **28-Pin PLCC & 28-Pin DIP packages**
- **Test outputs - Allow drive margin testing**

4

BLOCK DIAGRAM



SSI 32D5371/5372
Data Synchronization/1, 7 RLL ENDEC with Write Precompensation

OPERATION

The SSI 32D5371/5372 is designed to perform data recovery and data encoding in rotating memory systems which utilize a 1,7 RLL encoding format. In the Read Mode the SSI 32D5371/5372 performs Data Synchronization, Sync Field Search and Detect, Address Mark Detect, and Data Decoding. In the Write Mode, the SSI 32D5371/5372 converts NRZ data into the 1,7 RLL format described in Table 1, performs Write Precompensation, generates the Preamble Field, and inserts Address Marks as requested. The interface electronics and architecture of the SSI32D5371/5372 have been optimized for use as a companion device to the SSI 32C452 or AIC 010 controllers.

The SSI 32D5371/5372 can operate with data rates ranging from 10 to 24 Mbit/s. This data rate is established by a single 1% external resistor, RR, connected from pin IREF to VPA2. This resistor establishes a reference current which sets the VCO center frequency, the phase detector gain, and the 1/3 cell delay. The value of this resistor is given by:

$$RR = \frac{92.6}{DR} - 1.7\ (k\Omega)$$

where: DR = Data Rate in Mbit/s.

An internal crystal reference oscillator, operating at three times the data rate, generates the standby reference for the PLL. A series resonant crystal between XTAL1 and XTAL2 should be selected at three times the Data Rate. If a crystal oscillator is not desired, then either an attenuated external TTL compatible reference or an AC coupled ECL source may be applied to XTAL1, leaving XTAL2 open.

The SSI 32D5371/5372 employs a Dual Mode Phase Detector; Harmonic in the Read Mode and Non Harmonic in Write and Idle Modes. In the Read Mode the Harmonic Phase Detector updates the PLL with each occurrence of a DYLD DATA pulse. In the Write and Idle modes the Non-Harmonic Phase Detector is continuously enabled, thus maintaining both phase and frequency lock. By acquiring both phase and frequency lock to the crystal reference oscillator and utilizing a zero phase restart technique, false lock to DLYD DATA is eliminated.

The phase detector incorporates a charge pump in order to drive the loop filter directly. The polarity and width of the output current pulses correspond to the direction and magnitude of the phase error.

The READ GATE (RG), and WRITE GATE (WG) inputs control the device mode.

RG is an asynchronous input and may be initiated or terminated at any position on the disk. WG is also an asynchronous input, but should not be terminated prior to the last output Write Data pulse.

READ OPERATION

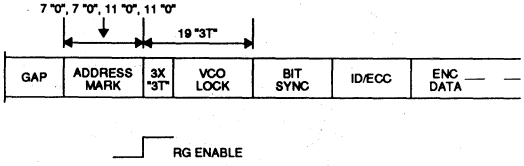
The Data Synchronizer utilizes a fully integrated fast acquisition PLL to accurately develop the decode window. Read Gate, RG, initiates the PLL locking sequence and selects the PLL reference input; a high level (Read Mode) selects the $\overline{RD}$ input and a low level selects the crystal reference oscillator.

In the Read Mode the falling edge of $\overline{DRD}$ enables the Phase Detector while the rising edge is phase compared to the rising edge of the VCO/2. As depicted in Figure 1, $\overline{DRD}$ is a 1/3 cell wide (TVCO) pulse whose leading edge is defined by the leading edge of $\overline{RD}$. An accurate and symmetrical decode window is developed from the VCO/2 clock. By utilizing a fully integrated symmetrical VCO running at three times the data rate, the decode window is insured to be accurate and centered symmetrically about the rising edges of $\overline{DRD}$. The accuracy of the 1/3 cell delay only affects the retrace angle of the phase detector and does not influence the accuracy of the decode window.

In Non-Read Modes, the PLL is locked to the crystal reference oscillator. This forces the VCO to run at a frequency which is very close to that required for tracking actual data and thus minimizes the associated frequency step during acquisition. When the reference input to the PLL is switched, the VCO is stopped momentarily, then restarted in an accurate phase alignment with the next PLL reference input pulse, and the VCO clock divider is reset. By minimizing the phase alignment in this manner (phase error $\leq$ 1 rads), the acquisition time is substantially reduced.

SOFT SECTOR OPERATION

Disk Operation Lock Sequence in Read Mode Soft Sector Operation



ADDRESS MARK DETECT

In Soft Sector Read Operation the SSI 32D5371/5372 must first detect an address mark to be able to initiate the rest of the read lock sequence. An address mark for the SSI 32D5371/5372 consists of two (2) 7 "0" patterns followed by two 11 "0" patterns. To begin the read lock sequence the Address Mark Enable (AMENB) is asserted high by the controller. The SSI32D5371/5372 Address Mark Detect ($\overline{AMD}$) circuitry then initiates a search of the read data ($\overline{RD}$) for an address mark. First the $\overline{AMD}$ looks for a set of 6 "0's" within the 7 "0" patterns. Having detected a 6 "0" the $\overline{AMD}$ then looks for a 9 "0" set within the 11 "0's". If $\overline{AMD}$ does not detect 9 "0's" within 5 $\overline{RD}$ bits after detecting 6 "0's" it will restart the Address Mark Detect sequence and look for 6 "0's." When the $\overline{AMD}$ has acquired a 6 "0," 9 "0" sequence the $\overline{AMD}$ transitions low. $\overline{AMD}$ will remain low for the duration of AMENB. When AMENB is released, $\overline{AMD}$ will be released by the SSI 32D5371/5372.

PREAMBLE SEARCH

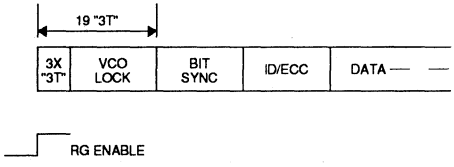
After the Address Mark (AM) has been detected a Read Gate (RG) can be asserted initiating the remainder of the read lock sequence. When RG is asserted an internal counter counts transitions of the incoming Read Data, (positive transitions for RD ECL, negative transitions for $\overline{RD}$ TTL. Once the counter reaches count 3 (finds (3) consecutive 3T preamble) the internal read gate enables switching the phase detector from the reference oscillator to the delayed Read Data input ($\overline{DRD}$); at the same time a zero phase (internal) restart signal restarts the VCO in phase with the $\overline{DRD}$. This prepares the VCO to be synchronized to data when the bit sync circuitry is enabled after VCO lock is established.

VCO LOCK & BIT SYNC ENABLE

When the internal counter counts 16 more "3T" or a total of 19 read data transitions from RG enable, an internal VCO lock signal enables. The VCO lock signal activates the decoder bit synchronization circuitry to define the proper decode boundaries. Also, at count 19, the RRC source switches from the reference oscillator to the VCO clock signal which is phase locked to $\overline{DRD}$. The VCO is assumed locked at this point. A maximum of 2 RRC time periods may occur for the RRC transition, however, no short duration glitches will occur. After the bit sync circuitry sets the proper decode window (VCO in sync with RRC and RRC in sync with data) NRZ is enabled and data is toggled in to be decoded for the duration of the read gate.

HARD SECTOR OPERATION

READ MODE



In hard sector operation a low AMENB disables the SSI 32D5371/5372's Address Mark Detection circuitry and $\overline{AMD}$ remains inactive. A hard sector read operation does not require an address mark search but starts with a preamble search as with soft sector and sequences identically. In all respects, with exception to the address mark search sequence, hard sector read operation is the same as soft sector read.

WRITE MODE

In the write mode the SSI 32D5371/5372 converts NRZ data from the controller into 1,7 RLL formatted data for storage on the disk. The SSI 32D5371/5372 can operate with a soft or hard sector hard drive.

In soft sector operation the device generates a "7, 7, 11, 11" Address Mark, and a preamble pattern.

In the hard sector operation the device generates a 19 x "3T" preamble pattern but no preceding Address Mark. Serial NRZ data is clocked into the SSI 32D5371/5372 and latched on defined cell boundaries. The NRZ

input data must be synchronous with the rising edges of the WCLK input. The WCLK input is a feature provided for operation in an ESDI application to compensate for large cable delays. In SCSI or ST506 operation, WCLK is connected directly to the RRC output.

Write precompensation circuitry is provided to compensate for media bit shift caused by intersymbol interference. The SSI 32D5371/5372 recognizes specific write data patterns and can add or subtract delays in the time position of write data bits to counteract the read back bit shift. The magnitude of the time shift, TPC, is determined by a combination of the RR value and of an external resistor on the PCS pin.

The SSI 32D5371/5372 performs write precompensation according to the algorithm outlined in Table 3.

SOFT SECTOR

In soft sector operation, when Read Gate (RG) transitions low, VCO source and RRC source switch from $\overline{RD}$ and VCO/3, respectively, to the reference crystal. At the same time the VCO (internal) lock goes inactive but the VCO is locked to the reference crystal. After a delay of 1 NRZ time period (min) from RG low, the Write Gate (WG) can be enabled while WDNRZ is maintained (NRZ write data) low. The Address Mark Enable (AMENB) is made active (high) a minimum of 1 NRZ time period later. The Address Mark (consisting of 7 "0's," 7 "0's," 11 "0's, "11 "0's") and the 19 x "3T" Preamble is then written by $\overline{WDO}$. WDNRZ goes active at this point and after a delay of 5 NRZ time periods begins to toggle out $\overline{WDO}$ encoded data. Finally, at the end of the write cycle, 5 NRZ of blank encoded time passes to insure the encoder is flushed of data; WG then goes low.

HARD SECTOR

In hard sector operation, when read gate (RG) transitions low, VCO source and RRC switch references and VCO lock (internal) goes inactive as with soft sector but the AMENB (address mark enable) is kept low.

The SSI 32D5371/5372 then sequences from RG disable to WG enable and WDNRZ active as in soft sector operation.

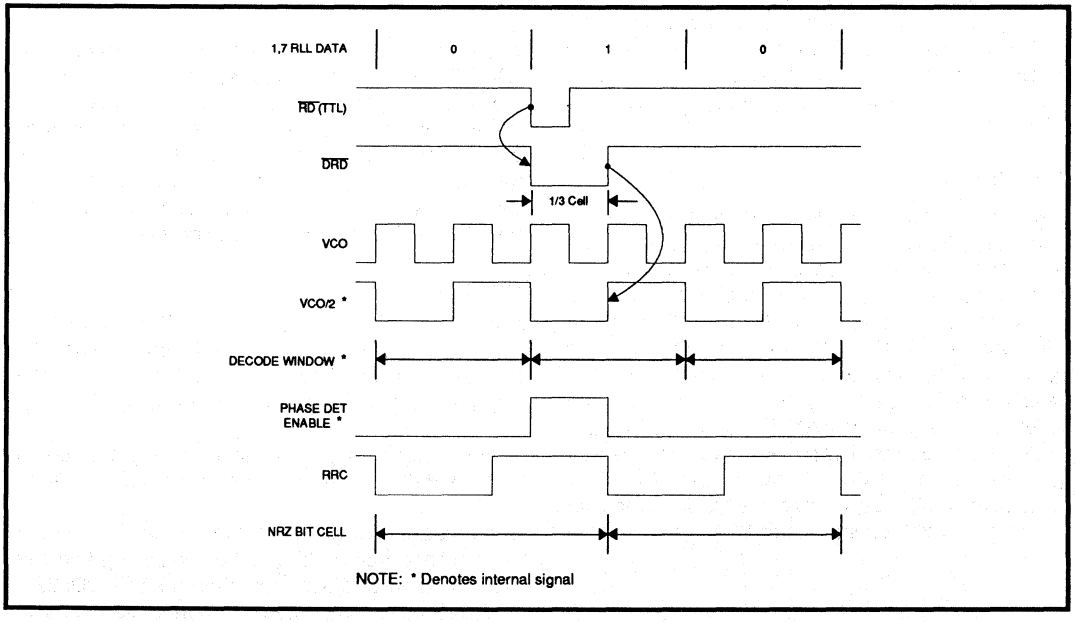


FIGURE 1: Data Synchronization Waveform

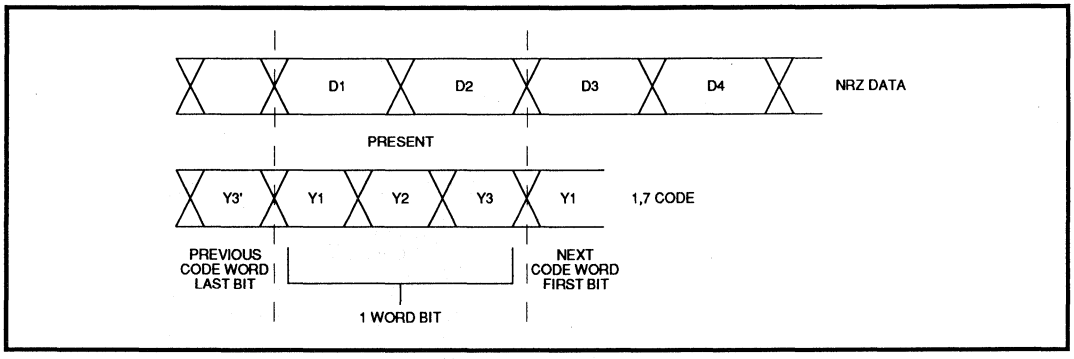


FIGURE 2: NRZ Data Word Comparision to 1, 7 Code Word Bit (See Table 1, for Decode Scheme)

TABLE 1: 1, 7 RLL Code Set

PREVIOUS CODE WORD LAST BITS		DATA BITS PRESENT		NEXT		CODE BITS		
X	0	1	0	0	X	1	0	1
X	0	1	0	1	X	0	1	0
X	0	1	1	0	0	0	1	0
X	0	1	1	*	*	1	0	0
1	0	0	0	0	X	0	0	1
1	0	0	0	1	X	0	0	0
0	0	0	1	0	X	0	0	1
0	0	0	1	1	X	0	0	0
X	1	0	0	0	X	0	0	1
X	1	0	0	1	X	0	1	0
X	1	0	1	0	0	0	1	0
X	1	0	1	*	*	0	0	0
Y2'	Y3'	D1	D2	D3	D4	Y1	Y2	Y3

X = Don't care
* = Not all zeros

TABLE 2: Clock Frequency

WG	RG	VCO REF	RRC	DECCLK	ENCCLK	MODE
0	0	XTAL/2	XTAL/3	XTAL/2	XTAL/2	IDLE
0	1	$\overline{RD}$	VCO/3	VCO/2	XTAL/2	READ
1	0	XTAL/2	XTAL/3	XTAL/2	XTAL/2	WRITE
1	1	XTAL/2	XTAL/3	XTAL/2	XTAL/2	IDLE

Note 1: Until the VCO locks to the new source, the VCO/2 entries will be XTAL/2.

2: Until the VCO locks to the new source, the VCO/3 entries will be XTAL/3.

TABLE 3: Write Precompensation Algorithm

BIT	BIT	BIT	BIT	BIT	COMPENSATION
n-2	n-1	n	n+1	n+2	BIT n
1	0	1	0	1	NONE
0	0	1	0	0	NONE
1	0	1	0	0	EARLY
0	0	1	0	1	LATE

LATE: Bit n is time shifted (delayed) from its nominal time position towards the bit n+1 time position.

EARLY: Bit n is time shifted (advanced) from its nominal time position towards the bit n-1 time position.

TABLE 4: Write Precompensation Magnitude

$\overline{WCI}$	$\overline{WCO}$	MAGNITUDE (WP)
0	0	3
0	1	2
1	0	1
1	1	0

The nominal magnitude,
TPC = WP x TPC0 is externally set with resistors on pins WCS and IREF.

PIN DESCRIPTION

INPUT PINS

NAME	TYPE	DESCRIPTION
$\overline{RD}$ (TTL) RD (ECL)	I	READ DATA: Encoded Read Data from the disk drive read channel. The TTL input version (5372) is an active low signal. The ECL input version (5371) is an active high signal.
RG	I	READ GATE: Selects the PLL reference input (REF), see Table 2. A change in state on RG initiates the PLL synchronization sequence. Pin RG has an internal resistor pullup.
WG	I	WRITE GATE: Enables the write mode, see Table 2. Pin WG has an internal resistor pullup.
WCLK	I	WRITE CLOCK: Write Clock input. Must be synchronous with the NRZ Write Data input. For small cable delays, WCLK may be connected directly to pin RRC.
EPD	I	ENABLE PHASE DETECTOR: A low level (Coast Mode) disables the phase detector and enables the test mode. This opens the PLL and the VCO will run at the frequency commanded by the voltage on pin VCO IN. In the test mode, functions normally driven by the VCO are switched to XTAL. Pin EPD has an internal resistor pull up.
AMENB	I	ADDRESS MARK ENABLE: Used to enable the address mark detection and address mark generation circuitry, active high. Pin AMENB has an internal resistor pullup.
$\overline{WC0}$, $\overline{WC1}$	I	WRITE PRECOMPENSATION CONTROL BITS: Pins $\overline{WC1}$, and $\overline{WC0}$ control the magnitude of the write precompensation, see Table 4. Internal resistor pull ups are provided. If unused, leave pins open or tie high.
$\overline{WCL}$	I	WRITE PRECOMPENSATION CONTROL LATCH: Used to latch the write precompensation control bits $\overline{WC1}$ and $\overline{WC0}$ into the internal DAC. An active low level latches the input bits. Pin $\overline{WCL}$ has an internal resistor pull up. If unused, leave pin open or tie high.
WDNRZ	I	NRZ WRITE DATA INPUT PIN: This pin can be connected to the NRZ pin to form a bidirectional data port.

OUTPUT PINS

$\overline{WD0}$	O	WRITE DATA: Encoded write data output, active low. The data is automatically resynchronized (independent of the delay between RRC and WCLK) to one edge of the XTAL1 input clock.
RRC	O	READ/REFERENCE CLOCK: A multiplexed clock source used by the controller, see Table 2. During a mode change, no glitches are generated and no more than two lost clock pulses will occur. When RG goes high, RRC is synchronized to the NRZ Read Data after 19 read data pulses.
$\overline{AMD}$	O	ADDRESS MARK DETECT: Tristate output pin that is in its high impedance state when WG is high or AMENB is low. A latched low level output indicates that an address mark has been detected. A low level on pin AMENB resets pin $\overline{AMD}$.

OUTPUT PINS (Continued)

NAME	TYPE	DESCRIPTION
VCO REF	O	VCO REFERENCE: An open emitter ECL output test point. The VCO reference input to the phase detector, the positive edges are phase locked to DLYD DATA. The negative edges of this open emitter output signal indicate the edges of the decode window. Two external resistors are required to perform this test, they should be removed during normal operation for reduced power dissipation.
VCO CLK	O	VCO CLOCK: An open emitter ECL output test point. Two external resistors are required to perform this test. They should be removed during normal operation for reduced power dissipation.
$\overline{\text{DRD}}$	O	DELAYED READ DATA: An open emitter ECL output test point. The positive edges of this open emitter output signal indicates the data bit position. The positive edges of the $\overline{\text{DRD}}$ and the VCO REF signals can be used to estimate window centering. The time jitter of DRD's positive edge is an indication of media bit shift. Two external resistors are required to perform this test. They should be removed during normal operation for reduced power dissipation.
NRZ	O	NRZ READ DATA OUTPUT: Tristate output pin that is enabled when read gate is high. This pin can be connected to the WDNRZ pin to form a bidirectional data port.

ANALOG PINS

IREF	I	TIMING PROGRAM PIN: The VCO center frequency and the 1/3 cell delay are a function of the current sourced into pin IREF. The current is set by an external resistor, RR, connected between pin IREF and VPA2.
XTAL1, 2	I	CRYSTAL OSCILLATOR CONNECTIONS: The pin frequency is at three times the data rate. If the crystal oscillator is used, an AC coupled parallel LC circuit must be connected from XTAL1 to ground. If the crystal oscillator is not desired, XTAL1 may be driven either by a direct coupled TTL source or by an AC coupled ECL source, with XTAL2 open. The source duty cycle should be as close to 50% as possible, since its duty cycle will affect the RRC clock duty cycle when XTAL is its source. The additional RRC duty cycle error will be one third the source duty cycle error.
PD OUT	O	PHASE DETECTOR OUTPUT: Drives the loop filter input.
VCO IN	I	VCO CONTROL INPUT: Driven by the loop filter output.
WCS	I	WRITE PRECOMPENSATION SET: Pin for a resistor to program the write precompensation magnitude value. The resistor, RC, is connected between pin PCS and VPA2. If this pin is left open, write precompensation is disabled.
DGND, AGND	I	Digital and Analog Ground
VPA1, VPA2	I	Analog +5V Supplies
VPD	I	Digital +5V Supply

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

Operation above maximum ratings may damage the device.

PARAMETER	RATING	UNIT
Storage Temperature	-65 to + 150	°C
Junction Operating Temperature, Tj	+150	°C
Supply Voltage, VPA1, VPA2, VPD	-0.5 to 7	V
Voltage Applied to Logic Inputs	-0.5 to VPD + 0.5	V
Maximum Power Dissipation	0.9	W

RECOMMENDED OPERATING CONDITIONS

PARAMETER	RATING	UNIT
Supply Voltage, VPA1 = VPA2 = VPD = VCC	4.75 < VCC < 5.25	V
Junction Temperature, Tj	0 < Tj < 135	°C
Ambient Temperature, Ta	0 < Ta < 70°	°C

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, 4.75V< VCC <5.25V, 10 MHz< 1/TORC <24 MHz, 30 MHz< 1/TVCO <72 MHz, 0 °C< Tj <135 °C.

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
VIH	High Level Input Voltage		2.0			V
VIL	Low Level Input Voltage				0.8	V
IIH	High Level Input Current	VIH = 2.7V			20	µA
IIL	Low Level Input Current	VIL = 0.4V			-0.36	mA
VOH	High Level Output Voltage	IOH = 400 µA	2.7			V
VOL	Low Level Output Voltage	IOL = 4 mA			0.5	V
ICC	Power Supply Current	All outputs & test point pins open Tj = 135°C			160	mA
PWR	Power Dissipation	All outputs & test point pins open Tj = 135°C			0.84	W

ELECTRICAL CHARACTERISTICS (Continued)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
VOHT	Test Point Output High Level $\overline{DRD}$, VCO CLK, VCO REF	262Ω to VPD 402Ω to DGND VPD = 5.0V VOHT - VPD		-0.85		V
VOLT	Test Point Output Low Level $\overline{DRD}$, VCO CLK, VCO REF	262Ω to VPD 402Ω to DGND VPD = 5.0V VOLT - VPD		-1.75		V

DYNAMIC CHARACTERISTICS AND TIMING

READ MODE (See Figure 3)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TRD	Read Data Pulse Width		12		4/3TORC-20	ns
TFRD	Read Data Fall Time	2.0V to 0.8V, $C_L \leq 15$ pF			9	ns
TRRC	Read Clock Rise Time	0.8V to 2.0V, $C_L \leq 15$ pF			8	ns
TFRC	Read Clock Fall Time	2.0V to 0.8V, $C_L \leq 15$ pF			5	ns
RRC	Duty Cycle	20 Mbit/s	43	50	57	%
TPNRZ	NRZ (out) Set Up/Hold Time	20 Mbit/s	15.5			ns
TPAMD	$\overline{AMD}$ Propogation Delay		13			ns
	1/3 Cell Delay	TD = 3.6E-12 (RR+1700)	0.8TD		1.2TD	ns

WRITE MODE (See Figure 4)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TWD	Write Data Pulse Width	$C_L \leq 15$ pF	2TOWC/3 -TPC -5		2TOWC/3 +TPC +5	ns
TFWD	Write Data Fall Time	2.0V to 0.8V, $C_L \leq 15$ pF			5	ns
TRWC	Write Data Clock Rise Time	0.8V to 2.0V			10	ns
TFWC	Write Data Clock Fall Time	2.0V to 0.8V			8	ns
TSNRZ	WDNRZ Set up Time		5			ns
THNRZ	WDNRZ Hold Time		5			ns

WRITE MODE (Continued)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TPC	Precompensation Time Shift Magnitude Accuracy	TPCO = 1.12T x A / (B + 3A) T = XTAL Period A = 0.19 / (Rc + 0.51) + 5.8E-3 B = 0.42 / (RR + 0.53) + 1.08E-2 $RC = \frac{0.19(1-2.7S)}{S[\frac{0.38}{RR+0.53)} + 0.025] - 0.006} - 0.51$ S = TPCO/T; RR, RC in kΩ (Rc tied between PCS and +5V)				
		$\overline{WC0}$ = 1 $\overline{WC1}$ = 1	0	0		ns
		$\overline{WC0}$ = 0 $\overline{WC1}$ = 1		TPCO		ns
		$\overline{WC0}$ = 1 $\overline{WC1}$ = 0		2TPCO		ns
		$\overline{WC0}$ = 0 $\overline{WC1}$ = 0		3TPCO		ns

DATA SYNCHRONIZATION

PARAMETER		CONDITIONS	MIN	MAX	UNIT
TVCO	VCO Center Frequency Period	VCO IN = 2.7V TO = 3.6E-12 (RR + 1700) VCC = 5.0V RR = (92.6/DR) –1.7(kΩ)	0.8TO	1.2TO	ns
VCO	Frequency Dynamic Range	1V ≤ VCO IN ≤ VCC-0.6V VCC = 5.0	±25	±45	%
KVCO	VCO Control Gain	ωo = 2π/TO 1V ≤ VCO IN ≤ VCC 0.6V	0.14ωo	0.26ωo	rad/s-V
KD	Phase Detector Gain	KD= 0.22/(RR+530) Read Mode = 0.11/(RR+530) Non-Read Mode VCC= 5V, PLL REF = $\overline{RD}$ 3T ('100') Pattern	0.83KD	1.17KD	A/rad
	KVCO x KD Product Accuracy*		-28	-28	%
	VCO Phase Restart Error*	Referred to RRC	-1	1	rad
	Decode Window Centering Accuracy			±1.5	ns
	Decode Window		(2TORC/3) - 1.5		ns

* Not Directly Testable; Design Characteristic

CONTROL CHARACTERISTICS (See Figure 5)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TSWS	$\overline{WC0}$, $\overline{WC1}$ SET UP TIME		7			ns
THWS	$\overline{WC0}$, $\overline{WC1}$ HOLD TIME		7			ns

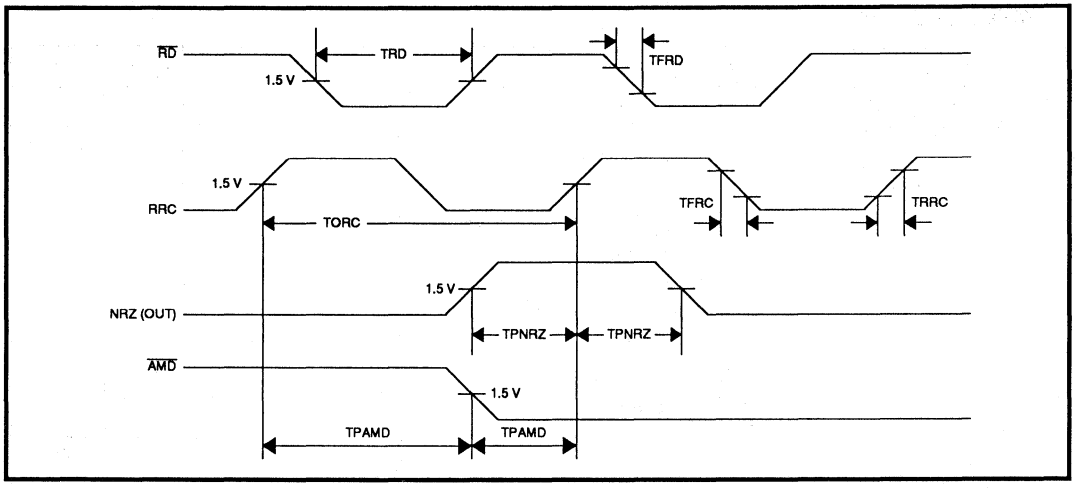


FIGURE 3: Read Timing

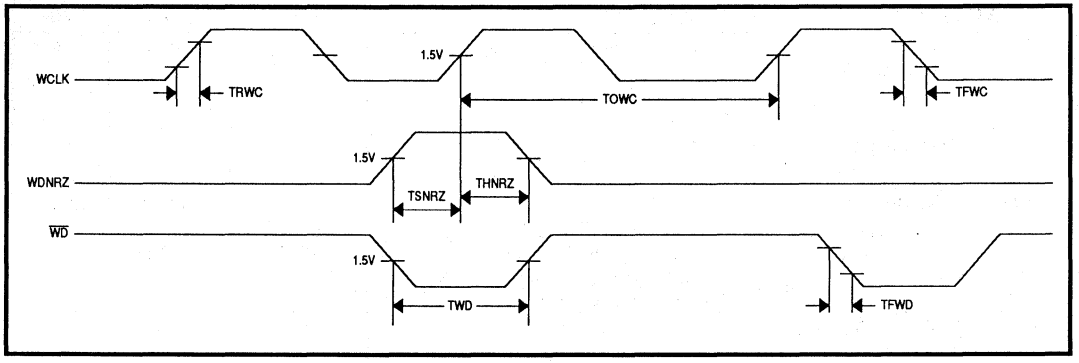


FIGURE 4: Write Timing

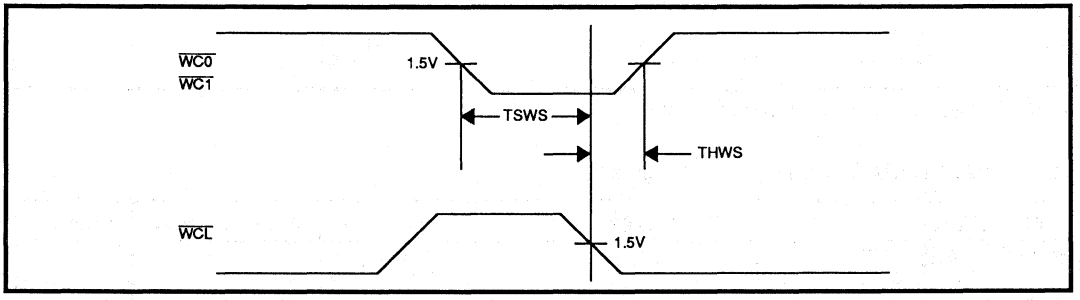


FIGURE 5: Control Timing

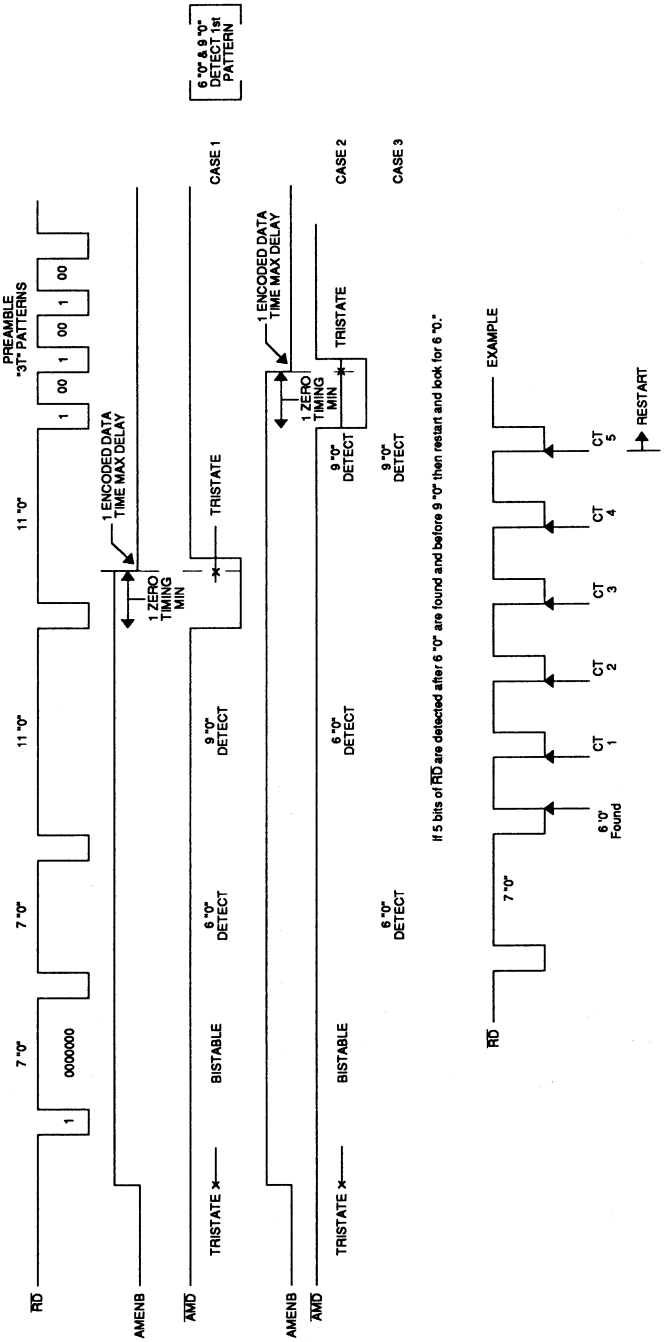


FIGURE 6: Address Mark Search

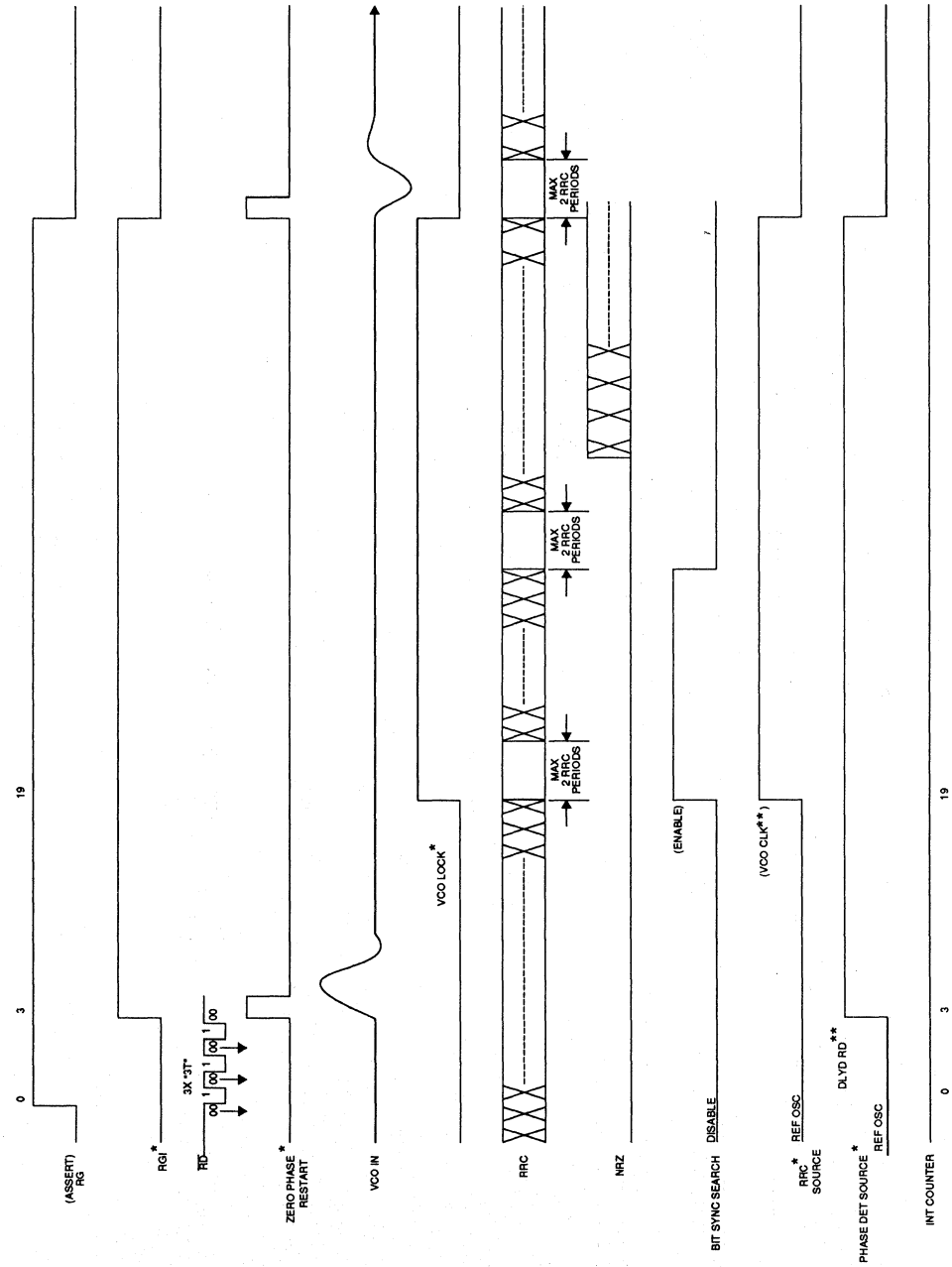


FIGURE 7: Read Mode Locking Sequence (Soft and Hard Sector)

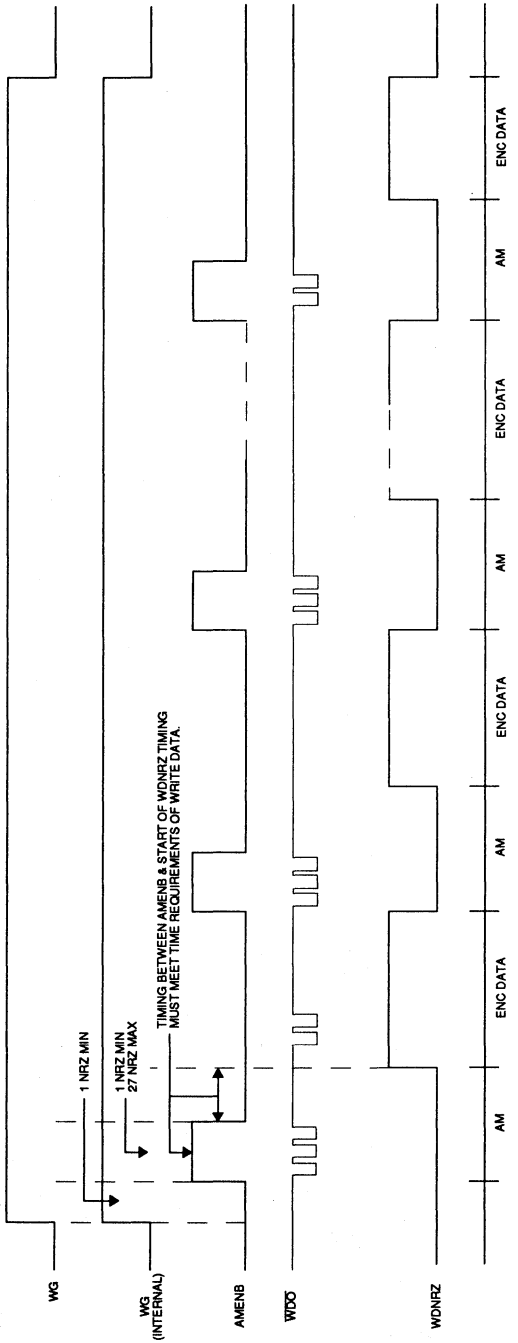


FIGURE 8: Multiple Address Mark Write

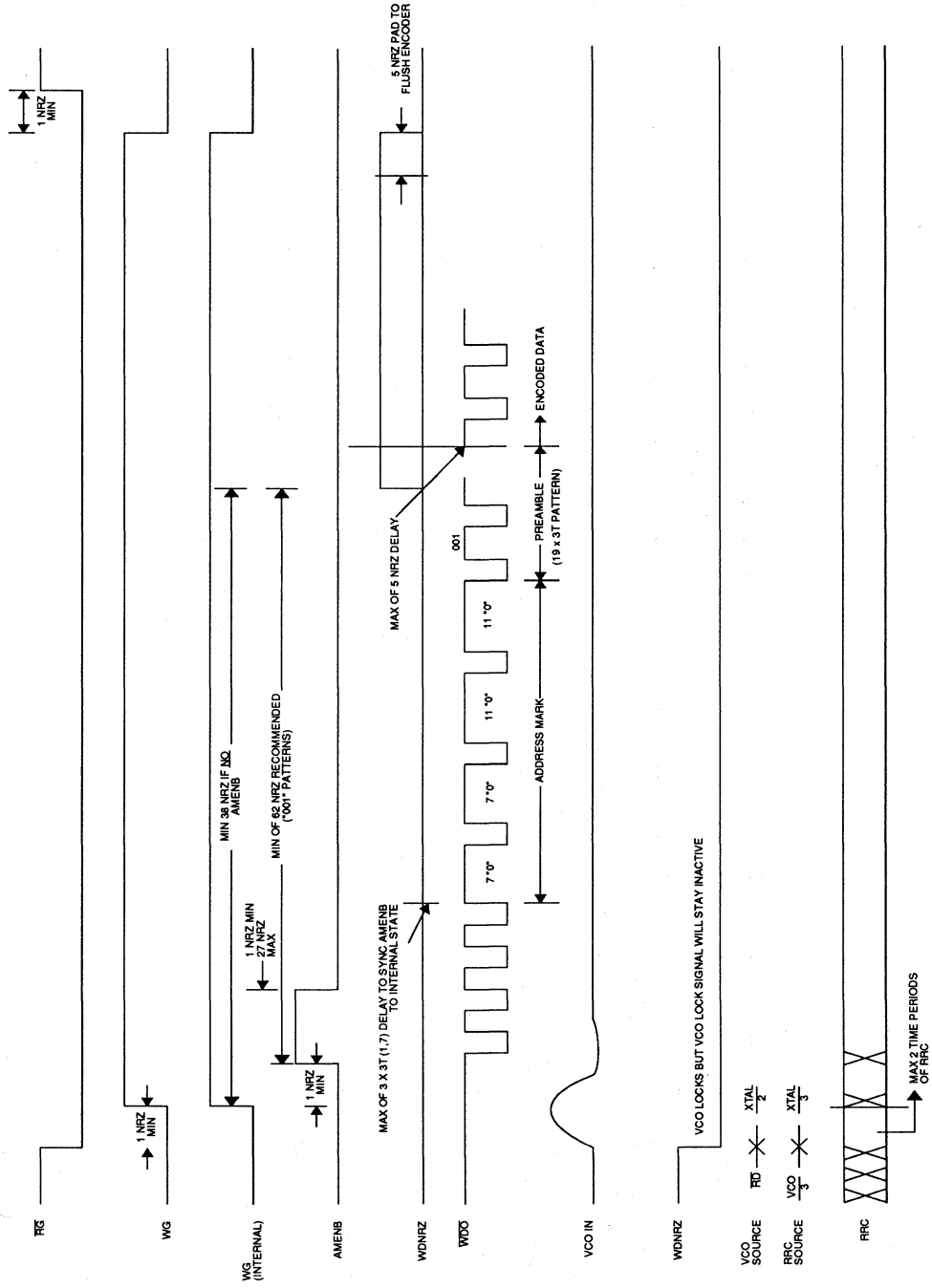
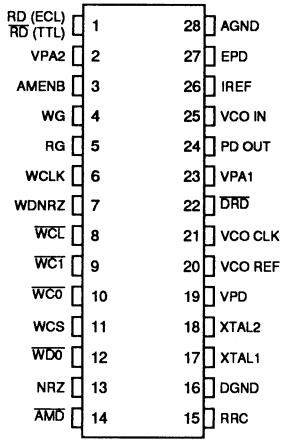


FIGURE 9: Write Data

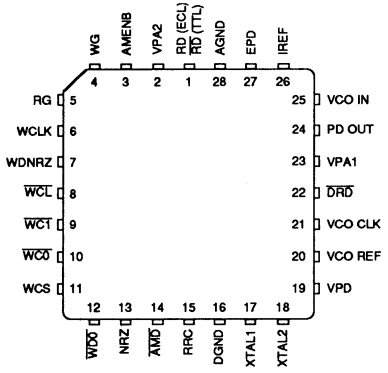
PACKAGE PIN DESIGNATIONS

(TOP VIEW)

CAUTION: Use handling procedures necessary for a static sensitive component.



28-Pin DIP
θja = 55 °C/W



28-Pin PLCC
θja = 65 °C/W

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only. Do not use for final design.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32D5381
Data Synchronizer/ 2, 7 RLL ENDEC

Advance Information

June, 1990

4

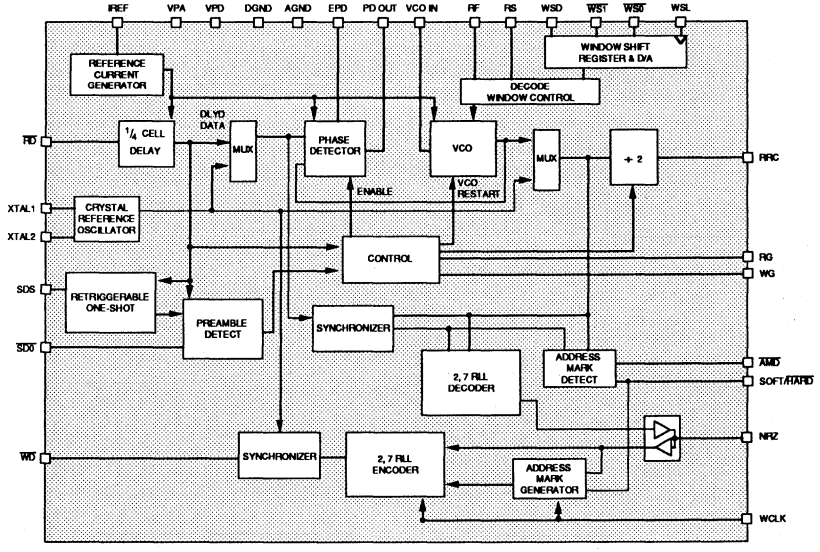
DESCRIPTION

The SSI 32D5381 Data Synchronizer/2, 7 RLL ENDEC provides data recovery and data encoding for storage systems which employ a 2, 7 RLL encoding format. Data synchronization is performed with a fully integrated high performance PLL. A zero phase restart technique is used to minimize PLL acquisition time. The SSI 32D5381 has been optimized for operation as a companion device to the SSI 32C452A and the AIC 010 controllers. The VCO frequency setting elements are incorporated within the SSI 32D5381 for enhanced performance and reduced board space. Data rate is established with a single external programming resistor. The SSI 32D5381 utilizes an advanced bipolar process technology which affords precise decode window control without the requirement of an accurate 1/ 4 cell delay or external devices. To enhance disk drive testability, decode window symmetry control is available through a digital µP port and/or two analog pins. This feature can facilitate defect mapping, automatic calibration, systematic error cancellation, window margin testing and error recovery. The SSI 32D5381 requires a single +5V power supply and is available in 28-pin DIP and PLCC packages.

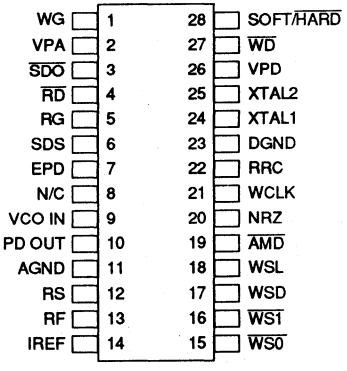
FEATURES

- **Data Synchronizer and 2, 7 RLL ENDEC**
- **Plug Compatible with SSI 32D5321**
- **7.5 to 15 Mbit/s Operation Programmed with a Single External Resistor**
- **Optimized for Operation with the SSI 32C452A and AIC 010 Controllers**
- **Programmable Decode Window Symmetry via a µP Port and/or Analog Pins**
- **Fast Acquisition Phase Locked Loop**
  - **Zero Phase Restart Technique**
- **Fully Integrated Data Separator**
  - **No External Delay Lines or Active Devices Required**
- **Crystal Controlled Reference Oscillator**
- **Hard/Soft Sector Operation**
- **+5V Operation**
- **28-Pin DIP and PLCC Packages**

BLOCK DIAGRAM



PIN DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

OPERATION

The SSI 32D5381 is designed to perform data recovery and data encoding in rotating memory systems which utilize a 2, 7 RLL encoding format. In the Read Mode the SSI 32D5381 performs Data Synchronization, Sync Field Search and Detect, Address Mark Detect and Data Decoding. In the Write Mode, the SSI 32D5381 converts NRZ data into the 2, 7 RLL format described in Table 1, it generates the Preamble Field, and inserts Address Marks as requested. The interface electronics and architecture of the SSI 32D5381 have been optimized for use as a companion device to the SSI 32C452 or AIC 010 controllers.

The SSI 32D5381 can operate with data rates ranging from 7.5 to 15 Mbit/s. This data rate is established by a single 1% external resistor, RR, connected from pin IREF to VPA. This resistor establishes a reference current which sets the VCO center frequency, the phase detector gain, and the 1/4 cell delay. The value of this resistor is given by:

$$RR = \frac{40.67}{DR} - 0.5\ (k\Omega)$$

where: DR = Data Rate in Mbit/s.

An internal crystal reference oscillator, operating at twice the data rate, generates the standby reference for the PLL. A series resonant crystal between XTAL1 and XTAL2 should be selected at twice the Data Rate. If a crystal oscillator is not desired, then an external TTL compatible reference may be applied to XTAL1, leaving XTAL2 open.

The SSI 32D5381 employs a Dual-Mode Phase Detector, Harmonic in the Read Mode and non-harmonic in Write and Idle Modes. In the Read Mode the harmonic phase detector updates the PLL with each occurrence of a DLYD DATA pulse. In the Write and Idle Modes the non-harmonic phase detector is continuously enabled, thus maintaining both phase and frequency lock. By acquiring both phase and frequency lock to the crystal reference oscillator and utilizing a zero phase restart technique, false lock to DLYD DATA is eliminated.

The phase detector incorporates a charge pump in order to drive the loop filter directly. The polarity and width of the output current pulses correspond to the direction and magnitude of the phase error. Figure 1 depicts the average output current as a function of the input phase error (relative to the VCO period).

The READ GATE (RG), and WRITE GATE (WG) inputs control the device mode as described in Table 2. RG is an asynchronous input and may be initiated or terminated at any position on the disk. WG is also an asynchronous input, but should not be terminated prior to the last output Write Data pulse.

READ OPERATION

The Data Synchronizer utilizes a fully integrated fast acquisition PLL to accurately develop the decode window. Read Gate, RG, initiates the PLL locking sequence and selects the PLL reference input; a high level (Read Mode) selects the $\overline{RD}$ input and a low level selects the crystal reference oscillator.

In the Read Mode the rising edge of DLYD DATA enables the phase detector while the falling edge is phase compared to the rising edge of the VCO. As depicted in Figure 2, DLYD DATA is a 1/4 cell wide (TVCO/2) pulse whose leading edge is defined by the leading edge of $\overline{RD}$. An accurate and symmetrical decode window is developed from the VCO clock. The decode window is generated from the falling edges of the VCO clock. By utilizing a fully integrated symmetrical VCO running at twice the data rate, the decode window is insured to be accurate and centered symmetrically about the falling edges of DLYD DATA. The accuracy of the 1/4 cell delay only affects the retrace angle of the phase detector and does not influence the accuracy of the decode window.

Shifting the symmetry of the VCO clock effectively shifts the relative position of the DLYD DATA pulse within the decode window. This powerful capability easily facilitates defect mapping, automatic calibration, window margin testing, error recovery, and systematic error cancellation. For enhanced disk drive testability and error recovery, decode window control is

provided via a µP port (WSL, WSD, $\overline{WS0}$, $\overline{WS1}$) as described in Table 3. In applications not utilizing this feature, WSL should be connected to ground, while WSD, $\overline{WS0}$, and $\overline{WS1}$ can be left open.

Window shifts in the range of ±1.5% to ±7.5% of TORC are easily programmed by latching the appropriate control word into the Window Shift Register with the WSL pin. Shifts in the positive or negative directions result in early or late decode windows, respectively, as depicted in Figure 3. Additionally, for small systematic error cancellation, a resistor, R, connected from either RS (Early) or RF (Late) to ground will provide analog control over the decode window. The magnitude of this shift, TSA is determined by:

$$TSA = 0.125\ TORC\left(1 - \frac{680 + R}{1180 + R}\right)$$

where: R is in ohms

Pins RF and RS are intended to be used as a trim and should be restricted to ±1.5% window shifts. They can be used in conjunction with the digital control port.

In Non-Read Modes, the PLL is locked to the crystal reference oscillator. This forces the VCO to run at a frequency which is very close to that required for tracking actual data and thus minimizes the associated frequency step during acquisition. When the reference input to the PLL is switched, the VCO is stopped momentarily, then restarted in an accurate phase alignment with the next PLL reference input pulse, and the VCO clock divider is reset. By minimizing the phase alignment in this manner (phase error ≤ 0.5 rads), the acquisition time is substantially reduced.

The SSI 32D5381 provides two sync modes for controlling the PLL locking sequence; Soft Sector and Hard Sector.

SOFT SECTOR MODE

The Soft Sector Mode activates the Preamble Search and Address Mark detection circuitry. As depicted in Figure 4, when RG transitions high, the counter is reset and the SSI 32D5381 requires 10 high to low transitions (Preamble '1' bits) before switching the reference input to the PLL, 48 high to low transitions before switching the Read Reference Clock to the VCO clock divided by two and activating the Address Mark Detect circuitry; then it must detect the Address Mark prior to 80 high to low transitions in order to enter the Read Mode. This sequence repeats after 95 input '1' bits until the read mode is successfully entered or until RG is cancelled.

When RG transitions high, the following PLL locking sequence begins:

a) PREAMBLE SEARCH:

The 3T detect circuitry initiates the PLL locking sequence once it has detected 10 consecutive '100' bit groups from the 3T preamble field. The 3T detect timing is set by the sum of the 1/4 cell delay and the retriggerable one-shot delay. The 1/4 cell timing capacitor is included on-chip and its timing is externally set by resistor RR. The retriggerable one-shot timing is externally set by resistor Rd and capacitor Cd. The sum of their delays is set to 3.5 bit cell times. Therefore, a continuous stream of input pulses with a 3T bit cell time pulse rate keeps the one-shot reset, and a 4T or longer bit cell time input period allows the one-shot to time out producing a 4T detect pulse. The 4T detect pulse resets the Input Counter and the search is started over.

b) PLL ACQUISITION:

Once 10 consecutive '100' bit groups are detected, the reference input to the PLL is switched from the crystal reference oscillator to the DLYD DATA, the VCO is phase reset to the next DLYD DATA pulse, and PLL acquisition begins. When an additional 38 '100' bit groups are detected, the Read Reference Clock output (RRC) is switched to the VCO clock divided by 2, the 4T Detect circuitry is inhibited, and the Address Mark Detection circuitry is enabled. If a 4T detect pulse occurs before 48 Preamble '1' bits are detected, then the PLL is locked back to the crystal reference oscillator, the RRC output is switched to the crystal reference oscillator divided by 2, the Input Counter reset, and the sequence is restarted. No short duration glitches will occur at the RRC output during this switching.

c) **ADDRESS MARK DETECTION:**

The circuit searches for the occurrence of the $5EAx_{16}$ Address Mark. If an Address Mark is detected prior to the Input Counter reaching count 80, the correct phase of the RRC is ensured by resetting the n/2 divider, the $\overline{AMD}$ output is latched low, the PLL training sequence is terminated, and the Read Mode is entered allowing the data field to be read. If the Input Counter reaches count 80 before the Address Mark is detected, the PLL is locked back to the crystal reference oscillator, the RRC output is switched to the crystal reference oscillator divided by 2, and the PLL training sequence is restarted when the Input Counter reaches count 96. Figure 5 depicts the Address Mark detection sequence.

HARD SECTOR MODE

In the Hard Sector mode (SOFT/$\overline{HARD}$ = 0) the SSI 32D5381 utilizes a 4T (1000) Preamble Field and disables the Preamble Search and Address Mark detection circuitry. It allows the PLL to be controlled directly by RG for Hard Sector format operation. With the absence of an Address Mark, the 4T Preamble Field is utilized to properly set the bit cell alignment boundaries for proper decoding.

When RG transitions high, as depicted in Figure 6, reference input to the PLL is switched from the crystal reference oscillator to DLYD DATA, the VCO is phase reset to the next DLYD DATA pulse, and the PLL acquisition begins. When 32 '1' Preamble bits are detected, the RRC output is switched to the VCO clock divided by 2, and the Read Mode is entered allowing the data field to be read.

In the Hard Sector mode, the NRZ output is inverted and will remain low until the data field is read, as shown in Figure 7. Since the Preamble Search circuitry is not utilized, the external one-shot timing components (Cd, Rd) are not required and the SDS pin can be left open.

WRITE OPERATION

In the Write Mode the SSI 32D5381 converts NRZ data from the controller into 2, 7 RLL formatted data for storage onto the disk. The SSI 32D5381 can operate with a soft or hard sectored disk drive. In the Soft Sector Mode, (SOFT/$\overline{HARD}$ = 1) the device generates a 3T Preamble Field and can insert a N7V Address Mark. The N7V Address Mark is a valid 2, 7 RLL pattern which is not contained in the code set. In the Hard Sector Mode, (SOFT/$\overline{HARD}$ = 0) the device generates a 4T Preamble Field and no Address Mark. Serial NRZ data is clocked into the SSI 32D5381 and latched on defined cell boundaries. The NRZ input data must be synchronous with the rising edges of the WCLK input. In a SCSI or ST506 operation, WCLK is connected directly to the RRC output.

SOFT SECTOR MODE

In the Soft Sector Mode, when WRITE GATE (WG), transitions high and the NRZ input is held low, the SSI 32D5381 automatically generates the 3T (100) Preamble Field at the WRITE DATA ($\overline{WD}$), output. The 3T Preamble Field will continue to be generated until the first low to high transition on the NRZ line. As shown in Figure 8, the first low to high transition occurs with the second bit '1' of the 5_{16} (0101) in the $5EAx_{16}$ Address Mark generation pattern. To generate the Address Mark, the SSI 32D5381 automatically changes the '1' in the eleventh position (see note 3) of the 2, 7 RLL encoded sequence, to a '0'. This generates a pattern of seven zero's followed by two zero's. This unique pattern satisfies the 2, 7 RLL constraints, but will never occur during a normal encoding sequence. The x_{16} of the $5EAx_{16}$ Address Mark generation pattern can be selected, a 'C_{16}' (1100) was utilized in this example.

HARD SECTOR MODE

In the Hard Sector Mode, when WG goes high and the NRZ input is held low, the SSI 32D5381 automatically generates the 4T (1000) Preamble Field at the WRITE DATA, $\overline{WD}$, output. Note that in the Hard Sector mode, the NRZ input is inverted, therefore a constant low is equivalent to an '11 . . . ' input which generates the 4T '1000 . . . ' Preamble Field. The 4T Preamble Field will be generated between the time WG goes high and the first low to high transition on the NRZ line. The 32D5381 requires a minimum of 32 4T (1000) bit groups prior to the data field.

PIN DESCRIPTIONS

INPUT PINS

NAME	TYPE	DESCRIPTION
$\overline{RD}$	I	READ DATA: Encoded Read Data from the disk drive read channel, active low.
RG	I	READ GATE: Selects the PLL reference input and initiates the PLL synchronization sequence. A high level selects the $\overline{RD}$ input and enables the Read Mode/Address Mark Detection sequences. A low level selects the crystal reference oscillator. Pin RG has an internal resistor pull-up.
WG	I	WRITE GATE: Enables the write mode. Pin WG has an internal resistor pull-up.
WSL	I	WINDOW SYMMETRY LATCH: Used to latch the input window symmetry control bits WSD, $\overline{WS0}$ and $\overline{WS1}$ into the internal DAC. An active high level latches the input bits. Pin WSL has an internal resistor pull-up.
WSD	I	WINDOW SYMMETRY DIRECTION: Controls the direction of the optional window symmetry shift. Pin WSD has an internal resistor pull-up.
$\overline{WS0}$	I	WINDOW SYMMETRY CONTROL BIT: A low level introduces a window shift of 1.5% TORC (Read Reference Clock Period) in the direction established by WSD. Pin $\overline{WS0}$ has an internal resistor pull-up.
$\overline{WS1}$	I	WINDOW SYMMETRY CONTROL BIT: A low level introduces a window shift of 6% TORC (Read Reference Clock Period) in the direction established by WSD. A low level at both $\overline{WS0}$ and $\overline{WS1}$ will produce the sum of the two window shifts. Pin $\overline{WS1}$ has an internal resistor pull-up.
SOFT/$\overline{HARD}$	I	SOFT/$\overline{HARD}$ SECTOR: Selects the address mark and the Preamble field patterns. A high level (Soft Sector) selects a 3T Preamble Field pattern and a non-violating 2, 7 address mark, N7V. A low level (Hard Sector) selects a 4T Preamble Field pattern and disables the address mark circuitry. Pin SOFT/$\overline{HARD}$ has an internal resistor pull-up.
WCLK	I	WRITE CLOCK: Write Clock input. Must be synchronous with the Write Data input on the NRZ Data Port. For small cable delays, WCLK may be connected directly to pin RRC (Read/Reference Clock).
EPD	I	ENABLE PHASE DETECTOR: A low level (Coast Mode) disables the phase detector and allows the VCO to coast. Pin EPD has an internal resistor pull up.

BIDIRECTIONAL PINS

NRZ	I/O	NRZ DATA PORT: Read Data output when RG is high and Write Data input when WG is high. In the idle mode NRZ is in a high impedance state.

PIN DESCRIPTIONS (Continued)

OUTPUT PINS

NAME	TYPE	DESCRIPTION
$\overline{WD}$	O	WRITE DATA: Encoded write data output, active low.
RRC	O	READ/REFERENCE CLOCK: A multiplexed clock source used by the controller. In the read mode, this clock is the VCO frequency divided by two (1/TORC) and in the write mode it is the crystal reference frequency divided by two (1/TORO). No short clock pulses are generated during a mode change.
$\overline{AMD}$	O	ADDRESS MARK DETECT: In the soft sector Read Mode, a latched low level output indicates that an address mark has been detected. In non-Read modes $\overline{AMD}$ is configured as a high impedance output.
$\overline{SDO}$	O	SYNC DETECT OUTPUT: An active low output that indicates successful detection of the 3T Preamble sync field. The $\overline{SDO}$ pin is not a TTL level signal.

ANALOG PINS

IREF	I	TIMING PROGRAM PIN: The VCO center frequency and the 1/4 Cell Delay are a function of the current source into pin IREF. The current is set by an external resistor, RR, connected from IREF to VPA.
XTAL1, XTAL2	I	CRYSTAL OSCILLATOR CONNECTIONS: If a crystal oscillator is not desired, XTAL1 maybe driven by a TTL source with XTAL2 open. The frequency must be at twice the data rate.
PD OUT	O	PHASE DETECTOR OUTPUT: Drives the Loop Filter input.
VCO IN	I	VCO CONTROL INPUT: Driven by the Loop Filter output.
SDS	I	SYNC DETECT SET: Used to program the sync detect retriggerable one-shot timing with an external R-C network. Connect the capacitor, Cd, to VPA and the resistor, Rd, to AGND.
RF, RS	I	WINDOW SYMMETRY ADJUST PINS: Provides analog control over the decode window symmetry; typically used to null out any window symmetry offset. A resistor connected from either RF or RS to AGND will provide magnitude and direction control. They can be used in conjunction with the digital control port WSD, $\overline{WS0}$, $\overline{WS1}$.

POWER

DGND, AGND	I	Digital and Analog Ground
VPA	I	Analog +5V
VPD	I	Digital +5V

NRZ	2, 7 RLL
10	0100
11	1000
000	000100
010	100100
011	001000
0010	00100100
0011	00001000

TABLE 1: 2, 7 RLL Code Set

WG	RG	MODE
0	0	IDLE
0	1	READ
1	0	WRITE
1	1	ILLEGAL

TABLE 2: Mode Control

Ts, NOMINAL WINDOW SHIFT	WSD	$\overline{WS1}$	$\overline{WS0}$
+TS3	0	0	0
+TS2	0	0	1
+TS1	0	1	0
0	0	1	1
-TS3	1	0	0
-TS2	1	0	1
-TS1	1	1	0
0	1	1	1

TABLE 3: Decode Window Symmetry Control

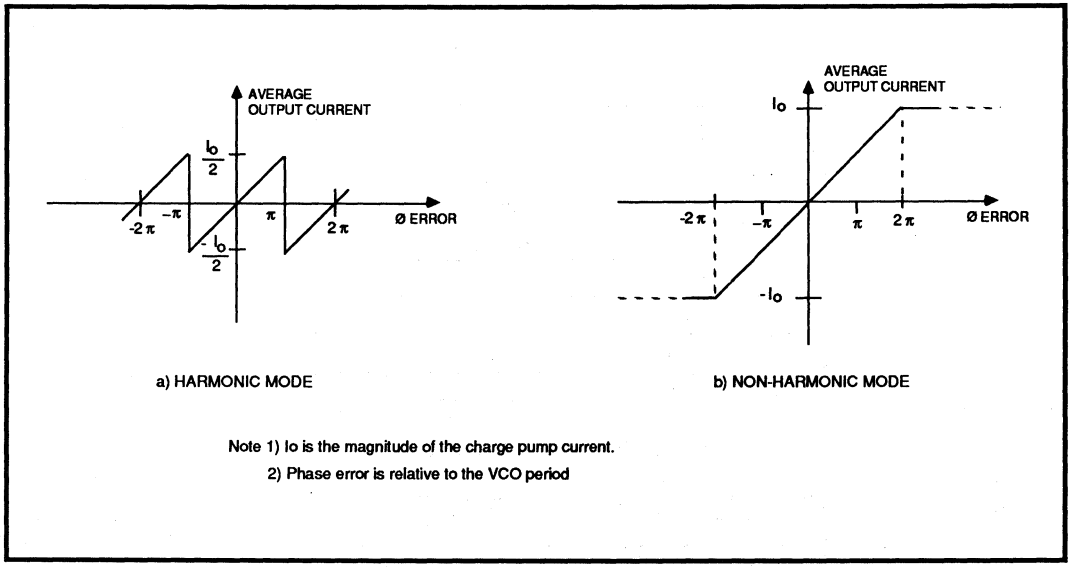


FIGURE 1: Phase Detector Transfer Function

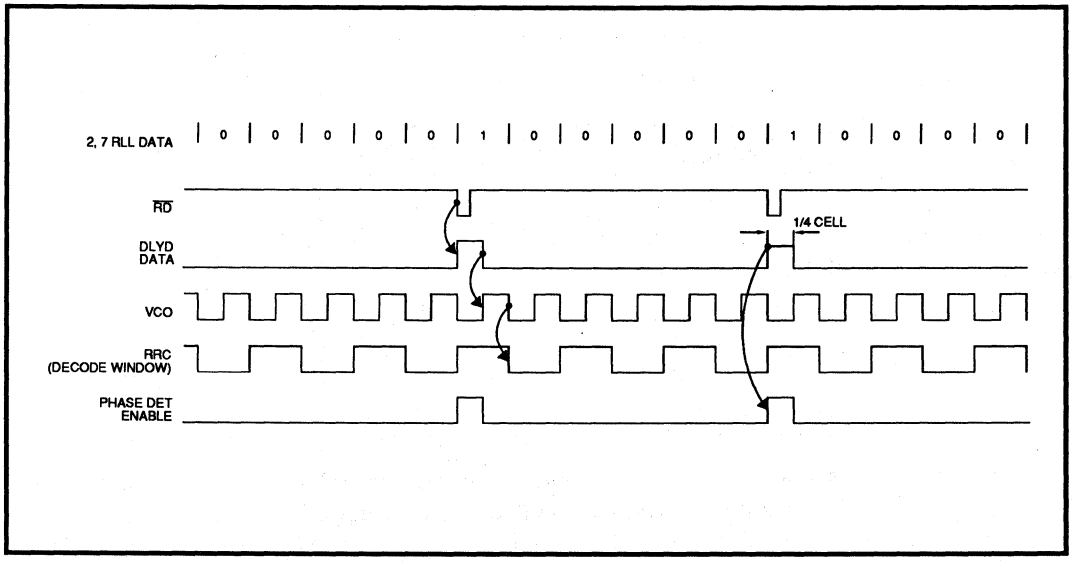


FIGURE 2: Data Synchronization Waveform Diagram

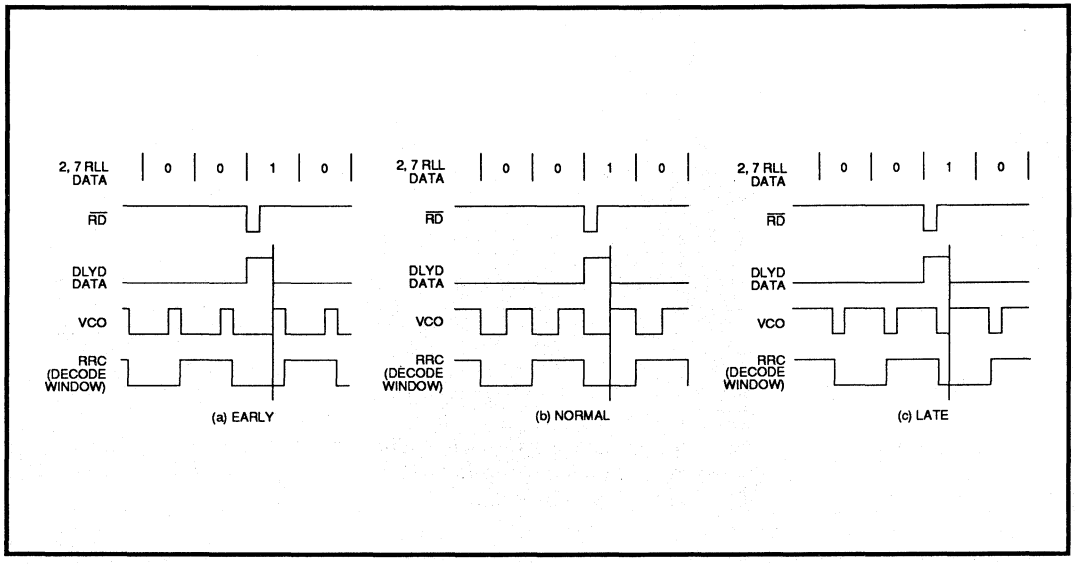
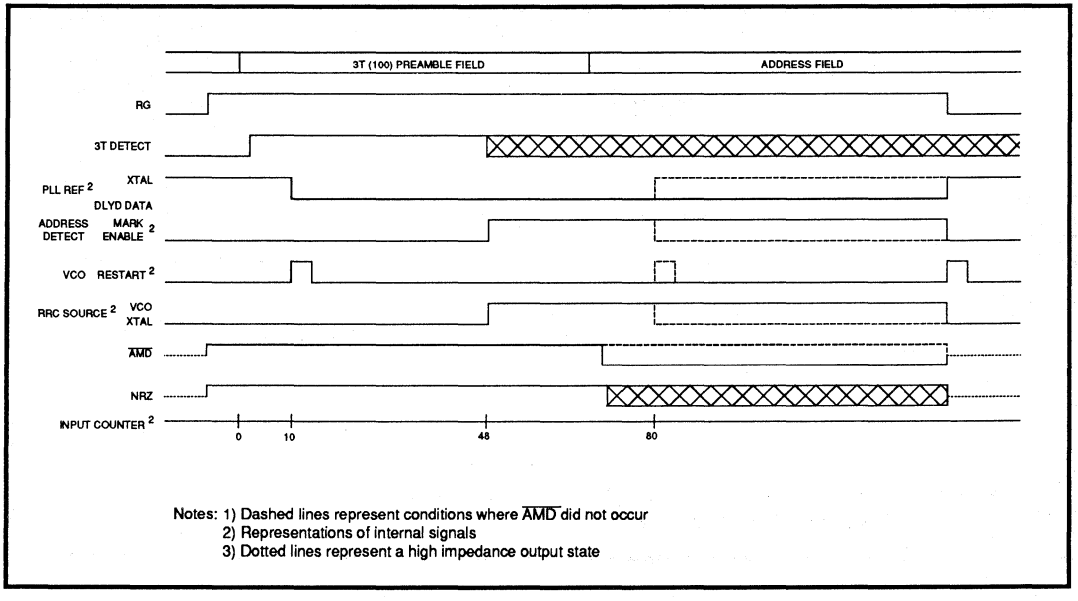
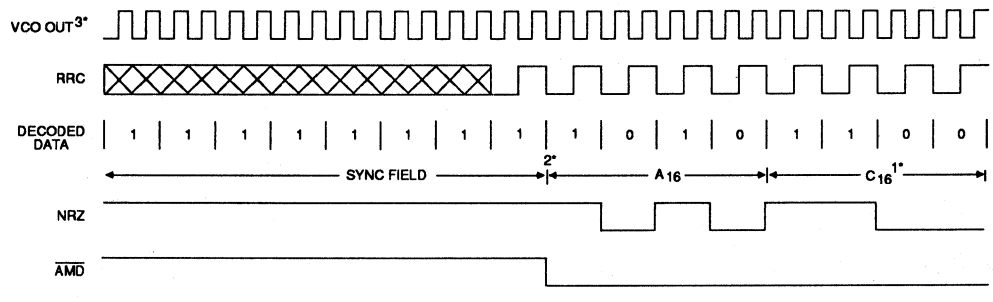


FIGURE 3: Decode Window



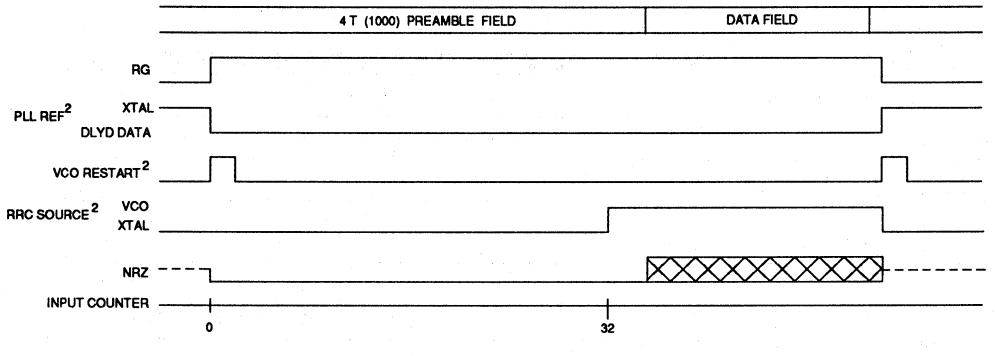
Notes: 1) Dashed lines represent conditions where $\overline{AMD}$ did not occur
2) Representations of internal signals
3) Dotted lines represent a high impedance output state

FIGURE 4: Soft Sector Mode Timing Diagram



Notes: *1) These four bits can be any combination, C16 (1100) was selected in this example
*2) The 5E16 of the 5EAx16 Address Mark is not read back
*3) Representations of internal signals

FIGURE 5: Address Mark Detection and NRZ Output Waveform



Notes: 1) Dashed lines represent a high impedance output state
2) Representations of internal signals

FIGURE 6: Hard Sector Mode Timing Diagram

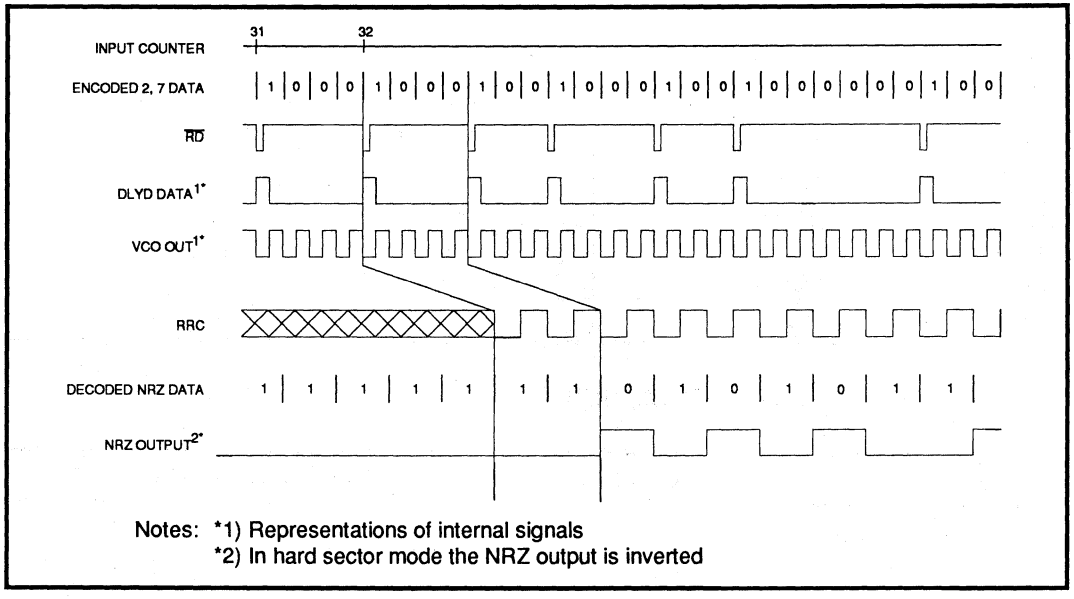


FIGURE 7: Hard Sector Mode Decode Timing

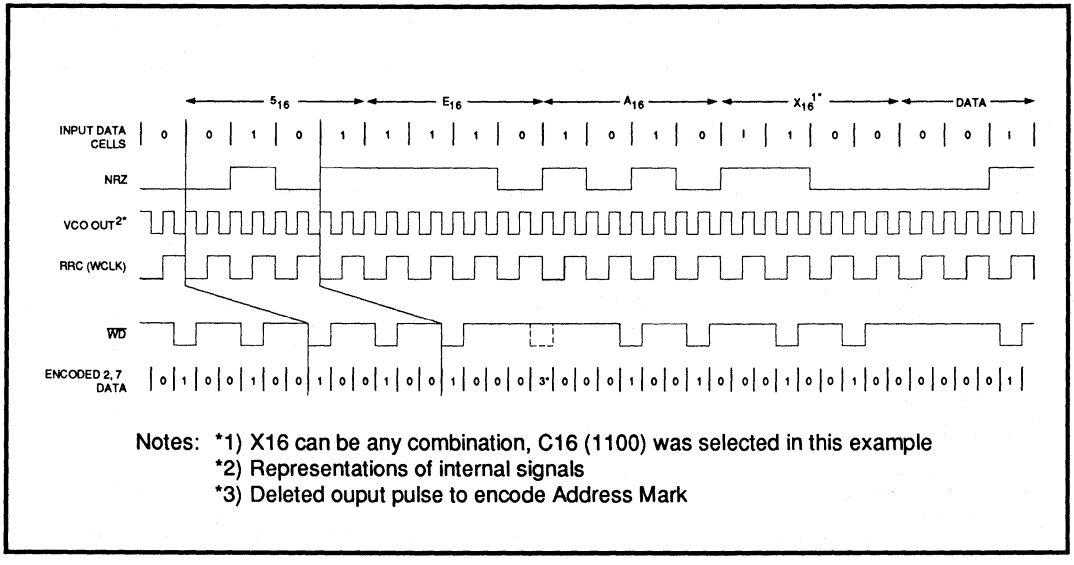


FIGURE 8: Write Address Mark Generation

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATINGS	UNIT
Storage Temperature	-65 to +150	°C
Ambient Operating Temperature, TA	0 to +70	°C
Junction Operating Temperature	0 to +130	°C
Supply Voltage, VCC	-0.5 to 7	Vdc
Voltage Applied to Logic inputs	-0.5 to VCC +0.5	Vdc
Maximum Power Dissipation	**TBD**	mW

DC ELECTRICAL CHARACTERISTICS (Unless otherwise specified, 4.75V < VCC < 5.25V, TA = 0°C to 70°C, 7.5 MHz < 1/TORC < 15 MHz , 15 MHz < 1/TVCO < 30 MHz.)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VIH High Level Input Voltage		2.0			V
VIL Low Level Input Voltage				0.8	V
IIH High Level Input Current	VIH = 2.7V			20	µA
IIL Low Level Input Current	VIL = 0.4V			-0.36	mA
VOH High Level Output Voltage	IOH = -400 µA	2.7			V
VOL Low Level Output Voltage	IOL = 4 mA			0.5	V
ICC Power Supply Current	All outputs open			**TBD**	mA

DYNAMIC CHARACTERISTICS AND TIMING

READ MODE (See Figure 9)

TRD Read Data Pulse Width		20		TORC-40	ns
TFRD Read Data Fall Time	2.0V to 0.8V, CL ≤ 15 pF			15	ns
TRRC Read Clock Rise Time	0.8V to 2.0V, CL ≤ 15 pF			8	ns
TFRC Read Clock Fall Time	2.0V to 0.8V, CL ≤ 15 pF			5	ns
TPNRZ, NRZ (out) Propagation Delay		-15		15	ns
TPAMD, $\overline{\text{AMD}}$ Propagation Delay		-15		15	ns
1/4 Cell + Retriggerable One-Shot Detect Stability		-4		+4	%

READ MODE (Cont.)

PARAMETER	CONDITIONS	MIN	MAX	UNIT
1/4 Cell + Retriggerable One-Shot Delay*	TD = 5.85 (RR +1.4) + 0.157 Rd (Cd +11.5) RR = kΩ Rd = kΩ Cd = 68 pF to 100 pF	0.89 TD	1.11 TD	ns
* Excludes External Capacitor and Resistor Tolerances				

4

WRITE MODE (See Figure 10)

TWD	Write Data Pulse Width	CL ≤ 15 pF	(TORO/2) -12	(TORO/2) +12	ns
TFWD	Write Data Fall Time	2.0V to 0.8V, CL ≤ 15 pF		8	ns
TOWC	Write Data Clock Repetition Period		TORO -12	TORO +12	ns
TRWC	Write Data Clock Rise Time	0.8V to 2.0V		10	ns
TFWC	Write Data Clock Fall Time	2.0V to 0.8V		8	ns
TSNRZ	NRZ (in) Set Up Time		20		ns
THNRZ	NRZ (in) Hold Time		7		ns

DATA SYNCHRONIZATION

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TVCO	VCO Center Frequency Period	VCO IN = 2.7V TO = 1.17E - 11 (RR +1400) VCC = 5.0V	0.8 TO		1.2 TO	sec
	VCO Frequency Dynamic Range	1.0V ≤ VCO IN ≤ VCC -0.6V VCC = 5.0V	±24		±40	%
KVCO	VCO Control Gain	ωo = 2π / TO 1.0V ≤ VCO IN ≤ VCC -0.6V	0.14 ωo		0.20 ωo	rad/s V
KD	Phase Detector Gain	KD = 0.309 / (RR + 500) VCC = 5.0V	0.83 KD		1.17 KD	A/rad
	KVCO x KD Product Accuracy		-28		+28	%
	Decode Window Centering Accuracy				± (0.01 TORC + 2)	ns
	Decode Window		(TORC/2) -2			ns

DATA SYNCHRONIZATION (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
TS1 Decode Window Time Shift Magnitude	TS1 = 0.015 TORC		1.0 TS1		sec
TS2 Decode Window Time Shift Magnitude	TS2 = 0.06 TORC		1.0 TS2		sec
TS3 Decode Window Time Shift Magnitude	TS3 = 0.075 TORC		1.0 TS3		sec
TSA Decode Window Time Shift Magnitude	$TSA = 0.125\ TORC\left(1 - \frac{680 + R}{1180 + R}\right)$ with: R in ohms	0.65 TSA		1.35 TSA	sec

CONTROL CHARACTERISTICS (See Figure 11)

TSWS, $\overline{WS0}$, $\overline{WS1}$, WSD Set Up Time		50			ns
THWS, $\overline{WS0}$, $\overline{WS1}$, WSD Hold Time		0			ns
RG, WG, SOFT/$\overline{HARD}$ Time Delay				100	ns

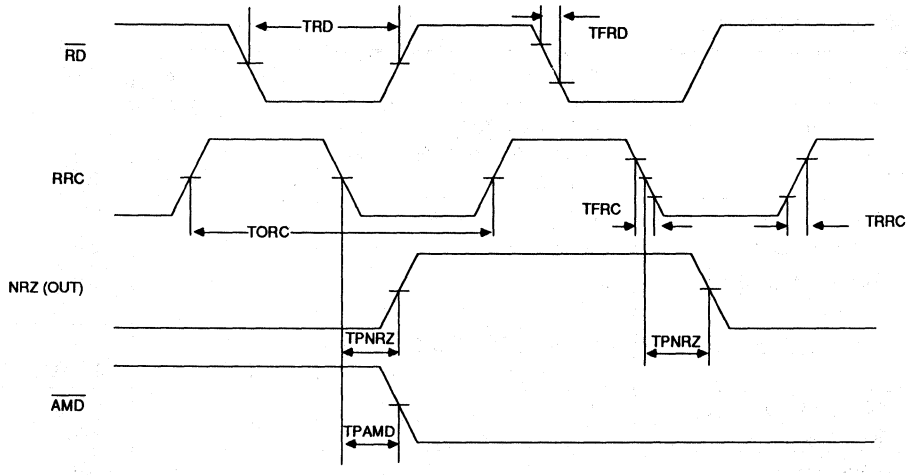


FIGURE 9: Read Timing

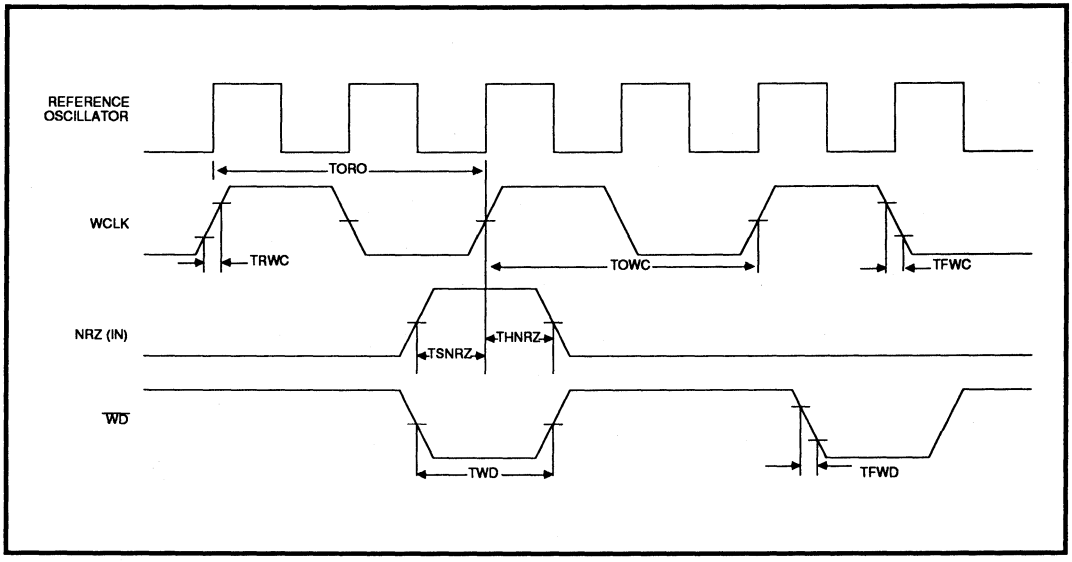


FIGURE 10: Write Timing

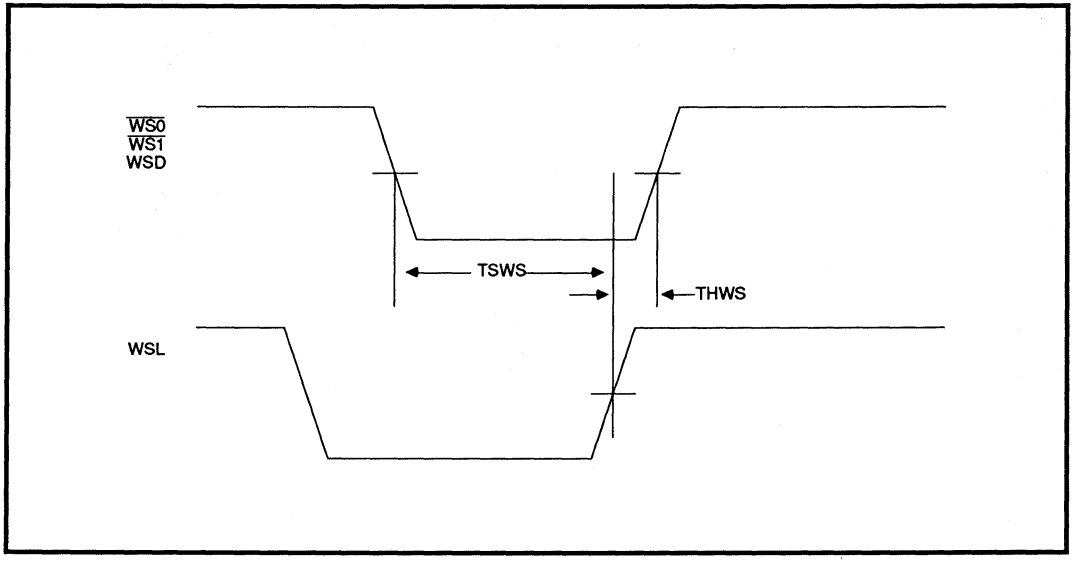


FIGURE 11: Control Timing

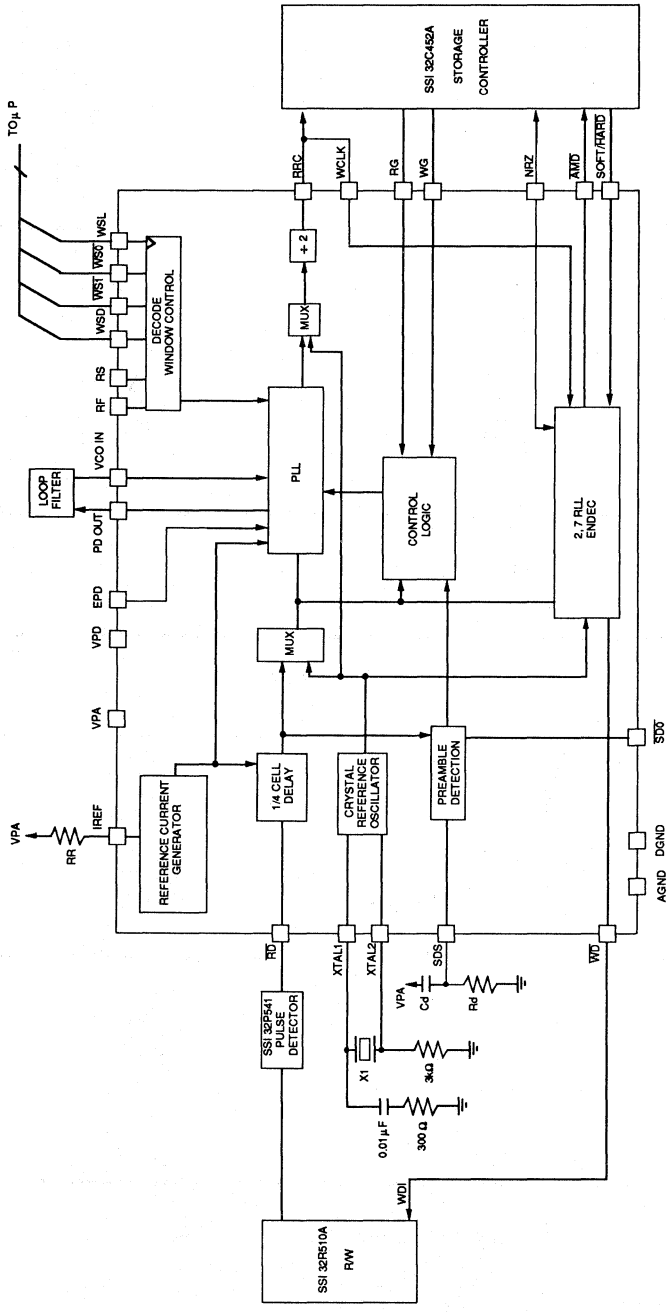
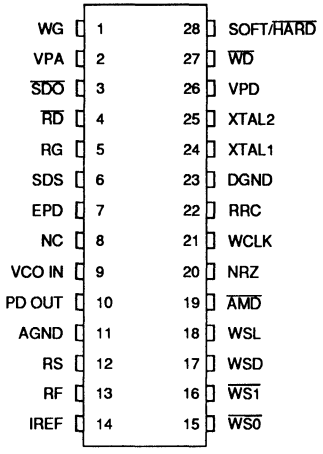
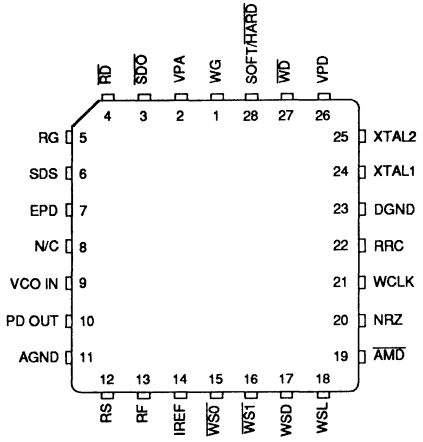


FIGURE 12: SSI 32D5381 Typical Application

PACKAGE PIN DESIGNATIONS
(TOP VIEW)



28-Pin DIP



28-Pin PLCC

4

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX: (714) 731-5457

Notes:

SSI 32D539
Data Synchronizer & 1, 7 RLL Endec

Advance Information

July, 1990

DESCRIPTION

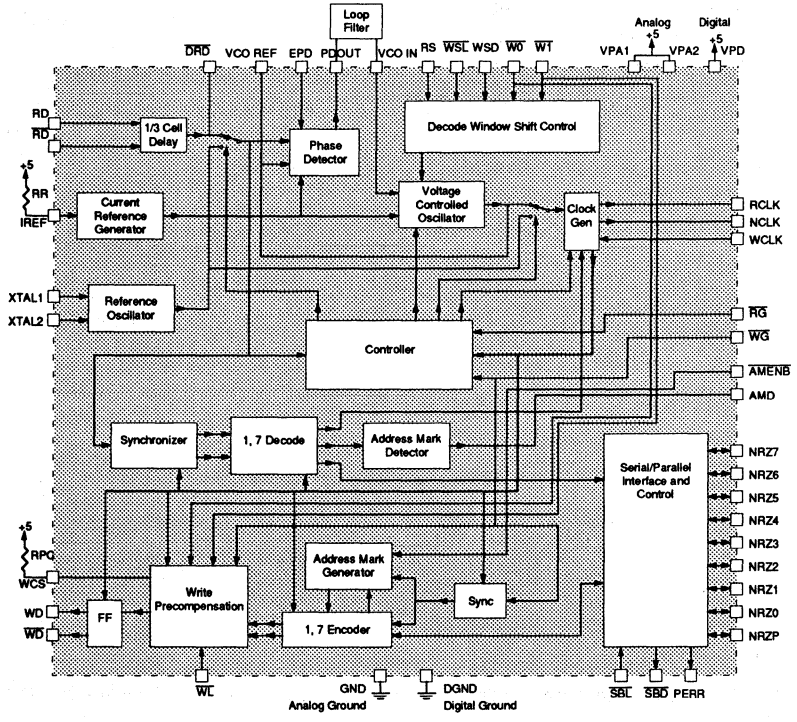
The circuit is intended to be used as a data/clock recovery circuit for 1, 7 RLL code in hard disk drive systems with a +5V supply.

FEATURES

- **Data synchronizer and 1, 7 RLL ENDEC**
- **9-bit bi-directional data bus interface**
  - **8 data bits plus 1 parity bit**
  - **Parity generation during read operation**
  - **Parity checking during write operation**
- **Up to 48 Mbit/s operation**
  - **Data rate programmed with a single external resistor or current source**
- **Programmable Sync-Byte pattern detection**
- **Fast acquisition phase locked loop with zero phase restart technique**
- **Fully integrated data separator**
  - **No external delay lines or active devices required**
- **Programmable decode window symmetry control**
  - **Includes delayed read data and VCO clock monitor points**
- **Programmable write precompensation**
- **Hard and soft sector operation**
- **Uses standard 5V ± 5% supply**
- **44-pin PLCC package**

4

BLOCK DIAGRAM



OPERATION

DATA/CLOCK RECOVERY CIRCUIT

The circuit is designed to perform data recovery and data encoding in rotating memory systems which utilize a 1, 7 RLL encoding format. In the read mode the circuit performs data synchronization, sync field search and detect, address mark detect, and data decoding. In the write mode, the circuit converts NRZ data into the 1, 7 RLL format described in Table 1, performs write precompensation, generates the preamble field and inserts address marks as requested.

This data rate is established by a single 1% external resistor, RR, connected from the IREF pin to VPA. This resistor establishes a reference current which sets the VCO center frequency, the phase detector gain, and the 1/3 cell delay. The value of this resistor is given by:

RR = (TBD/DR) - TBD kΩ

Where: DR = data rate in Mbit/s

Alternately, the IREF pin can be driven from the SSI 32D460 in a constant density recording application.

The circuit employs a dual mode phase detector; harmonic in the read mode and non-harmonic in the write and idle modes. In the read mode, the harmonic phase detector updates the PLL with each occurrence of a DLYD DATA pulse. In the write and idle modes, the non-harmonic phase detector is continuously enabled, thus maintaining both phase and frequency lock. By acquiring both phase and frequency lock to the input reference frequency and utilizing a zero phase restart technique, false lock to DLYD DATA is eliminated.

The phase detector incorporates a charge pump in order to drive the loop filter directly. The polarity and width of the output current pulses correspond to the direction and magnitude of the phase error.

The READ GATE ($\overline{RG}$) and WRITE GATE ($\overline{WG}$) inputs control the mode of the data/clock recovery section of the chip.

$\overline{RG}$ is an asynchronous input and may be initiated or terminated at any position on the disk. $\overline{WG}$ is also an asynchronous input, but should not be terminated prior to the last output write data pulse.

READ OPERATION

The data synchronizer utilizes a fully integrated fast acquisition PLL to accurately develop the decode window. Read gate, $\overline{RG}$, initiates the PLL locking sequence and selects the PLL reference input; a low level (read mode) selects the $\overline{RD}$ input and a high level selects the external reference clock.

In the read mode the falling edge of $\overline{DRD}$ enables the phase detector while the rising edge is phase compared to the rising edge of VCO. As depicted in Figure 1, $\overline{DRD}$ is a 1/3 cell wide (TVCO) pulse whose leading edge is defined by the leading edge of $\overline{RD}$. A decode window is developed from the VCO clock.

Shifting the symmetry of the VCO clock effectively shifts the relative position of the DRD pulse within the decode window. Decode window control is provided via the WS controls.

In the non-read modes, the PLL is locked to the external reference clock. When the reference input to the PLL is switched, the VCO is stopped momentarily, then restarted in an accurate phase alignment with the next PLL reference input pulse, and the VCO clock divider is reset.

ADDRESS MARK DETECT

In soft sector read operation the circuit must first detect an address mark to be able to initiate the rest of the read lock sequence. An address mark consists of two sets

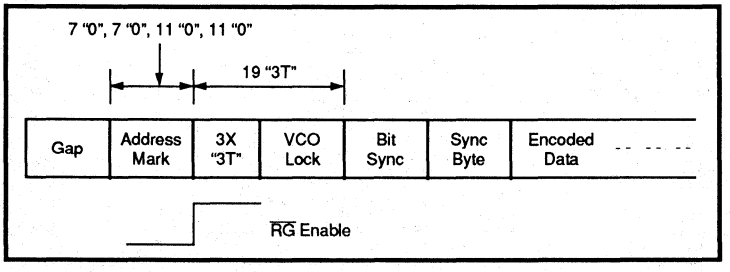


FIGURE 1: Disk Operation Lock Sequence in Read Mode Soft Sector Operation

of 7 "0" patterns followed by two sets of 11 "0" patterns. To begin the read lock sequence the Address Mark Enable ($\overline{AMENB}$) is asserted low by the controller. The address mark detect ($\overline{AMD}$) circuit then initiates a search of the read data ($\overline{RD}$) for an address mark. First the $\overline{AMD}$ looks for a set of 6 "0"s within the 7 "0" patterns. Having detected a 6 "0" the $\overline{AMD}$ then looks for a 9 "0" set within the 11 "0"s. If $\overline{AMD}$ does not detect 9 "0"s within 5 $\overline{RD}$ bits after detecting 6 "0"s it will restart the address mark detect sequence and look for 6 "0"s. When the $\overline{AMD}$ has acquired a 6 "0," 9 "0" sequence, the $\overline{AMD}$ transitions low.

PREAMBLE SEARCH

After the Address Mark (AM) has been detected, a Read Gate ($\overline{RG}$) can be asserted low, initiating the remainder of the read lock sequence. When $\overline{RG}$ is asserted, an internal counter counts negative transitions of the incoming read data ($\overline{RD}$) looking for 3 consecutive 3T preambles. Once the counter reaches count 3 (finds 3 consecutive 3T preambles) the internal read gate enables, switching the phase detector from the external reference clock to the delayed read data input ($\overline{DRD}$); at the same time a zero phase (internal) restart signal restarts the VCO in phase with the read reference clock. This prepares the VCO to be synchronized to data when the bit sync circuitry is enabled after VCO lock is established.

VCO LOCK AND BIT SYNC ENABLE

When the internal counter counts 16 more "3T" or a total of 19 negative transitions from RG enable, an internal VCO lock signal enables. The VCO lock signal activates the decoder bit synchronization circuitry to define the proper decode boundaries. Also, at count 19, the RRC source switches from the external reference clock to VCO clock signal which is phase locked to $\overline{DRD}$. The VCO is assumed locked at this point. A maximum of 2 RRC time periods may occur for the RRC transition, however, no short duration glitches will occur. After the bit sync circuitry sets the proper decode window (VCO in sync with RRC and RRC in sync with the data) NRZ is enabled and data is toggled in to be decoded for the duration of the read gate.

BYTE SYNC AND NRZ OUT

As the data is decoded, it is compared to a Sync Byte that was loaded prior to the read operation. When a match is found, RCLK and NCLK are resynchronized to the correct byte boundary. NRZ data then appears at the byte output beginning with the sync byte. The $\overline{SBD}$ output is also set low at this time. It remains low until the end of the read operation. A parity bit (NRZP) is also generated for each output byte (even parity).

HARD SECTOR OPERATION

In hard sector operation AMD remains inactive. A hard sector read operation does not require an address mark search but starts with a preamble search as with soft sector and sequences identically. In all respects, with exception to the address mark search sequence, hard sector read operation is the same as soft sector read.

WRITE MODE

In the write mode the circuit converts NRZ data from the controller into 1, 7 RLL formatted data for storage on the disk. The circuit can operate with a soft or hard sector hard drive.

In soft sector operation the circuit generates a "7, 7, 11, 11" address mark and a preamble pattern. In hard sector operation the circuit generates a 19 x "3T" preamble pattern but no preceding address mark.

Serial NRZ data is clocked into the circuit and latched on defined cell boundaries. The NRZ input data must be synchronous with the rising edges of the RRC.

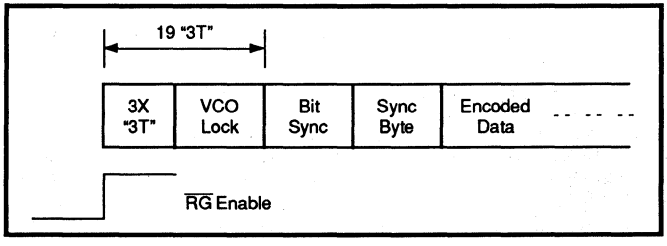


FIGURE 2: Disk Operation Lock Sequence In Read Mode Hard Sector Operation

WRITE MODE (Continued)

Write precompensation circuitry is provided to compensate for media bit shift caused by intersymbol interference. The circuit recognizes specific write data patterns and can add or subtract delays in the time position of write data bits to counteract the read back bit shift. The magnitude of the time shift, TPC, is determined by an external resistor on the WCS pin.

The circuit performs write precompensation according to the algorithm outlined in Table 3.

SOFT SECTOR

In soft sector operation, when read gate ($\overline{RG}$) transitions high, VCO source and RRC source switch from $\overline{RD}$ and VCO/3, respectively, to the external reference clock. At the same time the VCO (internal) lock goes inactive but the VCO is locked to the external reference clock. After delay of 1 NRZ time period (min) from $\overline{RG}$ high, the write gate ($\overline{WG}$) can be enabled low while NRZ is maintained (NRZ write data) low. The address mark enable ($\overline{AMENB}$) is made active (low) a minimum of 1 NRZ time period later. The address mark (consisting of 7 "0"s, 7 "0"s, 11 "0"s, 11 "0"s) and the 19 x "3T" preamble is then written by WD. While the preamble is being written, WCLK is clocking in an all "0" NRZ byte. The first non-zero NRZ byte input is assumed to be the sync byte. After a delay of 5 NRZ time periods, non-preamble data begins to toggle out WD. Finally, at the end of the write cycle, 2 bytes of blank NRZ time passes to insure the encoder is flushed of data; $\overline{WG}$ then goes high. WD stops toggling a maximum of 2 NRZ time periods after $\overline{WG}$ goes high.

As each NRZ byte is input for encoding, its parity is checked against the parity bit (NRZP). If a parity error is detected the PERR output flag is set high. It remains high until WG goes high.

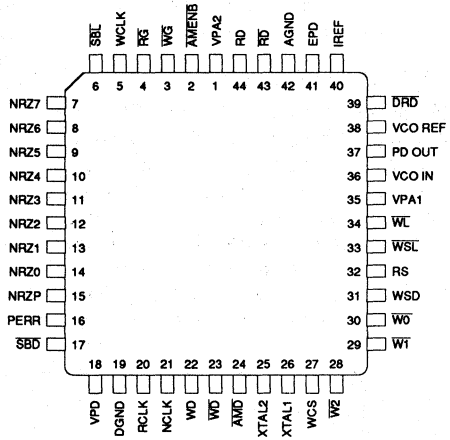
HARD SECTOR

In hard sector operation, when read gate ($\overline{RG}$) transitions high, VCO source and RRC switch references and VCO lock (internal) goes inactive as with soft sector but the $\overline{AMENB}$ (address mark enable) is kept high.

The circuit then sequences from $\overline{RG}$ disable to $\overline{WG}$ enable and NRZ active as in soft sector operation.

PACKAGE PIN DESIGNATIONS

(TOP VIEW)



CAUTION: Use handling procedures necessary for a static sensitive component.

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX (714) 731-5457

SSI 32D4660
Time Base Generator

Advance Information

June, 1990

DESCRIPTION

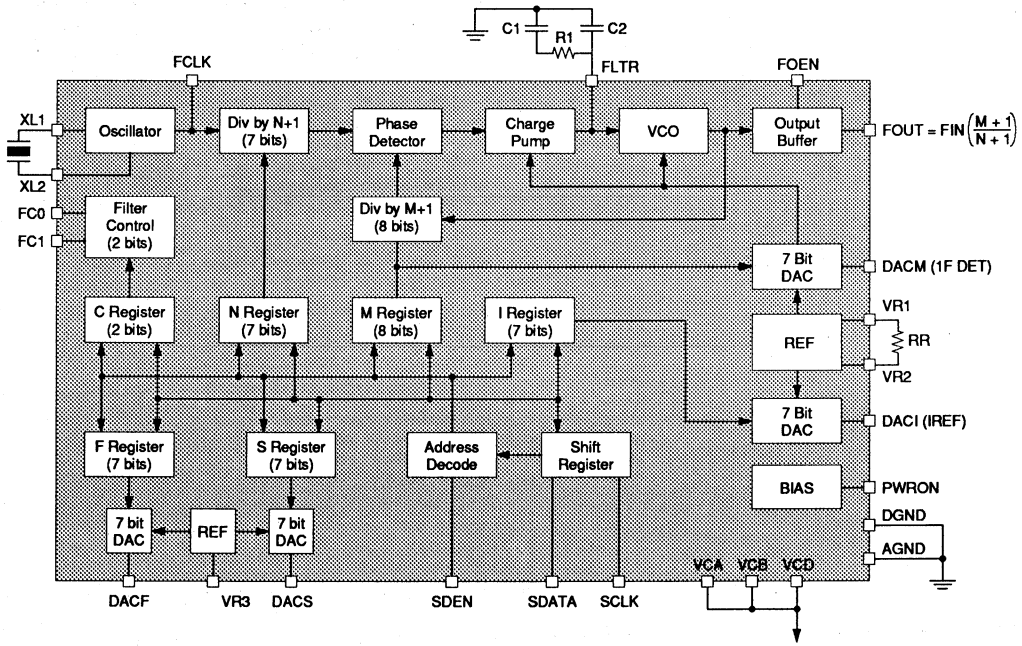
The SSI 32D4660 Time Base Generator provides a programmable reference generator, channel filter control and data rate control for constant density recording applications. It is optimized to operate with the 32D53xx series data separators and contains a high performance programmable PLL for 1% reference frequency control. A 7-bit DAC is provided to program the IREF current which sets the data separator PLL operating center frequency. A 7-bit DAC is provided to program the 1FDET current which sets the timing for the data separator synch field detect. Two additional 7-bit DAC's are provided for programmable electronic filter (slimmer) control. Two latched TTL outputs are provided to control filter multiplexers. A serial microprocessor interface reduces pin count and provides convenient access to the internal program storage registers. The 32D4660 only requires a +5V supply and will be available in 24-pin DIP and SO packages.

FEATURES

- **For constant density recording applications**
- **Reference frequency control**
- **Channel filter control**
- **Internal DAC available to program data separator data rate**
- **Internal DAC available to program data separator sync field detect timing**
- **Up to 24 Mbit/s operation**
- **1% frequency resolution**
- **No external active components required**
- **+5V only operation**
- **Low power mode**
- **24-pin DIP and SOL package**

4

BLOCK DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

PIN DESCRIPTIONS

INPUT PINS

NAME	DESCRIPTION
SDATA	Serial Data. Data input for an 8-bit control shift register. The data packet is transmitted MSB (D7) first. The first four bits are the register address and the last four are its data bits. Registers larger than 4-bits must be loaded with two 8-bit data packets. These packets should be loaded sequentially in less than 10 µs since the loading operation will cause output transients. With proper loop filter design, the output transients will recover within 1 ms. The data packet fields are given in Table 1.
SCLK	Serial Data Clock. Negative edge triggered clock input for the serial data.
SDEN	Serial Data Enable. A high level input enables data loading. The data is latched when the input is low.
PWRON	Power On. A high level input enables the chip. A low level puts the chip in a low power idle state.
FOEN	Frequency Output Enable. A high level input enables the FOUT output. A low level disables the output and minimizes the driven data separator jitter.

OUTPUT PINS

FOUT	Frequency Output. An ECL output with internal current source. The low voltage swing which minimizes data separator jitter must be AC coupled to the data separator XLT1 input. FOUT = [(M +1)/(N +1)]FIN where M = M Register number and N must be set to approximately [(FIN) (256) / 72MHz] - 1
DAC M	DAC Output. 7-bit DAC current sink output used to program timing current to the data separator sync field detect SDS pin. The current magnitude is controlled by the 7 MSB's of the M Register and is compensated to minimize the sensitivity to power supply and temperature variations. If this output isn't required, the pin must be connected to VCC.
DAC I	DAC Output. 7-bit DAC current source output used to program timing current for the data separator VCO center frequency. The current magnitude is controlled by the I Register and is compensated to minimize the sensitivity to power supply and temperature variations.
DAC F	DAC Output. 7-bit DAC voltage output used for electronic filter control. The output voltage is set by the voltage at VR3 and the F Register number.
DAC S	DAC Output. Similar to DAC F except controlled by the S Register number.
FC0	Filter Control 1. TTL output used to control an external filter multiplexer. C0 = H sets FC0 = H.
FC1	Filter Control 2. TTL output used to control an external filter multiplexer. C1 = H sets FC1 = H.

OUTPUT PINS (Continued)

NAME	DESCRIPTION
FCLK	Clock Output. Optional TTL output that may be used for a system clock. The output frequency is the same as the oscillator output frequency. For minimum FOUT jitter, parts with FCLK disabled should be used. FCLK remains active when PWR ON is low.

ANALOG PINS

XTL1, XTL2	Crystal Oscillator Connections. The circuit is designed to be used with an 8 MHz to 20 MHz crystal. If a crystal is not desired, XTL1 may be driven by a TTL source with XTL2 left open.
VR1, VR2	Current Setting Resistor Connections. An external resistor RR connected between VR1 and VR2 sets the DACM and DACI currents.
VR3	Reference Voltage Input. An external 2.2V supply sets the reference for the DACF and DACS currents.
FLTR	PLL Loop Filter Connection. Connection for loop filter components R1, C1 and C2.
DGND, AGND	Digital and Analog Ground
VCA, VCB	Analog +5V Supplies
VCD	Digital +5V Supply

TABLE 1: Data Packet Fields

ADDRESS BITS				USAGE	DATA BITS			
D7	D6	D5	D4		D3	D2	D1	D0
0	1	1	0	I REGISTER	X	I6	I5	I4
0	1	1	1	I REGISTER	I3	I2	I1	I0
1	0	0	0	F, C, REGISTER	C1	F6	F5	F4
1	0	0	1	F REGISTER	F3	F2	F1	F0
1	0	1	0	S, C, REGISTER	C0	S6	S5	S4
1	0	1	1	S REGISTER	S3	S2	S1	S0
1	1	0	0	M REGISTER	M7	M6	M5	M4
1	1	0	1	M REGISTER	M3	M2	M1	M0
1	1	1	0	N REGISTER	X	N6	N5	N4
1	1	1	1	N REGISTER	N1	N2	N1	N0

X = Don't care bit.

ABSOLUTE MAXIMUM RATINGS

Operation above maximum ratings may damage the device.

PARAMETER	RATING	UNITS
Storage Temperature	–65 to +150	°C
Junction Operating Temperature, Tj	+150	°C
Supply Voltage, VCA, VCB, VCD	–0.5 to 7	V
Voltage Applied to Logic Inputs	–0.5 to 5.5	V
Maximum Power Dissipation	0.6	mW

RECOMMENDED OPERATING CONDITIONS

PARAMETER	RATING	UNITS
Supply voltage, VCA = VCB = VCD	4.65<VCC<5.25	V
Junction Temperature, Tj	0<Tj<135	°C
Ambient Temperature, Ta	0<Ta<70	°C

ELECTRICAL CHARACTERISTICS

Unless Otherwise Specified: 4.65V<VCC<5.25, 0°C<Ta<70°C

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
VIH	High Level Input Voltage		2.0			V
VIL	Low Level Input Voltage				0.8	V
IIH	High Level Input Current	VIH = 2.7V			20	µA
IIL	Low Level Input Current	VIL = 0.4V			–1.5	mA
VOH	High Level Output Voltage	IOH = -400 µA	2.6			V
VOL	Low Level Output Voltage	IOL = 2 mA			0.5	V
VOH	FOUT ECL High Level	VCD = 5V, VOH-VCD	–1.02			V
VOL	FOUT ECL Low Level	VCD = 5V, VOL-VCD			–1.45	V
ICC	Power Supply Current	PWRON = 2.0V		77	103	mA
		PWRON = 0.8V		25		mA
IO	FOUT Output Current			±4		mA
VO	FOUT Output Swing		0.6			V

INPUT/OUTPUT CHARACTERISTICS

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
FIN	FIN Frequency		8		20	MHz
FO	FOUT Frequency				75	MHz
JFO	FOUT Jitter	TO = 1/FO; FCLK active			±400	ps(pk)
DFO	FOUT Duty Cycle	50% Amplitude FOUT = 72 MHz	42		58	%
M	M Divide Number		80		255	
N	N Divide Number		25		127	
I	I Register Number		50		127	
RR	External Resistor		4.50		5.25	KΩ
TVCO	VCO Center Frequency Period	1V<FLTR< VCC – 0.5V TO=(6.17 E-10)(RR/M)+2.4 ns VCC = 5V, RR = 4.75K	0.77TO		1.23TO	ns
	VCO Frequency Dynamic Range	1V < FLTR < VCC – 0.5V, VCC = 5V	±25		±45	%
KVCO	VCO Control Gain	Wi = 2π(FO)	0.14Wi		0.26Wi	rad/s V
KD	Phase Detector	KD = (4.16E – 3)/RR	0.83KD		1.17KD	A/rad
IOM	DACM Current	IO = (1.641 E-2) M/RR VCC = 5V, TA = 25°C, RR = 4.75K	0.97IO –1LSB		1.03IO +1LSB	A
IOI	DACI Current	IO = (7.41 E-2)I/RR VCC = 5V, TA = 25°C, RR = 4.75K	0.95IO –3/4LSB		1.05IO +3/4LSB	A
VOF	DACF Voltage	VOF = 0.98 F*VR3/127, VCC = 5V	0.97VOF –3/4LSB +15 mV		1.03VOF +3/4LSB +60 mV	V
VOS	DACS Voltage	VOS = 0.98 S*VR3/127 VCC = 5V	0.97VOS –3/4LSB +15 mV		1.03VOS +3/4LSB +60 mV	V
VR3	DAC Reference		2.0		2.4	V
IVR3	VR3 Input Current	VR3 = 2.4V			0.5	mA

INPUT/OUTPUT CHARACTERISTICS (Continued)

PARAMETER		CONDITIONS	MIN	MAX	UNITS
VODH	DACM Output Voltage		0.5	VCC	V
VODL	DACI Output Voltage			2	V
VOFL	DACF, DACS Output Voltage		0.1	2.4	V
ROUT	DACF, DACS Output Resistance			3.7	kΩ
SCLK	Data Clock Period, TC		100		ns
TDD	Data Set Up/Hold Time		25		ns
TDE	Data Enable Delay Time	Delay from data clock rising edge	– TC	TC/4	ns

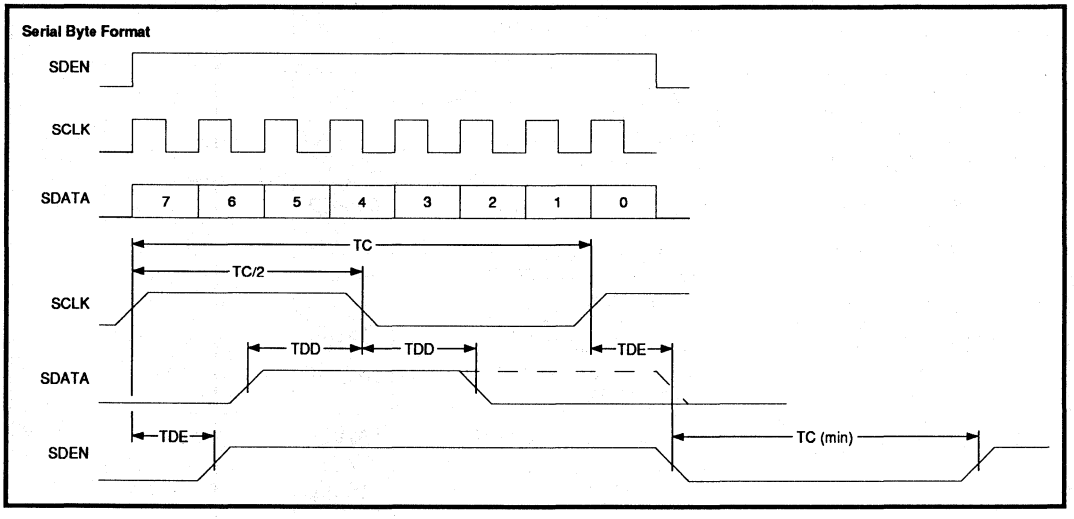
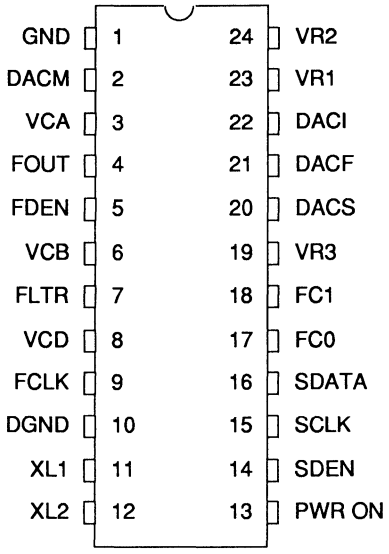


FIGURE 1: Serial Port Timing

PIN DIAGRAM
(Top View)



24 Pin PDIP, SOL

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32D4661
Time Base Generator

Advance Information

June, 1990

DESCRIPTION

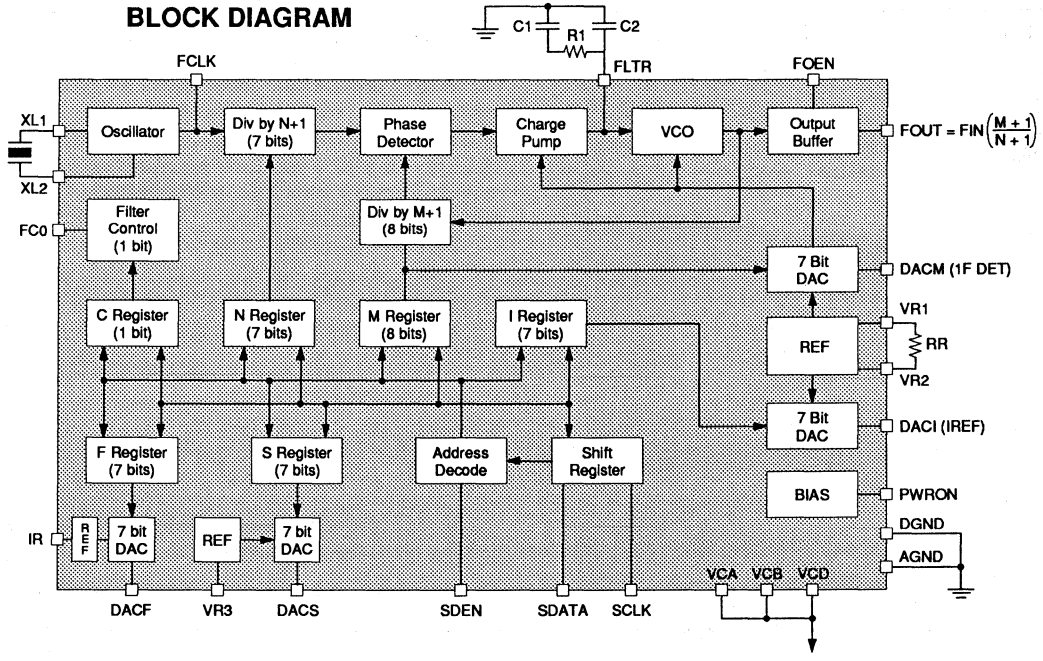
The SSI 32D4661 Time Base Generator provides a programmable reference generator, channel filter control and data rate control for constant density recording applications. It is optimized to operate with the 32D53xx series data separators and contains a high performance programmable PLL for 1% reference frequency control. A 7–bit DAC is provided to program the IREF current which sets the data separator PLL operating center frequency. A 7–bit DAC is provided to program the 1FDET current which sets the timing for the data separator synch field detect. Two additional 7–bit DACs are provided for programmable electronic filter (slimmer) control. Two latched TTL outputs are provided to control filter multiplexers. A serial microprocessor interface reduces pin count and provides convenient access to the internal program storage registers. The 32D4661 only requires a +5V supply and will be available in 24-pin DIP and SO packages.

FEATURES

- **Not plug compatible with SSI 32D4660**
- **For constant density recording applications**
- **Reference frequency control**
- **Channel filter control**
- **Internal DAC available to program data separator data rate**
- **Internal DAC available to program data separator sync field detect timing**
- **Up to 24 Mbit/s operation**
- **1% frequency resolution**
- **No external active components required**
- **+5V only operation**
- **Low power mode**
- **24-pin DIP and SOL package**

4

BLOCK DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

PIN DESCRIPTIONS

INPUT PINS

NAME	DESCRIPTION
SDATA	Serial Data. Data input for an 8-bit control shift register. The data packet is transmitted MSB (D7) first. The first four bits are the register address and the last four are its data bits. Registers larger than 4-bits must be loaded with two 8-bit data packets. These packets should be loaded sequentially in less than 10 µs since the loading operation will cause output transients. With proper loop filter design, the output transients will recover within 1 ms. The data packet fields are given in Table 1.
SCLK	Serial Data Clock. Negative edge triggered clock input for the serial data.
SDEN	Serial Data Enable. A high level input enables data loading. The data is latched when the input is low.
PWRON	Power On. A high level input enables the chip. A low level puts the chip in a low power idle state.
FOEN	Frequency Output Enable. A high level input enables the FOUT output. A low level disables the output and minimizes the driven data separator jitter.

OUTPUT PINS

FOUT	Frequency Output. An ECL output with internal current source. The low voltage swing which minimizes data separator jitter must be AC coupled to the data separator XTL1 input. FOUT = [(M +1)/(N +1)]FIN where M = M Register number and N must be set to approximately [(FIN) (256) / 72 MHz] - 1
DAC M	DAC Output. 7-bit DAC current sink output used to program timing current to the data separator sync field detect SDS pin. The current magnitude is controlled by the 7 MSB's of the M Register and is compensated to minimize the sensitivity to power supply and temperature variations. If this output isn't required, the pin must be connected to VCC.
DAC I	DAC Output. 7-bit DAC current source output used to program timing current for the data separator VCO center frequency. The current magnitude is controlled by the I Register and is compensated to minimize the sensitivity to power supply and temperature variations.
DAC F	DAC Output. 7-bit DAC current output used for electronic filter control. The output current is set by the voltage at VR3, and the F Register number and an external resistor Rx.
DAC S	DAC Output. 7-bit DAC voltage output used for electronic filter control. The output voltage is set by the voltage at VR3 and the S Register number.
FC0	Filter Control 1. TTL output used to control an external filter multiplexer. C0 = H sets FC0 = H.

OUTPUT PINS (Continued)

NAME	DESCRIPTION
FCLK	Clock Output. Optional TTL output that may be used for a system clock. The output frequency is the same as the oscillator output frequency. For minimum FOUT jitter, parts with FCLK disabled should be used. FCLK remains active when PWR ON is low.

ANALOG PINS

XTL1, XTL2	Crystal Oscillator Connections. The circuit is designed to be used with an 8 MHz to 20 MHz crystal. If a crystal is not desired, XTL1 may be driven by a TTL source with XTL2 left open.
VR1, VR2	Current Setting Resistor Connections. An external resistor RR connected between VR1 and VR2 sets the DACM and DACI currents.
VR3	Reference Voltage Input. An external 2.2V supply sets the reference for the DACS voltage.
FLTR	PLL Loop Filter Connection. Connection for loop filter components R1, C1 and C2.
DGND, AGND	Digital and Analog Ground
VCA, VCB	Analog +5V Supplies
VCD	Digital +5V Supply
IR	Reference Current Input. An external resistor Rx, connected from IR to VR3 reference voltage sets the reference current for the DACF current.

TABLE 1: Data Packet Fields

ADDRESS BITS				USAGE	DATA BITS			
D7	D6	D5	D4		D3	D2	D1	D0
0	1	1	0	I REGISTER	X	I6	I5	I4
0	1	1	1	I REGISTER	I3	I2	I1	I0
1	0	0	0	S REGISTER	X	S6	S5	S4
1	0	0	1	S REGISTER	S3	S2	S1	S0
1	0	1	0	F, C REGISTER	C0	F6	F5	F4
1	0	1	1	F REGISTER	F3	F2	F1	F0
1	1	0	0	M REGISTER	M7	M6	M5	M4
1	1	0	1	M REGISTER	M3	M2	M1	M0
1	1	1	0	N REGISTER	X	N6	N5	N4
1	1	1	1	N REGISTER	N1	N2	N1	N0

X = Don't care bit.

ABSOLUTE MAXIMUM RATINGS

Operation above maximum ratings may damage the device.

PARAMETER	RATING	UNITS
Storage Temperature	–65 to +150	°C
Junction Operating Temperature, Tj	+150	°C
Supply Voltage, VCA, VCB, VCD	–0.5 to 7	V
Voltage Applied to Logic Inputs	–0.5 to 5.5	V
Maximum Power Dissipation	540	mW

RECOMMENDED OPERATING CONDITIONS

PARAMETER	RATING	UNITS
Supply voltage, VCA = VCB = VCD	4.65 to 5.25	V
Junction Temperature, Tj	0<Tj<135	°C
Ambient Temperature, Ta	0<Ta<70	°C

ELECTRICAL CHARACTERISTICS

Unless Otherwise Specified: Recommended operating conditions apply

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
VIH	High Level Input Voltage		2.0			V
VIL	Low Level Input Voltage				0.8	V
IIH	High Level Input Current	VIH = 2.7V			20	µA
IIL	Low Level Input Current	VIL = 0.4V			-1.5	mA
VOH	High Level Output Voltage	IOH = -400 µA	2.7			V
VOL	Low Level Output Voltage	IOL = 2 mA			0.5	V
VOH	FOUT ECL High Level	VCD = 5V, VOH-VCD	-1.02			V
VOL	FOUT ECL Low Level	VCD = 5V, VOL-VCD			-1.45	V
ICC	Power Supply Current	PWRON = 2.0V		77	103	mA
		PWRON = 0.8V		25		mA
IO	FOUT Output Current			±4		mA
VO	FOUT Output Swing		0.6			V

INPUT/OUTPUT CHARACTERISTICS

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
FIN	FIN Frequency		8		20	MHz
FO	FOUT Frequency				75	MHz
JFO	FOUT Jitter	TO = 1/FO; FCLK active			±400	ps(pk)
DFO	FOUT Duty Cycle	50% Amplitude FOUT = 72 MHz	42		58	%
M	M Divide Number		80		255	
N,F	N,F Divide Number		25		127	
I	I Register Number		50		127	
RR	External Resistor		4.50		5.25	kΩ
TVCO	VCO Center Frequency Period	1V<FLTR< VCC – 0.5V TO=(6.17 E-10)(RR/M)+2.4 ns VCC = 5V, RR = 4.75K	0.77TO		1.23TO	ns
	VCO Frequency Dynamic Range	1V < FLTR < VCC – 0.5V, VCC = 5V	±25		±45	%
KVCO	VCO Control Gain	Wi = 2π(FO)	0.14Wi		0.26Wi	rad/s V
KD	Phase Detector	KD = (4.16 E-3)/RR		KD		A/rad
IOM	DACM Current	IO = (1.641 E-2) M/RR VCC = 5V, TA = 25°C, RR = 4.75K	0.97IO –1LSB		1.03IO +1LSB	A
IOI	DACI Current	IO = (7.41 E-2)I/RR VCC = 5V, TA = 25°C, RR = 4.75K	0.95IO –3/4LSB		1.05IO +3/4LSB	A
IOF	DACF Current	IOF=0.98 F*VR3/127•Rx VCC = 5V, Rx = 2.74K	0.97IOF –3/4LSB		1.03IOF +3/4LSB	A
VOS	DACS Voltage	VOS = 0.98 S*VR3/127 VCC = 5V	0.97VOS –3/4LSB +15 mV		1.03VOS +3/4LSB +80 mV	V
VR3	DAC Reference		2.0		2.4	V
IVR3	VR3 Input Current	VR3 = 2.2V			0.5	mA
Rx			2.5		3.0	kΩ

INPUT/OUTPUT CHARACTERISTICS (Continued)

PARAMETER	CONDITIONS	MIN	MAX	UNITS
VODH DACM Output Voltage		2.7	VCC	V
VODL DACI Output Voltage			2	V
VOFL DACF, DACS Output Voltage		0.1	2.4	V
ROUT DACF, DACS Output Resistance			3.7	kΩ
SCLK Data Clock Period, TC		100		ns
TDD Data Set Up/Hold Time		25		ns
TDE Data Enable Delay Time	Delay from data clock rising edge	– TC	TC/4	ns

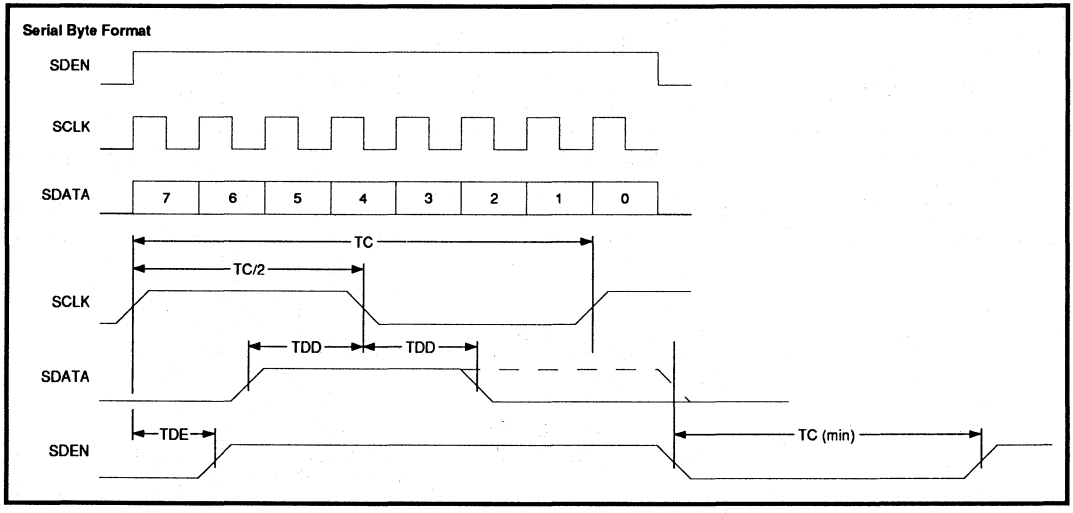
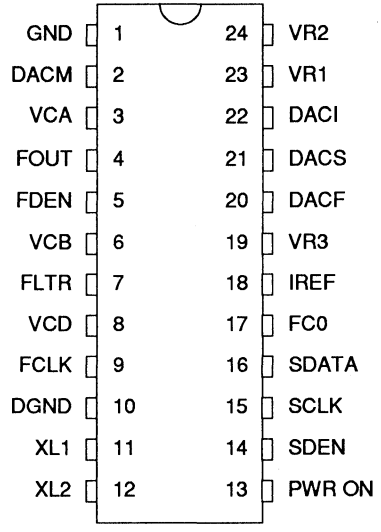


FIGURE 1: Serial Port Timing

PIN DIAGRAM
(Top View)



24-Pin PDIP, SOL

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only.

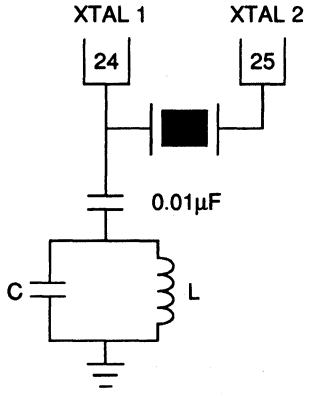
Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

REFERENCE OSCILLATOR

An internal reference oscillator generates the standby reference for the PLL. For the 32D5321/5322 and the 32D535/5351, a series resonant crystal of twice the data rate should be used between XTAL1 and XTAL2. For the 32D5362, the series resonant crystal should be selected at three times the data rate. If a crystal oscillator is not desired, then an external TTL compatible reference may be applied to XTAL1, leaving XTAL2 open.

If it is desired to operate a crystal at a non-fundamental or harmonic frequency, then the following network is suggested:



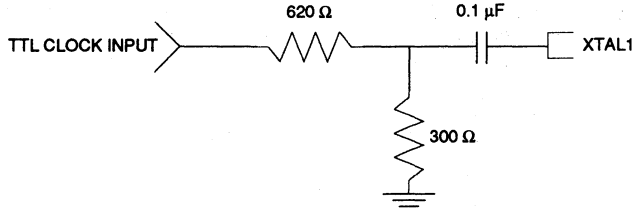
$$\omega_o = 2\Pi F_o = \frac{1}{\sqrt{LC}}$$

$$Q_o = \omega_o C R_{in}$$

The typical input impedance looking into XTAL1 is approximately Rin = 250Ω. It is recommended to design the value of Qo at approximately 10 to 15. Therefore, a resonant frequency of Fo = 20 MHz would result in L ≅ 0.16 µH and C ≅ 380 pF.

ATTENUATOR CIRCUIT

If a crystal oscillator is not desired, then an external TTL Compatiable reference may be applied to XTAL1 leaving XTAL2 open. It is required, however that the TTL signal be attenuated then A.C. coupled into XTAL1 using the following network:



The signal amplitude into XTAL1 should be attenuated to approximately 1.0 to 2.0 Vp-p; this will insure that the transients associated with TTL switching characteristics won't couple into the data synchronizer and degrade performance.

LOOP FILTER

The performance of the data synchronizer is directly related to the selection of the loop filter. The loop filter characteristics should be optimized for:

(A) Fast Acquisition

The ability of the loop to quickly obtain lock when the input signal to the Phase Detector is switched between the reference oscillator (crystal) and the Read Data ($\overline{RD}$). Fast acquisition implies a large loop bandwidth so that it can quickly respond to changes at the input.

(B) Data Margin

The ability of the loop to ignore bit shifts (jitter) and maintain a well centered window about the data pulse train. In general, it is not desirable to allow the loop to respond to a single shifted bit as this would cause the subsequent bit to be poorly centered within its window and possibly cause an error. This requirement implies a small loop bandwidth reducing the sensitivity to high frequency jitter.

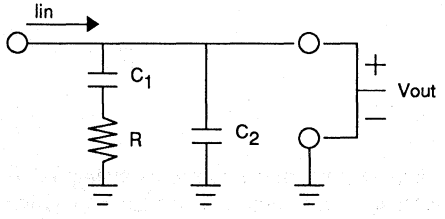
(C) Data Tracking

The ability to respond to instantaneous changes in phase and frequency of the data. This can be a result of such phenomena as disk rotational speed variations which cause changes in the characteristics of the incoming data stream. In general, this requirement is consistent with that of fast acquisition, however, this depends upon the application.

Although the loop performance characteristics place conflicting requirements on the loop bandwidth, the architecture of the Silicon Systems chip family significantly simplifies the design by minimizing the "step in phase" and "step in frequency" encountered when switching the Phase Detector input reference signal. A zero phase restart technique is employed to minimize the initial phase error while the standby reference oscillator keeps the VCO at the center frequency during non-read modes.

One approach in determining the initial loop filter selection is to consider the requirements imposed during acquisition. This includes both acquiring lock to the crystal reference in non-read modes, as well as locking to the preamble field prior to decoding data. The format of the sector will dictate which of these two criteria imposes the tightest restriction on acquisition.

The requirements for acquiring lock to the crystal oscillator are application specific and usually depend upon the length of the Write Splice gap. Therefore, the design approach employed in this analysis will be based upon the requirements during acquisition to the preamble field. The length (in time) of the preamble field is set by the data synchronizer's locking sequence. Knowing this length in time, and that our initial phase error is less than 0.5 radians, we can determine an acceptable loop bandwidth (ωn) and damping factor (ζ).
One possible loop filter configuration is as follows:



The role of C1 is as an integrating element. The larger this capacitance, the longer the acquisition time; the smaller the capacitance, the greater the ability to track high frequency jitter. The resistor R reduces the phase shift induced by C1. The capacitor C2 will suppress high frequency transients and will have minimal effect on the loop response if it is small relative to C1 (typically C2 = C1/10)

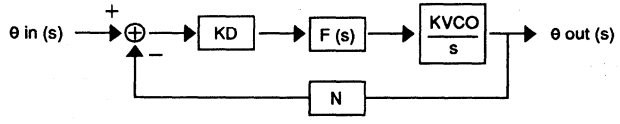
The loop filter transfer function is:

$$F(s) = \frac{Vout}{Iin} = \frac{1 + sRC_1}{sC_1\left(1 + sC_2R + C_2/C_1\right)}$$

If C2 << C1, then:

$$F(s) = \frac{Vout}{Iin} = \frac{1 + sRC_1}{sC_1}$$

The overall block diagram for the phaselock loop can be described as:



Where:

KD = Phase Detector gain [A/rad]

F(s) = Loop filter impedance [V/A]

KVCO/s = VCO control gain [rad/s V]

N = The ratio of the reference input frequency to the VCO output frequency

The closed loop transfer function is:

$$T(s) = \frac{\theta out(s)}{\theta in(s)} = \frac{G(s)}{1 + GH(s)} = \frac{KD \cdot KVCO[(1 + sRC_1)/C_1]}{s^2 + s[N \cdot KD \cdot KVCO \cdot R] + \frac{N \cdot KD \cdot KVCO}{C_1}}$$

by putting the characteristic equation (denominator) in the form of:

$$s^2 + 2s\zeta\omega n + \omega n^2$$

we can solve for ωn and ζ to get:

$$\omega n^2 = \frac{N \cdot KD \cdot KVCO}{C1} \qquad \zeta = \frac{N \cdot KD \cdot KVCO \cdot R}{2\omega n}$$

Now we can solve for R, C1 and C2:

$$C1 = \frac{N \cdot KD \cdot KVCO}{\omega n^2} \qquad R = \frac{2\zeta\omega n}{N \cdot KD \cdot KVCO} \qquad C_2 = \frac{C_1}{10}$$

where: ωn = loop bandwidth and, ζ = loop damping factor

Because of the nature of Run Length Limited (RLL) codes, the Phase Detector will only be enabled during a data pulse. This technique allows the VCO to run at a center frequency with period, TVCO, equal to one encoded data bit cell time.

Figure 1 represents the relationship between the VCO output when locked to various Phase Detector input signals.

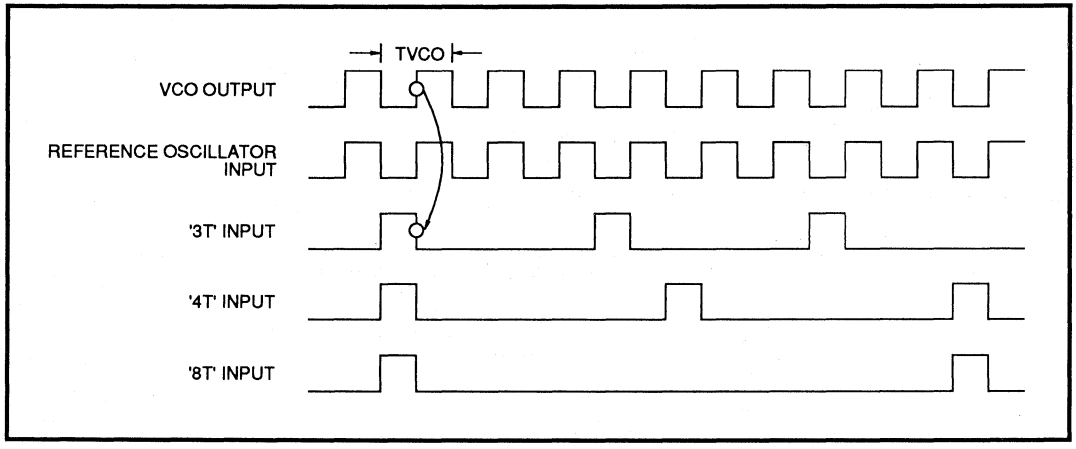


FIGURE 1: Relationship of VCO Output to Phase Detector Input

The average amplitude of the Phase Detector gain depends upon the Phase Detector input signal. When the PLL is locked to the reference oscillator, the Phase Detector is continuously enabled and the gain is at its maximum. When the PLL is tracking data and the input is an "8T" pattern, then the Phase Detector gain is at its minimum. The following indicates the value of "N" for various input conditions:

N = 1.0 for θin = reference oscillator

N = 0.33 for θin = 3T (100) preamble field (maximum data frequency)

N = 0.25 for θin = 4T (1000) preamble field

N = 0.125 for θin = 8T (minimum data frequency)

Throughout this analysis the PLL has been considered as a continuous time system. In actuality the characteristics of the Phase Detector result in a sampled data system. By utilizing an integrating loop filter to average and smooth the Phase Detector charge pump output pulses, this analogy should be reasonable.

Determining an acceptable amount of phase error after locking to the preamble field depends upon the system requirements. In addition, it may be necessary to consider the effects of frequency steps in applications where motor speed control tolerances are significant. Generally, an acceptable amount of error is defined to be that amount which when added to all other timing error contributors, results in the data being within its timing window by the required margin.

In general, it is desirable to have the loop damping factor "ζ" between 0.5 and 1.0 during acquisition. For a high gain, second-order loop this results in minimal noise bandwidth.

Figure 2 represents the phase error's response in time to a transient step in phase as a function of the loop bandwidth and damping factor. Figure 3 indicates the response of the VCO control voltage to compensate for this step in phase.

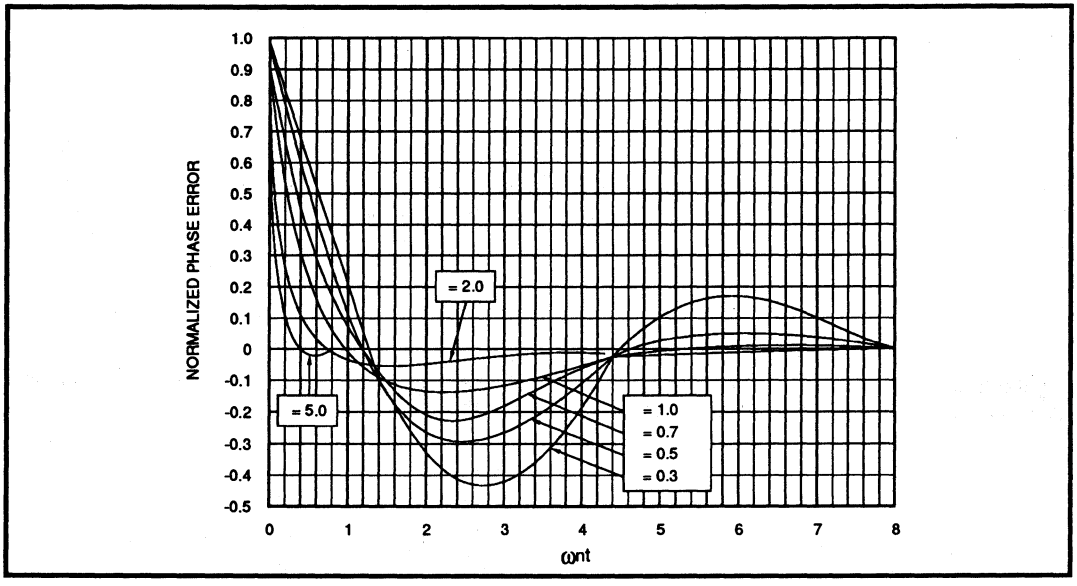


FIGURE 2: Transient Phase Error θe(t) Due To a Step In Phase Δθ

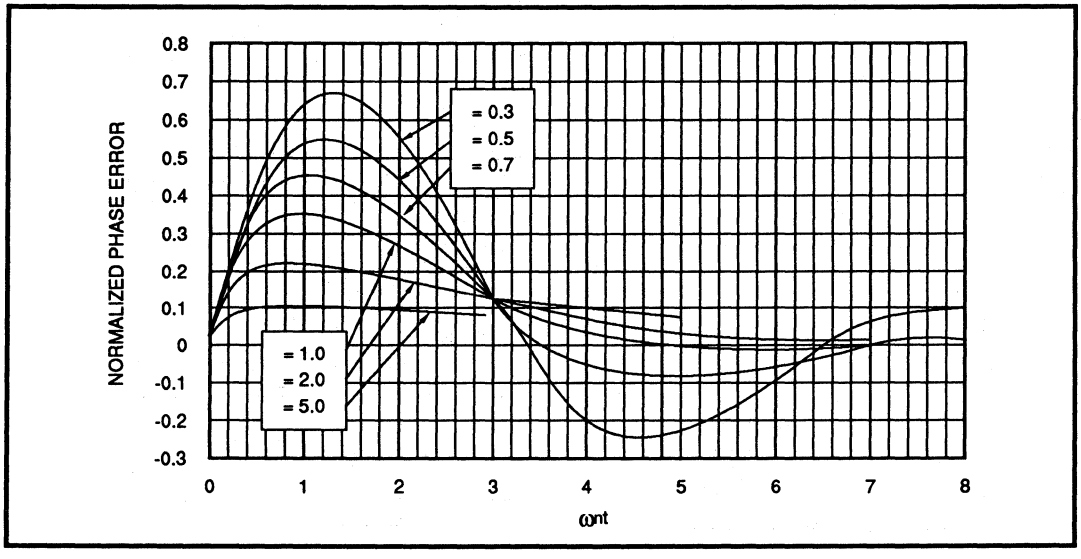


FIGURE 3: Transient Phase Error θe(t) Due to a Step In Frequency Δω

APPLICATION OF THE SSI 32D5321/5322

10 Mbit/s Soft Sector Example

For a data rate of 10 Mbit/s the SSI 32D5321/5322 requires a series resonant crystal of twice the data rate or 20 MHz. In the Soft Sector mode the PLL locking sequence allows the VCO to be within a determined amount of error after 38 x '3T' (100) bit groups. At 10Mbit/s each data bit cell time, TVCO, is equal to 50 ns. This results in:

$$t_{max} = (38)\ (3)\ (50\ ns) = 5.7\ \mu s$$

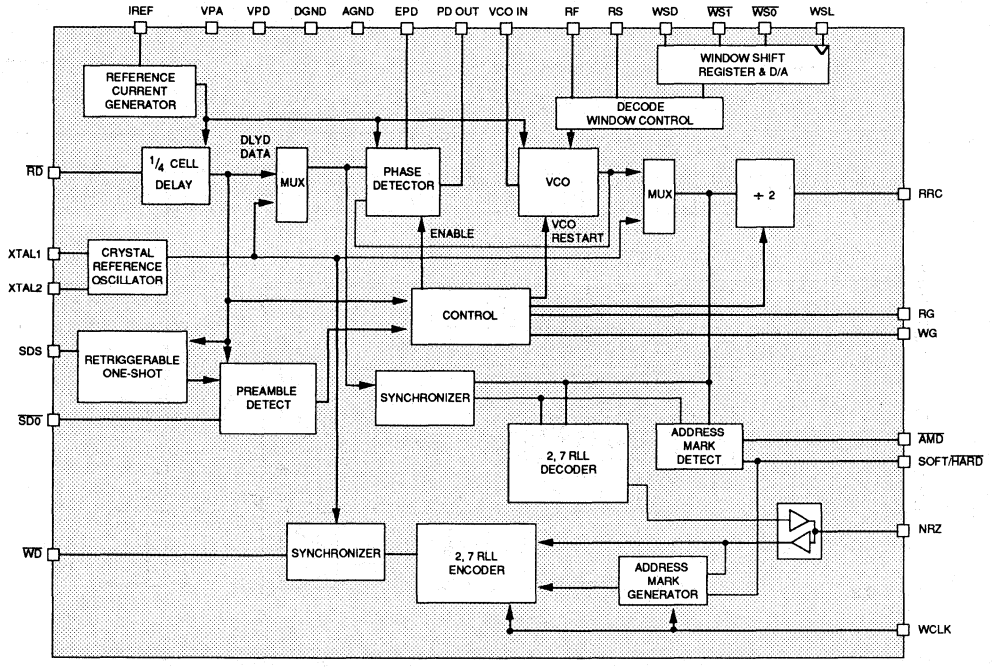
Therefore, the PLL has 5.7 µs to settle to within an acceptable amount of error before tracking and decoding data. Because the SSI 32D5321/22 employs a zero phase restart technique, the initial phase error is less than 8% TORC (0.5rad) or:

$$\theta e < (0.08)(100\ ns)$$

$$\theta e < 8\ ns$$

In general, it is desirable to have the loop damping factor "ζ" between 0.5 and 1.0 during acquisition. For a high gain, second-order loop this results in minimal noise bandwidth. For this example we will let $\zeta = 0.7$.

SSI 32D5321/5322 BLOCK DIAGRAM



As shown in Figure 2, with $\zeta = 0.7$, our initial transient phase error will be at most 22% of its original value at $\omega nt = 2.3$, 7.5% at $\omega nt = 4.0$, etc. For this example we want the final phase error to be less than 1% of its original level. This results in a ωnt between 5 and 6. To simplify the results, let $\omega nt = 5.7$.

Now, $\omega nt = 5.7$
and $t_{max} = 5.7\ \mu s$
$\therefore \omega n \cong 1.0 \cdot 10^6$ rad/s
with $\zeta = 0.7$

Since we are evaluating the loop response during acquisition to the '3T' preamble, N = 0.33.

Now we have all the information required to calculate the loop filter component values.

For the SSI 32D5321:

$$RR = \frac{40.67}{10\ Mbs} - 0.5 = 3.567\ k\Omega$$

$\omega n = 1.0 \cdot 10^6$ rad/s

$\zeta = 0.7$

$KD(typ) = 0.309/(RR+500) = 7.6 \cdot 10^{-5}$ A/rad

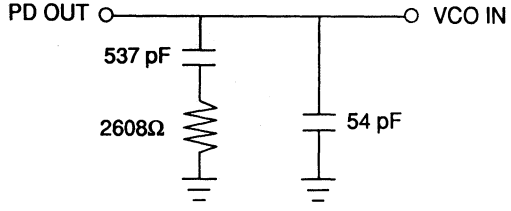
$KVCO(typ) = 0.17\omega o = 0.17(2\pi)/To = 2.14 \cdot 10^7$ rad/s V

$N = 0.33$

$$R = \frac{2\zeta\omega n}{N \cdot KD \cdot KVCO} = 2608\Omega$$

$$C_1 = \frac{N \cdot KD \cdot KVCO}{\omega n^2} = 537\ pF$$

$$C_2 = \frac{C_1}{10} = 54\ pF$$



For the SSI 32D5322:

$$RR = \frac{43.86}{10\ Mbs} - 1.2 = 3.186\ k\Omega$$

$\omega n = 1.0 \cdot 10^6$ rad/s

$\zeta = 0.7$

$KD(typ) = 0.309/(RR+500) = 8.38 \cdot 10^{-5}$ A/rad

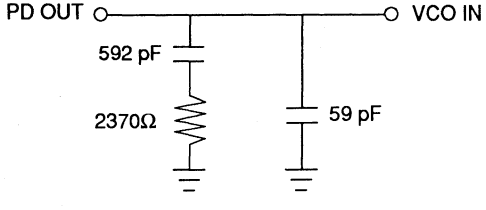
$KVCO(typ) = 0.17\omega o = 0.17(2\pi)/To = 2.14 \cdot 10^7$ rad/s V

$N = 0.33$

$$R = \frac{2\zeta\omega n}{N \cdot KD \cdot KVCO} = 2.37\ k\Omega$$

$$C_1 = \frac{N \cdot KD \cdot KVCO}{\omega n^2} = 592\ pF$$

$$C_2 = \frac{C_1}{10} = 59\ pF$$



This loop filter configuration and its component values should be considered a starting point. The final value of ωn depends upon the system requirements and can certainly be optimized for a specific application. In the table below, we have listed some suggested external component values for several common data rates.

32D5321

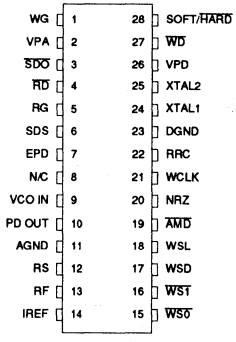
DATA RATE (Mbit/s)	DAMPING FACTOR,ζ	LOCK TIME t_{max} (µs)	ωnt	BANDWIDTH $\omega n \left(\frac{rad}{sec}\right)$	EXTERNAL COMPONENT VALUES					
					RR(KΩ)	Cd(pF)	Rd(KΩ)	R(KΩ)	C_1 (pF)	C_2 (pF)
7.5	0.7	7.5	5.0	6.67×10^5	4.92	100	11.0	3.1	680	68
10.0	0.7	5.7	5.7	1.0×10^6	3.57	82	10.0	2.7	510	51

32D5322

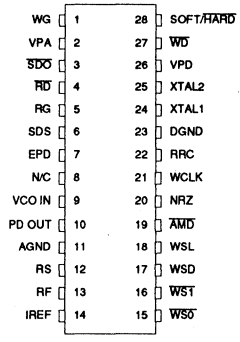
DATA RATE (Mbit/s)	DAMPING FACTOR,ζ	LOCK TIME t_{max} (µs)	ωnt	BANDWIDTH $\omega n \left(\frac{rad}{sec}\right)$	EXTERNAL COMPONENT VALUES					
					RR(KΩ)	Cd(pF)	Rd(KΩ)	R(KΩ)	C_1 (pF)	C_2 (pF)
7.5	0.7	7.5	5.0	6.67×10^5	4.64	100	13.0	2.94	710	71
10.0	0.7	5.7	5.7	1.0×10^6	3.19	100	10.0	2.37	590	59
15.0	0.7	3.8	5.7	1.5×10^6	1.72	100	6.49	1.43	654	65

LAYOUT CONSIDERATIONS

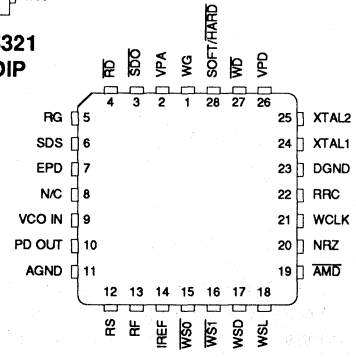
As with other high frequency analog devices the SSI 32D5321/22 requires care in layout. The designer should keep analog signal lines as short as possible and well balanced. Use of a ground plane is recommended, along with supply bypassing to separate the SSI 32D5321/22, and associated circuitry, from other circuits on the PCB.



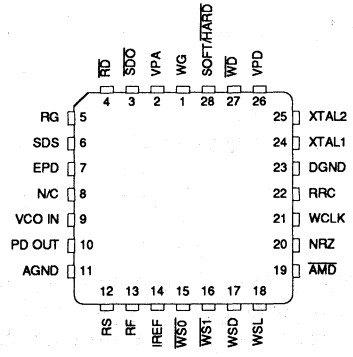
SSI 32D5321
28-Pin DIP



SSI 32D5322
28-Pin DIP



SSI 32D5321
28-Pin PLCC



SSI 32D5322
28-Pin PLCC

APPLICATION OF THE SSI 32D535/5351

10 Mbit/s Soft Sector Example:

For a data rate of 10 Mbit/s the SSI 32D535/5351 requires a series resonant crystal of twice the data rate or, 20 MHz. In the Soft Sector mode the PLL locking sequence allows the VCO to be within a determined amount of error after 38 x '3T' (100) bit groups. At 10 Mbit/s each data bit cell time, TVCO, is equal to 50 ns. This results in:

$$t_{max} = (38)(3)(50\ ns) = 5.7\ \mu s$$

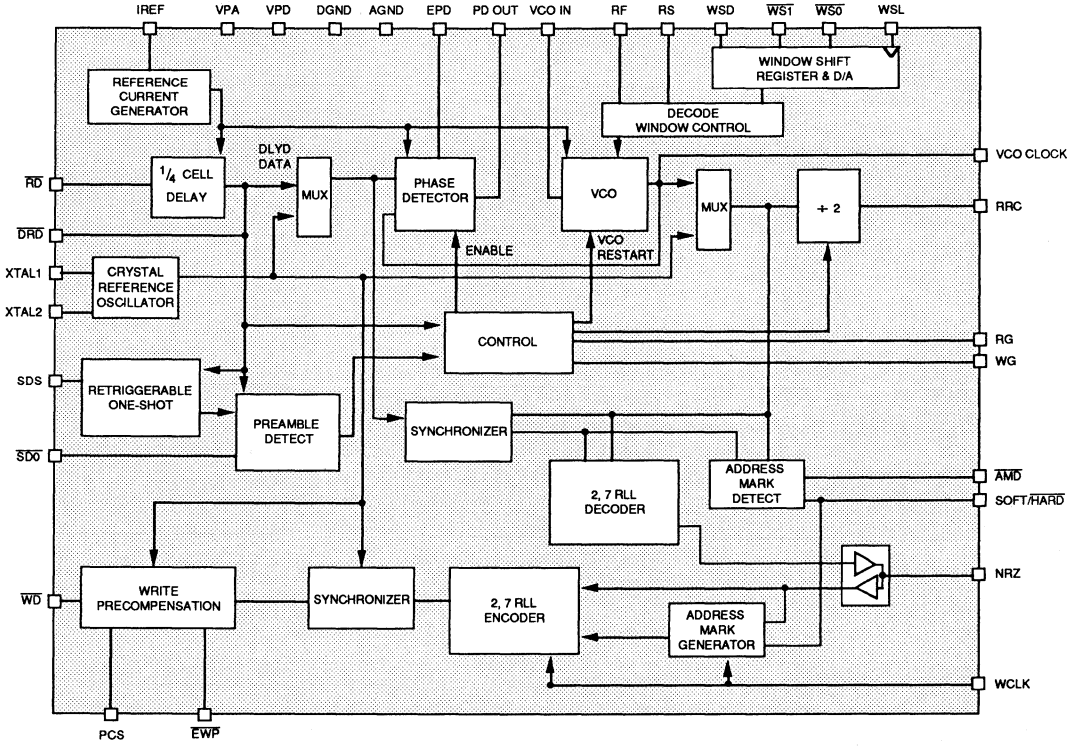
Therefore, the PLL has 5.7 µs to settle to within an acceptable amount of error before tracking and decoding data. Because the SSI 32D535 employs a zero phase restart technique, the initial phase error is less than 8% TORC (0.5rad) or:

$$\theta e < (0.08)(100\ ns)$$

$$\theta e < 8\ ns$$

4

SSI 32D535/5351 BLOCK DIAGRAM



In general, it is desirable to have the loop damping factor "ζ" between 0.5 and 1.0 during acquisition. For a high gain, second-order loop this results in minimal noise bandwidth. For this example we will let $\zeta = 0.7$.

As shown in Figure 2, with $\zeta = 0.7$, our initial transient phase error will be at most 22% of its original value at $\omega nt = 2.3$, 7.5% at $\omega nt = 4.0$, etc. For this example we want the final phase error to be less than 1% of its original level. This results in a ωnt between 5 and 6. To simplify the results, let $\omega nt = 5.7$.

This loop filter configuration and its component values should be considered a starting point. The final value of ωn depends upon the system requirements and can certainly be optimized for a specific application. In the table below, we have listed some suggested external component values for several common data rates.

Now,

$\omega nt = 5.7$

and $t_{max} = 5.7\ \mu s$

$\therefore\ \omega n = 1.0 \cdot 10^6$ rad/s

with $\zeta = 0.7$

Since we are evaluating the loop response during acquisition to the '3T' preamble, N = 0.33.

Now we have all the information required to calculate the loop filter component values.

For the SSI 32D535:

$$RR = \frac{40.67}{10MB} - 0.5 = 3.567\ k\Omega$$

$\omega n = 1.0 \cdot 10^6$ rad/s

$\zeta = 0.7$

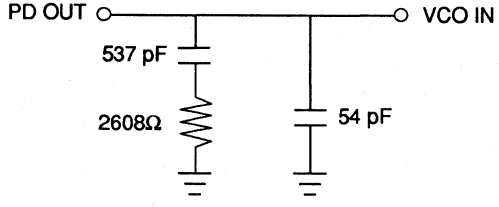
$KD(typ) = 0.309/(RR+500) = 7.6 \cdot 10^{-5}$ A/rad

$KVCO(typ) = 0.17\omega o = 0.17(2\pi)/T0 = 2.14 \cdot 10^7$ rad/s V

$N = 0.33$

$$R = \frac{2\zeta\omega_n}{N \cdot KD \cdot KVCO} = 2608\Omega$$

$$C_1 = \frac{N \cdot KD \cdot KVCO}{\omega n^2} = 537\,pF \qquad C_2 = \frac{C_1}{10} = 54\ pF$$



For the SSI 32D5351:

$$RR = \frac{76}{DR} - 1.75 = 5.85\ k\Omega$$

$\omega n = 1.0 \cdot 10^6$ rad/s

$\zeta = 0.7$

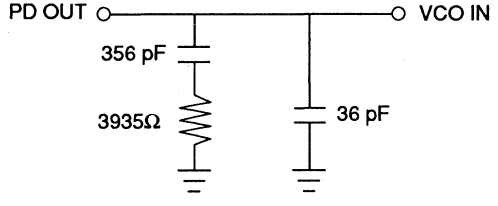
$KD(typ) = (0.34/RR+900) = 5.04 \cdot 10^{-5}$ A/rad

$KVCO(typ) = 0.17\omega o = 0.17(2\pi)/T0 = 2.14 \cdot 10^7$ rad/s V

$N = 0.33$

$$R = \frac{2\zeta\omega_n}{N \cdot KD \cdot KVCO} = 3935\Omega$$

$$C_1 = \frac{N \cdot KD \cdot KVCO}{\omega n^2} 356\,pF \qquad C_2 = \frac{C_1}{10} = 36\,pF$$



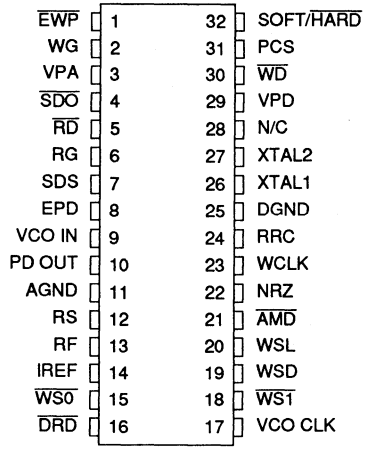
This loop filter configuration and its component values should be considered a starting point. The final value of ωn depends upon the system requirements and can certainly be optimized for a specific application. In the table below, we have listed some suggested external component values for several common data rates.

32D535

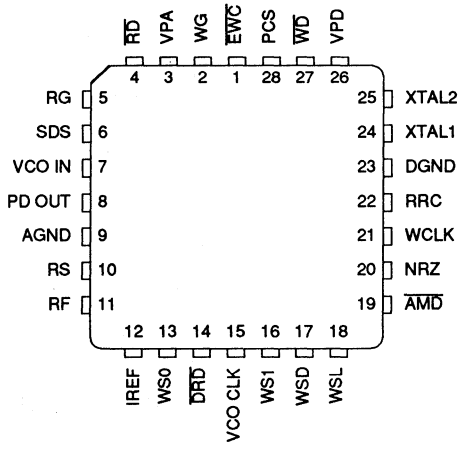
DATA RATE (Mbit/s)	DAMPING FACTOR,ζ	LOCK TIME t_{max} (μs)	ωnt	BANDWIDTH $\omega n\left(\frac{rad}{sec}\right)$	EXTERNAL COMPONENT VALUES					
					RR(KΩ)	Cd(pF)	Rd(KΩ)	R(KΩ)	C_1 (pF)	C_2 (pF)
7.5	0.7	7.5	5.0	6.67×10^5	4.92	100	11.0	3.0	687	69
10.0	0.7	5.7	5.7	1.0×10^6	3.57	82	10.0	2.7	510	51

32D5351

DATA RATE (Mbit/s)	DAMPING FACTOR,ζ	LOCK TIME t_{max} (μs)	ωnt	BANDWIDTH $\omega n\left(\frac{rad}{sec}\right)$	EXTERNAL COMPONENT VALUES					
					RR(KΩ)	Cd(pF)	Rd(KΩ)	R(KΩ)	C_1 (pF)	C_2 (pF)
10.0	0.7	5.7	5.7	1.0×10^6	5.85	100	10.0	3.94	356	36
15.0	0.7	3.8	5.7	1.5×10^6	3.32	100	6.49	2.46	379	38



32 LEAD SOW, DIP

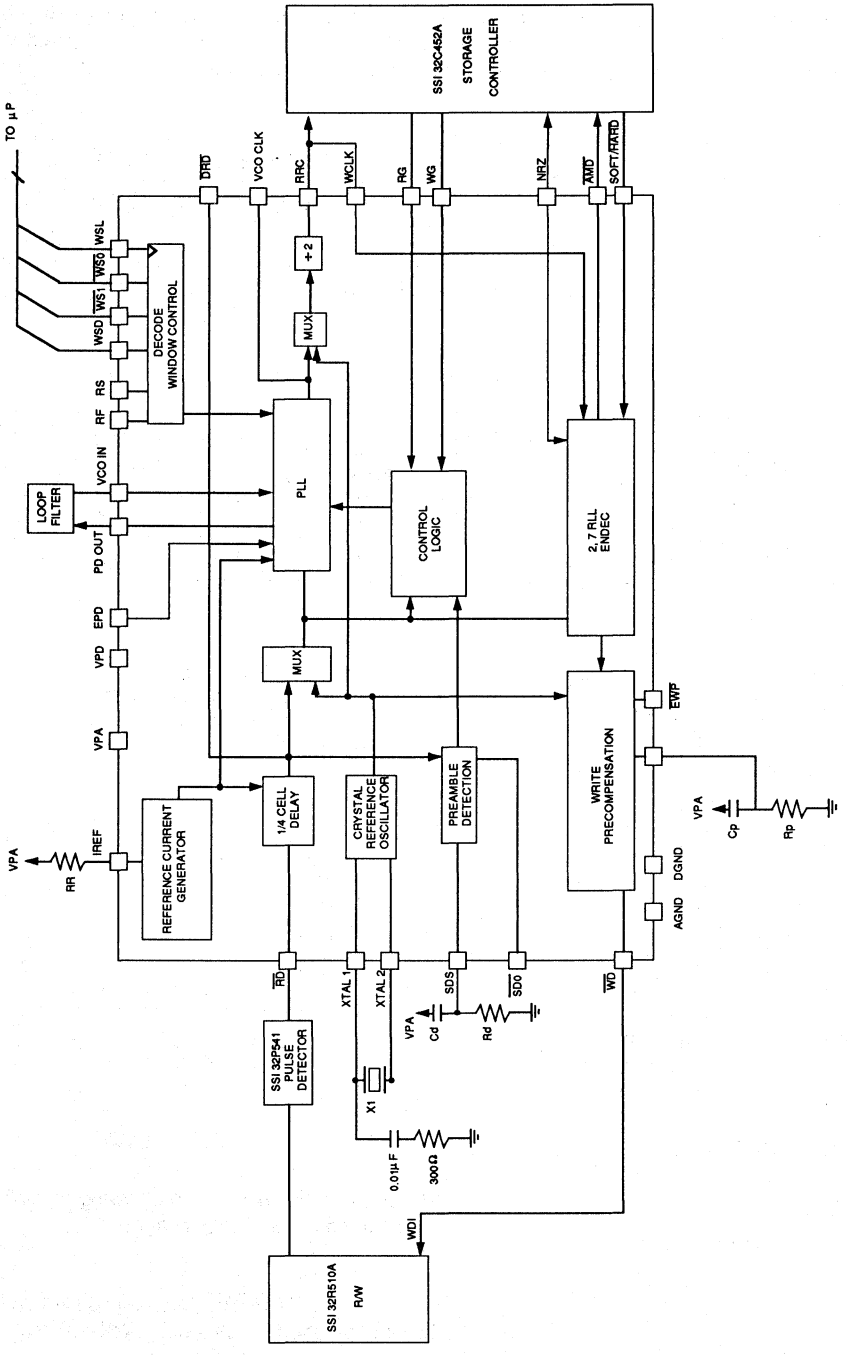


28 Pin PLCC

NOTE: Does not include the following pins which are available on the 32-Pin packages

- SD0
- EPD
- SOFT/HARD (internally pulled up high)

So must be used in soft sector applications only.



TYPICAL SSI 32D535/5351 APPLICATION

APPLICATION OF THE SSI 32D5362

15 Mbit/s Soft Sector Example

For a data rate of 15 Mbit/s the SSI 32D5362 requires a serial resonant crystal of three times the data rate or 45 MHz. In the Soft Sector mode the PLL locking sequence allows the VCO to be within a determined amount of error after 16 x '3T' (100) bit groups. At 15Mbit/s each data bit cell time, TVCO, is equal to 44.4 ns. This results in:

$$t_{max} = (16)\ (3)\ (44.4\ ns) = 2.1\ \mu s$$

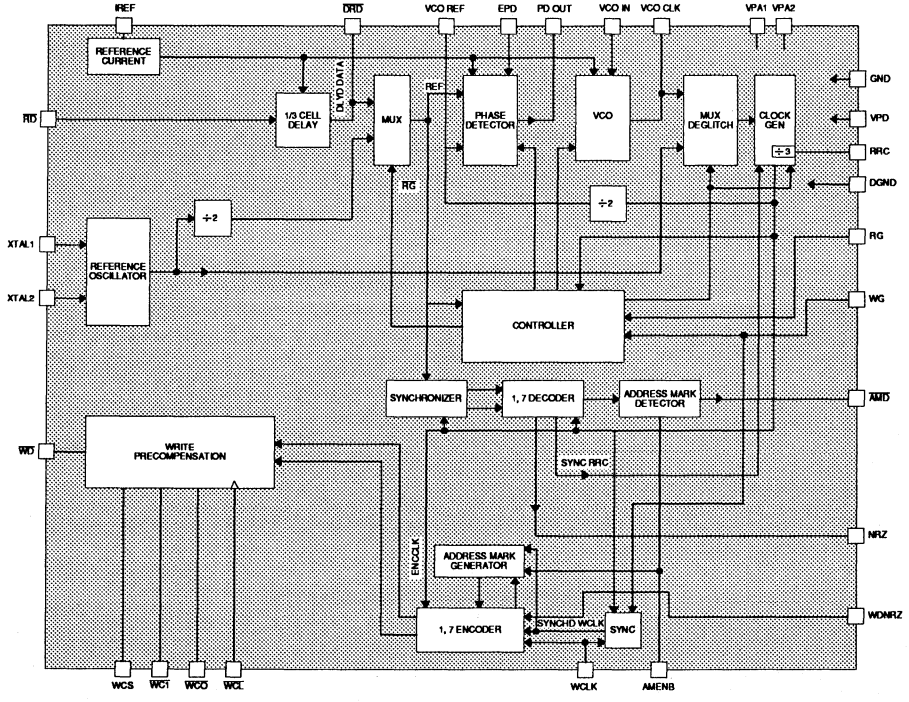
Therefore, the PLL has 2.1 µs to settle to within an acceptable amount of error before tracking and decoding data. Because the SSI 32D536 employs a zero phase restart technique, the initial phase error is less than 16% TORC (1.0rad) or:

$$\Delta\theta e < (0.16)(66.7\ ns)$$

$$\Delta\theta e < 10.7\ ns$$

In general, it is desirable to have the loop damping factor "ζ" between 0.5 and 1.0 during acquisition. For a high gain, second-order loop this results in minimal noise bandwidth. For this example we will let ζ = 0.7.

SSI 32D5362 BLOCK DIAGRAM



As shown in Figure 2, with $\zeta = 0.7$, our initial transient phase error will be at most 22% of its original value at $\omega nt = 2.3$, 7.5% at $\omega nt = 4.0$, etc. For this example we want the final phase error to be less than 15% of its original level. This results in a ωnt between 3 and 4. To simplify the results, let $\omega nt = 3.2$. This results in a maximum final phase error of 1.6 ns.

Now,

$$\omega nt = 3.2$$

and $$tmax = 2.1\ \mu s$$

$$\therefore \omega n = 1.5 \cdot 10^6\ rad/s$$

with $$\zeta = 0.7$$

Since we are evaluating the loop response during acquisition to the '3T' preamble, N = 0.33.

Now we have all the information to calculate the loop filter component values.

$$RR = 3873\Omega$$

$$\omega n = 1.5 \cdot 10^6\ rad/s$$

$$\zeta = 0.7$$

$$KD(typ) = 0.57/(RR+530) = 1.3 \cdot 10^{-4}\ A/rad$$

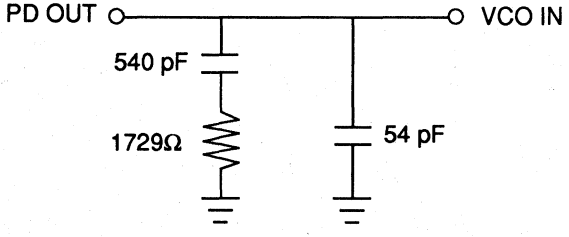
$$KVCO(typ) = \frac{0.20(2\pi)}{2To} = 2.83x10^7$$

$$N = 0.33$$

which results in:

$$R = \frac{2\zeta\omega n}{N \cdot KD \cdot KVCO} = 1729\Omega \qquad C_1 = \frac{N \cdot KD \cdot KVCO}{\omega n^2} = 540pF \qquad C_2 = \frac{C_1}{10} = 54pF$$

or,



This loop filter configuration and its component values should be considered a starting point. The final value of ωn depends on the system requirements and can certainly be optimized for a specific application. In the following table we have listed some suggested external component values for two common data rates:

DATA RATE (Mbit/s)	DAMPING FACTOR, ζ	LOCK TIME tmax (μs)	ωnt	BANDWIDTH $\omega n \left(\frac{rad}{sec}\right)$	EXTERNAL COMPONENT VALUES			
					RR(kΩ)	R(Ω)	C_1(pF)	C_2(pF)
10	0.7	3.2	3.2	1.0×10^6	6.96	2957	470	47
15	0.7	2.1	3.2	1.5×10^6	3.87	1729	540	54

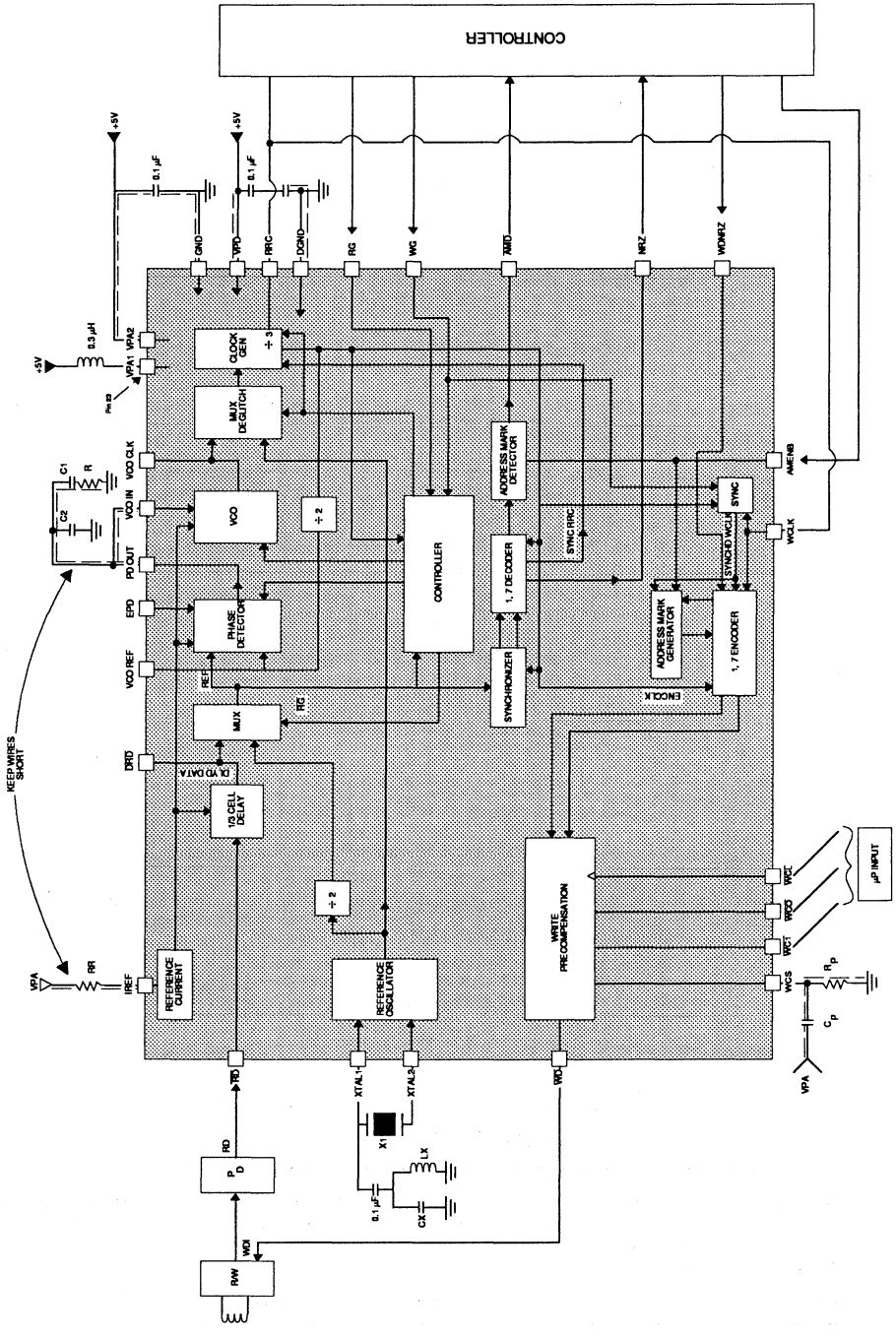
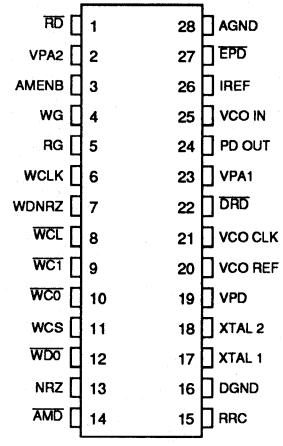
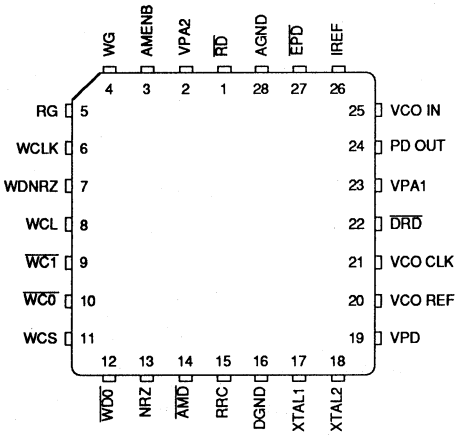


FIGURE 5: Typical Application



28-Pin DIP



28-Pin PLCC

LAYOUT CONSIDERATIONS

As with other high frequency devices the SSI 32D5362 requires care in layout. The designer should keep analog signal lines as short as possible and well balanced. Use of a ground plane is recommended, along with supply bypassing to separate the SSI 32D5362 and associated circuitry, from other circuits on the PCB. It is also recommended that an inductor (0.3 µH) be placed in series with the analog supply which supports the VCO circuitry (VPA1, Pin 23). This additional filtering has been shown effective in eliminating VCO jitter, which can degrade window margin performance.

TEST POINTS

The SSI 32D5362 provides three (3) test points which can be utilized to evaluate window margin characteristics.

(a) $\overline{\text{DRD}}$, delayed read data – the positive edges represent the data bit position
(b) VCO REF, the VCO reference which represents the input to the Phase Detector, synchronizer, and 1,7 decoder
(c) VCO CLK, the VCO clock output which represents the output of the VCO

The following figure describes the relationship between the various test points:

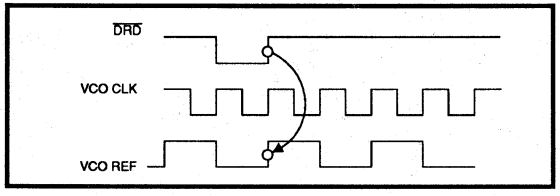


FIGURE 6: Test Point Relationships

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Section 5

HDD HEAD POSITIONING

SSI 32H101
Differential Amplifier

July, 1990

DESCRIPTION

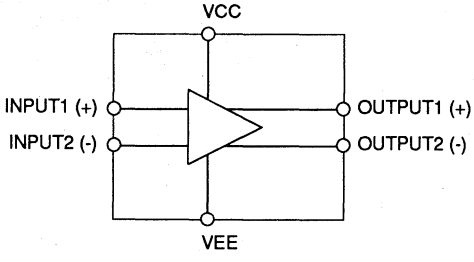
The SSI 32H101 is a two stage differential amplifier applicable for use as a preamplifier for the magnetic servo head circuit of Winchester technology disk drives.

FEATURES

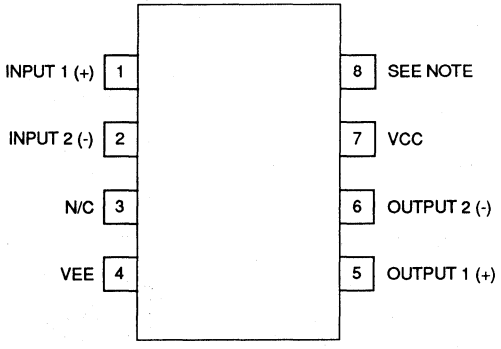
- **Very narrow gain range**
- **30 MHz bandwidth**
- **Electrically characterized at two power supply voltages: IBM Model 3340 compatible (8.3V) and standard OEM industry compatible (10V)**
- **Mechanically compatible with Model 3348 type head arm assembly**
- **SSI 32H1012 available to operate with a 12V power supply**
- **Packages include 8-pin DIP or SON**

5

BLOCK DIAGRAM



PIN DIAGRAM



8-Pin PDIP, SON

Note : Pin must be left open and not connected to any circuit etch.

CAUTION: Use handling procedures necessary for a static sensitive component.

ELECTRICAL CHARACTERISTICS

T_A = 25 °C, (V_{CC}-V_{EE}) = 8.3 to 10V ±10% (12V ±10% for 101-2)

ABSOLUTE MAXIMUM RATINGS

Operation above absolute maximum ratings may permanently damage the device.

PARAMETER	RATING	UNIT
Power Supply Voltage (V_{CC} - V_{EE})	12	V
SSI 32H1012	14	V
Differential Input Voltage	±1	V
Storage Temperature Range	-65 to 150	°C
Operating Temperature Range	0 to 70	°C

DC ELECTRICAL CHARACTERISTICS

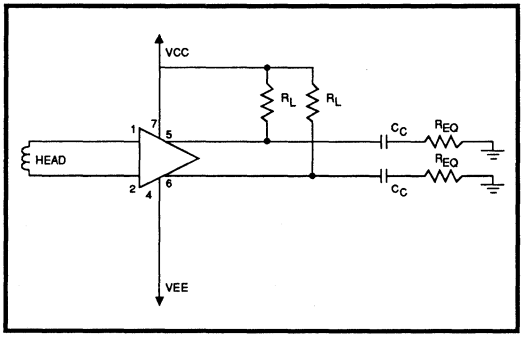
PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Gain (differential)	R_P = 130Ω	77	93	110	
Bandwidth (3dB)	V_{IN} = 2 mVpp	10	20		MHz
Input Resistance		750		1200	Ω
Input Capacitance			3		pF
Input Dynamic Range (Differential)	R_L = 130Ω	3			mVpp
Power Supply Current	(V_{CC} - V_{EE}) = 9.15V		26	35	mA
	(V_{CC} - V_{EE}) = 11V		30	40	mA
	(V_{CC} - V_{EE}) = 13.2V (32H101A-2)		35	45	mA
Output Offset (Differential)	Rs = 0, R_L = 130Ω			600	mV
Equivalent Input Noise	Rs = 0, R_L = 130Ω, BW = 4 MHz		8	14	µV
PSRR, Input Referred	Rs = 0, f ≤ 5 MHz	50	65		dB
Gain Sensitivity (Supply)	Δ (V_{CC} - V_{EE}) = ±10%, R_L = 130Ω		±1.3		%
Gain Sensitivity (Temp.)	T_A = 25 °C to 70 °C, R_L = 130Ω		-0.2		%/°C
CMRR, Input Referred	f ≤ 5 MHz	55	70		dB

RECOMMENDED OPERATING CONDITIONS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Supply Voltage (V_{CC} - V_{EE})		7.45	8.3	9.15	V
		9.0	10.0	11.0	V
	32H1012 only	10.8	12.0	13.2	V
Input Signal V_{IN}			2		mVpp
Ambient Temp. T_A		0		70	C

APPLICATIONS INFORMATION

CONNECTION DIAGRAM



RECOMMENDED LOAD CONDITIONS

1. Input must be AC coupled
2. Cc's are AC coupling capacitors
3. RL's are DC bias and termination resistors (recommended 130Ω)
4. REQ represents equivalent load resistance
5. For gain calculations $R_P = \frac{R_L \cdot R_{EQ}}{R_L + R_{EQ}}$
6. Differential gain = 0.72 RP (± 18%) (RP in Ω)
7. Ceramic capacitors (0.1 µF) are recommended for good power supply noise filtering

5

ORDERING INFORMATION

PART DESCRIPTION	ORDERING NUMBER	PACKAGE MARK
SSI 32H101 Differential Amplifier		
8-Pin PDIP	SSI 32H101-CP	32H101-CP
8-Pin SON	SSI 32H101-N	H101
SSI 32H1012 Differential Amplifier		
8-Pin PDIP	SSI 32H1012-P	32H1012-P
8-Pin SON	SSI 32H1012-N	H1012

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Notes:

SSI 32H116A
Differential Amplifier

July, 1990

DESCRIPTION

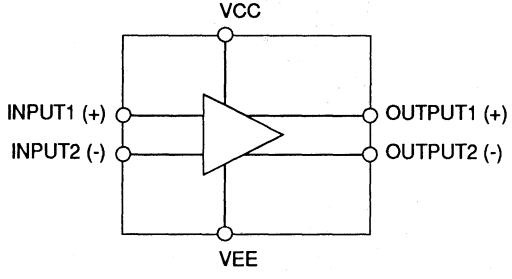
The SSI 32H116A is a high performance differential amplifier applicable for use as a preamplifier for the magnetic servo thin film head in Winchester disk drives.

FEATURES

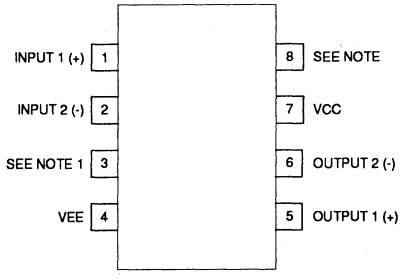
- **Narrow gain range**
- **50 MHz bandwidth**
- **IBM 3370/3380-compatible performance**
- **Operates on either IBM-compatible voltages (8.3V) or OEM-compatible (10V)**
- **Packages include 8-pin CERDIP, Plastic DIP or SON and custom 10-pin flatpack**
- **SSI 32H1162 available to operate with a 12V power supply**

5

BLOCK DIAGRAM



PIN DIAGRAM



8-Pin PDIP, SON

CAUTION: Use handling procedures necessary for a static sensitive component.

ELECTRICAL CHARACTERISTICS

Tj = 15 °C to 125 °C, (VCC-VEE) = 7.9V to 10.5V (to 13.2V for 32H1162)

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNIT
Power Supply Voltage (VCC-VEE)	12	V
SSI 32H1162	14	V
Differential Input Voltage	±1	V
Storage Temperature Range	-65 to 150	°C
Operating Ambient Temperature (T_A)	15 to 60	°C
Operating Junction Temperature (T_J)	15 to 125	°C
Output Voltage	VCC -2.0 to VCC +0.4	V

RECOMMENDED OPERATING CONDITIONS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Supply Voltage (VCC-VEE)		7.45	8.3	9.15	V
		9.0	10.0	11.0	V
	SSI 32H1162 only	10.8	12.0	13.2	V
Input Signal Vin			1		mVpp
Ambient Temp T_A		+15		+65	°C

DC ELECTRICAL CHARACTERISTICS

(Unless otherwise specified, recommended operating conditions apply.)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Gain (Differential)	Vin = 1mVpp, T_A = 25 °C, f = 1 MHz	200	250	310	mV/mV
Bandwidth (3dB)	Vin = 1mVpp, C_L = 15 pF	20	50		MHz
Gain Sensitivity (Supply)				1.0	%/V
Gain Sensitivity (Temp.)	15 °C < T_A < 55 °C		-0.16		%/C
Input Noise Voltage	Input Referred, Rs = 0		0.7	0.94	$nV/\sqrt{Hz}$
Input Capacitance (Differential)	Vin = 0, f = 5 MHz		40	60	pF
Input Resistance (Differential)			200		Ω
Common Mode Rejection Ratio Input Referred	Vin = 100 mVpp, f = 1 MHz	60	70		dB
Power Supply Rejection Ratio Input Referred	VEE + 100 mVpp, f = 1 MHz	46	52		dB

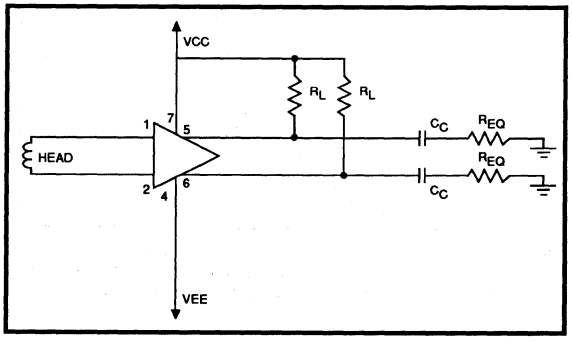
DC ELECTRICAL CHARACTERISTICS (Continued)
(Unless otherwise specified, recommended operating conditions apply.)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Input Dynamic Range (Differential)	AC input voltage where gain falls to 90% of its small signal gain value, f = 5MHz	±0.75			mV
Output Offset Voltage (Differential)	Vin = 0	-400		+400	mV
Output Voltage (Common Mode)	Inputs shorted together and Outputs shorted together	VCC-0.45	VCC-0.6	VCC-1.0	V
Single Ended Output Capacitance				10	pF
Power Supply Current	VCC-VEE = 9.15V		28	40	mA
	VCC-VEE = 11V		29	42	mA
	VCC-VEE = 13.2V, 32H1162 only		39	50	mA
Input DC Voltage	Common Mode		V_{EE} +2.6		V
Input Resistance	Common Mode		80		Ω

5

APPLICATIONS INFORMATION

CONNECTION DIAGRAM

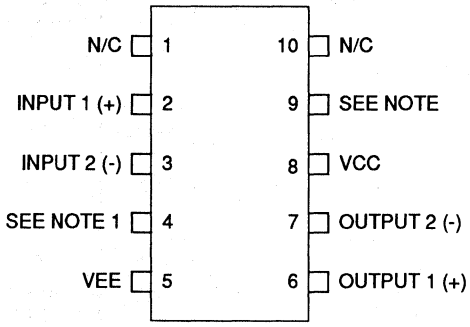


RECOMMENDED LOAD CONDITIONS

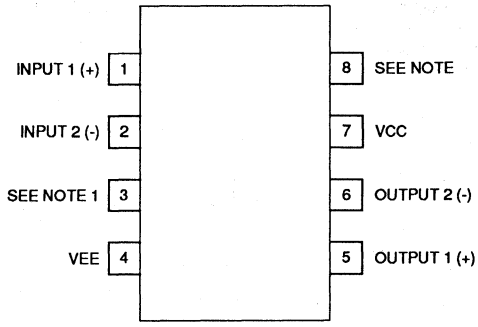
1. Input is directly coupled to the head
2. Cc's are AC coupling capacitors
3. RL's are DC bias and termination resistors, 100Ω recommended
4. REQ. represents equivalent load resistance
5. Ceramic capacitors (0.1 µF) are recommended for good power supply noise filtering

SSI 32H116A
Differential Amplifier

PACKAGE PIN DESIGNATIONS
(TOP VIEW)



10-Pin Flatpack



8-Pin PDIP, SON

NOTE : Pin must be left open and not connected to any circuit etch.

ORDERING INFORMATION

PART DESCRIPTION	ORDERING NUMBER	PACKAGE MARK
SSI 32H116A Differential Amplifier		
10-Pin Flatpack	SSI 32H116A-CF	H116A-F
8-Pin SON	SSI 32H116A-CN	H116A
8-Pin PDIP	SSI 32H116A-CP	32H116A-CP
SSI 32H1162A		
10-Pin Flatpack	SSI 32H1162A-CF	H1162A-F
8-Pin SON	SSI 32H1162A-N	H1162A
8-Pin PDIP	SSI 32H1162A-CP	32H1162A-CP

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SSI 32H523R
Thin Film Single Channel Servo Read/Write Device

July, 1990

DESCRIPTION

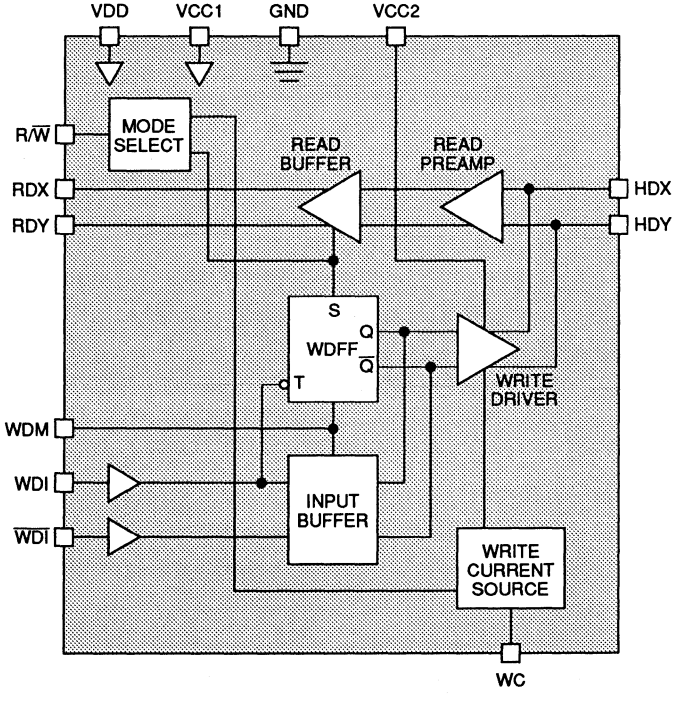
The SSI 32H523R Read/Write device is a bipolar monolithic integrated circuit designed for use with a two terminal thin film recording head. It provides a low noise read amplifier and write current control. In its servo application, the device will be used in write mode once then switched permanently to read mode. Data protection is provided in both write and read modes to guarantee servo data security. Power supply fault protection is effective in both write and read modes while head short circuit protection is provided in write mode. Further data security can be provided in read mode by removing the write current source voltage. It requires +5V and +12V power supplies and is available in a 14-pin SON surface mount package. Internal 1000Ω damping resistors are provided.

FEATURES

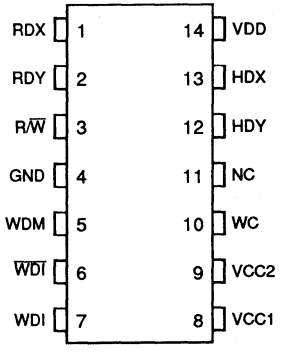
- **High performance:**
  - **Read mode gain = 250 V/V**
  - **Input noise = 1.0 nV/√Hz max.**
  - **Input capacitance = 45 pF max.**
  - **Write current range = 10 mA to 40 mA**
  - **Head voltage swing = 3.4 Vpp min.**
  - **Write current rise time = 13 nsec**
- **Highest level of data security provided**
- **Power supply fault protection**
- **Head to ground short circuit protection**
- **+5V, +12V power supplies**

5

BLOCK DIAGRAM



PIN DIAGRAM



14-PIN SON

CAUTION: Use handling procedures necessary for a static sensitive component.

CIRCUIT OPERATION

The SSI 32H523R provides write drive or read amplification. Mode control is accomplished with pins WDM, Write Data Mode, and R/$\overline{W}$, as shown in Table 1. An internal resistor pullup on R/$\overline{W}$ will force the device into a non-writing condition if the line is opened accidentally.

WRITE MODE

The write mode configures the SSI 32H523R as a differential current switch. The WDM pin state determines whether write current transitions are controlled by a single-ended TTL input, WDI, or by differential (ECL-like) inputs, WDI and $\overline{WDI}$. With WDM open, write current is toggled between the X and Y direction of the head on each high to low transition on pin WDI, Write Data Input. A preceding read operation initializes the Write Data Flip-Flop (WDFF) to pass write current in the X-direction of the head.

With WDM grounded the head current direction is controlled by differential inputs WDI and $\overline{WDI}$. For (WDI - $\overline{WDI}$) > 200mV the current is in the X-direction.

The magnitude of the write current (0-pk) given by:

$$Iw = \frac{Vwc}{Rwc}$$

where Vwc (WC pin voltage) = 1.65V ± 5%, is programmed by an external resistor Rwc, connected from pin WC to ground. The actual head current Ix, y is given by:

$$Ix, y = \frac{Iw}{1 + Rh/Rd}$$

where:
Rh = head resistance + external wire resistance, and
Rd = damping resistance.

Power supply fault protection improves data security by disabling the write current generator during a voltage fault or power supply sequencing. In addition a head to ground short circuit protection circuit will shut off the write driver and current to prevent excessive current and power dissipation. Triggering of this feature occurs when the DC voltage at either HDX or HDY is less than 2.0V ± 15% in write mode

READ MODE

The read mode configures the SSI 32H523R as a low noise differential amplifier and deactivates the write current generator. The RDX and RDY outputs are open collectors.

In read mode, the write data channel is powered down to reduce power consumption. Note that in write mode, the read amplifier is deactivated and will not pull any current from the load resistor.

For maximum data security in read mode VCC2 is left open or grounded. This eliminates the voltage source for write current.

TABLE 1: Mode Select

WDM	R/$\overline{W}$	MODE
GND	0	Write Differential input
OPEN	0	Write Single-ended input
X	1	Read

PIN DESCRIPTIONS

NAME	TYPE	DESCRIPTION
R/$\overline{W}$	I	Read/Write: a high level selects Read mode
WDI, $\overline{WDI}$	I	Write Data In: toggles the direction of the head current
HDX, HDY	I/O	X, Y Head Connections: current in the X-direction flows into the X-port
RDX, RDY	O	X, Y Read Data: differential read data output
WC	-	Write Current: used to set the magnitude of the write current
WDM	I	Write Data Mode: Ground this pin for direct differential input using both WDI and $\overline{WDI}$, leave open to select TTL input using WDI and the internal Write Data Flip-Flop.
VCC1	-	+5V logic circuit supply
VDD	-	+12V supply for read
VCC2	-	+5V power supply for write current drivers (see note)
GND	-	Ground

Note: To ensure maximum data integrity in write-once servo applications, this pin should be left open or shorted to ground after writing servo information.

5

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

Operation above absolute maximum ratings may permanently damage the device.

PARAMETER	SYMBOL	VALUE	UNITS
DC Supply Voltage	VDD	-0.3 to +14	VDC
	VCC1, 2	-0.3 to +7	VDC
Write Current	Iw	60	mA
Digital Input Voltage	Vin	-0.3 to VCC1 +0.3	VDC
Head Port Voltage	VH	-0.3 to VCC2 +0.3	VDC
RDX, RDY Output Current	Io	-10	mA
Storage Temperature	Tstg	-65 to +150	°C
Package Temperature (20 sec Reflow)		215	°C

RECOMMENDED OPERATING CONDITIONS

PARAMETER		SYMBOL	VALUE	UNITS
DC Supply Voltage	Read Mode	VDD	12 ± 10%	VDC
		VCC1	5 ± 10%	VDC
	Write Mode	VDD	12 ± 5%	VDC
		VCC1	5 ± 5%	VDC
		VCC2	5 ± 5%	VDC
Output Pullup Resistors (to VCC1)		RL	100	Ω
Ambient Temperature	Read Mode	TAR	0 - 70	°C
	Write Mode	TAW	20 - 43	°C
Operating Junction Temperature		Tj	0 to +135	°C

DC CHARACTERISTICS (Unless otherwise specified, recommended operating conditions apply.)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
VDD Supply Current		Read Mode	-	-	26	mA
		Write Mode	-	-	12	mA
VCC1 Supply Current		Read Mode	-	-	35	mA
		Write Mode	-	-	30	mA
VCC2 Supply Current		Read Mode, see Note 1	-	-	7	mA
		Write Mode	-	-	19 + Iw	mA
Power Dissipation (Tj = +135°C)		Read Mode, VCC2 = 0	-	-	500	mW
		Write Mode: Iw = 40mA	-	-	500	mW
Input Low Voltage (VIL)		Includes WDI w/WDM = open	-	-	0.8	VDC
Input High Voltage (VIH)		Includes WDI w/WDM = open	2.0	-	-	VDC
Input Low Current (IIL)		VIL = 0.8v	-0.4	-	-	mA
Input High Current (IHL)		VIH = 2.0v	-	-	100	µA
Input Voltage (WDI, $\overline{WDI}$)		WDM = GND	3.0	-	VCC1	VDC
Differential Input Voltage (WDI, $\overline{WDI}$)		WDM = GND	200	-	-	mVDC
VDD Fault Voltage			8. 5	-	10.0	VDC
VCC1 Fault Voltage			3.5	-	4.1	VDC
Head Current (HDX, HDY)	Write Mode	0 ≤ VDD ≤ 8.5V 0 ≤ VCC1 ≤ 3.5V	-200	-	+200	µA
	Write Mode	VCC2 = open or ground	-200	-	+200	µA
	Read Mode	0 ≤ VCC1 ≤ 5.5V 0 ≤ VDD ≤ 13.2V	-200	-	+200	µA

Note 1: If VCC2 is at ground or open this current is zero.

WRITE CHARACTERISTICS
Unless otherwise specified, recommended operating conditions apply, Iw = 15mA, Lh = 1.5µH, Rh = 30Ω f(DATA) = 5MHz, and +20°C < Tj < + 135°C

PARAMETER	CONDITIONS	MIN.	NOM	MAX	UNITS
WC Pin Voltage (Vwc)		-	1.65 ± 5%	-	V
Differential Head Voltage Swing		3.4	-	-	Vpp
Differential Output Capacitance		-	-	25	pF
Differential Output Resistance		800	1000	1400	Ω
Write Current Range		10	-	40	mA

READ CHARACTERISTICS
Unless otherwise specified, recommended operating conditions apply, CL (RDX, RDY) < 20pF

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
Differential Voltage Gain		Vin=1mVpp @1MHz, T_A = 25°C	200	250	300	V/V
Gain Sensitivity		15°C < T_A < 55°C	-	-0.16	-	%/°C
Bandwidth	-1dB	|Zs|<5Ω, Vin = 1mVpp @ 300kHz	10	20	-	MHz
	-3dB	|Zs|<5Ω, Vin = 1mVpp @ 300kHz	20	45	-	MHz
Input Noise Voltage		BW=15MHz, Lh=0 µH, R =0Ω	-	0.7	1.0	nV/√Hz
Differential Input Capacitance		Vin = 1mVpp, f = 5MHz	-	40	45	pF
Differential Input Resistance		Vin = 1mVpp, f = 5MHz	460	750	1.4K	Ω
Dynamic Range		AC input voltage where gain falls to 90% of its small signal gain value, f=5MHz	±2	-	-	mV
Common Mode Rejection Ratio		Vin = 0VDC+100mVpp @ 5MHz	54	-	-	dB
Power Supply Rejection Ratio		100m Vpp @ 5MHz on VDD, 100m Vpp @ 5MHz on VCC1	54	-	-	dB
Output Offset Voltage		Vin = 0V	-600	-	+600	mV
Output Voltage (Common Mode)		Inputs shorted together, and outputs shorted together	**	-	*	VDC

*VCC1 - 0.42
**VCC1 - 1.0

SWITCHING CHARACTERISTICS (See Figure 1)
Unless otherwise specified, recommended operating conditions apply, Iw = 15mA, Lh = 0, Rh = 0, f(DATA) = 5MHz, and +20°C < TA < +43°C

PARAMETER	CONDITIONS	MIN	MAX	UNITS
R/$\overline{W}$				
R/$\overline{W}$ to Write Mode	Delay to 90% of write current	-	0.6	µs
R/$\overline{W}$ to Read Mode	Delay to 90% of 100mV 10MHz Read signal envelope or to 90% decay of write current	-	0.6	µs
Head Current				
Prop. Delay - TD1	From 50 % points, Lh=0µh, Rh=0Ω	-	32	ns
Asymmetry	Input has 50 % duty cycle and 1ns rise/fall time, Lh=0µh, Rh=0Ω	-	1	ns
Rise/Fall Time	10% - 90% points, Lh=0µh, Rh=0Ω	-	13	ns

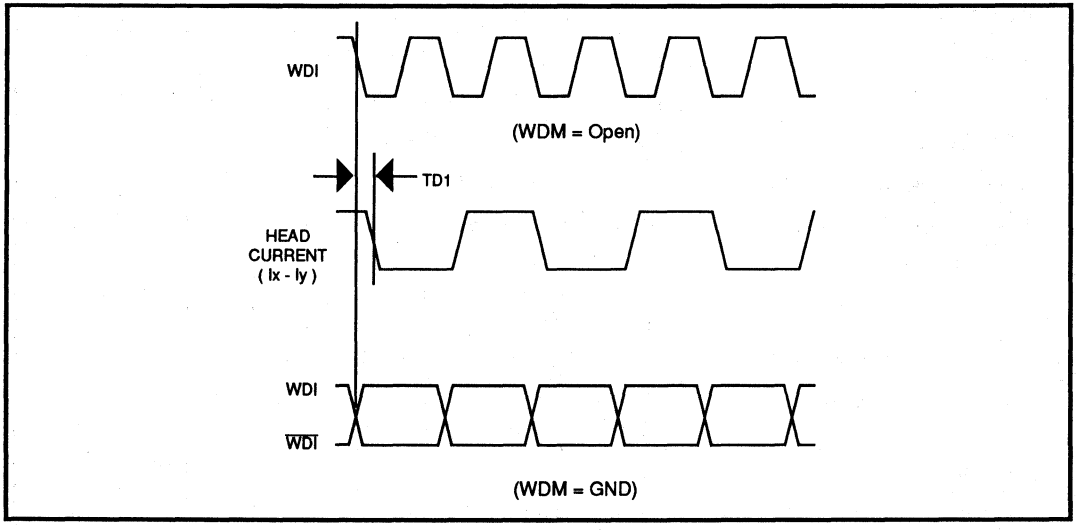


FIGURE 1: Write Mode Timing Diagram

PACKAGE PIN DESIGNATIONS

(TOP VIEW)

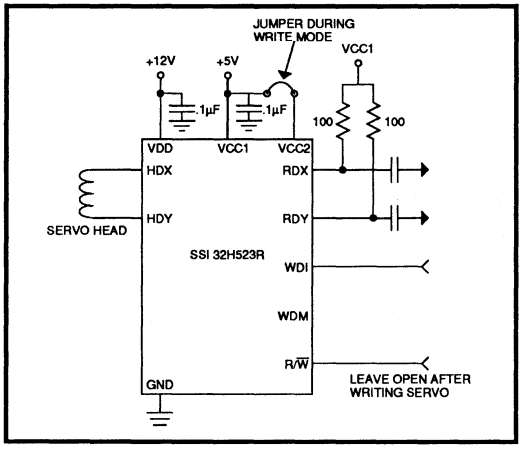


FIGURE 2: Typical Application

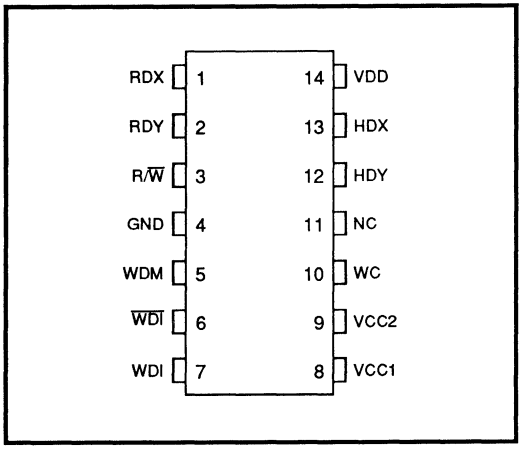


FIGURE 3: 14-Pin SON

ORDERING INFORMATION

PART DESCRIPTON	ORDER NO.	PKG. MARK
SSI 32H523R Servo Read/Write IC	SSI 32H523R-CN	32H523R-CN

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32H566R
Ferrite Single-Channel Servo Read/Write Device
Preliminary Data

July, 1990

DESCRIPTION

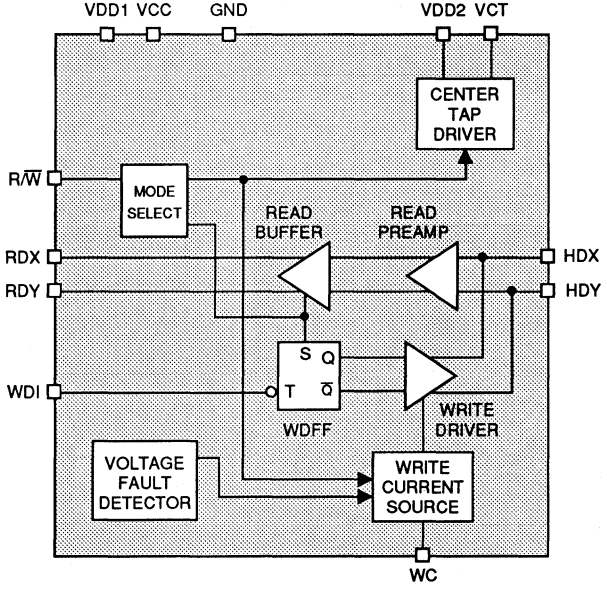
The SSI 32H566R Read/Write device is a bipolar monolithic integrated circuit designed for use with center-tapped ferrite recording heads. It provides a low noise read amplifier, write current control and data protection circuitry for a single channel. The SSI 32H566R provides internal 750Ω damping resistors. Power supply fault protection is provided by disabling the write current generator during power sequencing. System write to read recovery time is significantly improved by controlling the read channel common mode output voltage shift in the write mode.

FEATURES

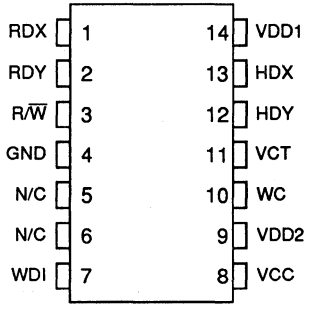
- **High performance:**
  - **Read mode gain = 150 V/V**
  - **Input noise = 1.5nV/$\sqrt{Hz}$ max.**
  - **Input capacitance = 20 pF max.**
  - **Write current range = 10 mA to 40 mA**
- **Enhanced system write to read recovery time**
- **Power supply fault protection**
- **Designed for center-tapped ferrite heads**
- **Programmable write current source**
- **TTL compatible control signals**
- **+5V, +12V power supplies**
- **Socket compatible with the SSI 32H523R**

5

BLOCK DIAGRAM



PIN DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

CIRCUIT OPERATION

The SSI 32H566R provides center-tapped ferrite head write drive or read amplification. Mode control is accomplished with pin R/$\overline{W}$. Internal resistor pullups, provided on pin R/$\overline{W}$, will force the device into a non-writing condition if a control line is opened accidentally.

WRITE MODE

The write mode configures the SSI 32H566R as a current switch. Write current is toggled between the X and Y side of the selected head on each high to low transition of the Write Data Input (WDI).

The magnitude of the write current (0-pk) is programmed by an external resistor RWC, connected from pin WC to ground and is given by:

$$Iw = \frac{K}{Rwc}$$

where K is the Write Current Constant.

Note that actual head current Ix, y is given by:

$$Ix,y = \frac{Iw}{1 + Rh/Rd}$$

Where: Rh = Head resistance plus external wire resistance
Rd = Damping resistance

Power supply fault protection improves data security by disabling the write current generator during a voltage fault or power supply sequencing.

To reduce internal power dissipation, an optional external resistor, RCT, given by RCT ≤ 130Ω x 40/Iw (Iw in mA), is connected between pins VDD1 and VDD2. Otherwise connect pin VDD1 to VDD2.

To initialize the Write Data Flip Flop (WDFF) to pass current through the X-side of the head, pin WDI must be low when the previous read mode was commanded.

READ MODE

The read mode configures the SSI 32H566R as a low noise differential amplifier and deactivates the write current generator. The RDX and RDY outputs are emitter followers. These outputs should be AC coupled to the load. The RDX, RDY common mode voltage is maintained in the write mode, minimizing the transient between write mode and read mode, substantially reducing the write to read recovery time in the subsequent pulse detection circuitry.

PIN DESCRIPTIONS

NAME	TYPE	DESCRIPTION
R/$\overline{W}$	I	Read/Write - A high level selects Read Mode
WDI	I	WRITE DATA IN - Negative transition toggles direction of head current
HDX, HDY	I/O	X,Y head connections
RDX, RDY	O	X, Y READ DATA - Differential read signal output
WC	I	WRITE CURRENT - Used to set the magnitude of the write current
VCT	O	VOLTAGE CENTER TAP - Voltage source for head center tap
VCC	-	+5V
VDD1	-	+12V
VDD2	-	Positive power supply for the center-tap voltage source
GND	-	GROUND

ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS

All voltages referenced to GND. Currents into device are positive. Maximum limits indicate when permanent device damage occurs. Continuous operation at these levels is not intended and should be limited to those conditions specified in the DC Operating Characteristics.

PARAMETER		RATING	UNIT
VDD1	DC Supply Voltage	-0.3 to +14	VDC
VDD2	DC Supply Voltage	-0.3 to +14	VDC
VCC	DC Supply Voltage	-0.3 to +7	VDC
V_{IN}	Digital Input Voltage Range	-0.3 to VCC + 0.3	VDC
V_H	Head Port Voltage Range	-0.3 to VDD1 + 0.3	VDC
Iw	Write Current (0-pk)	60	mA
	RDX, RDY (lo) Output Current	-10	mA
	VCT Output Current	-60	mA
Tstg	Storage Temperature Range	-65 to 150	°C
	Lead Temperature PDIP, Flat Pack (10 sec Soldering)	260	°C
	Package Temperature PLCC, SO (20 sec Reflow)	215	°C

RECOMMENDED OPERATING CONDITIONS

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
VDD1	DC Supply Voltage		10.8	12.0	13.2	VDC
VCC	DC Supply Voltage		4.5	5.0	5.5	VDC
Lh	Head Inductance				15	µH
RCT*	RCT Resistor	Iw = 40 mA	123	130	137	Ω
Iw	Write Current (0-pk)		10		40	mA
Tj	Junction Temperature Range		+25		+135	°C

*For Iw = 40 mA. At other Iw levels refer to Applications Information that follows this specification.

DC CHARACTERISTICS (Recommended operating conditions apply unless otherwise specified.)

POWER SUPPLY

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VCC Supply Current					
Read	Read Mode			13	mA
Write	Write Mode			25	mA
VDD Supply Current (sum of VDD1 and VDD2)					
Read	Read Mode			33	mA
Write	Write Mode			10+Iw	mA
Power Dissipation (Tj = +135°C)					
Read	Read Mode			500	mW
Write	Write Mode, Iw = 40 mA, RCT = 0Ω			700	mW
	Write Mode, Iw = 40 mA, RCT = 130Ω			500	mW

DIGITAL I/O

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
VIL	Input Low Voltage				0.8	VDC
VIH	Input High Voltage		2.0			VDC
IIL	Input Low Current	VIL = 0.8V	-0.4			mA
IIH	Input High Current	VIH = 2.0V			100	µA

WRITE MODE

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
VCT	Center Tap Voltage	Write Mode		6.7		VDC
Head Current (per side)		Write Mode, 0 ≤ VCC ≤ 3.7V, 0 ≤ VDD1 ≤ 8.7V	-200		200	µA
Write Current Range			10		40	mA
Write Current Constant "K"			2.375		2.625	V
Iwc to Head Current Gain				0.99		mA/mA
RDX, RDY Output Offset Voltage		Write/Idle Mode	-20		+20	mV

WRITE MODE (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
RDX, RDY Common Mode Output Voltage	Write/Idle Mode		5.3		VDC
RDX, RDY Leakage	RDX, RDY = 6V Write/Idle Mode	-100		100	µA

READ MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VCT Center Tap Voltage	Read Mode		4.0		VDC
Head Current (per side)	Read or Idle Mode 0 ≤ VCC ≤ 5.5V 0 ≤ VDD1 ≤ 13.2V	-200		200	µA
Input Bias Current (per side)				45	µA
Output Offset Voltage	Read Mode	-615		+615	mV
Common Mode Output Voltage	Read Mode	4.5		6.5	VDC

5

DYNAMIC CHARACTERISTICS AND TIMING
(Iw = 35 mA, Lh = 10 µH, Rd = 750Ω, f(WDI) = 5 MHz, CL(RDX, RDY) ≤ 20 pF. Recommended operating conditions apply unless otherwise specified.)

WRITE MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Differential Head Voltage Swing		7.0			V(pk)
Differential Output Capacitance				15	pF
Differential Output Resistance		600		960	Ω

READ MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Differential Voltage Gain, R_L = 100Ω	Vin = 1 mVpp @ 300 KHz ZL(RDX), ZL(RDY) = 1 KΩ	125		175	V/V
Dynamic Range	AC Input Voltage, Vi, @ 300 KHz Where Gain Falls by 10%.	2			mVpp

READ MODE (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Bandwidth (-3dB)	|Zs| < 5Ω, Vin = 1 mVpp	30			MHz
Input Noise Voltage	BW = 15 MHz, Lh = 0, Rh = 0			1.5	nV/√Hz
Differential Input Capacitance	f = 5 MHz			20	pF
Differential Input Resistance	f = 5 MHz	500		1000	Ω
Common Mode Rejection Ratio	Vcm = VCT + 100 mVpp @ 5 MHz	50			dB
Power Supply Rejection Ratio	100 mVpp @ 5 MHz on VDD1, VDD2 or VCC	45			dB
Single Ended Output Resistance	f = 5 MHz			30	Ω
Output Current	AC Coupled Load, RDX to RDY	±2.1			mA

SWITCHING CHARACTERISTICS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
R/$\overline{W}$					
R/$\overline{W}$ To Write Mode	Delay to 90% of Write Current			1.0	µs
R/$\overline{W}$ to Read Mode	Delay to 90% of 100 mV 10 MHz Read Signal Envelope or to 90% decay of Write Current			1.0	µs
Head Current (Lh = 0µH, Rh = 0Ω)					
Prop Delay - TD1	From 50% points, WDI to I(x-y)			25	ns
Asymmetry	WDI has 50% duty cycle and 1 ns Rise/Fall Time			2	ns
Rise/Fall Time	10% - 90% points			20	ns

APPLICATIONS INFORMATION

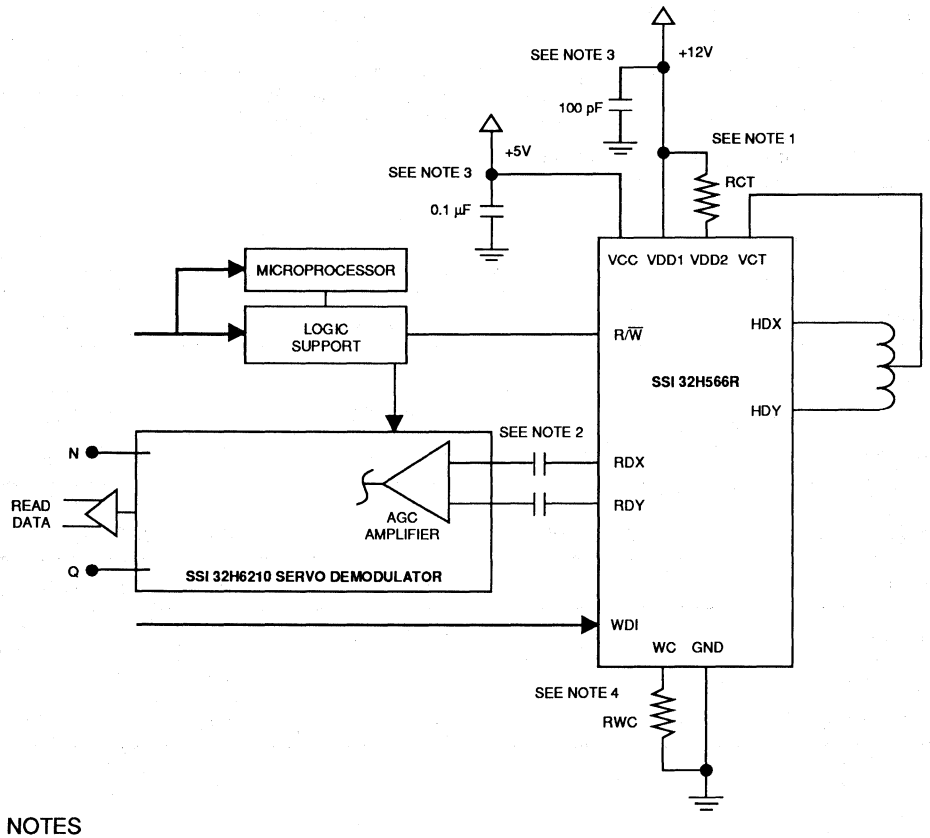
The specifications, provided in the data section, account for the worst case values of each parameter taken individually. In actual operation, the effects of worst case conditions on many parameters correlate. Tables 3 & 4 demonstrate this for several key parameters. Notice that under the conditions of worst case input noise, the higher read back signal resulting from the higher input impedance can compensate for the higher input noise. Accounting for this correlation in your analysis will be more representative of actual performance.

TABLE 3: KEY PARAMETERS UNDER WORST CASE INPUT NOISE CONDITIONS

PARAMETER	Tj=25°C	Tj=125°C	UNIT
Inputs Noise Voltage (max.)	1.1	1.5	$nV/\sqrt{Hz}$
Differential Input Resistance (min.)	850	1000	Ω
Differential Input Capacitance (max.)	11.6	10.8	pF

TABLE 4: KEY PARAMETERS UNDER WORST CASE INPUT IMPEDANCE CONDITIONS

PARAMETER	Tj=25°C	Tj=125°C	UNIT
Inputs Noise Voltage (max.)	0.92	1.2	$nV/\sqrt{Hz}$
Differential Input Resistance (min.)	500	620	Ω
Differential Input Capacitance (max.)	10.1	10.3	pF



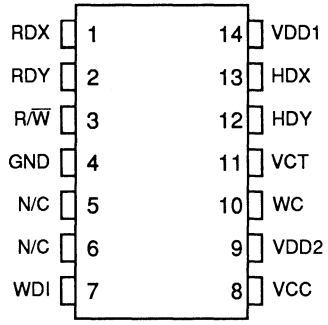
NOTES

1. An external resistor, RCT, given by; RCT ≤ 130 (40/Iw) where Iw is the zero-peak write current in mA, can be used to limit internal power dissipation. Otherwise connect VDD2 to VDD1.
2. Limit DC current from RDX and RDY to 100 µA and load capacitance to 20 pF.
3. The power bypassing capacitor must be located close to the device with its ground returned directly to device ground, with as short a path as possible.
4. To reduce ringing due to stray capacitance this resistor should be located close to the device. Where this is not desirable a series resistor can be used to buffer a long WC line.

FIGURE 2: Typical Application

PACKAGE PIN DESIGNATIONS

(TOP VIEW)



14-Pin SON

THERMAL CHARACTERISTICS: Øja = 130 °C/W

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ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32H566R Servo Ferrite Single Channel Read/Write Device		
14-Pin SON	SSI 32H566R-N	32H566R-N

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32H569
Servo Motor Driver

July, 1990

DESCRIPTION

The SSI 32H569 Servo Motor Driver is a bipolar device intended for use in Winchester disk drive head positioning systems employing linear or rotary voice coil motors. When used in conjunction with a position controller, such as the SSI 32H568 Servo Controller, and a position reference, such as the SSI 32H567 Servo Demodulator, the device allows the construction of a high performance, dedicated surface head positioning system.

The SSI 32H569 serves as a transconductance amplifier by driving 4 MOSFETs in an H-bridge configuration, performs motor current sensing and limits motor current and velocity. In its linear tracking mode, class B operation is guaranteed by crossover protection circuitry, which ensures that only one MOSFET in each leg of the H-bridge is active. The MOSFET drivers are disabled when motor velocity or current exceed externally programmable limits. In addition, automatic head retraction and spindle braking may be initiated by a low voltage condition or upon external command.

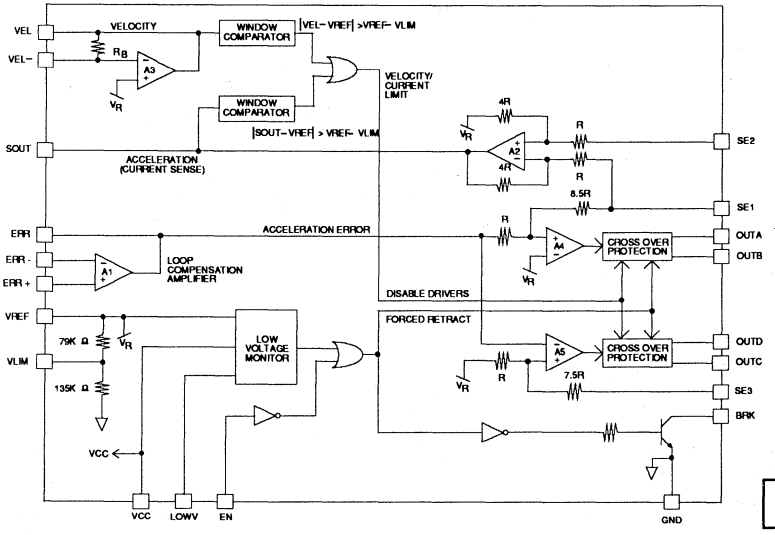
(Continued)

FEATURES

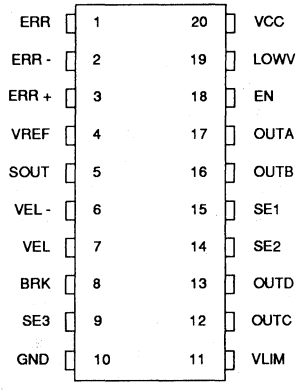
- **Predriver for linear and rotary voice coil motors**
- **Interfaces directly to MOSFET H-Bridge motor driver**
- **Class B linear mode and constant velocity retract mode**
- **Precision differential amplifier for motor current sensing**
- **Motor current and velocity limiting circuitry**
- **Automatic head retract and spindle braking signal on power failure**
- **External digital enable**
- **Servo loop parameters programmed with external components**
- **Advanced bipolar IC requires under 240 mW from 12V supply**
- **Available in 20-pin DIP or SO packaging**

5

BLOCK DIAGRAM



PIN DIAGRAM



20-Pin SO, DIP

CAUTION: Use handling procedures necessary for a static sensitive component.

DESCRIPTION (Continued)

The SSI 32H569 is implemented in an advanced bipolar process and dissipates less than 240 mW from a 12V supply. The IC is available in 20-pin DIP and 20-pin SO packaging.

FUNCTIONAL DESCRIPTION

(Refer to block diagram and typical application Fig.2)

The SSI 32H569 has two modes of operation, linear and retract. The retract mode is activated by a power supply failure or when the control signal EN is false. Otherwise the device operates in linear mode.

During linear operation, an acceleration signal from the servo controller is applied through amplifier A1, whose three connections are all available externally. RC components may be used to provide loop compensation at this stage. The ERR signal drives two precision amplifiers, each with a gain of 8.5. The first of these amplifiers is inverting, and is formed from opamp A4, an on-chip resistor divider and an off-chip complementary MOSFET pair. The second is non-inverting, and is formed in a similar manner from opamp A5. Feedback from the MOSFET drains, on sense inputs SE1 and SE3, allows the amplifiers gains to be established precisely. The voice coil motor and a series current sense resistor are connected between SE1 and SE3.

Crossover protection circuitry between the outputs of A4 and A5, and the external MOSFETs, ensures class B operation by allowing only one MOSFET in each leg of the H-bridge to be in conduction. The crossover separation threshold, illustrated in Figure 5, is the maximum drive on any MOSFET gate when the motor voltage changes sign. The crossover circuitry can also disable all MOSFETS simultaneously (to limit motor current or velocity) or apply a constant voltage across the motor (to retract the heads at a constant velocity).

Motor current is sensed by a small resistor placed in series with the motor. The voltage drop across this resistor is amplified by a differential amplifier with a gain of 4 (A2 and associated resistors), whose inputs are SE1 and SE2. The resulting voltage, SOUT, is proportional to motor current, and hence acceleration. This signal is externally fed back to A1, so that the signal ERR represents the difference between the desired acceleration (from the servo controller) and the actual motor acceleration. If SOUT is integrated, using opamp A3 and an external RC network, the resulting signal, VEL, is proportional to the motor velocity.

Both SOUT and VEL are connected to window comparators, which are used to detect excessive motor current or velocity. The comparator outputs disable the MOSFET drivers until the motor comes within limits again. The VLIM pin may be used to program the voltage limits for the window comparators. The maximum voltage excursion allowed about VREF is (VREF-VLIM). An on-chip resistor divider sets a default value for VLIM and if VLIM is connected to ground, the windowing is effectively disabled.

The SSI 32H569 has low voltage monitor circuitry that will detect a loss of voltage on the VREF, VCC or LOWV pins. The power supply pin, VCC, should be connected to the disk drive's spindle motor so that its stored rotational energy may be used to hold up VCC briefly during a power failure. LOWV is used to detect a system power supply failure. When a low voltage condition is detected, the MOSFET drivers switch from linear operation to retract mode. In this mode a constant voltage is applied across the motor which will cause the heads to move at a constant speed. A mechanical stop must be provided for the heads when they reach a safe location. The current limiting circuitry will disable the MOSFET drivers when motor current increases due to loss of the velocity-induced back EMF. An open collector output, BRK, which is active while the device is in retract mode, is provided for spindle motor braking. An external RC delay may be used to defer braking until the heads are retracted. For proper operation of the SSI 32H569, a pullup resistor on BRK is required even if the BRK output is not used.

An example of an entire servo path implemented with the SSI 32H569 and its companion devices, the SSI 32H567 and 32H568, is shown in Figure10.

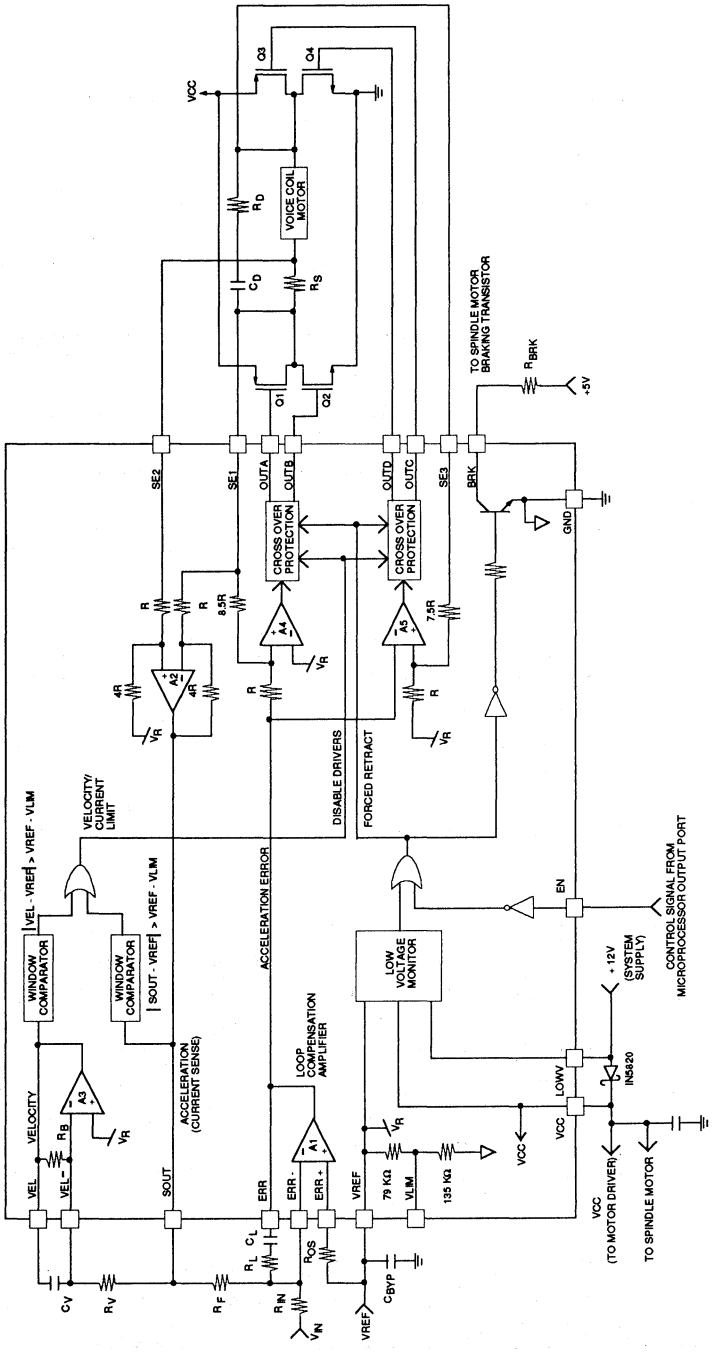


FIGURE 2: Typical Application

PIN DESCRIPTION

POWER

NAME	PIN	TYPE	DESCRIPTION
VCC	20		POSITIVE SUPPLY - 12V power supply. Usually taken from spindle motor supply. Spindle motor stored energy permits head retraction during power failure. If VCC falls below 9V, a forced head retraction occurs.
LOWV	19	I	LOW VOLTAGE - System 12V supply. If this input falls below 9V, a forced head retraction occurs.
VREF	4	I	REFERENCE VOLTAGE - 5.4V input. All analog signals are referenced to this voltage. If VREF falls below 4.3V, a forced head retraction occurs.
GND	10		GROUND

CONTROL

NAME	PIN	TYPE	DESCRIPTION
ERR	1	O	POSITION ERROR- Loop compensation amplifier output. This signal is amplified by the MOSFET drivers and applied to the motor by an external MOSFET H-bridge, as follows: SE3-SE1 = 17(ERR-VREF)
ERR-	2	I	POSITION ERROR INVERTING INPUT - Inverting input to the loop compensation amplifier.
ERR+	3	I	POSITION ERROR NON-INVERTING INPUT - Non-inverting input to the loop compensation amplifier.
SOUT	5	O	MOTOR CURRENT SENSE OUTPUT - This output provides a voltage proportional to the voltage drop across the external current sense resistor, as follows: SOUT-VREF=4(SE2-SE1)
VEL-	6	I	VELOCITY INVERTING INPUT - Inverting input to the velocity integrating amplifier. The non-inverting input is connected internally to VREF.
VEL	7	O	VELOCITY OUTPUT - Output of the velocity integration amplifier. This signal is internally applied to a window comparator whose output limits motor drive current when the voltage at VEL exceeds a set limit.
BRK	8	O	BRAKE OUTPUT - Active high, open collector output which may be used to enable an external spindle motor braking transistor upon power failure or deassertion of EN.
VLIM	11	I	LIMITING VOLTAGE - The voltage at this pin sets motor current and velocity limits. Limiting occurs when: |SOUT-VREF|>VREF-VLIM or |VEL-VREF|>VREF-VLIM. An internal resistor divider establishes a default value that may be externally adjusted.

CONTROL (Continued)

NAME	PIN	TYPE	DESCRIPTION
SE2	14	I	MOTOR CURRENT SENSE INPUT - Non-inverting input to the current sense differential amplifier. It should be connected to one side of an external current sensing resistor in series with the motor. The inverting input of the differential amplifier is connected internally to SE1.
EN	18	I	ENABLE - Active high TTL compatible input enables linear tracking mode. A low level will initiate a forced head retract.

FET DRIVE

NAME	PIN	TYPE	DESCRIPTION
SE3	9	I	MOTOR VOLTAGE SENSE INPUT - This input provides feedback to the non-inverting MOSFET driver amplifier. It is connected to one side of the motor. The gain to this point is: SE3-VREF = 8.5(ERR-VREF)
OUTC	12	O	P-FET DRIVE (NON-INVERTING) - Drive signal for a P channel MOSFET connected between one side of the motor and VCC. This MOSFET drain is connected to SE3.
OUTD	13	O	N-FET DRIVE (NON-INVERTING) - Drive signal for an N channel MOSFET connected between one side of the motor and GND. This MOSFET drain is connected to SE3. Crossover protection circuitry ensures that the P and N channel devices driven by OUTC and OUTD are never enabled simultaneously.
SE1	15	I	MOTOR VOLTAGE SENSE INPUT - This input provides feedback to the inverting MOSFET driver amplifier. It is connected to the current sensing resistor which is in series with the motor. The gain to this point is: SE1-VREF = -8.5(ERR-VREF) This input is internally connected to the current sense differential amplifier inverting input.
OUTB	16	O	N-FET DRIVE (INVERTING) - Drive signal for an N channel MOSFET connected between the current sense resistor and GND. This MOSFET drain is also connected to SE1.
OUTA	17	O	P-FET DRIVE (INVERTING) - Drive signal for a P channel MOSFET connected between the current sense resistor and VCC. This MOSFET drain is also connected to SE1. Crossover protection circuitry ensures that the P and N channel devices driven by OUTC and OUTD are never enabled simultaneously.

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

(Maximum limits indicates where permanent device damage occurs. Continuous operation at these limits is not intended and should be limited to those conditions specified in the DC operating characteristics.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
VCC		0		16	V
VREF		0		10	V
SE1, SE2, SE3		-1.5		15	V
All other pins		0		14	V
Storage temperature		-45		165	°C
Solder temperature	10 sec duration			260	°C

RECOMMENDED OPERATION CONDITIONS (Unless otherwise noted, the following conditions are valid throughout this document.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
VCC	Normal Mode	9	12	13.2	V
	Retract Mode	3.5V		14	V
VREF		5		7	V
Operating temperature		0		70	°C

DC CHARACTERISTICS

ICC, VCC current				20	mA
IREF, VREF current				2	mA

A1, LOOP COMPENSATION AMPLIFIER

Input bias current				500	nA
Input offset voltage				3	mV
Voltage swing	About VREF	2			V
Common mode range	About VREF	±1			V
Load resistance	To VREF	4			KΩ
Load capacitance				100	pF
Gain		80			dB
Unity gain bandwidth		1			MHz
CMRR	f<20 kHz	60			dB
PSRR	f<20 kHz	60			dB

A2, CURRENT SENSE AMPLIFIER

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input impedance	SE1 to SE2	3.5	5		KΩ
Input offset voltage				2	mV
Output voltage swing		VREF-4		VCC-1.2	V
Common mode range		0		VCC-0.2	V
Load Resistance	To VREF	4			KΩ
Load Capacitance				100	pF
Output impedance	f<40 KHz			20	Ω
Gain (SOUT-VREF)/(SE1-SE2)		3.9	4	4.1	V/V
Unity gain bandwidth		1			MHz
CMRR	f<20 KHz	52			dB
PSRR	f<20 KHz	60			dB

A3, VELOCITY INTEGRATING AMPLIFIER

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input bias current				250	nA
Input offset voltage				2	mV
Voltage swing		VREF-4		VCC-1.2	V
Common mode range		4.5		6	V
Load resistance	To VREF	10			KΩ
Load capacitance				100	pF
RB, internal feedback resistor		80		150	KΩ

WINDOW COMPARATORS AND LIMITING

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Window comparator threshold (SOUT-VREF or VEL-VREF)		VREF-VLIM			V
Threshold hysteresis		35	50	65	%
VLIM voltage	No external parts	VREF-1.8		VREF-2.2	V
VLIM input resistance		50			KΩ

5

POWER SUPPLY MONITOR

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
VCC fail threshold		8.5	9	9.8	V
LOWV fail threshold	|ILowv| < 0.5 mA	8.5	9	9.8	V
VREF fail threshold		3.9	4.3	4.8	V
Hysteresis (LOWV, VCC)			250		mV
Hysteresis (VREF)			110		mV
EN input low voltage	|IIL| < 0.5 mA	0.8			V
EN input high voltage	|IIH| < 40 uA			2	V
BRK voltage	normal mode, |IOL| < 1 mA			0.4	V
BRK leakage current	retract mode			10	µA
BRK delay (from power fail or EN false to BRK floating)				1	ms

MOSFET DRIVERS

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
SE3 Input impedance	To VREF	10	25		KΩ
OUTA, OUTC voltage swing |Io|<1 mA		0.7		VCC-1	V
OUTB, OUTD voltage swing |Io|<1 mA		1		VCC-1	V
VTH, Crossover separation threshold				2	V
Slew rate (OUTA, OUTB, OUTC, OUTD)	Cl<1000 pF	1.4			V/µs
Crossover time	300 mV step at ERR			5	µs
Output impedance (OUTA,B,C,D)			50		KΩ
Transconductance I(OUTA,B,C,D)/(ERR-VREF)			8		mA/V
Gain (-(SE1-VREF)/(ERR-VREF) or (SE3-VREF)/(ERR-VREF))		8	8.5	9	V/V
Offset current	R_S = 0.2Ω, R_F = R_{IN}, V_{IN}=VREF			20	mA
Retract motor voltage (SE1-SE3)		0.7	1	1.3	V

APPLICATIONS INFORMATION

A typical SSI 32H569 application is shown in Figure 2. The selection criteria for the external components shown are discussed below. Figure 3 shows the equivalent circuit and equations for the DC motor used in the following derivations. While the nomenclature chosen is for a rotating motor, the results are equally applicable to linear motors.

MOTOR CURRENT SENSE AND LIMITING

The series resistor which senses motor current, Rs, is chosen to be small compared to the resistance of the motor, Rm. A value of Rs = 0.2Ω is typical in disk drive applications. The window comparator threshold, programmed by VLIM, must be chosen to cause limiting when the motor current reaches its maximum permissible value. If iMAX is the maximum motor current in Amps, then this value may be chosen as follows:

$$VLIM = VREF - 4 \cdot R_s \cdot iMAX \ (V)$$

VLIM may be set with a resistor divider whose thevenin resistance is substantially less than the output resistance of the VLIM pin (50 KΩ). The window comparators have hysteresis (typically 50% of their threshold, VREF-VLIM) to prevent multiple triggerings of the driver disable signal.

VELOCITY LIMITING

The values of Rv and Cv in the velocity integrator are chosen to produce a voltage excursion of VREF-VLIM, when the motor speed is at its maximum permissible value. Rv must be large enough to prevent overloading of opamp A2. The following equation ignores the effect of RB, the internal resistor between VEL and VEL- which prevents saturation of A3 due to offsets. For the motor in Figure 3, with maximum velocity ωMAX (rad/s) these components may be chosen as follows:

$$R_V // R_F > 4K\Omega \ (\text{A2 output loading restriction})$$

$$C_V = \frac{4 R_s \cdot J\theta \cdot \omega MAX}{(VREF - VLIM) \cdot R_V \cdot K_m} \ (F)$$

LOOP COMPENSATION

The transfer function of the SSI 32H569 in the application of Figure 2 is shown in figure 4(a). If the zero due to RL and CL in the loop compensation circuit is chosen to cancel the pole due to the motor inductance, Lm, then the transfer function can be simplified as shown in figure 4(b), under the assumption that this pole and the pole due to the motor mechanical response are widely separated. CL may then be chosen to set the desired open loop unity gain bandwidth.

$$C_L = \frac{68 \cdot R_s}{2 \cdot \pi \cdot R_F \cdot (R_m + R_s) \cdot BW}$$

where BW is the unity gain open loop bandwidth

$$R_L = \frac{L_m}{C_L \cdot (R_m + R_s)}$$

The closed loop response of the servo driver and motor combination, using the component values and simplifying assumptions given above, is given by:

$$\frac{i_m}{V_{in}}(s) = -\frac{1}{R_{in}} \cdot \frac{R_F}{4 \cdot R_s} \cdot \frac{1}{\left(1 + \frac{s}{2 \cdot \pi \cdot BW}\right)}$$

(This analysis neglects the pole due to the output impedance of the MOSFET drivers and the MOSFET gate capacitance, an effect that may be significant in some systems).

RF is chosen to be sufficiently large to avoid overloading A2 ($R_F // R_V > 4K\Omega$). The input resistor, RIN, sets the conversion factor from servo controller output voltage to servo motor current. RIN is chosen such that the servo controller internal voltages are scaled conveniently. The resistor ROS is optional and cancels out the effect of the input bias current of A1.

$$R_{os} = R_{in} // R_F$$

The external components RD and CD have no effect on the motor dynamics, but may be used to improve the stability of the MOSFET drivers. The load represented by the motor, ZM, is given by:

At frequencies above (Rs+Rm)/(2 • π • Lm) Hz, this load

$$ZM = (R_s + R_m)\left(1 + s\frac{L_m}{R_s + R_m}\right)\left(1 + \frac{K_m^2}{s \cdot J\theta \cdot (R_s + R_m)}\right)(\Omega)$$

becomes entirely inductive, which is undesireable. R_D and C_D may be used to add some parallel resistive loading at these frequencies.

H-BRIDGE MOSFETS

The MOSFETs chosen for the H-bridge should have gate capacitances in the range of 500-1000 pF. The MOSFET input capacitance forms part of the compensation for the MOSFET drivers, so values below 500 pF may cause some driver instability. Excessive input capacitance will degrade the slew mode performance of the drivers.

When the motor voltage is changing polarity, the crossover protection circuits at outputs OUTA-OUTD ensure that the maximum MOSFET gate drive is less than 2V (the crossover separation threshold), as illustrated in Figure 5. The thresholds of the MOSFET devices chosen should be as large as possible to minimize conduction in this region. If the device thresholds are significantly less than the crossover separation threshold, the N and P channel devices in each leg of the H-bridge will conduct simultaneously, causing unnecessary power dissipation.

POWER FAILURE OPERATION

The power supply for the SSI 32H569, VCC, should be taken from the system 12V supply through a schottky diode (maximum 0.5V drop at If = 3A) and connected to the disk drive spindle motor. If the system power fails, the IC will continue to operate as the spindle motor becomes a generator. The SSI 32H569 will detect the power failure and cause a forced head retract, continuing to operate with VCC as low as 3.5V. The power fail mode will commence if either VCC or LOWV falls below 9V, or VREF falls below 4.3V, or EN is false. Hysteresis on the low voltage thresholds prevents the device from oscillating between operating modes when the power supply is marginal.

The BRK output, which is pulled low during normal operation, floats during a power failure. This allows an external transistor to be enabled for spindle motor braking. An external RC delay may be added to defer braking until head retraction is complete, since the spindle motor is required to generate the supply voltage during retraction.

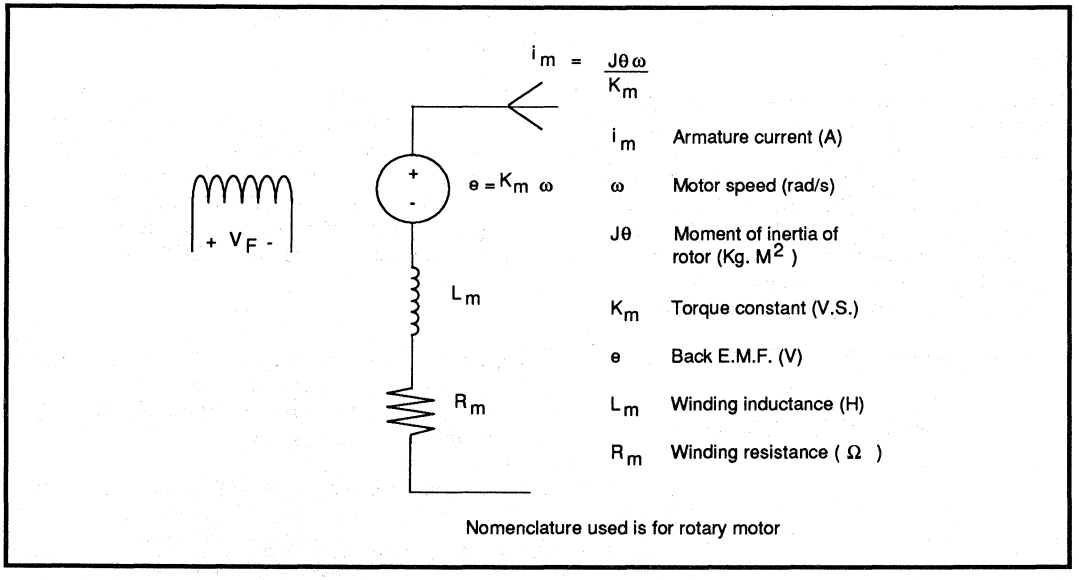


FIGURE 3: Equivelant Circuit For Fixed Field DC Motor

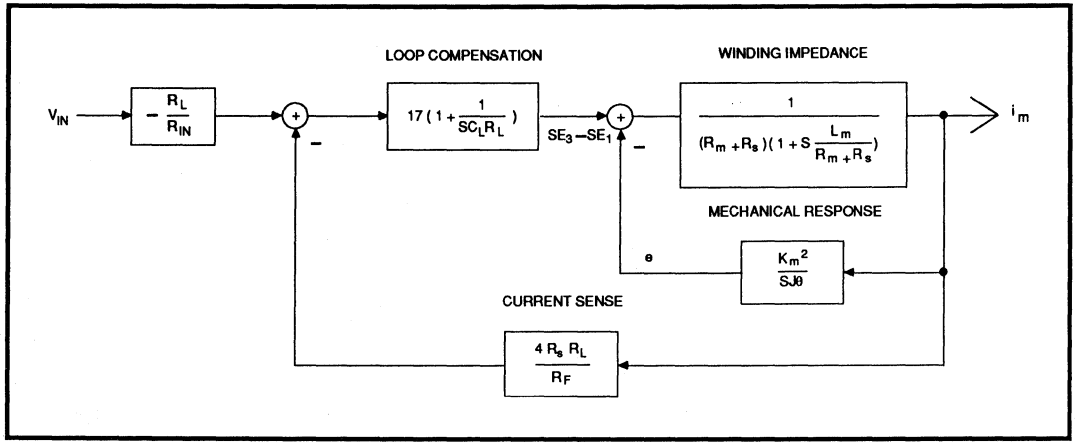


FIGURE 4(A): Transfer Function Of SSI 32H569 In Typical Application With Fixed Field DC Motor

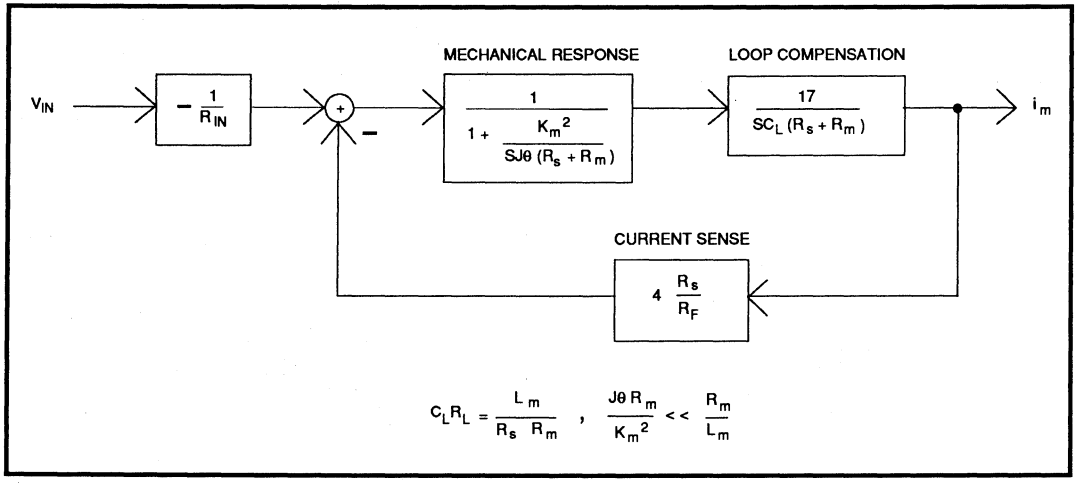


FIGURE 4(B): Simplified Transfer Function Of SSI 32H569 In DC Motor Application

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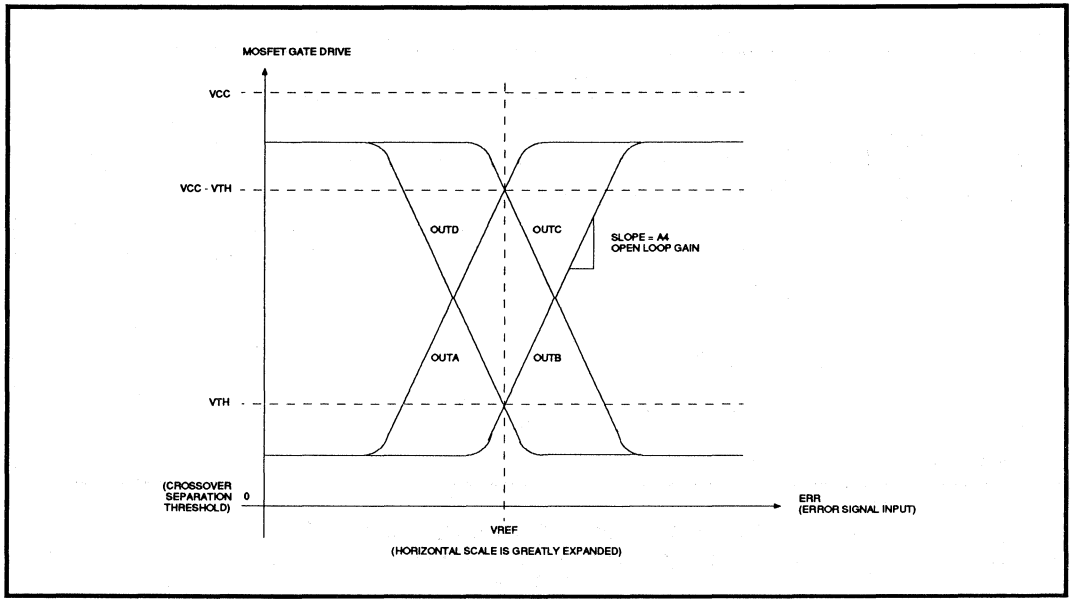


FIGURE 4(B): Simplified Transfer Function Of SSI 32H569 In DC Motor Application

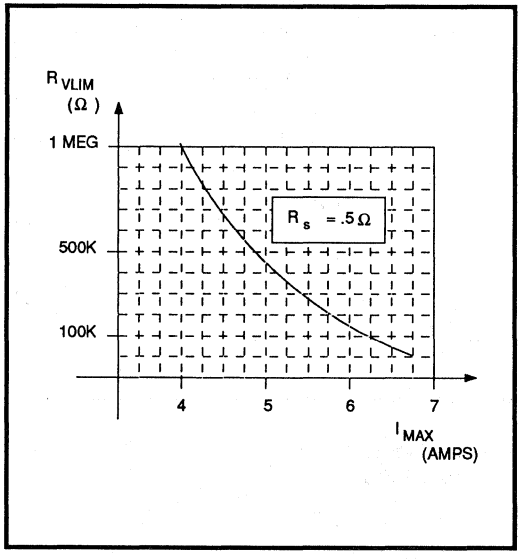


FIGURE 6: RVLIM To Ground Typical Motor Current Limit

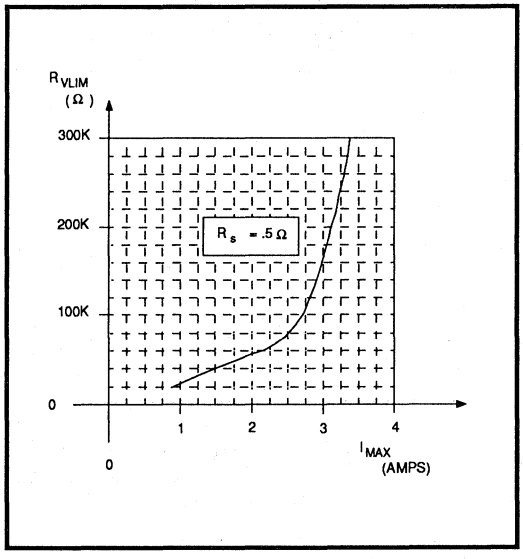


FIGURE 7: RVLIM To VREF Typical Motor Current Limit

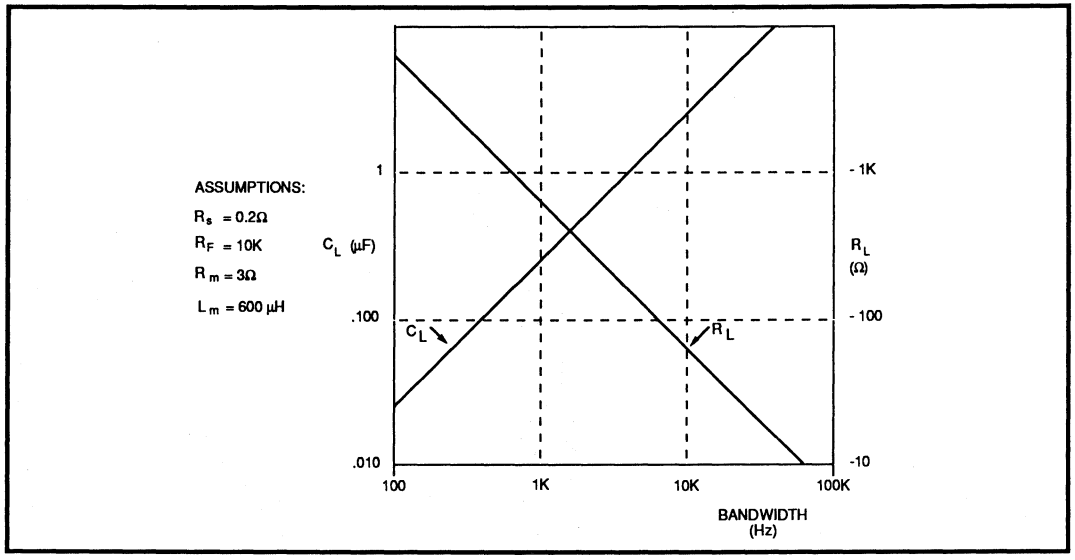


FIGURE 8: Typical Motor Driver Compensation

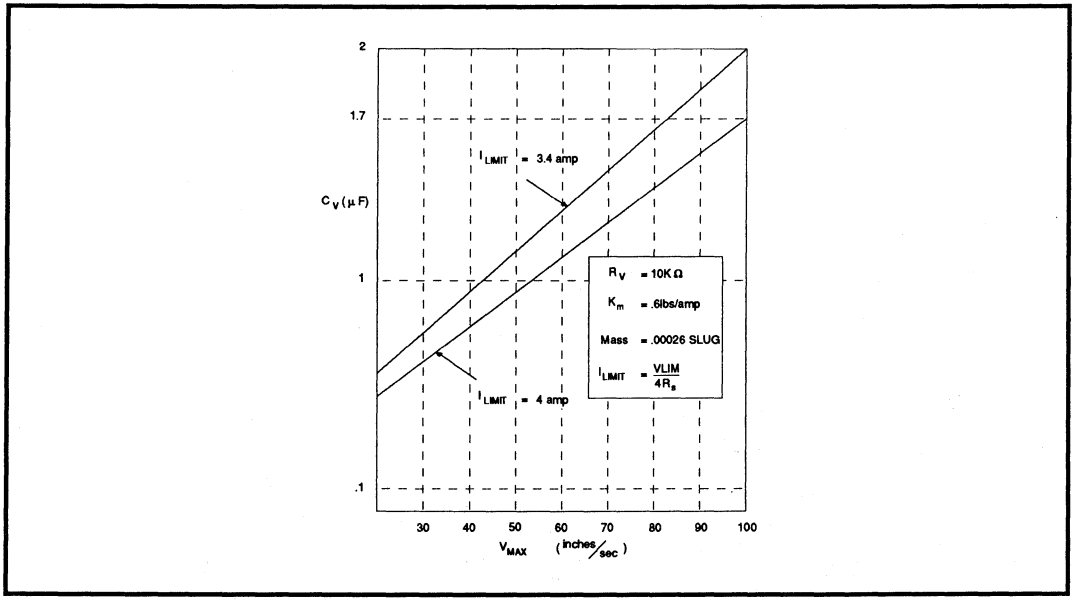


FIGURE 9: Typical Motor Velocity Limit

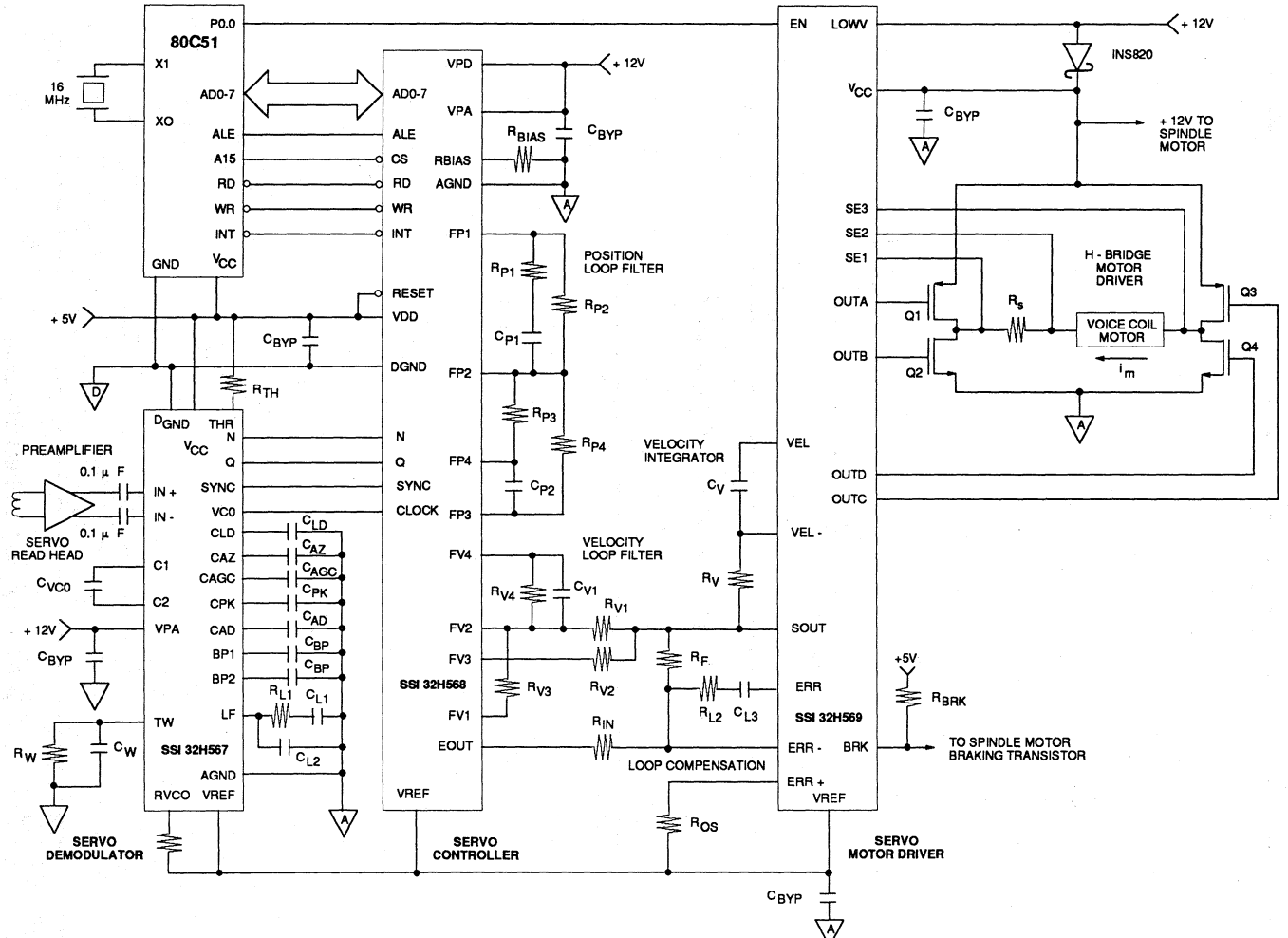
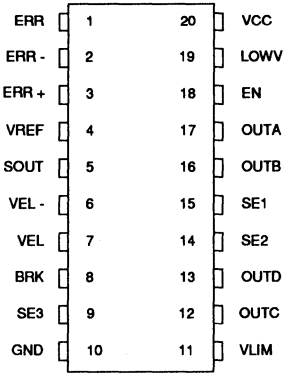


FIGURE 10: Complete Example Of Servo Path Electronics Using The SSI 32H567/568/569 Chip Set

PACKAGE PIN DESIGNATIONS

(TOP VIEW)



20-Pin SO, DIP

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ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32H569, Servo Motor Driver		
20-Pin DIP	SSI 32H569-CP	32H569-CP
20-Pin SOL	SSI 32H569-CL	32H569-CL

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Notes:

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SSI 32H4630
Embedded Servo & Spindle Motor Controller
Advance Information

July, 1990

FEATURES

- **Head Positioning**
  - **Embedded servo control with digital timing generator and ABCD burst sampling**
  - **Quadrature peak detection with sample/hold and normalized conversion**
  - **60 kHz 8-bit A/D and D/A convertors**
  - **Write protection of embedded servo frame**
  - **H-Bridge predriver compatible with +5V designs**
- **Spindle Motor Control**
  - **Sensor-less motor commutation with precise speed control**
  - **Compatibility with Bipolar and Unipolar, Delta, and Star motors**
  - **Adjustable commutation delay for optimum motor operation**
  - **Microprocessor speed lock status**
  - **3-Phase predriver compatible with +5V designs**
- **Internal registers addressed by Motorola or Intel μP interface**
- **Voltage fault protection, including R/$\overline{W}$ guarding, retract, and brake**
- **Low power, +5V only operation, including programmable power down modes**
- **Available in 100-pin QFP package**
- **Less than 300 mW power dissipation**

5

GENERAL DESCRIPTION

The SSI 32H4630 combines the head positioning and spindle motor control electronics along with voltage fault protection and a flexible microprocessor interface into a high performance, low power, CMOS integrated circuit. The spindle motor controller utilizes a sensor-less technique for motor commutation and provides precise motor speed regulation. The voice coil motor is controlled by an embedded servo system under microprocessor direction. The SSI 32H4630 motor predrivers are compatible with external bridge output structures and can be configured with high efficiency power FETs in order to maximize the power to the spindle and the voice coil motors. The 32H4630 requires only a +5 volt power supply, and is compatible with +5V motor power drivers. The 32H4630 is available in a 100-pin QFP package.

SSI 32H4630
Embedded Servo & Spindle Motor Controller

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only. Do not use for final design.

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SSI 32H4631
Hybrid Servo & Spindle Motor Controller

Advance Information

July, 1990

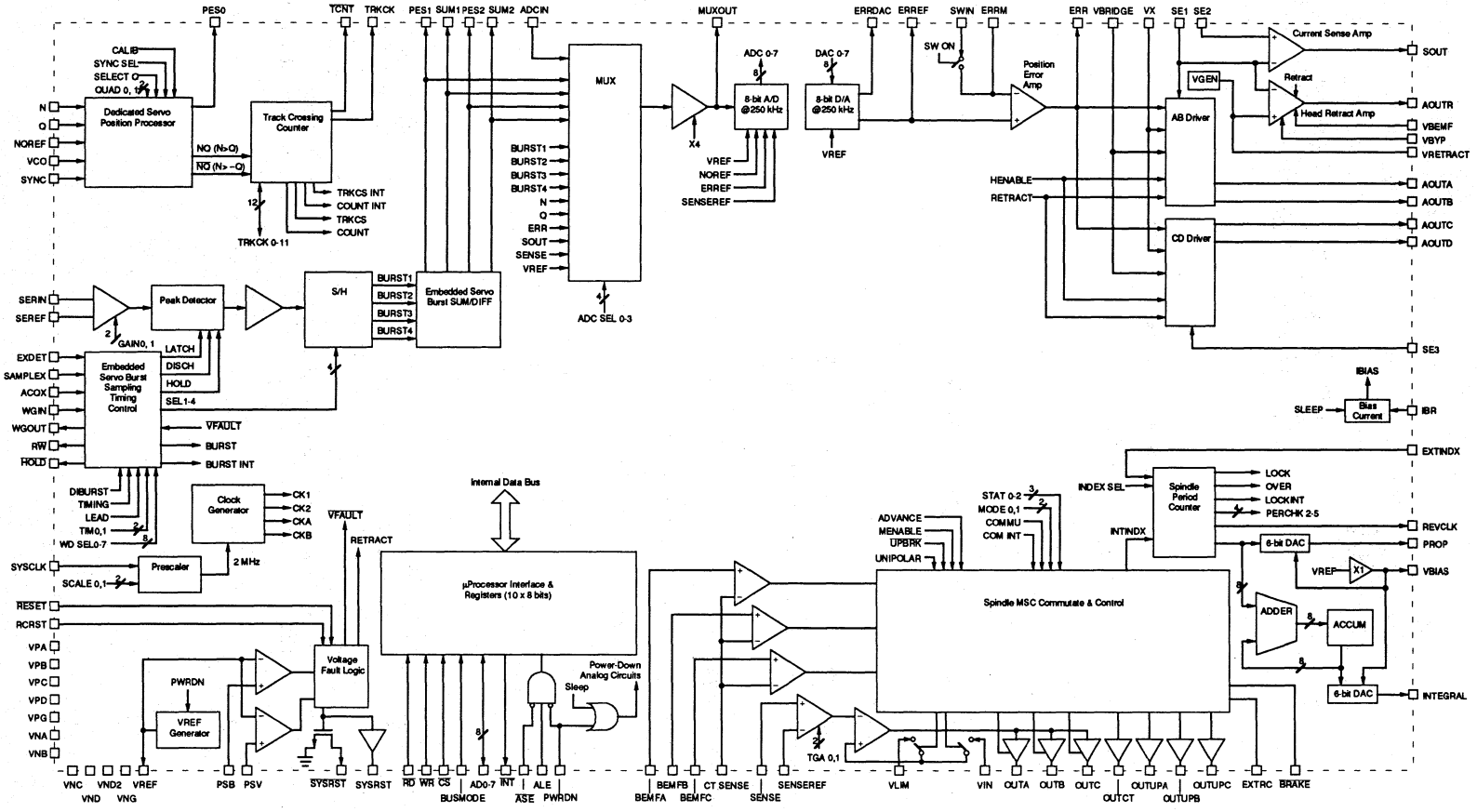
FEATURES

- **Head Positioning**
  - **Embedded servo control with digital timing generator and ABCD burst sampling**
  - **Hybrid servo features with N/Q interface and track counter**
  - **Quadrature peak detection with sample/hold circuits**
  - **250 kHz 8-bit A/D and D/A converters**
  - **Write protection of embedded servo frame**
  - **H-Bridge predriver compatible with +5V and +12V designs**
- **Spindle Motor Control**
  - **Sensor-less motor commutation with precise speed regulation**
  - **Compatibility with Bipolar and Unipolar, Delta, and Star motors**
  - **Adjustable commutation delay for optimum motor operation**
  - **Microprocessor speed lock status**
  - **3-Phase predriver compatible with +5V and +12V designs**
- **Internal registers addressed by Motorola or Intel μP interface**
- **Voltage fault protection, including R/$\overline{W}$ guarding, retract, and brake**
- **Low power, +5V only operation, including programmable power down modes**
- **Available in 100-pin QFP package**

5

GENERAL DESCRIPTION

The SSI 32H4631 combines the head positioning and spindle motor control electronics along with voltage fault protection and a flexible microprocessor interface into a high performance, low power, CMOS integrated circuit. The spindle motor controller utilizes a sensor-less technique for motor commutation and provides precise motor speed regulation. The voice coil motor is controlled by a hybrid servo system that utilizes embedded servo control and an external dedicated servo demodulator like the SSI 32H6210, all under microprocessor direction. The SSI 32H4631 motor predrivers are compatible with external bridge output structures and can be configured with high efficiency power FETs in order to maximize the power to the spindle and the voice coil motors. The 32H4631 requires only a +5 volt power supply, but is compatible with both +5V and +12V motor power drivers. The 32H4631 is available in a 100-pin QFP package.



BLOCK DIAGRAM
SSI 32H4631

PIN DESCRIPTION

This section describes the names of the pins, their symbols, their functions and their active states. The pins are grouped together into function for clarity.

POWER SUPPLIES

NAME	TYPE	DESCRIPTION
VPA, B, C, D, G	-	+5 volt supply
VNA, B, C, D, D2, G	-	Ground
VREF	-	Reference voltage which is used as the DC reference level for the device.
VBEMF	-	Head retract and motor brake predriver voltage source.
VBRIDGE	-	+5V or +12V motor drive supply.
VBYP	-	Power fault supply equals VBRIDGE less one diode voltage drop.
IBR	-	Pin for connecting an external resistor to set bias current.
VBIAS	-	VBIAS is buffered internal VREF used for VLIM and motor speed setting bias.
PWRDN	I	Causes analog circuits and microprocessor interface to power down.

MICROPROCESSOR INTERFACE

AD7-AD0	I/O	Address/Data bus - 8-bit bus which carries register address information and bidirectional data. These pins are in the high impedance state when the chip is not selected by $\overline{CS}$ and $\overline{RD}$.
ALE; AS	I	Address Latch Enable - Falling edge latches the register address from the AD7-AD0 bus.
$\overline{MWR}$; MR/W	I	For INTEL-type microprocessors, active low strobe latching data on AD7-AD0. For MOTOROLA-type microprocessors, read/write state line.
$\overline{MRD}$; DS	I	For INTEL type microprocessors, active low strobe gating read data out onto AD7-AD0. For MOTOROLA-type microprocessors, provides a data strobe for data clocking.
$\overline{CS}$	I	Chip Select - Active low signal enabling the device to respond to microprocessor register access. Qualifies read and write control lines.
BUSMODE	I	Selects Intel or Motorola µP interface type.
$\overline{ASE}$	I	Alternative chip select qualification.
$\overline{INT}$	O	Interrupt providing an open drain output asserted by the device when an interrupt event enabled in the interrupt mask register occurs. Cleared when all pending interrupt sources are specifically serviced.

GENERAL SUPPORT PINS

NAME	TYPE	DESCRIPTION
RCRST	-	Capacitor and resistor for reset timing providing both power on $\overline{\text{SYSRST}}$ delay and rejection against glitches falsely triggering a power-down cycle.
$\overline{\text{RESET}}$	I	Externally generated master reset which is merged internally with the power reset logic. When asserted active low, resets all internal registers to default values and results in the assertion of $\overline{\text{SYSRST}}$.
$\overline{\text{SYSRST}}$	O	Open drain active low output, generated by the internal reset and power sensing logic used to reset the microprocessor and other system chips. Asserted on active low $\overline{\text{RESET}}$ and on power up/down fault conditions.
SYSRST	O	Active high version of $\overline{\text{SYSRST}}$.
SYSCLK	I	System input clock from which the servo and spindle control timing is derived. The clock rate may range up to 10 MHz. An internal programmable prescaler divides SYSCLK to an internal 2 MHz.
PSB, PSV	I	Supply fault comparator inputs to monitor supply voltage through an external resistive divider.
ADCIN	I	User available input to internal ADC. Addressable through MUX.
MUXOUT	O	Output of internal analog MUX.

EMBEDDED SERVO PINS

$\overline{\text{HOLD}}$	O	AGC Gain Hold - TTL compatible control signal active low during the embedded servo frame. This signal serves to hold the read path AGC at a fixed value so that the position burst field amplitudes may be detected.
WGIN	I	TTL active high write gate signal asserted by storage controller when writing data.
WGOUT	O	TTL active high write gate signal guarded by the 32H4631. During an embedded servo frame, WGOUT is unconditionally forced inactive low.
EXTDET	I	External Detect - trigger for embedded servo timing controller.
SERIN	I	Full wave rectified amplitude corresponding to the pulse amplitude read from the disk. Compatible with the SSI 32P4620.
SEREF	I	Reference for SERIN compatible with SSI 32P4620.
R/$\overline{\text{W}}$	O	This signal is compatible with write amplifiers. It provides guarded accidental write prevention down to 3.6V. Inverse polarity of WGOUT.
PES1, PES2	O	Quadrature position error signals - output difference of selectable burst field pairs. Useful for testing and evaluation. The same signal is normally digitized internally and read by the microprocessor to implement the track following loop.
SAMPLEX	I	Peak detector enable signal, used when the external timing generator is programmed with the timing bit.
ACQX	I	Peak detector acquisition control signal used when external timing generator is programmed with the timing bit.
SUM1, SUM2	O	SUM outputs corresponding to difference signals PES1 and PES2.

DEDICATED/HYBRID SERVO PINS

NAME	TYPE	DESCRIPTION
N	I	Normal - Analog position signal from a dedicated servo demodulator. This input along with Q is used to extract the position information from a dedicated servo surface.
Q	I	Quadrature - Analog signal similar to N above but in quadrature with it.
SYNC	I	A synchronization signal used to sample and hold the N and Q signals. The falling edge of this clock causes the N and Q analog signals to be sampled. Leaving the pin disconnected provides compatibility with continuous N Q demodulators which do not provide a SYNC signal. One SYNC per servo frame with a maximum frame rate of 500 kHz.
TRKCK	O	Track crossing strobe useful when implementing an external track counting scheme. For every track crossing (there are four for a full N period), an active going strobe is asserted on this pin.
NQREF	I	Reference for N and Q signals.
VCO	I	Clock from servo demodulator.
$\overline{\text{TCNT}}$	O	Terminal count resulting from the internal track crossing counter under flowing. This is useful in generating an interrupt associated with reaching the end of the seek slew and entry into the deceleration portion of the velocity profile.
PES0	O	Dedicated position error signal which is the output of the position processor. This analog signal is useful for testing and evaluation. This signal is normally digitized internally and read by the microprocessor.

H BRIDGE PREDRIVER INTERFACE

AOUTR	O	Control voltage to external retract transistor.
VRETRACT	I	Resistively controlled retract voltage.
ERRDAC	O	Output of DAC used by the microprocessor to apply error commands to the head actuator transconductance amplifier.
ERREF	I	H-Bridge predriver reference voltage.
ERRM	I	Error opamp inverting input.
ERR	O	Error opamp output.
SWIN	I	Programmable analog input error op-amp.
SOUT	O	Motor current sense output. This output provides a voltage proportional to the voltage drop across the external current sense resistor.
SE1, SE3	I	Motor voltage sense inputs providing feedback for linear class B predriver block.
SE2	I	Motor sense current input to internal opamp providing amplification of the current sense before summing with the DAC.
AOUTA, AOUTC	O	PFET drive (inverting) - Drive signal for a P channel MOSFET connected between VDD and voice coil motor. Crossover circuitry prevents simultaneous conduction.
AOUTB, AOUTD	O	NFET drive (noninverting) - Drive signal for an N channel MOSFET connected between the current sense resistor and the voice coil motor.
VX	O	Crossover protection voltage. It is used with an external resistor to define the crossover voltage.

MOTOR SPEED CONTROL PINS

NAME	TYPE	DESCRIPTION
EXTINDX	I	External index input used to provide a once-per-revolution indication of angular position and speed to the device, when selected via the INDEX_SEL bit.
SENSE	I	Coil current sense input. The input senses the coil current and limits the sense voltage to the specified threshold by limiting voltage on the lower predriver outputs.
SENSEREF	I	Kelvin reference for SENSE signal.
OUTUPA, B, C	O	Upper predriver outputs. These three predrive outputs are used to activate external PFET power transistors.
OUTA, B, C	O	Lower predriver outputs. These three driver outputs drive external NFET power transistors to control the motor current sensed across resistor Re. An internal programmable amplifier provides programmable transconductance. When the motor is at speed, the drive voltages are adjusted as necessary to maintain the proper motor speed with a proper motor current.
BEMFA, B, C	I	Back EMF sense voltage inputs which are connected directly to the three motor terminals.
PROP	O	Proportional channel output to be connected in series with an external proportional gain setting resistor and summed at the VIN pin.
INTEGRAL	O	Integral channel output to be connected in series with an external proportional gain setting resistor and summed at the VIN pin.
EXTRC	-	Timing RC network used to delay the actual motor commutation time from the back EMF derived commutation time. This optional delay may be used to optimize motor efficiency at the target speed.
VIN	I	Input to the summing amplifier, connected through external resistors to the PROP and integral pins.
CTSENSE	O	Neutral or center tap connection used by the back EMF sense circuit. For a STAR configured motor, CTSENSE is connected directly to the center tap. For DELTA or Y configured motors, three external resistors forming a DELTA to Y transformation network generate a neutral which is then connected directly to CTSENSE.
$\overline{\text{BRAKE}}$	I	Active low input causing dynamic braking of spindle motor.
OUTCT	O	Centertap predriver output, asserted when in unipolar mode.
VLIM	I	Programmable spindle motor limit current achieved by setting this voltage.
REVCLK	O	Based on the number of motor poles, the frequency of REVCLK indicates actual motor speed derived from back EMF events

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only. Do not use for final design.

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SSI 32H6110
Differential Amplifier

Preliminary Data

July, 1990

DESCRIPTION

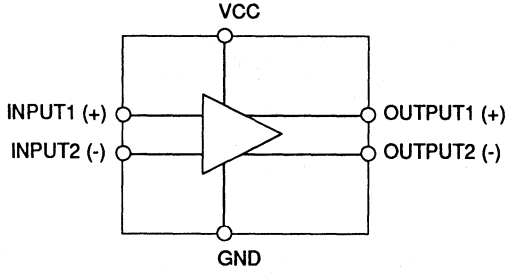
The SSI 32H6110 is a high performance, differential amplifier used as a preamplifier for the magnetic servo thin-film head in Winchester disk drives. The SSI 32H6110 is offered in an 8-pin Plastic DIP, SON, or custom 10-pin flatpack.

FEATURES

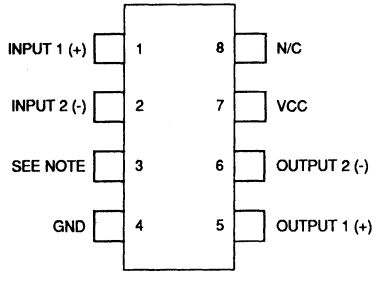
- **High gain (Av=300)**
- **Low noise, 0.85 nV/$\sqrt{Hz}$ maximum**
- **Operates with a +5V power supply**
- **Packages include 8-pin Plastic DIP, SON or custom 10-pin flatpack**

5

BLOCK DIAGRAM



PIN DIAGRAM



8-Pin PDIP, SON

CAUTION: Use handling procedures necessary for a static sensitive component.

ELECTRICAL SPECIFICATIONS

Tj = 15°C to 135°C, Vcc = +5V

ABSOLUTE MAXIMUM RATINGS – operating above maximum ratings may damage the device

PARAMETER	RATING	UNIT
Power Supply Voltage (VCC)	7	V
Differential Input Voltage	±1	V
Storage Temperature Range	-65 to 150	°C
Operating Ambient Temperature, Ta	15 to 60	°C
Operating Junction Temperature, Tj	10 to 130	°C

RECOMMENDED OPERATING CONDITIONS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Supply Voltage (VCC)		4.75	5.0	5.25	V
Input Signal (Vin)			1		mVpp
Ambient Temperature		+15		+65	°C
Operating Junction Temperature		+15		+135	°C

DC ELECTRICAL CHARACTERISTICS

Unless otherwise specified, recommended operating conditions apply.

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
Gain (Differential)	R_L = 120Ω	Vin = 1mVpp, R_L = 120Ω Ta = 25°C, f = 1 MHz	225	300	375	mV/mV
	R_L = 100Ω	Vin = 1mVpp, R_L = 100Ω Ta = 25°C, f = 1 MHz	200	250	300	mV/mV
Bandwidth (3 dB)		Vin = 1mVpp, C_L = 15 pF R_L = 120Ω	10	20		MHz
Gain Sensitivity (Supply)		Ta = 25°C			3.0	%/V
Gain Sensitivity (Temp.)		15°C < Ta < 55°C			–0.16	%/°C
Input Noise Voltage		Input Referred, Rs = 0		0.6	0.85	$nV/\sqrt{Hz}$
Input Capacitance (Differential)		Vin = 1 mVpp, f = 5 MHz			35	pF
Input Resistance (Differential)				200		Ω
Common Mode Rejection Ratio (Input Referred)		Vin = 100 mVpp, f = 1 MHz	60			dB
Power Supply Rejection Ratio (Input Referred)		Vin = 100 mVpp, f = 1 MHz	46			dB
Input Dynamic Range (Differential)		AC input voltage where gain falls to 90% of its small signal value, f = 5MHz	2			mVpp

DC ELECTRICAL CHARACTERISTICS, (Continued)
Unless otherwise specified, recommended operating conditions apply.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Output Offset Voltage (Differential)	Vin = 0V	-400	±50	+400	mV
Output Voltage (Common Mode)	Inputs shorted together and Outputs shorted	VCC-0.56	VCC-0.88	VCC-1.2	V
Single Ended Output Capacitance				10	pF
Power Supply Current	VCC = 5V		23	34	mA
Input DC Voltage	Common Mode		2.1		V

5

APPLICATIONS INFORMATION

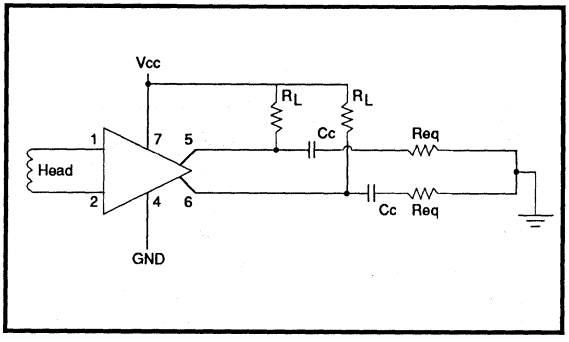


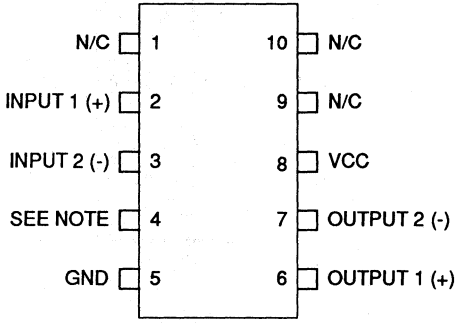
FIGURE 1: Connection Diagram

RECOMMENDED LOAD CONDITIONS

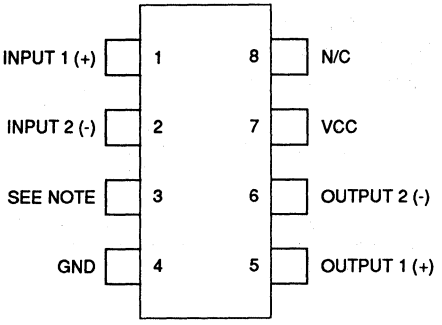
1. Input is directly coupled to the head.
2. Cc's are AC coupling capacitors.
3. RL's are DC bias and termination resistors, 120Ω recommended.
4. REQ. represents equivalent load resistance.
5. Ceramic capacitors (0.1 µF) are recommended for good power supply noise filtering.

SSI 32H6110
Differential Amplifier

PACKAGE PIN DESIGNATIONS
(TOP VIEW)



10-Pin Flatpack



8-Pin PDIP, SON

NOTE : Pin must be left open and not connected to any circuit etch.

ORDERING INFORMATION

PART DESCRIPTION	ORDERING NUMBER	PACKAGE MARK
SSI 32H6110 Differential Amplifier		
10-Pin Flatpack	SSI 32H6110-CF	H6110-F
8-Pin SON	SSI 32H6110-CN	H6110
8-Pin PDIP	SSI 32H6110-CP	32H6110-CP

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32H6210
Servo Demodulator

Advance Information

July, 1990

DESCRIPTION

The SSI 32H6210 Servo Demodulator is a bipolar device intended for use in Winchester disk drives with dedicated surface head positioning systems. It processes a di-bit quadrature pattern read from the servo surface by a preamplifier, such as the SSI 32H101 or SSI 32H116, and generates normal and quadrature (N and Q) position reference signals. These signals provide the servo controller with position error feedback. A complete position control system can be realized with the SSI 32H6210 and its companion devices, the SSI 32H6220 Servo Controller and SSI 32H6230 Servo Motor Driver.

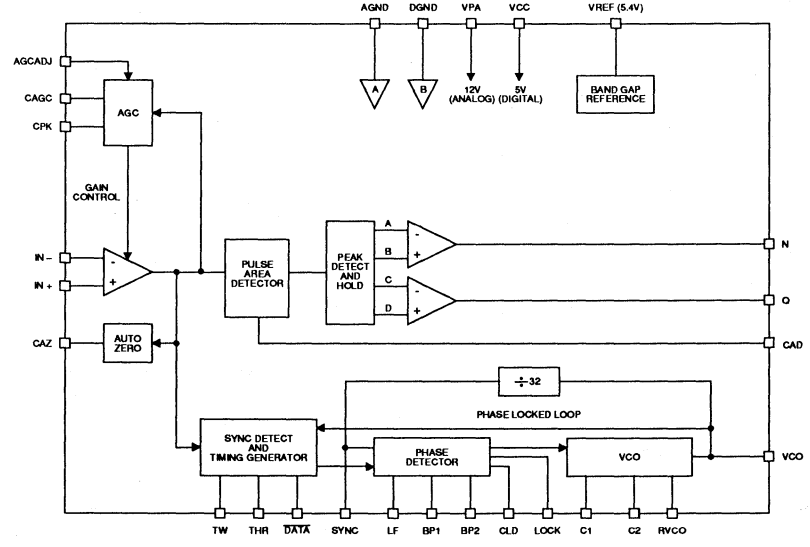
The SSI 32H6210 incorporates an input amplifier with automatic gain control and offset cancellation, a phase locked loop and sync separator to recover timing information, and pulse area detectors to recover the position information. External components are used to set the operating characteristics of the SSI 32H6210, such as AGC response, VCO center frequency, PLL response and sync separator threshold. Its high performance analog/digital circuitry is capable of supporting servo frame rates of up to 400 kHz.

FEATURES

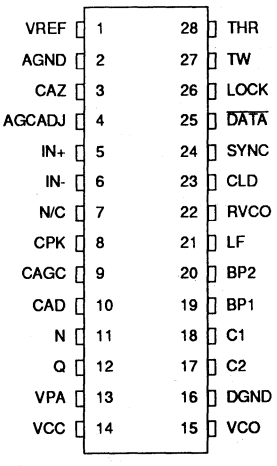
- **Servo signal demodulation for dedicated surface head positioning systems**
- **Supports industry standard di-bit quadrature servo pattern with frame rates up to 400 kHz**
- **N, Q outputs convey track crossing and position error information**
- **PLL for timing recovery and synchronization**
- **Adjustable sync separator threshold**
- **Auto-zeroing AGC input amplifier**
- **AGC reference level adjustment**
- **Precision bandgap voltage reference output**
- **AGCOUT gain controlled output signal**
- **Advanced bipolar process dissipates less than 900 mW (5V, 12V)**
- **Available in 28-pin PLCC, DIP, SO packages**

5

BLOCK DIAGRAM



PIN DIAGRAM



28-PIN DIP, SO

FUNCTIONAL DESCRIPTION

(Refer to block diagram, typical application, Fig.2, and complete data sheet available from Silicon Systems.)

The SSI 32H6210 processes servo position information which is read from a dedicated surface by a pre-amplifier. The servo information must conform to the 'di-bit quadrature' pattern which is illustrated in Figure 4. Servo frames, consisting of data and sync pulses followed by four information pulses (A, B, C, D) are prerecorded along each track of the servo surface. All the servo frames on an individual track are identical, but in the radial direction four different frame types are encountered, with every fourth track being identical. The N signal generated by the SSI 32H6210 is proportional to the difference in sizes of pulses A and B, while the Q signal is proportional to the difference between pulses C and D. When the read head is off track, the read signal is effectively a linear interpolation between the prerecorded information of two adjacent tracks, making it possible to sense the head displacement exactly.

The SSI 32H6210 has a differential input amplifier which incorporates offset voltage cancellation and automatic gain control. An external read preamplifier must provide a differential input signal of 23 to 400 mV peak to peak from the servo read head. This signal is applied to a pulse detector whose output is proportional to the peak amplitude of the input pulse.

An AGC circuit adjusts the input gain so that the maximum pulse detector output is 2V peak. The AGC circuit incorporates a peak detector which stores the maximum pulse area signal on the external capacitor C_{PK}. This signal is compared to an internal amplitude reference and the input amplifier gain is adjusted until they are equal. The capacitor C_{AGC} determines the response time of the gain control circuit. An offset cancellation circuit , whose response is set with the external capacitor C_{AZ}, ensures that the average level at the differential amplifier output is zero.

An AGC adjust (AGCADJ) pin allows the user to adjust the AGC reference level. AGCADJ can be driven with a potentiometer or a D/A (a simple Pulse Width Modulated signal is usually sufficient.) This pin is left open if no AGC adjustment is required.

All internal analog signals are referenced to a 5.4V bandgap reference voltage. This level is available at the VREF output, which is capable of supplying 10 mA to the rest of the servo path electronics.

In a standard servo frame, the data and sync pulses are more closely spaced than the information pulses (A-D). This allows the sync detect circuit to recover the SYNC pulses. A threshold, which is defined as percentage of the peak signal at the output of the AGC amplifier, is set externally with R_{TH}. Pulses which exceed this threshold are defined as valid pulses (ie. potentially SYNC or DATA). As illustrated in Figure 6, at the end of the positive going half of a valid pulse, a window set by Rw and Cw is opened. If a second valid pulse occurs within this window, it is recognized as a SYNC pulse. This pulse becomes the input signal to a phase locked loop whose VCO clock frequency is 32 times the SYNC frequency (servo frame rate). The $\overline{\text{DATA}}$ output pin is low whenever a SYNC pulse is detected. The example illustrated in Figure 6 includes the case of a missing DATA pulse. The SYNC clock output, which marks the start of a new servo frame, is derived from the VCO output so that the clock continues to run when a data pulse is missing. Absolute positioning information such as track 0 and guardband flags may be encoded on the servo surface by the omission of data pulses.

To generate the servo pattern shown in the timing diagram, Figure 5, the DATA and SYNC pulses must be written to overlap as shown in Figure 7.

The phase detector compares the detected sync pulses with the SYNC output. A current pulse proportional to the phase error is applied to an external loop filter network connected to the LF pin, to generate the VCO control voltage. If improved power supply rejection is required, bypassing may be provided at pins BP1 and BP2. The VCO center frequency is determined by the external components R_{VCO} and C_{VCO}.

A lock detect circuit measures the phase difference between the detected sync pulses and the sync output. When this difference exceeds half of a VCO clock cycle, a pulse of discharge current is applied to CLD. Otherwise a pulse of charging current is applied to CLD.

A clamp circuit limits the swing of the CLD pin and also insures that a small amount of hysteresis is present. When the voltage on CLD falls below the upper clamp level by more than the "lock margin," the LOCK output transistor is turned on. Likewise, when the voltage on CLD rises above the lower clamp level by more than the "unlock margin," the LOCK output transistor is turned off.

FUNCTIONAL DESCRIPTION (Continued)

Internal timing windows are generated from the recovered SYNC pulse and VCO clock. These windows, WA, WB, WC, and WD, in Figure 5, enable the four peak detectors to capture the A, B, C and D information pulses. The N and Q analog outputs are formed by differencing adjacent pulses. These outputs change during a servo frame and only become valid after the D pulse has been detected. N and Q should be sampled by the servo controller on the next falling edge of the SYNC output clock.

An example of an entire servo path implemented with the SSI 32H6210 and its companion devices, the

(Complete data sheet available from Silicon Systems.)

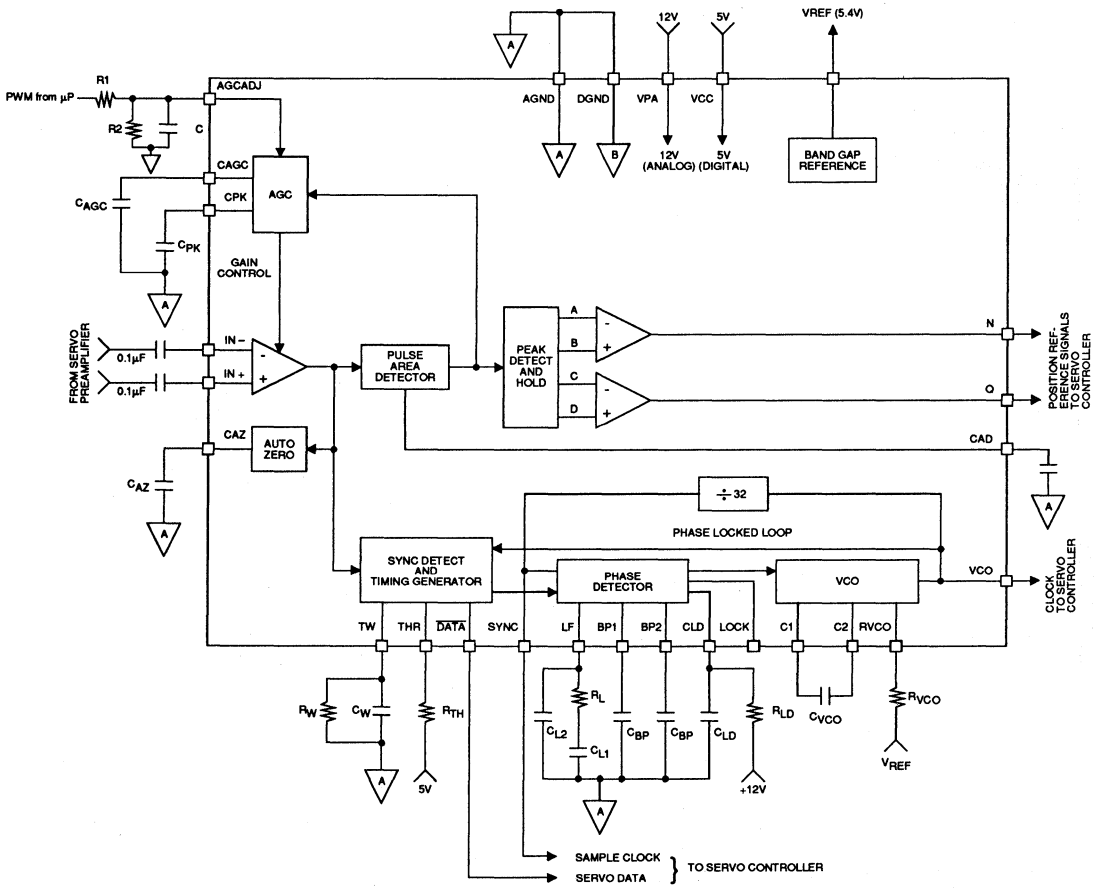


FIGURE 2: Typical Application

PIN DESCRIPTION

POWER

NAME	TYPE	DESCRIPTION
VREF	O	REFERENCE VOLTAGE - 5.4V output. All analog signals are referenced to this voltage.
AGND	-	ANALOG GROUND
VPA	-	ANALOG SUPPLY - 12V power supply.
VCC	-	DIGITAL SUPPLY - 5V power supply.
DGND	-	DIGITAL GROUND

INPUT AMPLIFIER

NAME	TYPE	DESCRIPTION
CAZ	-	AUTOZERO CAPACITOR - A capacitor which sets the response of the input amplifier offset cancellation circuit should be connected between this pin and analog ground.
IN +	I	NON-INVERTING INPUT - AGC input amplifier connection. The non-inverting output of the differential servo pre-amplifier should be AC coupled to this pin.
IN -	I	INVERTING INPUT - AGC input amplifier connection. The inverting output of the differential servo pre-amplifier should be AC coupled to this pin.
CPK	-	PEAK HOLD CAPACITOR - A capacitor which is used by the peak detector of the AGC circuitry must be connected between this pin and analog ground.
CAGC	-	AGC CAPACITOR - A capacitor which sets the AGC attack and decay times must be connected between this pin and analog ground.
AGCADJ	I	AGC Adjust - This pin allows for AGC reference level adjustment. It is driven by a potentiometer or D/A. Normally this pin is left open.

TIMING RECOVERY

NAME	TYPE	DESCRIPTION
VCO	O	VCO OUTPUT - TTL compatible digital clock which is 32 times the sync frequency (servo frame rate).
C2,C1	-	VCO CAPACITOR - Connection points for a capacitor which sets the VCO center frequency in conjunction with an external resistor connected to RVCO.
BP1,BP2	-	PLL BYPASS - Bypass capacitors may be connected between these pins and analog ground to provide additional power supply rejection in the phase locked loop.

TIMING RECOVERY (Continued)

NAME	TYPE	DESCRIPTION
LF	-	PHASE LOCKED LOOP FILTER - An external RC network which sets the PLL loop characteristics must be connected between this pin and analog ground.
RVCO	-	VCO RESISTOR - Connection for a resistor which sets the VCO center frequency, in conjunction with the capacitor between pins C1 and C2. The resistor must be connected between this pin and the VREF output.
SYNC	O	SYNC OUTPUT - TTL compatible digital clock whose falling edge indicates the presence of valid analog signals on the N and Q outputs. There is one SYNC cycle per servo frame.
$\overline{\text{DATA}}$	O	DATA OUTPUT - Active low TTL compatible digital output that indicates the presence of a data pulse in the servo frame. This signal is updated on the falling edge of the SYNC output.
TW	-	TIMING WINDOW - A resistor and capacitor must be connected in parallel between this pin and analog ground to set a timing window which is used in detecting SYNC pulses.
THR	-	PULSE THRESHOLD - A resistor which sets a threshold for SYNC and $\overline{\text{DATA}}$ pulse detection must be connected between this pin and VCC (digital 5V supply).
CLD	-	LOCK DETECT CAPACITOR - The value of this capacitor determines how quickly the LOCK output responds.
LOCK	O	LOCK OUTPUT - An open collector output that indicates the lock status of the PLL.

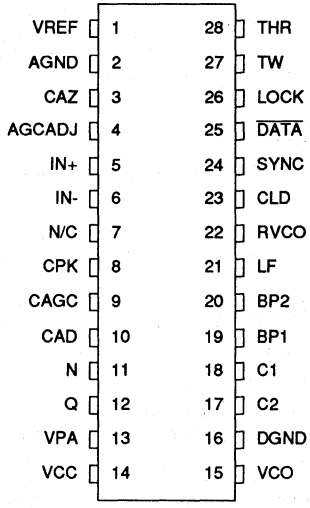
POSITION INFORMATION

NAME	TYPE	DESCRIPTION
CAD	-	AREA DETECTOR CAPACITOR - A capacitor, which forms an integrator to sense the pulse area of the servo position signals, must be connected between this point and analog ground.
N	O	N OUTPUT - This sampled analog signal is the normal position reference output. N is referenced to VREF and is periodic in radial displacement, with a period of 4 tracks.
Q	O	Q OUTPUT - This sampled analog signal is the quadrature position reference output. Q is referenced to VREF and is periodic in radial displacement, with a period of 4 tracks. It is 90 degrees out of phase with N.

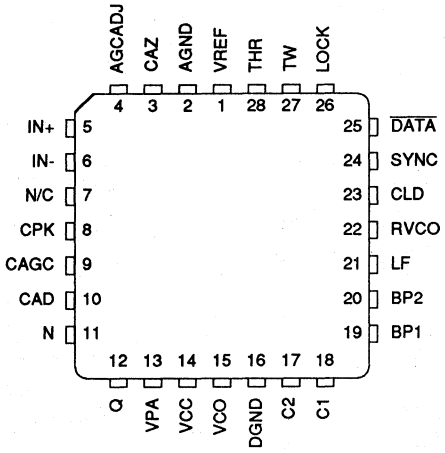
SSI 32H6210
Servo Demodulator

PACKAGE PIN DESIGNATIONS
(TOP VIEW)

CAUTION: Use handling procedures necessary for a static sensitive component.



28-Pin DIP,SOL



28-Pin PLCC

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32H6220
Servo Controller

Preliminary Data

July, 1990

DESCRIPTION

The SSI 32H6220 Servo Controller is a CMOS device intended for use in Winchester disk drive head positioning systems. When used in conjunction with a position reference, such as the SSI 32H567 Servo Demodulator, and a motor driver, such as the SSI 32H569 or the SSI 32H6230 Servo Motor Driver, the device allows the construction of a high performance, dedicated surface, head positioning system which operates under microprocessor control.

The SSI 32H6220 generates position and track crossing information from standard normal and quadrature position signals, derived from a dedicated servo surface. In its seek mode the controller drives the actual head velocity towards a programmed target value, while in its track mode, it keeps the head centered on a track.

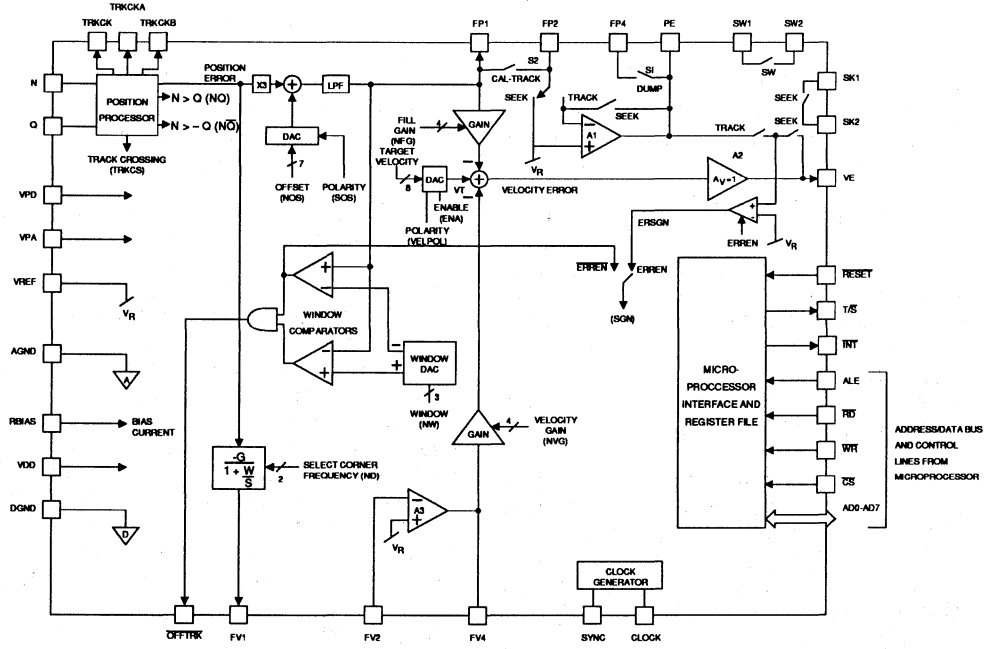
(Continued)

FEATURES

- **Servo control for Winchester disk drives with dedicated surface head positioning systems**
- **Accepts standard normal and quadrature position information**
- **500 kHz maximum servo frame rate**
- **Microprocessor bus interface compatible with 16 MHz 8051**
- **Seek and track modes**
- **Separate position and velocity error outputs**
- **Programmable velocity profile and loop gains**
- **Internal offset cancellation capability**
- **Track crossing output clock**
- **Low power CMOS design**
- **Available in a 44-pin PLCC package**

5

BLOCK DIAGRAM



DESCRIPTION (Continued)

Internal status and control registers allow a microprocessor to select operating modes, monitor track information and establish velocity targets. Digital outputs are available to monitor track crossings and head position accuracy. The microprocessor bus interface is optimized for use with multiplexed address/data bus microprocessors such as Intel's 8051, operating at up to 16 MHz.

The SSI 32H6220 is a low power, CMOS device and is available in a 44-pin PLCC package.

FUNCTIONAL DESCRIPTION

The SSI 32H6220 receives position information from a servo demodulator through the analog inputs N and Q, which are sampled on the falling edge of SYNC. FSYNC, the maximum SYNC frequency (which is the servo frame rate) is 500 kHz. The position processor compares the analog N signal with both Q and –Q, to generate the digital signals NQ and N$\overline{Q}$. Since the N and Q signals have a period of four tracks, NQ and N$\overline{Q}$ provide additional information over which track the head is positioned. Figure 6 shows the behavior of various position signals as radial displacement changes.

The 32H6220 is compatible with both hardware and software track counting techniques. The software track counter interface is bits NQ, N$\overline{Q}$, and TRKCS in the STATUS register. TRKCS can be programmed to pulse on each track crossing or on alternate track crossings. NQ and N$\overline{Q}$ provide information useful to "debounce" the TRKCS bit. Internal timing hysterisis prevents NQ, N$\overline{Q}$, and TRKCS from changing on successive frames. The hardware interface is TRKCK, an output clock intended to drive a hardware counter such as is available in the Intel 8051 family. TRKCK is a single frame pulse that occurs whenever a track boundary is crossed. During seek mode, TRKCK has one full track of hysteresis to prevent false counting. In track mode, hysteresis is removed.

The SSI 32H6220 has two modes of operation, track and seek, which are selected under microprocessor control. In the track mode, the control loop drives the position error signal to zero. In the seek mode, the loop attempts to match the head velocity to a velocity target programmed through the microprocessor interface.

In track mode, the head position error signal is summed with an 8-bit programmable offset signal which may be used to null out circuit offsets or to permit reading of off-track data. This adjusted position error signal is available on pin FP1. A lowpass filter with a corner frequency above 0.1 • FSYNC provides a small amount of smoothing. A position loop filter may be constructed from external RC components and amplifier A1. Switch S1, controlled by the DUMP bit, is used to keep the feedback capacitor in the position loop filter discharged while the controller is in seek mode. The output of A1 is the position error signal (PE) which should be connected to the servo motor driver circuitry. The position error is also applied to a window comparator with programmable limits that provide a digital indication of whether the head is on track or not. In systems employing the SSI 32H569 or the SSI 32H6230, PE should be summed in to the ERR- pin through an input resistor.

In seek mode, the position error is differentiated by a switched capacitor differencer, to produce a velocity estimate. The differencer does not sample the position error immediately after the discontinuity that occurs when a track boundary is crossed. This prevents the discontinuity from disturbing the differentiator output. The velocity estimate is applied to a velocity loop filter consisting of external RC components and amplifier A3. A signal proportional to motor current may also be summed in at A3 to provide a better velocity estimate during rapid acceleration. A velocity error term is computed as the difference between the velocity target and the actual head velocity. The velocity target is generated by a DAC from the digital word stored in the TARGET register. The output of the velocity loop filter (pin FV4) is proportional to the actual head velocity and is scaled by a 4-bit programmable velocity gain before being subtracted from the velocity target. Also, a fill signal which is generated by multiplying the position error by a 4-bit programmable fill gain is subtracted from the velocity error. The fill signal compensates for the 8-bit quantization of the velocity target signal, which becomes a factor as the head velocity approaches zero. As the head nears the destination track at the end of a seek operation, the target velocity is zero, so if a fill term which is proportional to position error is subtracted from the velocity error term, the velocity loop will cause the head to come to rest at the center of the track. Without this additional fill signal, the velocity loop would not necessarily center the head in the destination track. The velocity error signal is buffered by A2

which drives the VE pin. The separate error outputs, PE and VE, allow for independent adjustment of the track and seek loop gains by specifying different values for RINP and RINV.

The actual velocity profile of the head is determined by the values written to the target velocity DAC. Typically, a new velocity target is written at each track crossing. An automatic update feature (enabled when UPDATE=1) causes the next velocity target to be loaded from a holding register when a track crossing occurs, so that the microprocessor does not have to perform this time-critical operation.

The 32H6220 is capable of interactively nulling out offsets at FP1, PE, and VE. The basic technique is to use the low offset ERR comparator (enable with the ERREN bit and visible on the SGN bit) to monitor the offset and then adjust an appropriate DAC value. Offset at FP1 is nulled with the NOS DAC, offset at PE is nulled with the TARGET DAC, and offset at VE is nulled with either NOS or TARGET.

The SSI 32H6220 has 8 registers, described in "Register Description," which are accessed through a microprocessor interface optimized for multiplexed address/data bus processors. A 3-bit register address is latched from the bus on the falling edge of ALE (address latch enable) and a bus cycle occurs if $\overline{CS}$ (chip select) and either $\overline{RD}$ (read strobe) or $\overline{WR}$ (write strobe) are asserted. An open drain interrupt line ($\overline{INT}$) may be used to cause a microprocessor interrupt when a track crossing occurs.

5

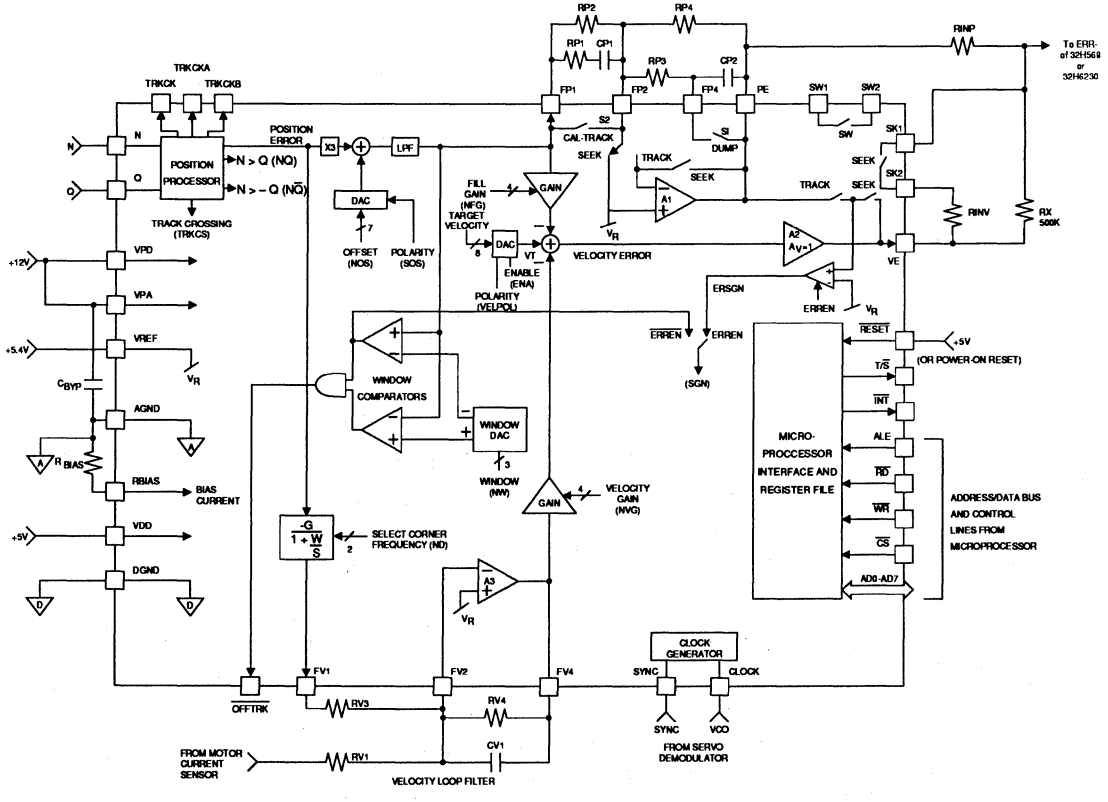


FIGURE 2: SSI 32H6220 Typical Application

PIN DESCRIPTION

POWER

NAME	44-pin PLCC	TYPE	DESCRIPTION
RBIAS	16	I	BIAS INPUT - This input sets the internal opamp bias currents. A 20 kΩ 1% resistor should be connected between RBIAS and AGND.
VREF	17	I	REFERENCE VOLTAGE - 5.4V input which is used as the DC reference level for all analog signals. (This level is available as an output from the SSI 32H567).
AGND	19		ANALOG GROUND
DGND	27		DIGITAL GROUND
VDD	28		DIGITAL 5V SUPPLY - 5 volt supply for the microprocessor interface circuitry.
VPD	43		DIGITAL 12V SUPPLY - 12 volt supply for the switched capacitor filter clocks.
VPA	44		ANALOG 12V SUPPLY - 12 volt supply for all analog circuitry.

POSITION REFERENCE INTERFACE

Q	14	I	QUADRATURE INPUT - Analog position signal from servo demodulator.
N	15	I	NORMAL INPUT - Analog position signal from servo demodulator (90 degrees or 1 track out of phase with Q signal).
SYNC	40	I	SYNC INPUT - The falling edge of this clock causes the analog information on the N, Q inputs to be sampled. There is one SYNC pulse per servo frame and the maximum rate is 500 kHz. This signal is generated by the SSI 32H567. If it is not necessary to synchronize to N and Q samples, and FRFMT is set, SYNC should be grounded. In this case, FSYNC will be internally generated as FCLOCK/32.
CLOCK	41	I	CLOCK INPUT - This clock must be either 32 or 72 times the rate of the SYNC clock (selected by the FRFMT bit in STATUS register). It is usually supplied by the VCO output of the servo demodulator (e.g., SSI 32H567).
TRKCK	33	O	TRACK CROSSING CLOCK - This output drives external hardware track counters and is compatible with the counter function available in the Intel 8251 family of microcontrollers. It is normally low and pulses high one cycle per track.
TRKCKA	20	O	TRACK CROSSING A - This output is derived from TRKCK, it toggles on the rising edges of TRKCK.
TRKCKB	25	O	TRACK CROSSING B - This output is derived from TRKCK, it toggles on the falling edges of TRKCK.

MICROPROCESSOR INTERFACE

$\overline{CS}$	21	I	CHIP SELECT - Active low signal enables device to respond to microprocessor read or write.
ALE	22	I	ADDRESS LATCH ENABLE - Falling edge latches register address from pins AD0-AD2.
$\overline{RD}$	23	I	READ STROBE - Active low signal causes the contents of the addressed register to be placed on the address/data bus (AD0–7) if $\overline{CS}$ is also active.
$\overline{WR}$	24	I	WRITE STROBE - Active low signal causes the data on the address/data bus to be written to the addressed register if $\overline{CS}$ is also active.
$\overline{INT}$	29	O	INTERRUPT - This active low open drain output is asserted when a track crossing is detected. It is released when the internal track crossing status bit (TRKCS) is read by the microprocessor.
T/$\overline{S}$	30	O	TRACK/SEEK - This output reflects the state of the T/$\overline{S}$ bit in the STATUS register. It is high when the device is in track mode and low when it is in seek mode.
AD7 -AD0	31-32 34-39	I/O	ADDRESS/DATA BUS - 8-bit bus which carries register address information and bi-directional data.
$\overline{RESET}$	42	I	RESET - This active low input is used to force all the internal registers to their reset condition.
$\overline{OFFTRK}$	26	O	OFFTRACK - This open drain output is asserted whenever the head position is outside the window specified by NW. It is always asserted in seek mode.

CONTROL LOOP

FV4	1	O	VELOCITY FILTER OUTPUT - This is the output of amplifier A3 which forms part of the velocity loop filter. This signal is internally amplified and compared to the target velocity.
FV2	4	I	VELOCITY FILTER INPUT - Direct connection to the inverting input of amplifier A3.
FV1	7	O	ESTIMATED VELOCITY OUTPUT - Output of the position error differentiating high pass filter.
VE	9	O	VELOCITY ERROR - This signal should be summed in to the servo motor driver circuitry. In systems using the SSI 32H569 or the SSI 32H6230 servo driver, VE is connected to the ERR- pin through a resistor.
SW1, SW2	2	3	UNCOMMITTED SWITCH - This switch can be used to reset a notch filter during seek mode. The switch is controlled by the SW bit in the status word.
SK1, SK2	5	6	UNCOMMITTED SEEK SWITCH - This switch is on during seek operations.

CONTROL LOOP (Continued)

NAME	44-pin PLCC	TYPE	DESCRIPTION
FP4	11	O	POSITION FILTER CAPACITOR - The external position loop filter feedback capacitor should be connected between this pin and PE. When the DUMP bit in register WINDOW is set, an internal switch (S1) shorts PE to FP4. This allows the external capacitor to be kept discharged during seek mode.
PE	10	O	POSITION ERROR OUTPUT - Output of position loop filter amplifier A1.
FP2	12	I	POSITION FILTER INPUT - Inverting input to opamp A1.
FP1	13	O	POSITION ERROR OUTPUT - Offset-corrected output of the position processing circuitry, which is proportional to the radial displacement of the head from the center of the current track.
The actual transfer function from N, Q to FP1 is: $H(z) = \frac{3}{2z-1}\frac{\sin(\omega T/2)}{\omega T/2}$ where: $T = 1/FSYNC$, $z = e^{sT}$			
This transfer function exhibits a high frequency roll off with a 3 dB point at f = 0.11 FSYNC.			
Unused pins on PLCC package: 8, 18			

REGISTER DESCRIPTION

The SSI 32H6220 has 8 internal registers which contain status, control and loop parameter information. A three bit register address is latched from inputs AD0-AD2 on the falling edge of ALE. The corresponding register is accessed if $\overline{CS}$ is then asserted, with the direction of access being determined by $\overline{RD}$ or $\overline{WR}$. The registers are summarized in Figure 3.

REGISTER	ADDRESS	ACCESS	D7	D6	D5	D4	D3	D2	D1	D0
GAIN	0	READ/ WRITE	NFG				NVG			
TARGET	1	READ/ WRITE	TARGET VELOCITY							
NEXT	2	READ/ WRITE	NEXT TARGET VELOCITY							
VELCON	3	READ/ WRITE	UNUSED			ND		UPDATE	ENA	VELPOL
WINDOW	4	READ/ WRITE	CAL	UNUSED	DUMP	T/$\overline{S}$	ERREN	NW		
STATUS	5	AS NOTED	SGN (READ ONLY)	SW (READ/WRITE)	CSMOD (READ/WRITE)	FRFMT (READ/WRITE)	ONTRK (READ ONLY)	NO (READ ONLY)	$\overline{NO}$ (READ ONLY)	TRKCS (READ ONLY)
OFFSET	6	READ/ WRITE	SOS	NOS						
RESET	7	WRITE ONLY	RESET (ANY VALUE)							

FIGURE 3: SSI 32H6220 Register Map

REGISTER DESCRIPTION (Continued)

GAIN **Address 0** **Read/Write**

GAIN SETTINGS - Used to set the velocity gain and fill gain. These settings are only significant in the seek mode.

BIT	NAME	DESCRIPTION
3-0	NVG0-3	VELOCITY GAIN - 4-bit quantity which sets the gain applied to the velocity signal at the output of opamp A3.
7-4	NFG0-3	FILL GAIN - 4-bit quantity which sets the gain applied to the position error which is added to the velocity signal.

If NVG and NFG are represented as integers ranging from 0 to 15, then for a zero velocity target, the VE output is given by:

$$VE - VREF = \frac{NVG}{15}(FV4 - VREF) + \frac{NFG}{255}(FP1 - VREF)$$

TARGET **Address 1** **Read/Write**

CURRENT VELOCITY TARGET - This register selects the 8-bit velocity target which is subtracted from the actual velocity to yield velocity error in seek mode. The sign of the velocity target is determined by the VELPOL bit in register VELCON. If TARGET is represented as an integer from 0 to 255, then the voltage at the output of the velocity target DAC, VT, is given by:

$$VT = VREF\left(1 - \frac{TARGET}{340}\right), VELPOL = 0$$

$$VREF\left(1 + \frac{TARGET}{340}\right), VELPOL = 1$$

The SSI 32H6220 has an update feature which allows this register to be loaded automatically with the contents of the next target register when a track crossing occurs. The target register may also be written directly by the microprocessor to cause an immediate change in target velocity.

NEXT **Address 2** **Read/Write**

NEXT TARGET VELOCITY - This register contains an 8-bit value that will be loaded automatically into the velocity target register when a track crossing occurs, if the UPDATE bit in VELCON is set. This register is unused if UPDATE is cleared.

REGISTER DESCRIPTION (Continued)

VELCON Address 3 Read/Write

BIT	NAME	DESCRIPTION
0	VELPOL	VELOCITY TARGET POLARITY - If this bit is set, the velocity target will be positive (with respect to VREF) and if it is reset, the velocity target will be negative.
1	ENA	ENABLE VELOCITY TARGET DAC - If ENA is set, the velocity target DAC will be enabled and if it is cleared the output of the DAC will be clamped to VREF.
2	UPDATE	UPDATE MODE SELECT - When this bit is set, the contents of the NEXT register will be transferred to TARGET automatically when a track crossing occurs. If it is cleared, new velocity targets must be written directly to the TARGET register by the microprocessor.
3-4	ND0-ND1	DIFFERENTIATOR CHARACTERISTIC SELECT - These bits select the characteristic of the differentiator high pass filter as follows: $H(s) = \frac{-G}{1 + \frac{W}{s}}$, $W = \frac{1}{2T}\left(1 + \frac{ND}{1.75}\right)$ rad/s $G = 8.2$ Where T is the period of the SYNC clock input in seconds, s is the complex frequency variable in radians/second and ND is an integer from 0 to 3. For s<<W the high pass filter H(s) acts like a differentiator. For a SYNC rate of 500 kHz, the corner frequency W will be: ND1 | ND0 — W/2π (kHz) 00 — 39.8 01 — 62.5 10 — 85.3 11 — 108 The actual transfer function from N, Q, to FV1 is: $H(z) = \frac{7G(z-1)}{z[7(z-1)+(3.5+2ND)z]} \frac{\sin(\omega T/2)}{\omega T/2}$ where: $T = 1/FSYNC$ $z = e^{sT}$ This transfer function is approximated throughout this data sheet with the above domain approximation which is accurate to 0.5 db for f< .05 • FSYNC.
5-7	unused	

REGISTER DESCRIPTION (Continued)

WINDOW Address 4 Read/Write

WINDOW CONTROL - This register is used to program the on-track window comparator and also contains several control bits.

BIT	NAME	DESCRIPTION
0-2	NW0-NW2	WINDOW SELECT BITS - This 3 bit word selects the window comparator threshold voltage. The on track indicator bit will be true as long as: $\|FP1 - VREF\| < VREF[(1 + NW)/32]$ where NW is an integer from 0 to 7.
3	ERREN	ERROR ENABLE - When set, this bit enables the offset comparator and causes SGN to be its output. When reset, SGN is the lower side of the window comparator.
4	T/$\overline{S}$	TRACK/SEEK MODE SELECT - When this bit is set, track mode is selected and when it is reset, seek mode is selected.
5	DUMP	POSITION LOOP FILTER DUMP CONTROL - When this bit is set, pins PE and FP4 are switched together internally by S1. This causes the external position loop filter feedback capacitor to be discharged.
6	unused	
7	CAL	CALIBRATION MODE - When this bit is reset, the N and Q inputs are connected to the position processor and normal operation occurs. When CAL is set, the processor inputs are connected to VREF, causing the FP1 output to reflect the offset voltage errors in the position sensing path.

STATUS Address 5 Read/Write access as noted

STATUS REGISTER - Contains track status information and several control bits.

BIT	NAME	DESCRIPTION
0	TRKCS	TRACK CROSSING INDICATOR - The function of TRKCS is determined by the CSMOD bit in this register. When CSMOD is set, TRKCS will be set every time NQ or N$\overline{Q}$ change state (i.e., on every track crossing). When CSMOD is reset, TRKCS will be set every time NQ changes state (i.e., on alternate track crossings). TRKCS is reset when STATUS is read by the microprocessor. The $\overline{INT}$ interrupt output is the inverse of TRKCS. (TRKCS is read only.)
1	N$\overline{Q}$	TRACK QUADRANT - This bit is set when: N-VREF > VREF-Q and reset otherwise. (N$\overline{Q}$ is read only)
2	NQ	TRACK QUADRANT - This bit is set when: N-VREF > Q-VREF and reset otherwise. (NQ is read only)

REGISTER DESCRIPTION (Continued)

BIT	NAME	DESCRIPTION
3	ONTRK	ON TRACK INDICATOR - This bit is set when the voltage on pin FP1 is within the window selected by the WINDOW register. It is reset otherwise (ONTRK is read only).
4	FRFMT	FRAME FORMAT - Used to indicate the relationship between CLOCK and SYNC. If this bit is set, the VCO clock rate must be 32 times the SYNC clock rate. If it is reset, the VCO clock rate must be 72 times the SYNC clock rate. (FRFMT is read/write).
5	CSMOD	CROSSING INDICATOR MODE - If this bit is reset, TRKCS will be set on alternate track crossings. If it is set, TRKCS will be set on every track crossing. (CSMOD is read/write).
6	SW	SWITCH - This bit controls the SW switch. This uncommitted switch can be used to initialize a notch filter in the servo loop. (SW is read/write).
7	SGN	VOLTAGE SIGN - This bit indicates whether the head position is above or below the lower edge of the track window. If used with the ONTRK bit, it allows the microcontroller to divide a track into three regions and make more informed decisions about overshoot and undershoot. When ERREN is set, SGN is the output of the error comparator. (SGN is read only).

OFFSET **Address 6** **Read/Write**

OFFSET VOLTAGE REGISTER - The 8-bit value in this register drives the offset DAC which adds a correcting voltage to the position error signal.

BIT	NAME	DESCRIPTION
0-6	NOS0-NOS6	OFFSET MAGNITUDE
7	SOS	OFFSET SIGN

The offset correction voltage, VOS, is given by:

$$VOS = -0.89 \left(\frac{NOS}{127}\right) V, \quad SOS=0$$

$$0.89 \left(\frac{NOS}{127}\right) V, \quad SOS=1$$

RESET **Address 7** **Write only**

RESET REGISTER - When any value is written to this register, all writeable register bits in the SSI 32H6220 are reset.

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

(Maximum limits indicate where permanent device damage occurs. Continous operation at these limits is not intended and should be limited to those conditions specified in the DC operating characteristics.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
VPA		0		14	V
Voltage on any pin		0		VPA+0.1V	V
Storage Temp.		-45		165	°C
Solder Temp.	10 sec duration			260	°C

RECOMMENDED OPERATION CONDITIONS (Unless otherwise noted, the following conditions are valid throughout this document.)

VPA, VPD		10.8		13.2	V
VDD		4.5		5.5	V
VREF		5.1	5.4	5.7	V
Operating temp.		0		70	°C
RBIAS, bias resistor to AGND		22.3	22.6	22.9	kΩ
Resistive loading (FP1, FV1, PE, FV4, VE)	About VREF	5			kΩ
Capacitive loading (FP1, FV1, PE, FV4, VE)				40	pF

DC CHARACTERISTICS

IVP	Total VPA and VPD current				40	mA
IDD	VDD current				10	mA
IREF	VREF current				3	mA

DIGITAL I/O

Digital Inputs					
VIH	|IIH| < 10µA	2			V
VIL (Except Reset)	|IIL| < 10µA			0.7	V
VIL Reset Pin	|IIL| < 100µA			0.7	V
Digital Outputs (AD0-AD7, T/$\overline{S}$)					
VOH	|IOH| < 40µA	2.4			V
VOL	|IOL| < 1.6mA			0.4	V
Open Drain Digital Outputs ($\overline{INT}$, $\overline{OFFTRK}$)					
VOL	|IOL| < 1.6mA			0.4	V
Off leakage	VOH = VPD			10	µA

5

MICROPROCESSOR INTERFACE TIMING (see figure 4(a) and figure 4(b)). (Timing measurements for digital signals are measured at 1.3V, unless otherwise noted.)

PARAMETER		CONDITIONS	MIN	TYP	MAX	UNITS
TLHLL	ALE pulse width		45			ns
TAVLL	Address setup time		8			ns
TLLAX	Address hold time		20			ns
TRLVD	$\overline{RD}$ to data valid				145	ns
TRHDX	data hold time after $\overline{RD}$		0		50	ns
TRLRH	$\overline{RD}$ pulse width		200			ns
TLLWL	ALE to $\overline{RD}$ or $\overline{WR}$		25			ns
TRLCL	$\overline{RD}$ or $\overline{WR}$ to $\overline{CS}$ low				20	ns
TRHCH	$\overline{RD}$ or $\overline{WR}$ to $\overline{CS}$ high		10			ns
TWLWH	$\overline{WR}$ pulse width		100			ns
TQVWH	data set up to $\overline{WR}$ high		70			ns
TWHQX	data hold after $\overline{WR}$ high		10			ns

ANALOG I/O

PARAMETER		CONDITIONS	MIN	TYP	MAX	UNITS
N, Q Inputs						
Input resistance			50			kΩ
Input capacitance					25	pF
Offset voltage			-15		15	mV
N, Q Timing (see figure 5)						
fc	VCO input frequency		4		16	MHz
TSYH	SYNC hold time		0			ns
TSYS	SYNC setup time		34			ns
Nc	VCO/SYNC	FRFMT=1	32		32	
	frequency ratio	FRFMT=0	72		72	
TADS	N or Q analog setup time		400			ns
TADH	N or Q analog hold time		180			ns

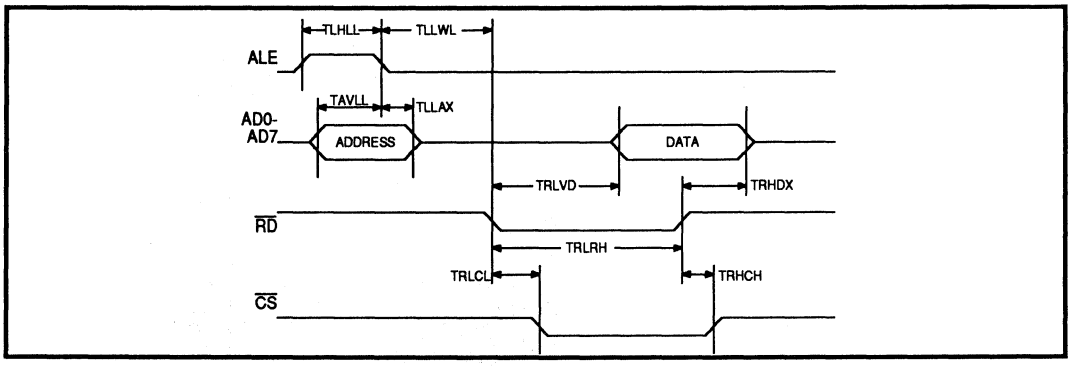


FIGURE 4(a): Read Cycle Timing

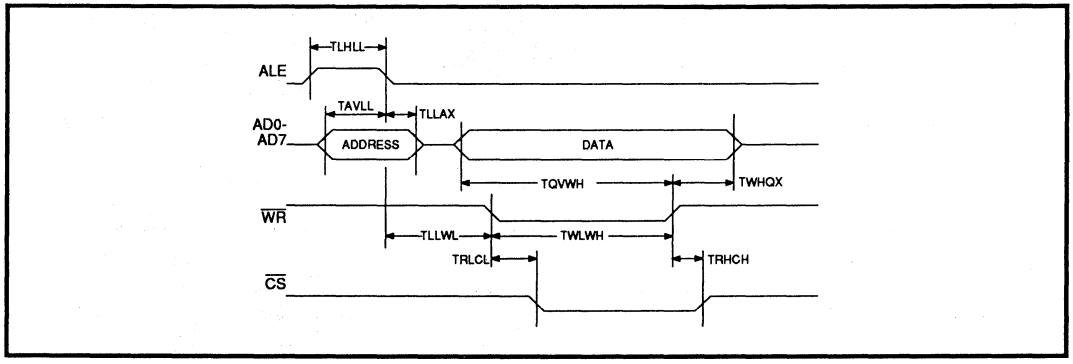


FIGURE 4(b): Write Cycle Timing

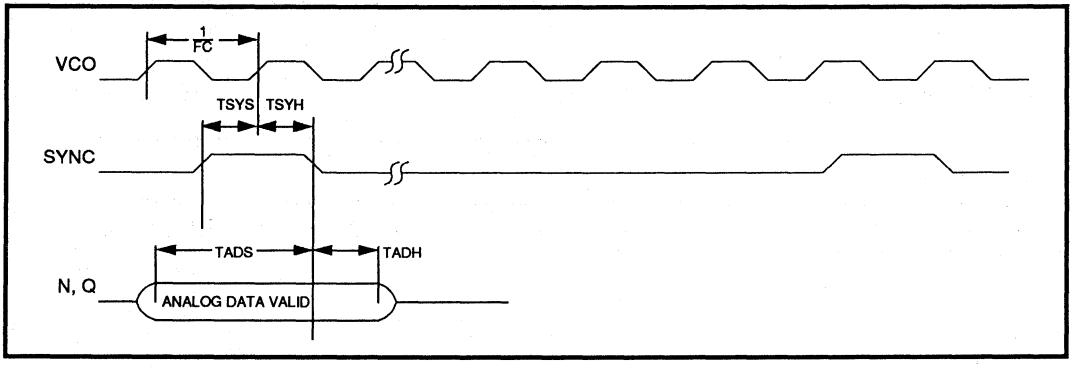


FIGURE 5: Analog Timing

ANALOG I/O (Continued)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
FP2, FV2 Inputs					
Input resistance	About VREF	100			kΩ
Input capacitance				20	pF
Offset voltage		-15		15	mV
Analog Outputs					
Output impedance	|Vo-VREF| < 3V			20	Ω
Output swing (FP1, FV1)	About VREF	4			V
Output swing (PE, FV4)	About VREF	3.5			V
Output swing (VE)	About VREF	3.7			V
Gain (FP1 from N or Q)		9.35	9.55	9.75	dB
Gain (Amplifier A1, A3)	Open loop DC gain	60			dB
Gain (Amplifier A2)			0		dB
Unity gain bandwidth (Amplifier A1, A3)	Open loop	1			MHz
Unity gain bandwidth (Amplifier A2)	Open loop		.5		MHz

WINDOW COMPARATOR

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Threshold step size accuracy	Nominal=VREF/32	-30		30	%

FILL GAIN

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Maximum gain	NFG=15	57	58	60	mV/V
Gain step size		3	4	5	mV/V

ANALOG SWITCHES

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
S1	PE ≤ VREF			200	Ω
SW	SW2 ≤ VREF			200	Ω
SK	SK1 ≤ VREF			200	Ω
S2	FP1 ≤ VREF			1500	Ω

VELOCITY GAIN

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Maximum gain	NVG=15	.97	1	1.03	V/V
Gain step size		48	67	82	mV/V

TARGET VELOCITY DAC

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Full scale - VREF	VELPOL=1	72	75	78	%VREF
	VELPOL=0	-72	-75	-78	%VREF
Step size		0.16	0.29	0.50	%VREF
Offset Match (VELPOL=1)- (VELPOL=0)	TARGET=0	0		35	mV

OFFSET CORRECTION DAC

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Full scale - VREF	NOS=127, SOS=1	15	16	18	%VREF
	NOS=127, SOS=0	15	16	18	%VREF
Step size		0.08	0.13	0.18	%VREF

DIFFERENTIATOR

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
High pass gain (N,Q TO FV1)	FIN/FSYNC = 0.02,				
	ND = 0	5.45	5.85	6.25	db
	ND = 1	1.7	2.1	2.5	db
	ND = 2	-.9	-.5	-.1	db
	ND = 3	-2.9	-2.5	-2.1	db

APPLICATIONS INFORMATION

In the examples shown in Figures 7a & 7b, the SSI 32H6220 is used with its companion devices, the SSI 32H567 and SSI 32H569 or SSI 32H6230, as well as a microprocessor and some external components, to implement a complete head positioning system.

Position Reference

The position feedback signal for the servo loop is generated by a servo demodulator from information prerecorded on the disk drive's servo surface. The SSI 32H567 provides quadrature position signals (N and Q), recovered clocks (SYNC and VCO) and an analog reference level (VREF) for the rest of the system. The SSI 32H567 translates the radial displacement of the servo read head to a voltage with a gain of 2 volts/track. The SSI 32H6220 has a front end gain of 3, so the gain from actual position error to the voltage at pin FP1 (the input to the position loop filter) is 6 volts/track.

In order to produce the position error signal illustrated in figure 6, the position processor in the SSI 32H6220 selects either N, Q or an inverted signal, based on the value of the digital signals NQ and $N\overline{Q}$. The resulting error signal is zero (equal to VREF) when the head is perfectly centered on a track. The error signal has a maximum absolute value in the vicinity of a track boundary (i.e., when the head is displaced one half track from a track center) and has a polarity that indicates the direction of the position error.

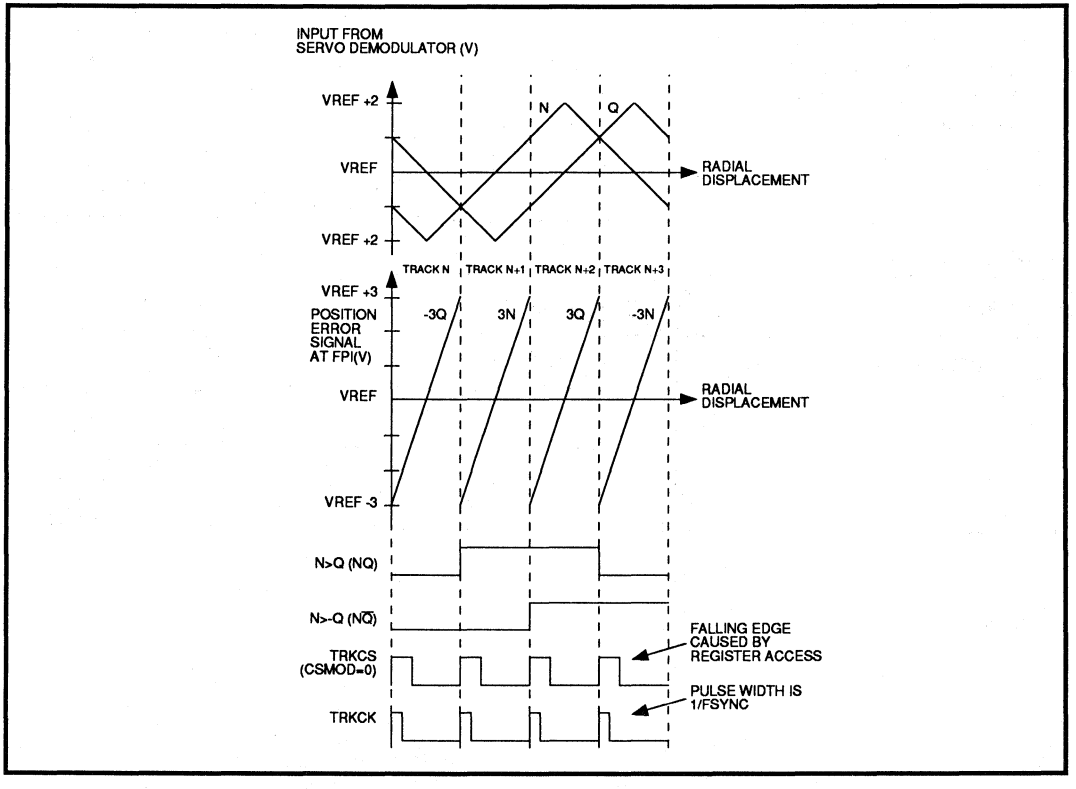


FIGURE 6: Position Signal Waveforms

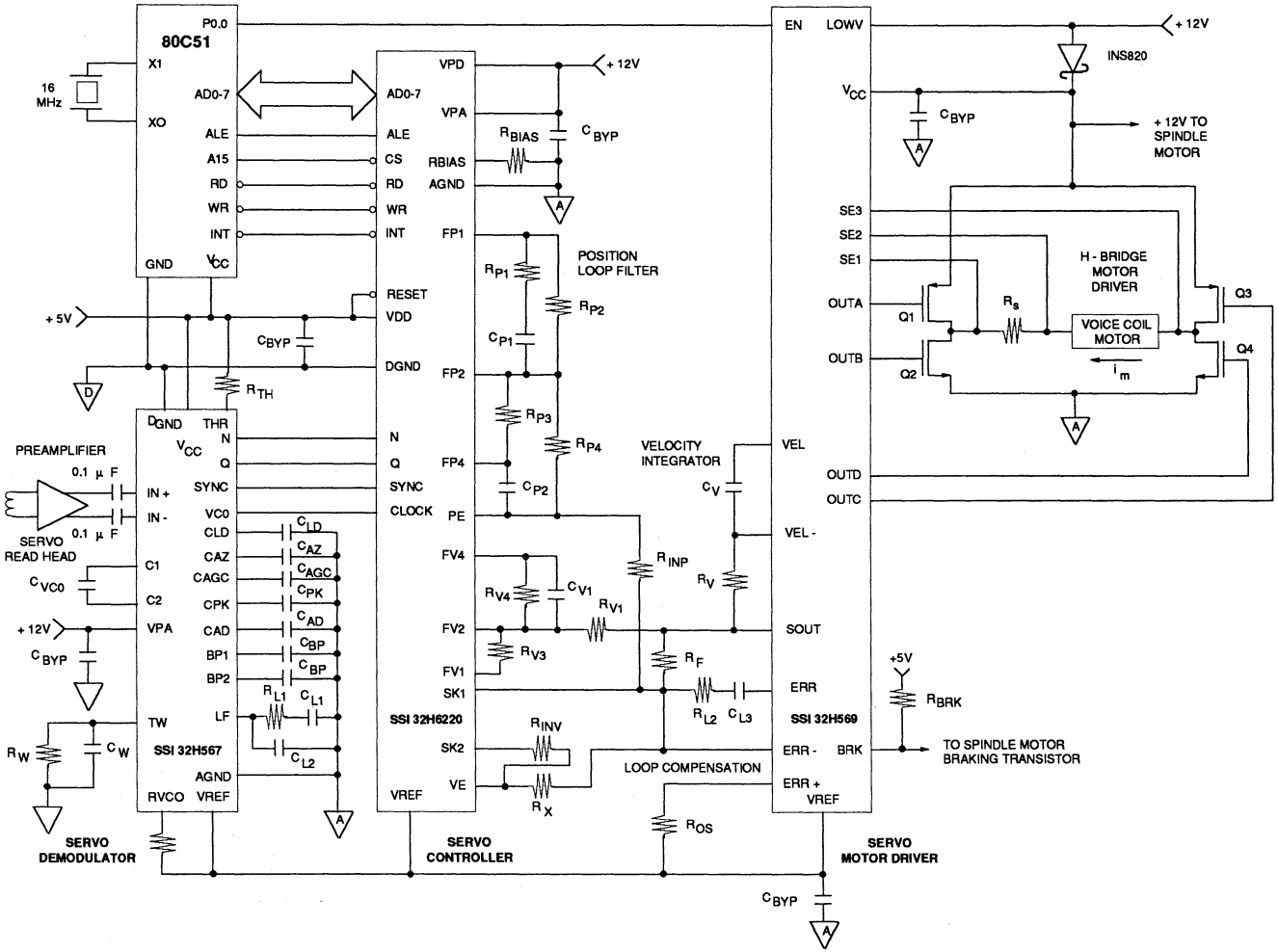


FIGURE 7(a): Complete Example of Servo Path Electronics Using SSI 32H567/6220/569 Chip Set

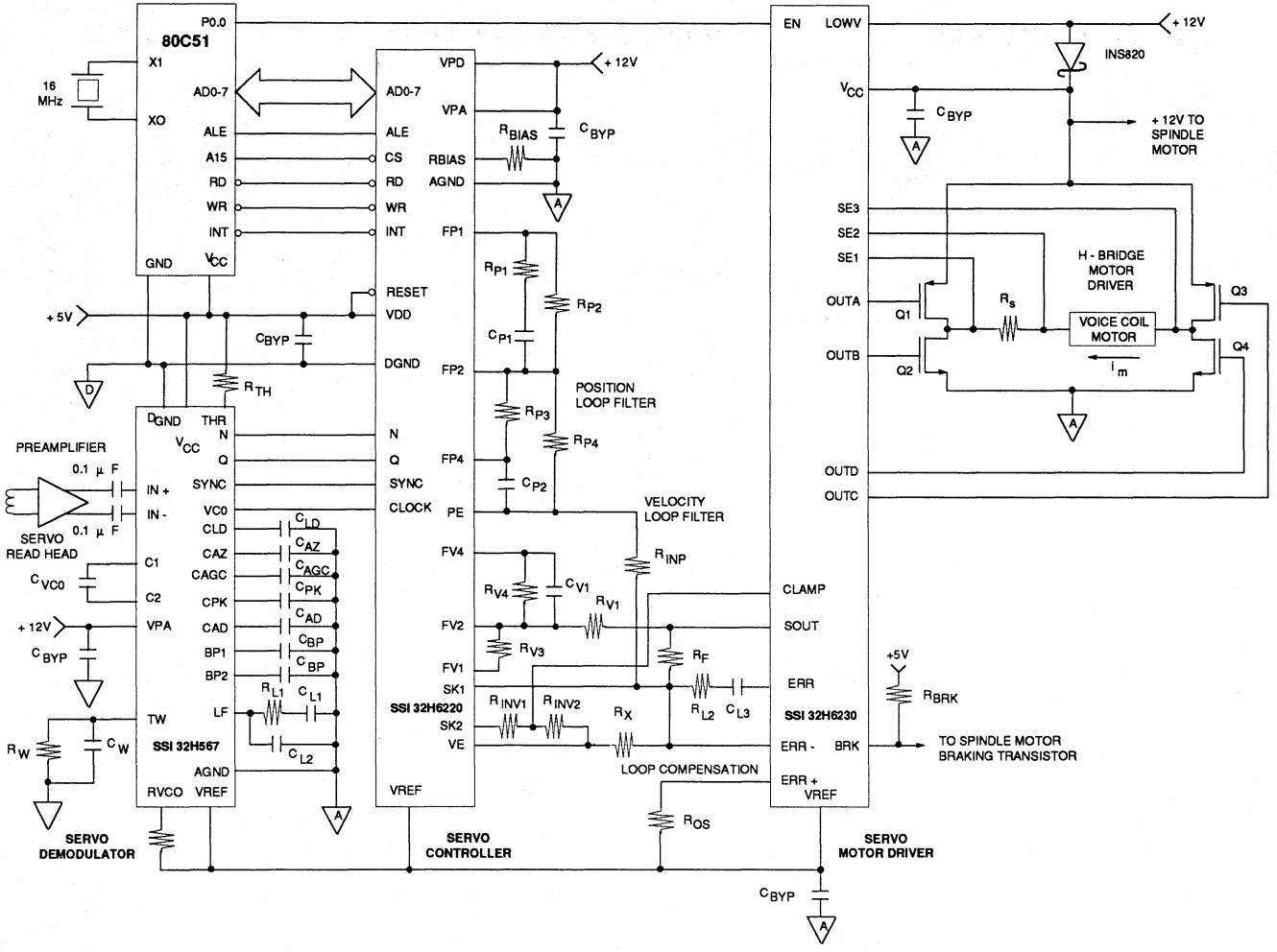


FIGURE 7(b): Complete Example of Servo Path Electronics Using SSI 32H567/6220/6230 Chip Set

Servo Motor and Driver

For the purposes of illustration, the following simple model for the servo motor in Figure 7 is assumed.

$$i_m = \frac{J\theta}{K_m} \cdot \frac{d\omega}{dt} \qquad e = K_e \cdot \omega$$

Definition of terms:

im	Armature current (A)
ω	Motor speed (rad/s)
Jθ	Rotor moment of inertia (kg • m²)
Km	Torque constant (Nm/A)
e	Motor back EMF (V)
Lm	Winding inductance (H)
Rm	Winding resistance (Ohm)
Ke	Motor voltage constant (V/rad/s)

Numerically, Ke and Km are equal.

Under the assumption that the electrical and mechanical poles of the motor above are widely separated (Rm/Lm >> Jθ • Rm/Km²), the servo driver loop compensation components, R_{L2} and C_{L3}, may be chosen to cancel the effect of Lm, as follows:

$$C_{L3} = \frac{68\,R_S}{2\pi R_F\,(R_m + R_S)\,BW}, \quad R_{L2} = \frac{L_m}{C_{L3}(R_m + R_S)}$$

where BW is the desired servo driver open loop bandwidth (Hz). This results in the following relationship between motor current (im) and error voltage at the servo controller output (EOUT).

$$\frac{i_m}{EOUT}(s) = \frac{-R_F}{4\,R_{in}\,R_S\left(1 + \frac{s}{2\pi BW}\right)}$$

Where Rin is either Rinp or Rinv depending whether you're in seek or track modes.

This simple first order approximation of the servo motor behaviour neglects effects such as resonance due to the motor inductance, Lm, or the pole due to servo driver transconductance. However, it is sufficient to illustrate the design goals for the velocity and position loop filters that are required with the SSI 32H6220. A more detailed description of the SSI 32H569 may be found in the SSI 32H569 data sheet.

TRACK MODE

Loop Compensation

Track mode is engaged when the head has reached its destination and the current position must be maintained. The control objective is to drive the position error signal at FP1 to zero and minimize excursions of the head due to noise and other perturbations of the system. The transfer function of the complete servo loop in track mode is shown in figure 8(a), using the servo motor model derived above. The gain G1 is the combined effect of the SSI 32H567 and the front end gain of the SSI 32H6220, and has a nominal value of 6 volts/track. The gain G2 is a property of the head transport system, and has units of tracks/radian for rotary servo motors and tracks/meter for linear motors. (The nomenclature chosen for the motor model is that of rotary motors but the results are applicable to linear motors as well, if appropriate units are substituted). To ensure that the control loop has negative feedback, positive motor current (as indicated in Figure 7) must result in negative motor acceleration. This inversion is accomplished in the prerecorded servo pattern and is accounted for in the transfer function by showing G2 to be negative.

Since the servo driver/motor combination has a double pole at the origin and an additional real pole at frequency BW (which is selectable with external components in the SSI 32H569), the position loop filter is essential to ensure a stable system. The effect of the position filter used in this example is to provide lag-lead compensation. Systems of this type are usually designed by trial and error, but a further simplification of the transfer function may be made to obtain an initial solution. If the pole at BW is ignored, RP4 is removed and RP2 made large (RP2 is necessary to provide a DC path for leakage current at pin FP2) then the system illustrated in figure 8(b) is obtained. The compensation has been reduced to lead compensation only. If the following quantities are defined:

$$Gtot = \left(\frac{G_1 G_2 C_{P1}}{C_{P2}}\right)\left(\frac{R_F}{4R_{in}R_S}\right)\left(\frac{K_m}{J\theta}\right)(s^{-2})$$

PM = Desired closed loop phase margin (degrees)

FB = Desired open loop unity gain bandwidth (rad/s)

then appropriate values for the time constants of the

lead compensation circuit (T_1, T_2) may be chosen using the following relationships, assuming $1/T_2 << FB << 1/T_1$:

$$FB = Gtot \cdot T_2 \text{ (rad/s)}$$

$$PM = 90 - \arctan (FB \cdot T_1) \text{ (degrees)}$$

The values for T_1 and T_2 thus chosen form a starting point for the selection of appropriate values for the more complex lag-lead compensator required by the real system.

Position Loop Filter Initialization

Switch S1, which is controlled by the DUMP bit in the WINDOW register, may be used to short out the external feedback capacitor C_{P2}, discharging it. S1 is usually closed during a seek operation, so that when the system is switched to track mode, no sudden transients occur due to charge stored on C_{P2}. Disturbances to the position signal when the system is switching to track mode can greatly extend the disk drive's access time, since the system response is much slower in this mode.

On Track Window

The on track window comparator may be used to monitor the positioning accuracy of the head. The position error voltage at pin FP1 is compared to a signal selected by the bits NW0-2 in the WINDOW register. The ONTRK bit in register STATUS is set if the position error is within the specified limits and cleared if it is outside the limits (in either the positive or the negative direction). The programmable excursion limits (ex-

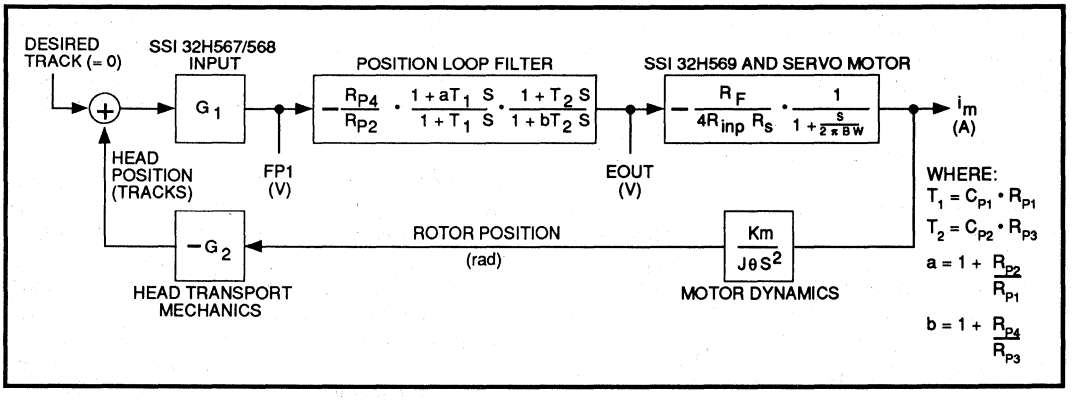


FIGURE 8(a): System Transfer Function in Track Mode

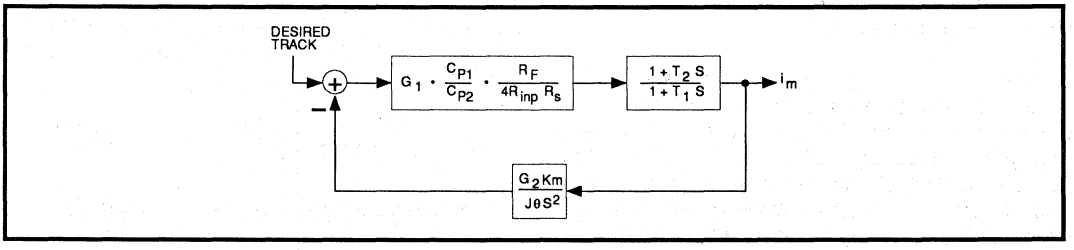


FIGURE 8(b): Simplified Track Mode Transfer Function

pressed as a percentage of a track) range from 2.8% to 22.5% in 8 equal steps. By monitoring the ONTRK bit, the microprocessor can determine when the head has settled sufficiently for read and write operations to commence. The ONTRK bit may also be used to decide when it is appropriate to switch from seek to track mode at the end of a period of deceleration.

SEEK MODE

Velocity Profile

The velocity profile that results in the shortest seek time, subject to motor current and head velocity limitations, is as follows:

1) Maximum acceleration (maximum motor current) until the half-way point or maximum velocity is reached.
2) Constant velocity motion until it is time to commence deceleration (if maximum velocity was reached).
3) Maximum deceleration until head comes to rest over the destination track. The decceleration period is of approximately the same duration as the acceleration period.

The microprocessor computes a velocity profile according to the rules above, based on the current head location and destination track. During the final approach to the destination track, updates to the velocity DAC become more infrequent since the track crossing rate is approaching zero. The fill signal which is derived from the position error can be used to provide a smooth target velocity profile between track crossing updates. Figure 9 shows a set of typical waveforms as the head approaches the destination track. The fill gain is adjusted at each track crossing so that the fill signal interpolates smoothly between target DAC settings. In the destination track, where the target DAC output is zero, the fill signal is especially important, since it becomes zero only when the head is centered on the track. The velocity control loop thus causes the head to come to rest at the center of the destination track.

Loop Compensation

The transfer function for the controller electronics of figure 7 is shown in figure 10(a). This transfer function may be simplified as shown in figure 10(b), under the following conditions:

$$\omega^2 >> \frac{(GG_1G_2)(K_m R_{V1})}{J\theta R_{V3}}$$

$$R_{V4} C_{V1} = \frac{J\theta \omega R_{V3}}{(GG_1G_2)(K_m R_{V1})}$$

The value of ω, the corner frequency of the internal position differentiator, is dependent on the sync rate, but the above condition is generally satisfied by most systems. The condition on RV4 and CV1 sets the position of the zero due to the external components in the velocity loop filter, whose function is described below. The resulting system has two real poles, one of which is at the origin, and is thus unconditionally stable.

The position of the SSI 32H6220 internal differentiator pole is selectable under microprocessor control. It is desireable to select as low a frequency as is consistent with the required seek performance. This pole prevents the differentiator from amplifiying high frequency noise. In order to provide feedback of a velocity signal for frequencies above the differentiator pole, the external velocity loop filter is configured to act as an integrator which integrates the motor current sense output of the SSI 32H569, or the SSI 32H6230, SOUT. Since SOUT is proportional to motor acceleration, this integration produces a signal proportional to velocity. Thus, at low frequencies the velocity feedback is generated by differentiating the position error signal and at high frequencies, the velocity term results from integrating motor current. It is more accurate to estimate velocity from a direct observation of head position, but at higher frequencies it is necessary to provide increased noise immunity. The system described above balances these two considerations.

OFFSET CANCELLATION

The 32H6220 is capable of cancelling position offset, velocity offset, and motor current offset. The following procedures may be used to null out these effects.

A. Position offset

This procedure removes any offset introduced by the position processing circuitry in the SSI 32H6220.

1. Set T/$\overline{S}$. (Enter track mode.)
2. Set CAL and DUMP. (This switches the N and Q inputs to VREF and shorts out CP2).
3. Set ERREN. (This activates the ERR comparator and connects its output to SGN.)
4. Adjust NOS and SOS until a 1LSB change causes SGN to change state. The final values should be stored and used whenever track mode is used.
5. Clear CAL, DUMP, ERREN to resume normal track mode operation.

B. Velocity offset

This procedure removes any offset generated in the velocity path of the SSI 32H6220.

1. Clear T/$\overline{S}$. (Enter seek mode).
2. Set CAL, ERREN, and ENA.
3. Adjust TARGET and VELPOL until 1LSB change causes SGN to change state. This value of TARGET should be stored for use in future seeks as the velocity offset.
4. Clear CAL and ERREN to resume normal seek mode.

Finer offset adjustment can be made by using the OFFSET register, however the calculation must be done for each value of NFG that is planned to be used.

C. Motor Current Offset

Motor current offset (caused, for instance, by cable bias and windage on the head as well as voltage offset in the motor driver) results in an ontrack voltage at PE that is not zero. In some drives, the time from when DUMP is turned off to when the final value of PE is achieved adds appreciably to the loop settling time. The PE voltage can be minimized (and therefore, the settling time) as follows.

1. Enter track mode and wait for the head position to settle. Make sure CAL is reset.
2. Set ERREN.
3. Adjust TARGET until PE is zero (evidenced by SGN toggling equally between 1 and 0. Program target with this value whenever a seek to this area of the disk is performed.

Since this technique compensates for cable bias, care must be taken to interpret the results. Cable bias will be position dependent and can also depend on the previous head positions.

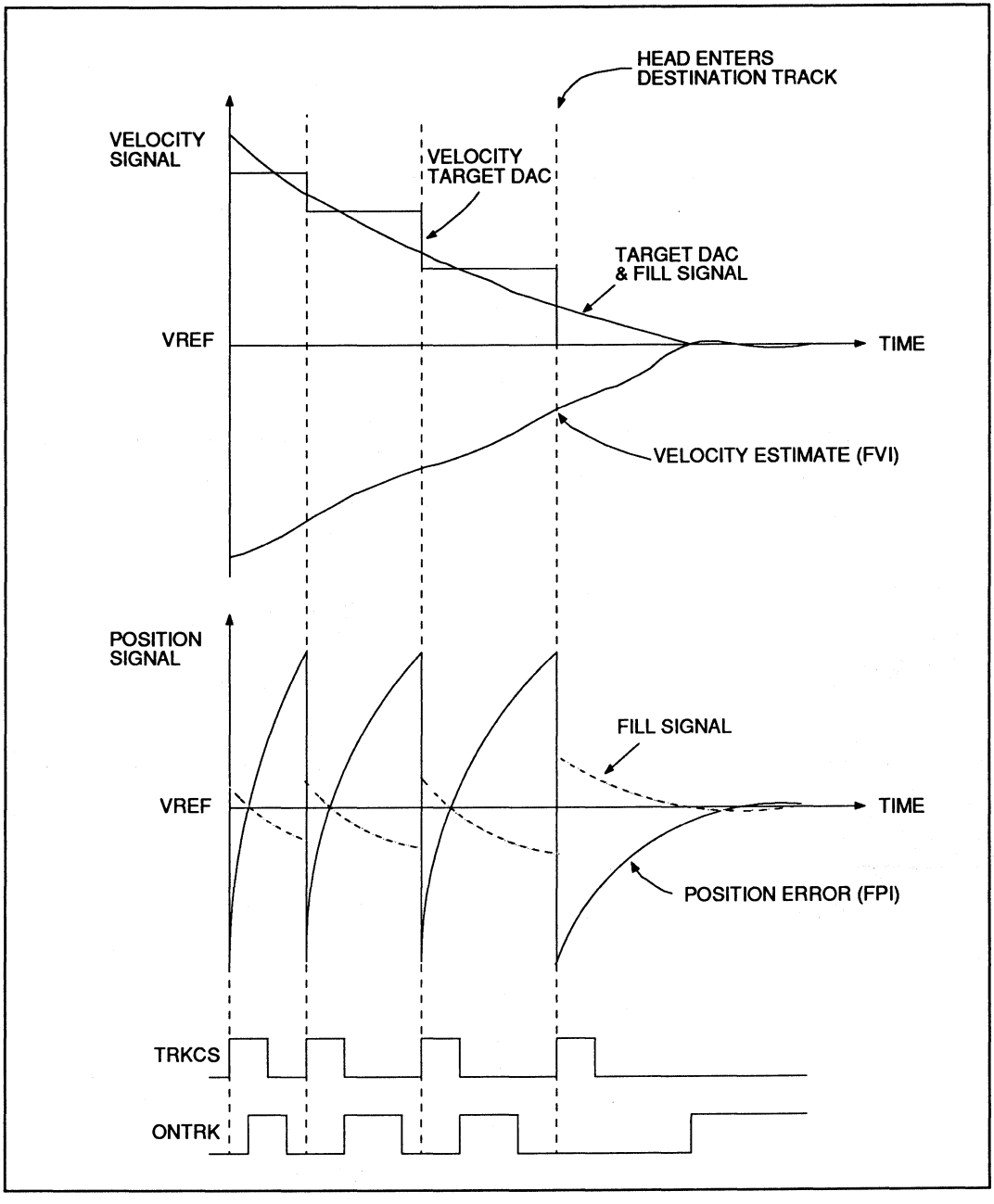


FIGURE 9: Typical Waveforms During Final Deceleration Mode

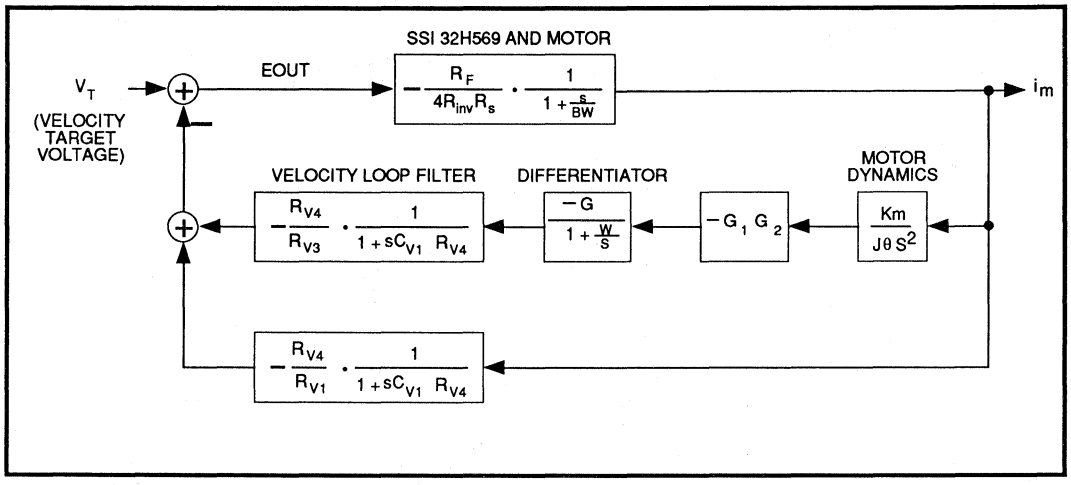


FIGURE 10(a): Transfer Function of SSI 32H6220 in Seek Mode

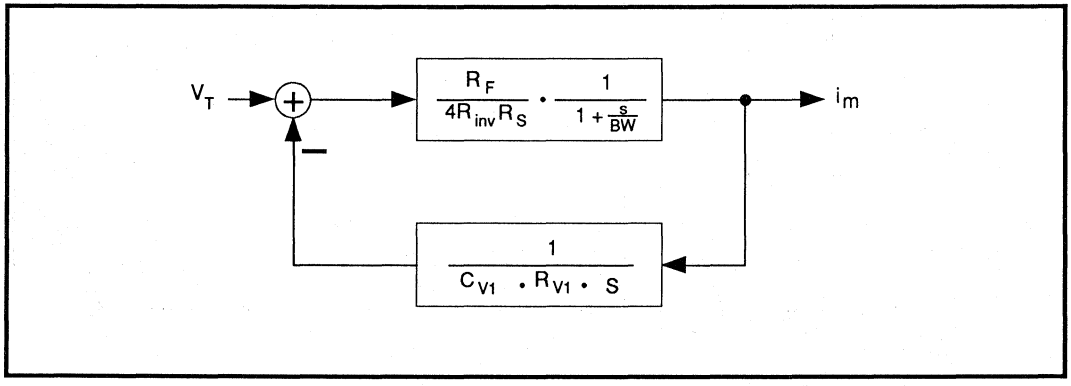


FIGURE 10(b): Simplified Transfer Function of SSI 32H6220 in Seek Mode

$$\omega^2 >> \frac{(GG_1G_2)(K_m R_{V1})}{J\theta R_{V3}}$$

$$R_{V4}C_{V1} = \frac{J\theta\omega R_{V3}}{(GG_1G_2)(K_m R_{V1})}$$

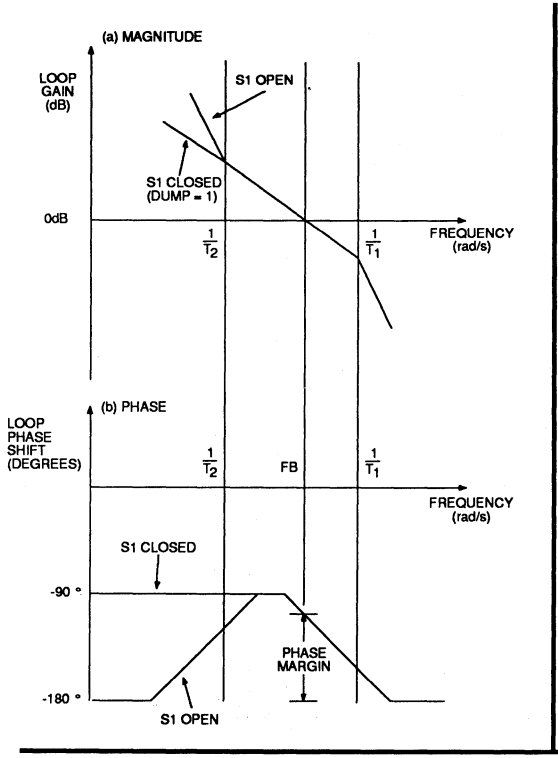


FIGURE 11: Bode Plot of Simplified Track Mode Transfer Function

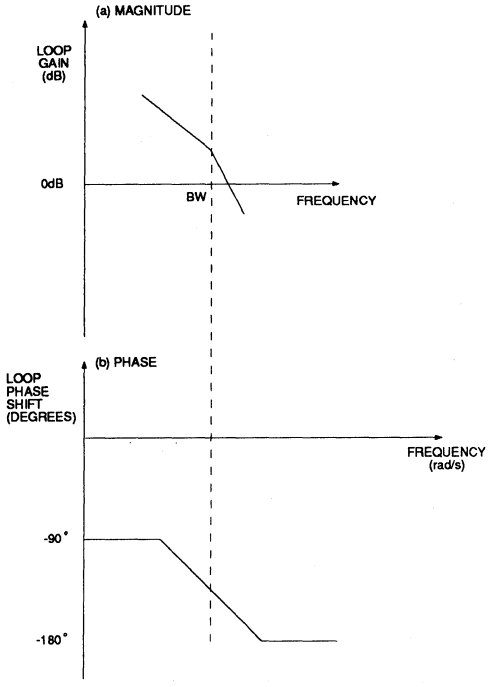


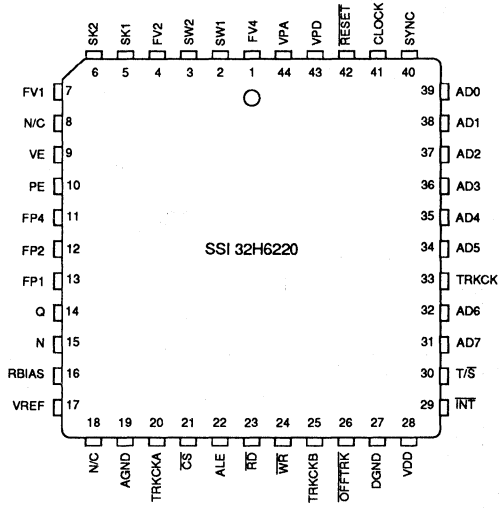
FIGURE 12: Bode Plot of Simplified Seek Mode Transfer Function

SSI 32H6220
Servo Controller

PACKAGE PIN DESIGNATIONS

(TOP VIEW)

CAUTION: Use handling procedures necessary for a static sensitive component.



44-Pin PLCC

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32H6220, Servo Controller		
44-Pin PLCC	SSI 32H6220-CH	32H6220-CH

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32H6230
Servo Motor Driver

Preliminary Data

July, 1990

DESCRIPTION

The SSI 32H6230 Servo Motor Driver is a bipolar device intended for use in Winchester disk drive head positioning systems employing linear or rotary voice coil motors. When used in conjunction with a position controller, such as the SSI 32H568 or the SSI 32H6220 Servo Controllers, and a position reference, such as the SSI 32H567 Servo Demodulator, the device allows the construction of a high performance, dedicated surface head positioning system.

The SSI 32H6230 serves as a transconductance amplifier by driving 4 MOSFETs in an H-bridge configuration, performs motor current sensing and limits motor current. In its linear tracking mode, class B operation is guaranteed by crossover protection circuitry, which ensures that only one MOSFET in each leg of the H-bridge is active. The MOSFET drivers are disabled when motor velocity or current exceed externally programmable limits. In addition, automatic head retraction and spindle braking may be initiated by a low voltage condition or upon external command.

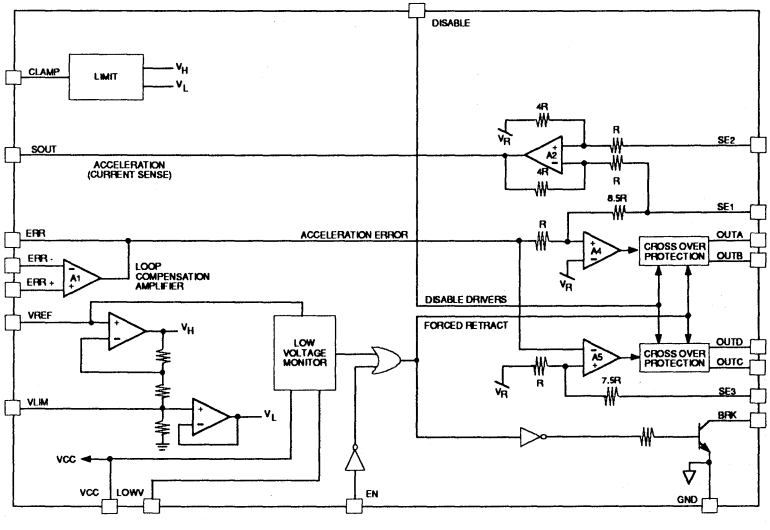
(Continued)

FEATURES

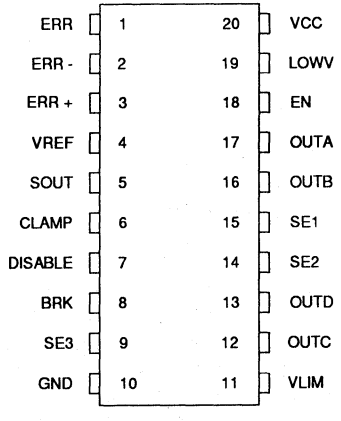
- **Predriver for linear and rotary voice coil motors**
- **Interfaces directly to MOSFET H-Bridge motor driver**
- **Class B linear mode and constant velocity retract mode**
- **FET disable function**
- **Precision differential amplifier for motor current sensing**
- **Clamp for motor current limiting**
- **Automatic head retract and spindle braking signal on power failure**
- **External digital enable**
- **Servo loop parameters programmed with external components**
- **Advanced bipolar IC requires under 240 mW from 12V supply**
- **Available in 20-pin DIP or SO packaging**

5

BLOCK DIAGRAM



PIN DIAGRAM



DESCRIPTION (Continued)

The SSI 32H6230 is implemented in an advanced bipolar process and dissipates less than 240 mW from a 12V supply. The IC is available in 20-pin DIP and 20-pin SO packaging.

FUNCTIONAL DESCRIPTION

(Refer to block diagram and typical application Fig.2)

The SSI 32H6230 has two modes of operation, linear and retract. The retract mode is activated by a power supply failure or when the control signal EN is false. Otherwise the device operates in linear mode.

During linear operation, an acceleration signal from the servo controller is applied through amplifier A1, whose three connections are all available externally. RC components may be used to provide loop compensation at this stage. The ERR signal drives two precision amplifiers, each with a gain of 8.5. The first of these amplifiers is inverting, and is formed from opamp A4, an on-chip resistor divider and an off-chip complementary MOSFET pair. The second is non-inverting, and is formed in a similar manner from opamp A5. Feedback from the MOSFET drains, on sense inputs SE1 and SE3, allows the amplifiers gains to be established precisely. The voice coil motor and a series current sense resistor are connected between SE1 and SE3.

Crossover protection circuitry between the outputs of A4 and A5, and the external MOSFETs, ensures class B operation by allowing only one MOSFET in each leg of the H-bridge to be in conduction. The crossover separation threshold, illustrated in Figure 5, is the maximum drive on any MOSFET gate when the motor voltage changes sign. The crossover circuitry can also disable all MOSFETS simultaneously (to limit motor current or velocity) or apply a constant voltage across the motor (to retract the heads at a constant velocity).

Motor current is sensed by a small resistor placed in series with the motor. The voltage drop across this resistor is amplified by a differential amplifier with a gain of 4 (A2 and associated resistors), whose inputs are SE1 and SE2. The resulting voltage, SOUT, is proportional to motor current, and hence acceleration. This signal is externally fed back to A1, so that the signal ERR represents the difference between the desired acceleration (from the servo controller) and the actual motor acceleration.

An adjustable voltage clamp is provided to prevent over current to the motor. It accomplishes the current limiting by clamping the voltage excursion at the input of A1. The voltage clamp values are programmed by VREF and VLIM. VLIM is the lower clamp value and the upper clamp limit is 2 • VREF - VLIM.

Disable function will cause all 4 bridge FETs to turn off. Note that this function does not override the retract function.

The SSI 32H6230 has low voltage monitor circuitry that will detect a loss of voltage on the VREF, VCC or LOWV pins. The power supply pin, VCC, should be connected to the disk drive's spindle motor so that its stored rotational energy may be used to hold up VCC briefly during a power failure. LOWV is used to detect a system power supply failure. When a low voltage condition is detected, the MOSFET drivers switch from linear operation to retract mode. In this mode a constant voltage is applied across the motor which will cause the heads to move at a constant speed. A mechanical stop must be provided for the heads when they reach a safe location. The current limiting circuitry will disable the MOSFET drivers when motor current increases due to loss of the velocity-induced back EMF. An open collector output, BRK, which is active while the device is in retract mode, is provided for spindle motor braking. An external RC delay may be used to defer braking until the heads are retracted.

Two examples of an entire servo path implemented with the SSI 32H6230 and its companion devices, the SSI 32H567, 32H568, and the SSI 32H567, 32H6220 are shown in Figures 7 and 8.

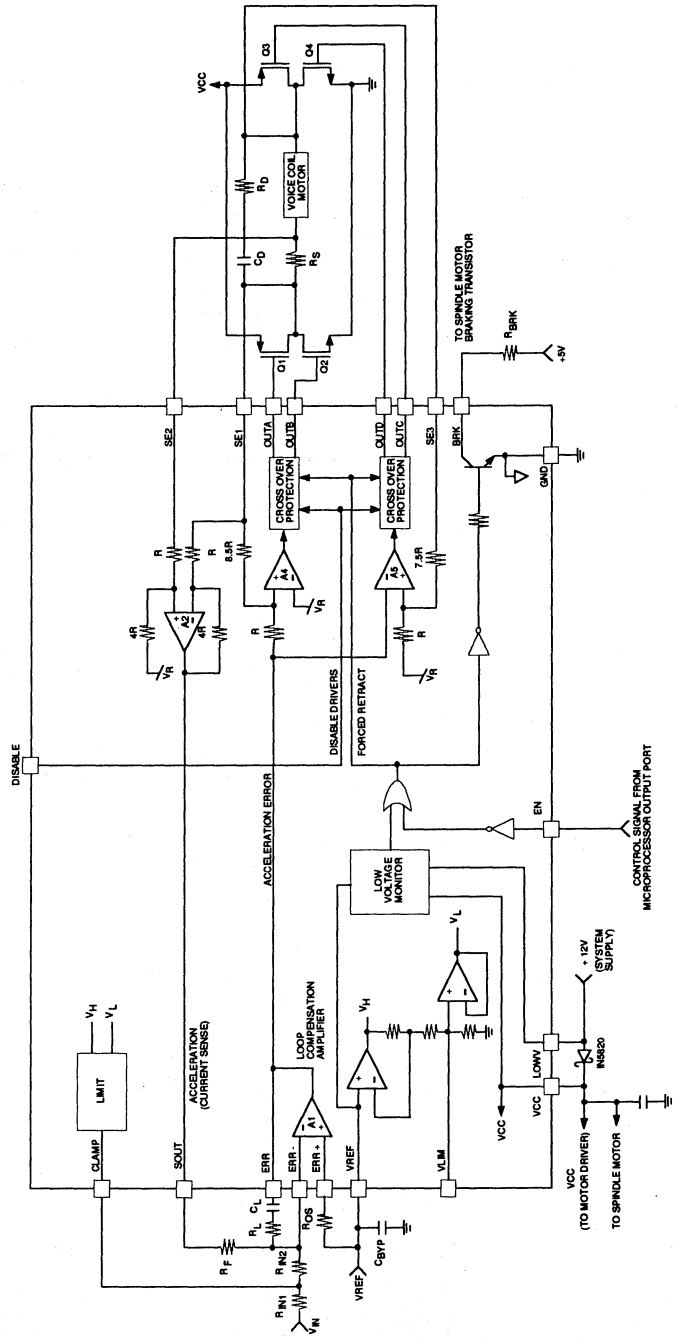


FIGURE 2: Typical Application

PIN DESCRIPTION

POWER

NAME	PIN	TYPE	DESCRIPTION
VCC	20		POSITIVE SUPPLY - 12V power supply. Usually taken from spindle motor supply. Spindle motor stored energy permits head retraction during power failure. If VCC falls below 9V, a forced head retraction occurs.
LOWV	19	I	LOW VOLTAGE - System 12V supply. If this input falls below 9V, a forced head retraction occurs.
VREF	4	I	REFERENCE VOLTAGE - 5.4V input. All analog signals are referenced to this voltage. If VREF falls below 4.3V, a forced head retraction occurs.
GND	10		GROUND

CONTROL

NAME	PIN	TYPE	DESCRIPTION
ERR	1	O	POSITION ERROR- Loop compensation amplifier output. This signal is amplified by the MOSFET drivers and applied to the motor by an external MOSFET H-bridge, as follows: SE3-SE1 = 17(ERR-VREF)
ERR-	2	I	POSITION ERROR INVERTING INPUT - Inverting input to the loop compensation amplifier.
ERR+	3	I	POSITION ERROR NON-INVERTING INPUT - Non-inverting input to the loop compensation amplifier.
SOUT	5	O	MOTOR CURRENT SENSE OUTPUT - This output provides a voltage proportional to the voltage drop across the external current sense resistor, as follows: SOUT-VREF=4(SE2-SE1)
DISABLE	7	I	DISABLE INPUT – Active High TTL input will cause all 4 bridge FETs to turn off. DISABLE does not override the retract function.
CLAMP	6	I	CLAMP – A clamp pin to limit the input error voltage. The voltage swing at this pin is limited to VREF +- (VREF - VLIM).
BRK	8	O	BRAKE OUTPUT – Active high, open collector output which may be used to enable an external spindle motor braking transistor upon power failure or deassertion of EN.
VLIM	11	I	VOLTAGE LIMIT – The voltage at this pin sets the upper and lower clamp voltage limits in conjunction with the voltage at VREF. Upper Clamp Limit = 2 • VREF - VLIM Lower Clamp Limit = VLIM.
SE2	14	I	MOTOR CURRENT SENSE INPUT - Non-inverting input to the current sense differential amplifier. It should be connected to one side of an external current sensing resistor in series with the motor. The inverting input of the differential amplifier is connected internally to SE1.
EN	18	I	ENABLE - Active high TTL compatible input enables linear tracking mode. A low level will initiate a forced head retract.

FET DRIVE

NAME	PIN	TYPE	DESCRIPTION
SE3	9	I	MOTOR VOLTAGE SENSE INPUT - This input provides feedback to the non-inverting MOSFET driver amplifier. It is connected to one side of the motor. The gain to this point is: SE3-VREF = 8.5(ERR-VREF)
OUTC	12	O	P-FET DRIVE (NON-INVERTING) - Drive signal for a P channel MOSFET connected between one side of the motor and VCC. This MOSFET drain is connected to SE3.
OUTD	13	O	N-FET DRIVE (NON-INVERTING) - Drive signal for an N channel MOSFET connected between one side of the motor and GND. This MOSFET drain is connected to SE3. Crossover protection circuitry ensures that the P and N channel devices driven by OUTC and OUTD are never enabled simultaneously.
SE1	15	I	MOTOR VOLTAGE SENSE INPUT - This input provides feedback to the inverting MOSFET driver amplifier. It is connected to the current sensing resistor which is in series with the motor. The gain to this point is: SE1-VREF = -8.5(ERR-VREF) This input is internally connected to the current sense differential amplifier inverting input.
OUTB	16	O	N-FET DRIVE (INVERTING) - Drive signal for an N channel MOSFET connected between the current sense resistor and GND. This MOSFET drain is also connected to SE1.
OUTA	17	O	P-FET DRIVE (INVERTING) - Drive signal for a P channel MOSFET connected between the current sense resistor and VCC. This MOSFET drain is also connected to SE1. Crossover protection circuitry ensures that the P and N channel devices driven by OUTC and OUTD are never enabled simultaneously.

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

(Maximum limits indicates where permanent device damage occurs. Continuous operation at these limits is not intended and should be limited to those conditions specified in the DC operating characteristics.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
VCC		0		16	V
VREF		0		10	V
SE1, SE2, SE3, OUT D		-1.5		15	V
All other pins		-.3		VCC + .3	V
Storage temperature		-45		165	°C
Solder temperature	10 sec duration			260	°C

RECOMMENDED OPERATION CONDITIONS (Unless otherwise noted, the following conditions are valid throughout this document.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
VCC	Normal Mode	9	12	13.2	V
	Retract Mode	3.5V		14	V
VREF		5		7	V
Operating temperature		0		70	°C

DC CHARACTERISTICS

ICC, VCC current				20	mA
IREF, VREF current				2	mA

A1, LOOP COMPENSATION AMPLIFIER

Input bias current				500	nA
Input offset voltage				3	mV
Voltage swing	About VREF	2			V
Common mode range	About VREF	±1			V
Load resistance	To VREF	4			kΩ
Load capacitance				100	pF
Gain		80			dB
Unity gain bandwidth		1			MHz
CMRR	f <20 kHz	60			dB
PSRR	f <20 kHz	60			dB

A2, CURRENT SENSE AMPLIFIER

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input impedance	SE1 to SE2	3.5	5		kΩ
Input offset voltage				2	mV
Output voltage swing		VREF-4		VCC-1.2	V
Common mode range		0		VCC-0.2	V
Load Resistance	To VREF	4			kΩ
Load Capacitance				100	pF
Output impedance	f < 40 kHz			20	Ω
Gain (SOUT-VREF)/(SE1-SE2)		3.9	4	4.1	V/V
Unity gain bandwidth		1			MHz
CMRR	f < 20 kHz	52			dB
PSRR	f < 20 kHz	60			dB

5

VOLTAGE CLAMP

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
CLAMP bias current	CLAMP = VREF			0.1	µA
Upper CLAMP limit (VREF + 1/3 VREF)	ICLAMP = 10 µA VLIM open		$\frac{4}{3}$VREF		V
Lower CLAMP limit (VREF - 1/3 VREF)	ICLAMP = -10 µA VLIM open		$\frac{2}{3}$VREF		V
CLAMP accuracy	| ICLAMP | = 10 µA	-3		3	%
CLAMP Impedance	1.0 mA> | ICLAMP | >10 µA			20	Ω
VLIM Voltage			$\frac{2\,VREF}{3}$		V
VLIM Accuracy		-1		+1	%

POWER SUPPLY MONITOR

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
VCC fail threshold		8.5	9	9.8	V
LOWV fail threshold	|ILowv| < 0.5 mA	8.5	9	9.8	V
VREF fail threshold		3.9	4.3	4.8	V
Hysteresis (LOWV, VCC)			250		mV
Hysteresis (VREF)			110		mV
EN input low voltage	|IIL| < 0.5 mA	0.8			V

POWER SUPPLY MONITOR (Continued)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
EN input high voltage	|IIH| < 40 uA			2	V
BRK voltage	normal mode, |IOL| < 1 mA			0.4	V
BRK leakage current	retract mode			10	µA
BRK delay (from power fail or EN false to BRK floating)				1	ms

MOSFET DRIVERS

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
SE3 Input impedance	To VREF	10	25		kΩ
OUTA, OUTC voltage swing |Io|<1 mA		0.7		VCC-1	V
OUTB, OUTD voltage swing |Io|<1 mA		1		VCC-1	V
VTH, Crossover separation threshold				2	V
Slew rate (OUTA, OUTB, OUTC, OUTD)	Cl<1000 pF	1.4			V/µs
Crossover time	300 mV step at ERR			5	µs
Output impedance (OUTA,B,C,D)			50		kΩ
Transconductance I(OUTA,B,C,D)/(ERR-VREF)			8		mA/V
Gain (-(SE1-VREF)/(ERR-VREF) or (SE3-VREF)/(ERR-VREF))		8	8.5	9	V/V
Offset current	R_S = 0.2Ω, R_F = R_{IN}, V_{IN}=VREF			20	mA
Retract motor voltage (SE1-SE3)		0.7	1	1.3	V

APPLICATIONS INFORMATION

A typical SSI 32H6230 application is shown in Figure 2. The selection criteria for the external components shown are discussed below. Figure 3 shows the equivalent circuit and equations for the DC motor used in the following derivations. While the nomenclature chosen is for a rotating motor, the results are equally applicable to linear motors.

MOTOR CURRENT SENSE AND LIMITING

The series resistor which senses motor current, Rs, is chosen to be small compared to the resistance of the motor, Rm. A value of Rs = 0.2Ω is typical in disk drive applications.

VLIM, RIN1, and RIN2 must be chosen to keep the motor current below Imax. The voltage clamp values programmed by VREF and VLIM must be chosen to cause limiting when the motor current reaches its maximum permissible current in amps, this value may be chosen as follows:

$$|Imax| = \frac{CLAMP}{RIN2} \cdot \frac{RF}{4 \cdot Rs}$$

Where the upper clamp limit is 2 • VREF - VLIM and the lower clamp limit is VLIM. If VLIM is left open, a value of 0.667 • VREF will appear. The upper clamp limit is then 1.33 • VREF and the lower clamp limit is 0.667 • VREF. The values of RIN1, RIN2 must be chosen to satisfy the maximum swing of Vin before limiting occurs,

$$Vin(max) = CLAMP\left(1 + \frac{RIN1}{RIN2}\right) - \frac{RIN1}{RIN2}(VREF) + VREF$$

and they should also satisfy the maximum current VCLAMP can source or sink

$$\frac{Vin\ (max)\ [Actual] - CLAMP}{RIN1} \leq 1mA$$

LOOP COMPENSATION

The transfer function of the SSI 32H6230 in the application of Figure 2 is shown in Figure 4(a). If the zero due to RL and CL in the loop compensation circuit is chosen to cancel the pole due to the motor inductance, Lm, then the transfer function can be simplified as shown in Figure 4(b), under the assumption that this pole and the pole due to the motor mechanical response are widely separated. CL may then be chosen to set the desired open loop unity gain bandwidth.

$$C_L = \frac{68 \cdot R_s}{2 \cdot \pi \cdot R_F \cdot (R_m + R_s) \cdot BW}$$

where BW is the unity gain open loop bandwidth

$$R_L = \frac{L_m}{C_L \cdot (R_m + R_s)}$$

The closed loop response of the servo driver and motor combination, using the component values and simplifying assumptions given above, is given by:

$$\frac{i_m}{V_{in}}(s) = -\frac{1}{R_{in}} \cdot \frac{R_F}{4 \cdot R_s} \cdot \frac{1}{\left(1 + \frac{s}{2 \cdot \pi \cdot BW}\right)}$$

Where: Rin = RIN1 + RIN2

(This analysis neglects the pole due to the output impedance of the MOSFET drivers and the MOSFET gate capacitance, an effect that may be significant in some systems.)

RF is chosen to be sufficiently large to avoid overloading A2 (RF > 4 kΩ). The input resistor, RIN, sets the conversion factor from servo controller output voltage to servo motor current. RIN is chosen such that the servo controller internal voltages are scaled conveniently. The resistor ROS is optional and cancels out the effect of the input bias current of A1.

$$R_{os} = R_{in} // R_F$$

The external components RD and CD have no effect on the motor dynamics, but may be used to improve the stability of the MOSFET drivers. The load represented by the motor, ZM, is given by:

$$ZM = (R_s + R_m)\left(1 + s\frac{L_m}{R_s + R_m}\right)\left(1 + \frac{K_m^2}{s \cdot J\theta \cdot (R_s + R_m)}\right)(\Omega)$$

At frequencies above (Rs+Rm)/(2π • Lm) Hz, this load becomes entirely inductive, which is undesireable. RD and CD may be used to add some parallel resistive loading at these frequencies.

H-BRIDGE MOSFETS

The MOSFETs chosen for the H-bridge should have gate capacitances in the range of 500-1000 pF. The MOSFET input capacitance forms part of the compensation for the MOSFET drivers, so values below 500 pF may cause some driver instability. Excessive input capacitance will degrade the slew mode performance of the drivers.

When the motor voltage is changing polarity, the crossover protection circuits at outputs OUTA-OUTD ensure that the maximum MOSFET gate drive is less than 2V (the crossover separation threshold), as illustrated in Figure 5. The thresholds of the MOSFET devices chosen should be as large as possible to minimize conduction in this region. If the device thresholds are significantly less than the crossover separation threshold, the N and P channel devices in each leg of the H-bridge will conduct simultaneously, causing unnecessary power dissipation.

POWER FAILURE OPERATION

The power supply for the SSI 32H6230, VCC, should be taken from the system 12V supply through a schottky diode (maximum 0.5V drop at If = 3A) and connected to the disk drive spindle motor. If the system power fails, the IC will continue to operate as the spindle motor becomes a generator. The SSI 32H6230 will detect the power failure and cause a forced head retract, continuing to operate with VCC as low as 3.5V. The power fail mode will commence if either VCC or LOWV falls below 9V, or VREF falls below 4.3V, or EN is false. Hysteresis on the low voltage thresholds prevents the device from oscillating between operating modes when the power supply is marginal.

The BRK output, which is pulled low during normal operation, floats during a power failure. This allows an external transistor to be enabled for spindle motor braking. An external RC delay may be added to defer braking until head retraction is complete, since the spindle motor is required to generate the supply voltage during retraction.

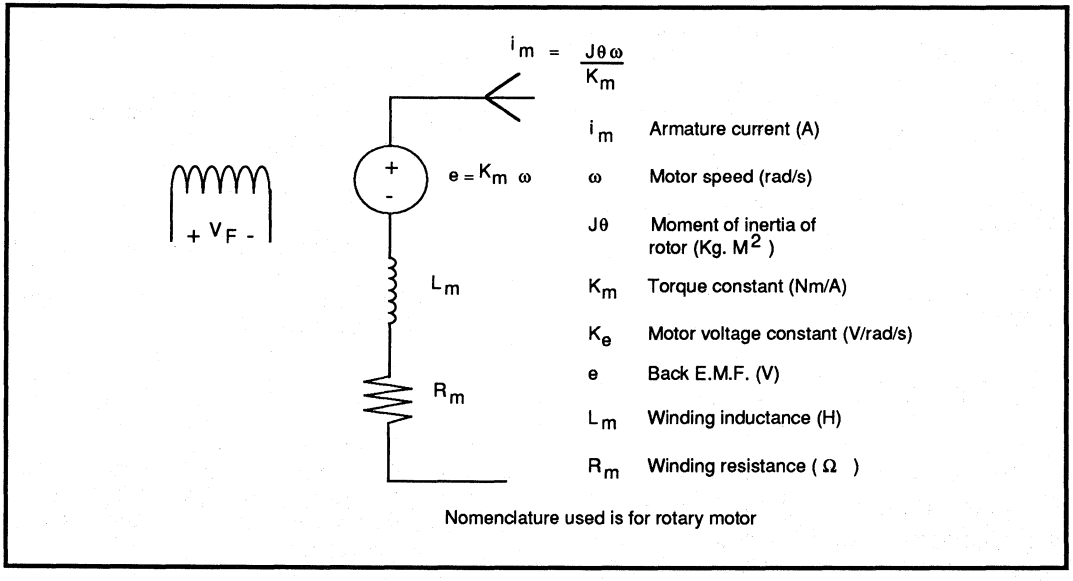


FIGURE 3: Equivalent Circuit for Fixed Field DC Motor

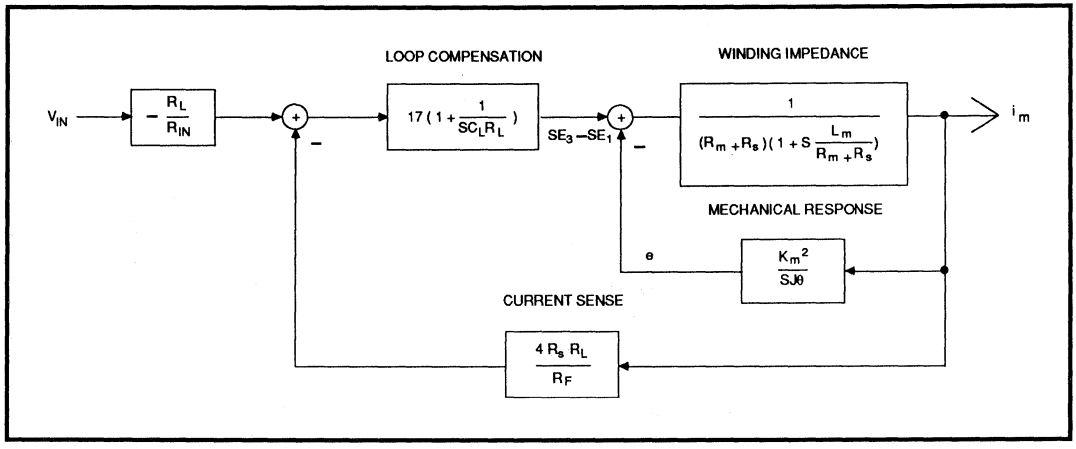


FIGURE 4(A): Transfer Function of SSI 32H6230 in Typical Application with Fixed Field DC Motor

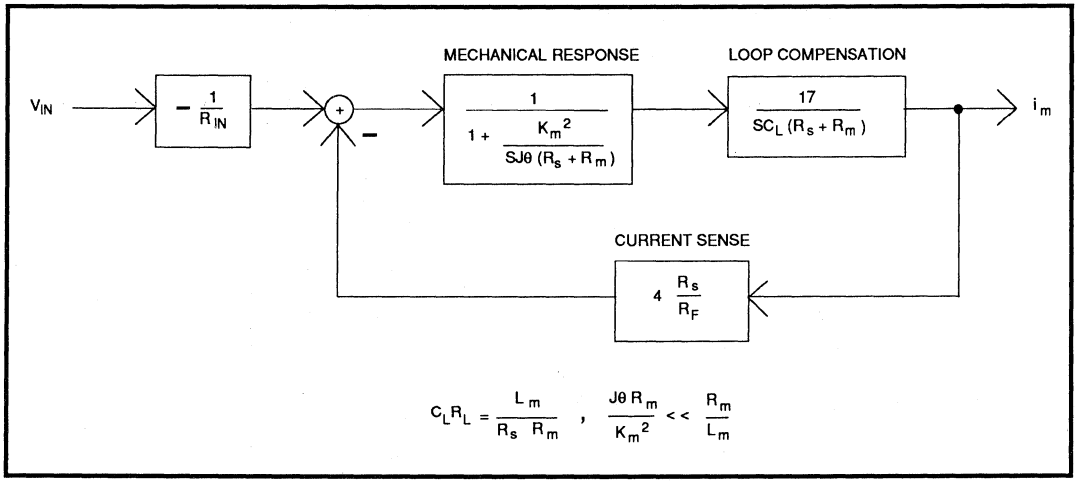


FIGURE 4(B): Simplified Transfer Function of SSI 32H6230 in DC Motor Application

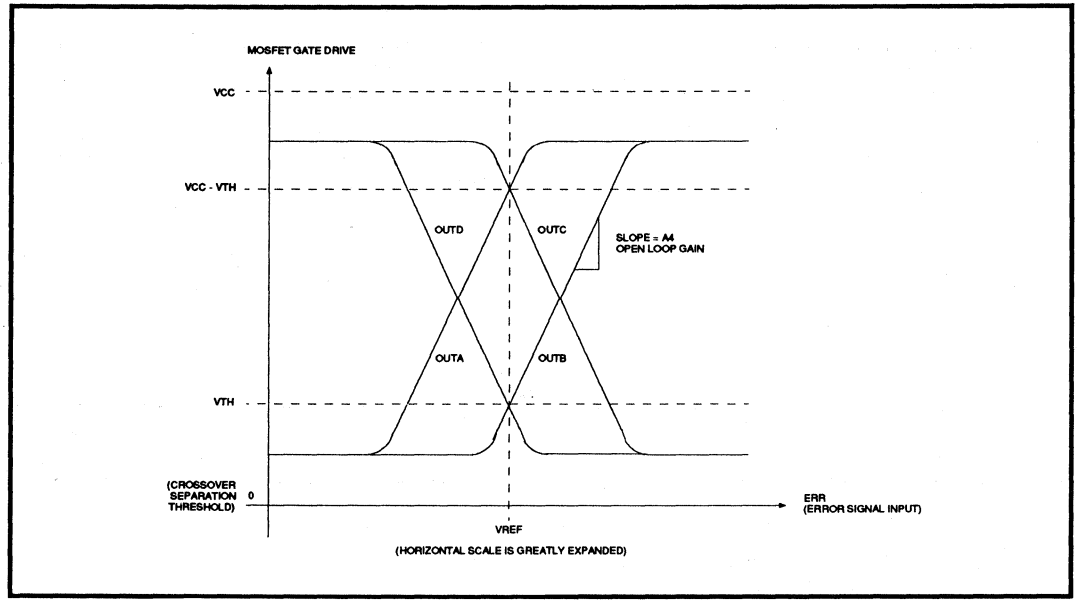


FIGURE 5: Simplified Transfer Function of SSI 32H6230 in DC Motor Application

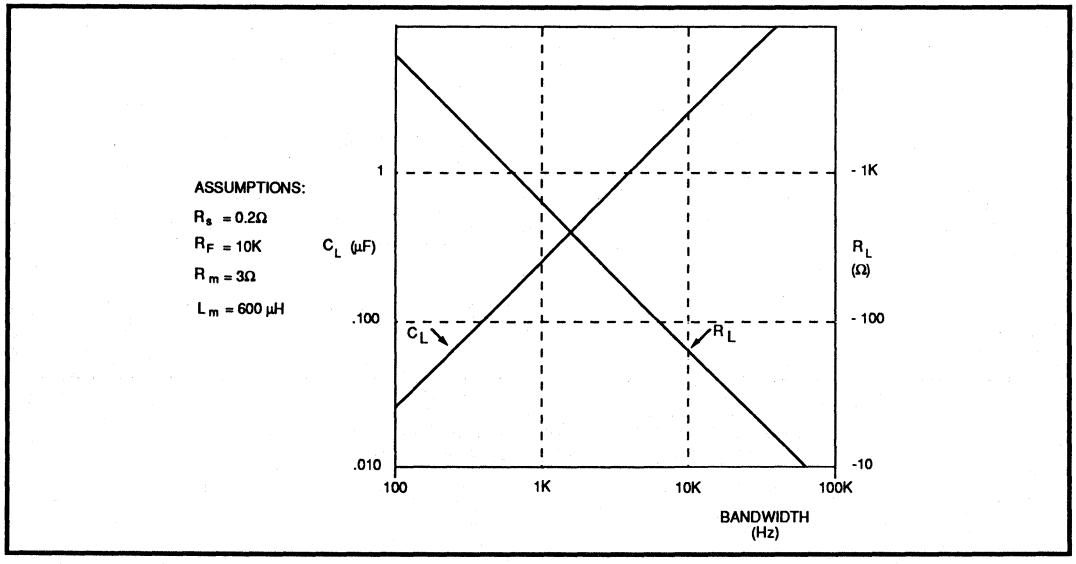


FIGURE 6: Typical Motor Driver Compensation

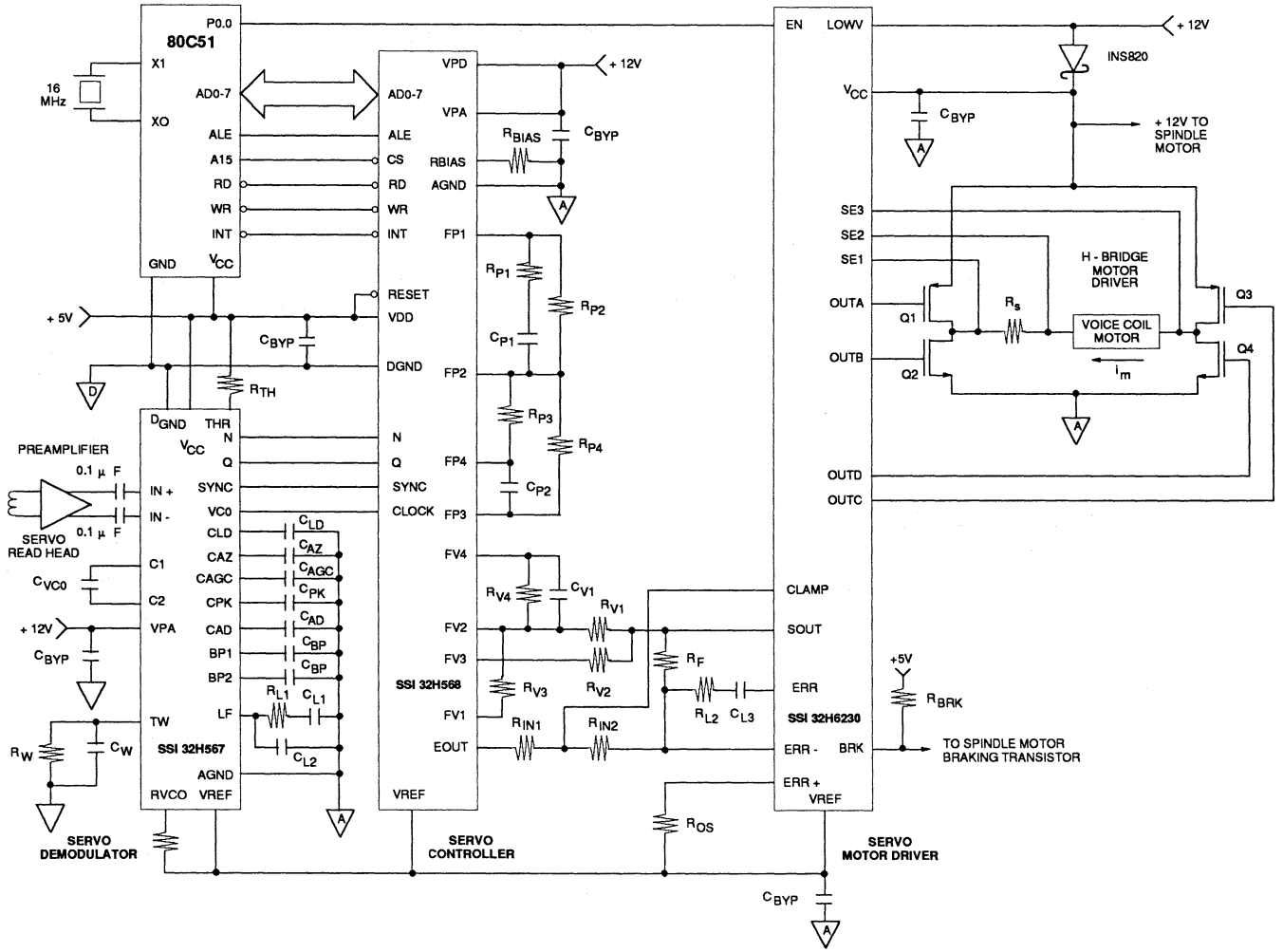


FIGURE 7: Complete Example of Servo Path Electronics Using the SSI 32H567/568/6230 Chip Set

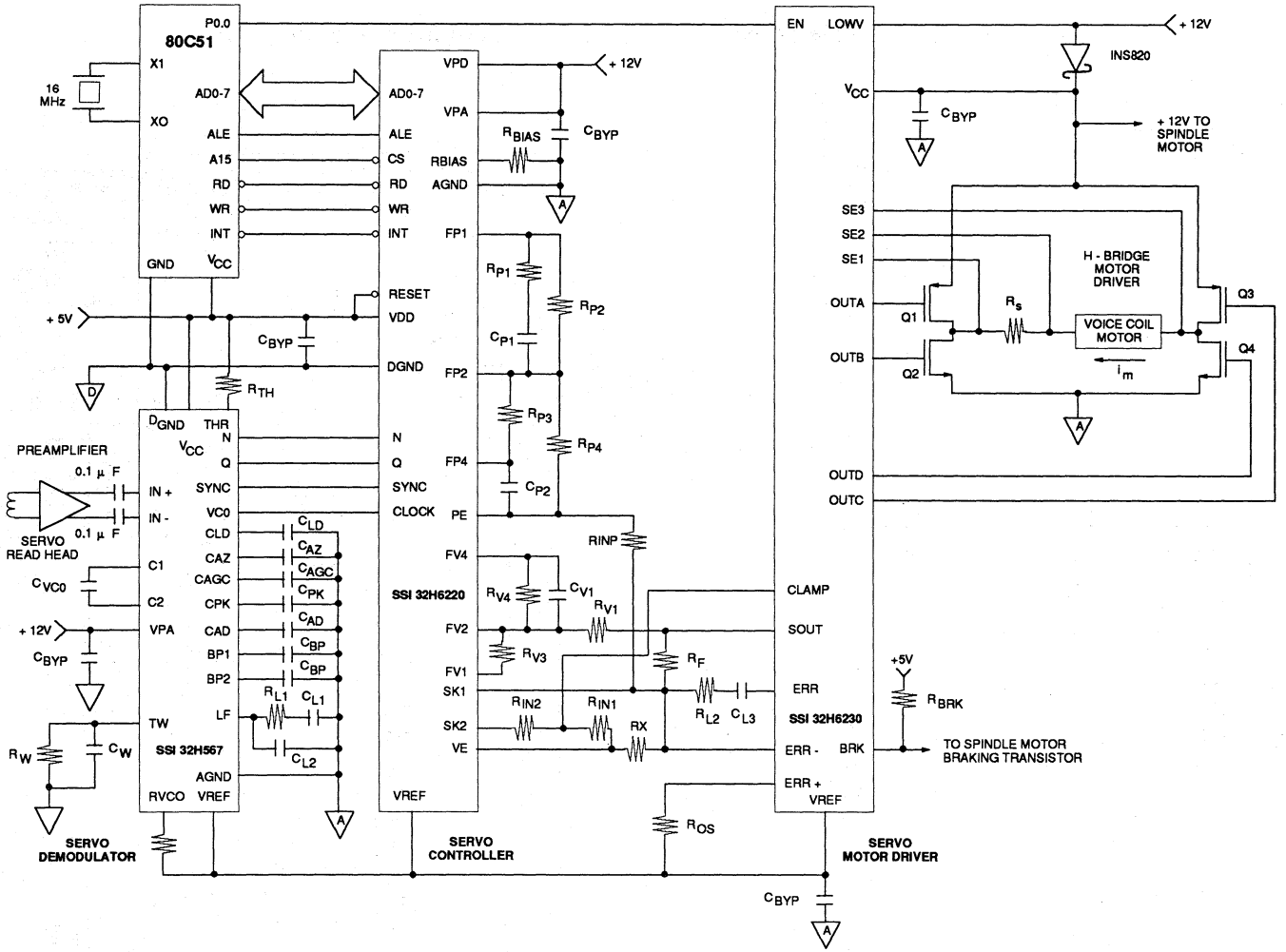
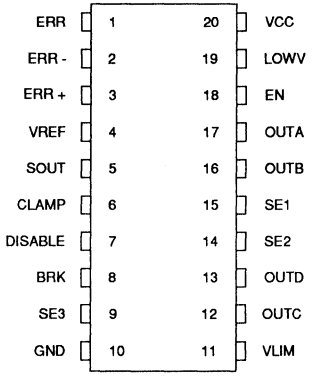


FIGURE 8: Complete Example of Servo Path Electronics Using the SSI 32H567/6220/6230 Chip Set

PACKAGE PIN DESIGNATIONS
(TOP VIEW)

CAUTION: Use handling procedures necessary for a static sensitive component.



20-Pin SO, DIP

5

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32H6230, Servo Motor Driver		
20-Pin DIP	SSI 32H6230-CP	32H6230-CP
20-Pin SOL	SSI 32H6230-CL	32H6230-CL

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

Notes:

SSI 32H6240
Servo Motor Driver

Advance Information

July, 1990

DESCRIPTION

The SSI 32H6240 Servo Motor Driver is a bipolar device intended for use in Winchester disk drive head positioning systems employing linear or rotary voice coil motors. When used in conjunction with a position controller, such as the SSI 32H568 or the SSI 32H6220 Servo Controllers, and a position reference, such as the SSI 32H567 Servo Demodulator, the device allows the construction of a high performance, dedicated surface head positioning system.

The SSI 32H6240 serves as a transconductance amplifier by driving 4 bipolar power transistors in an H–bridge configuration and performs motor current sensing by using an on-chip differential amplifier. In its linear tracking mode, class B operation is guaranteed by crossover protection circuitry, which ensures that only one transistor in each leg of the H-bridge is active. Automatic head retraction and spindle braking may be initiated by a low voltage condition or upon external command.

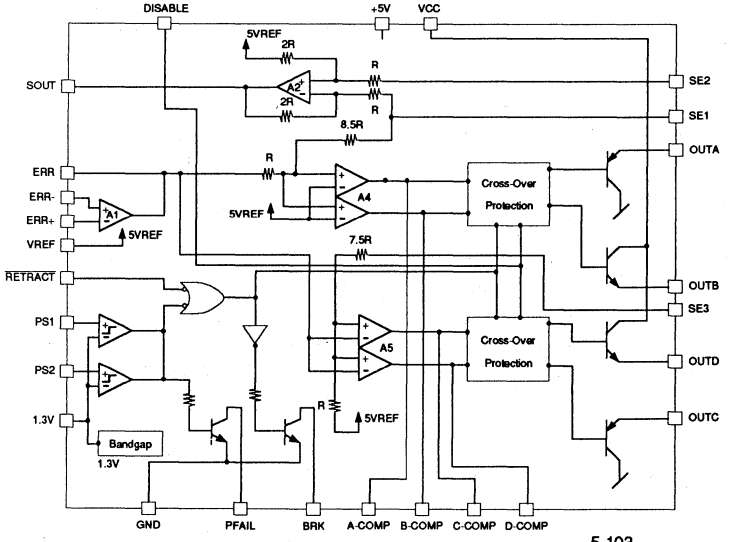
The SSI 32H6240 is implemented in an advanced bipolar process and dissipates less than (240 mW) from a 12V supply. The SSI 32H6240 is available in a 28-pin PLCC.

FEATURES

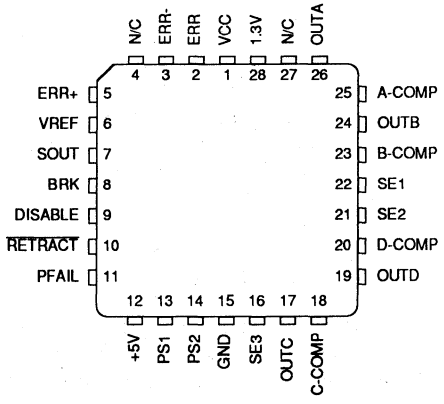
- **Predriver for linear and rotary voice coil motors**
- **Interfaces directly to Bipolar H-Bridge motor driver**
- **Class B linear mode and constant velocity retract mode**
- **Power transistor disable function**
- **Precision differential amplifier for motor current sensing**
- **On-chip precision power fail detect**
- **Automatic head retract and spindle braking signal on power failure**
- **External digital enable**
- **Servo loop parameters programmed with external components**
- **Advanced bipolar IC requires under (240 mW) from 12V supply**
- **Available in 28-pin PLCC packaging**
- **+5V, +12V operation**

5

BLOCK DIAGRAM



PIN DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

FUNCTIONAL DESCRIPTION

(Refer to block diagram and typical application Fig.2)

There are three modes of operation of the SSI 32H6240: Disable, Retract, and Linear. The circuit mode is controlled by the DISABLE , $\overline{\text{RETRACT}}$, PS1, and PS2 pins.

DISABLE mode turns off the output drivers. OUTA and OUTC are pulled to VCC through internal 1.5 kΩ resistors. OUTB and OUTD are pulled to GND through internal 1.5 kΩ resistors. Disable mode does not override Retract mode.

RETRACT mode turns off OUTB and OUTC. OUTD is turned on. OUTA is turned on in a special manner to force 1V at SE1. Retract mode does override Disable mode.

POWER FAIL mode occurs when either PS1 or PS2 fall below 1.3V. Power fail overrides Retract and Disable inputs and forces the chip into RETRACT mode.

When the $\overline{\text{RETRACT}}$ pin is pulled low the SSI 32H6240 will go into retract mode. The BRK pin will go high. When the DISABLE pin is pulled high it will cause all 4 bridge power transistors to turn off. PFAIL and BRK will remain low if PS1, PS2, and $\overline{\text{RETRACT}}$ pins do not change.

During linear mode operation an acceleration signal from the servo controller is applied through amplifier A1. Amplifier A1's three connections are available for connection to external loop compensation components. The ERR signal drives two precision amplifiers, each with a gain of 8.5. The first of these amplifiers is inverting, and is formed from opamp A4, an on-chip resistor divider, and an off-chip complementary Bipolar Power Transistor pair. The second amplifier is non-inverting and is formed in a similar manner from opamp A5. Feedback from external transistor's collectors on sense inputs SE1 and SE3 allows the amplifier's gains to be precisely set. The voice coil motor and a series current sense resistor are connected between SE1 and SE3. The output of the amplifiers will provide the base current for the external H-Bridge Bipolar Power Transistors. The chip is designed to work with external transistors with a minimum Beta of 40 and minimum f_T of 40 MHz. The base bias resistors for the external bridge transistors are internal to the IC.

Cross over protection circuitry between the outputs of A4 and A5 and the external power transistors ensure Class B operation by allowing only one transistor in each leg of the H-bridge to be in conduction. The crossover circuitry can also disable all Power Transistors simultaneously (to limit motor current or velocity) or apply a constant voltage across the motor (to retract the heads at a constant velocity.)

Motor current is sensed by a small resistor placed in series with the motor. The voltage drop across this resistor is amplified by a differential amplifier with a gain of 4 (A2 and associated resistors), whose inputs are SE1 and SE2. The resulting output voltage, SOUT, is proportional to motor current, and hence acceleration. This signal is externally fed back to A1 so that the signal ERR represents the difference between the desired acceleration (from the servo controller) and the actual motor acceleration. The total output offset current (Vin = Vref, Rsense = 0.5 Ω) is less than 5.5 mA.

The SSI 32H6240 has low voltage monitor circuitry that will detect a decrease in the voltage at PS1 and PS2 pins. The +5V and +12V power supplies are divided down by external resistors and then compared to an internal 1.25V ±5% reference. The power supply pin, VCC, should be connected to the disk drive's spindle motor so that its stored rotational energy may be used to hold up VCC briefly during a power failure. When a low voltage condition is detected on either the PS1 or PS2 pins the BIPOLAR drivers switch from linear operation to retract mode. In this mode a constant voltage is applied across the motor which will cause the heads to move at a constant speed. A mechanical stop must be provided for the heads when they reach a safe location. External current limiting circuitry is required for both the linear and retract modes of operation. An open collector output, PFAIL, which is low in the linear mode, will go high to indicate a power failure. This signal is gated with the $\overline{\text{RETRACT}}$ input signal to force the chip into the Retract mode during power failure and to signal a BRK spindle. A BRK spindle is signaled by forcing a High level on the BRK open collector output which is normally low in the Linear mode. The BRK pin is provided for spindle motor braking. An external RC delay may be used to defer braking until the heads are retracted.

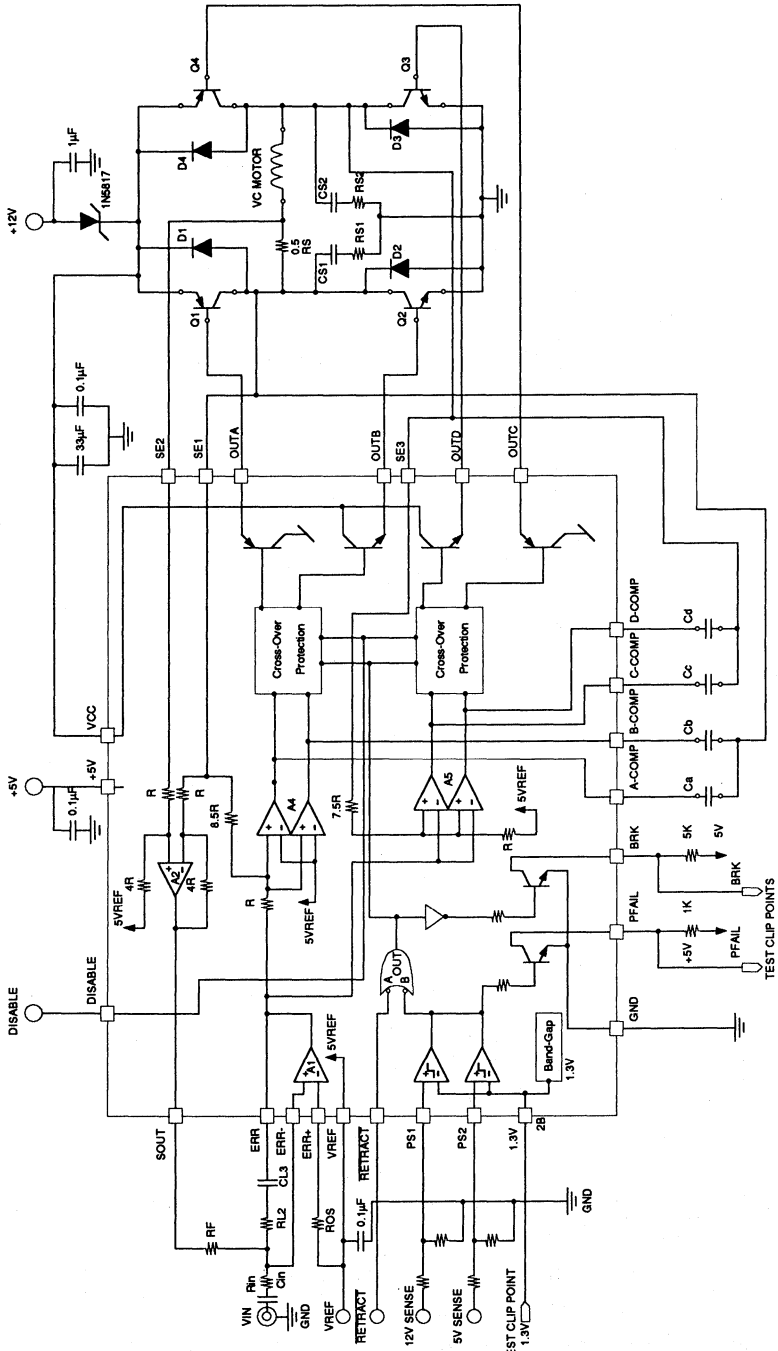


FIGURE 2: SSI 32H6240 Typical Application

5

PIN DESCRIPTION

POWER

NAME	TYPE	DESCRIPTION
VCC	-	POSITIVE SUPPLY - Usually taken from spindle motor supply. Spindle motor stored energy permits head retraction during power failure. If either a "Power Failure" or a "Retract" is asserted a forced head retraction occurs. Usually supplied through a power Schottky diode from Spindle Motor Supply.
+5V	I	5-volt power supply
VREF	I	REFERENCE VOLTAGE - 5.0V input. All analog signals are referenced to this input.
GND	-	GROUND

CONTROL

NAME	TYPE	DESCRIPTION
ERR	O	POSITION ERROR- Loop compensation amplifier output. This signal is amplified by the BIPOLAR drivers and applied to the motor by an external BIPOLAR H-bridge, as follows: SE3-SE1 = 17 (ERR-VREF)
ERR-	I	POSITION ERROR INVERTING INPUT - Inverting input to the loop compensation amplifier.
ERR+	I	POSITION ERROR NON-INVERTING INPUT - Non-inverting input to the loop compensation amplifier.
SOUT	O	MOTOR CURRENT SENSE OUTPUT - This output provides a voltage proportional to the voltage drop across the external current sense resistor, as follows: SOUT-VREF=4 (SE2-SE1)
BRK	O	BRAKE OUTPUT - Active high, open collector output which may be used to enable an external spindle motor braking transistor upon power failure. External resistor may be tied to +5 or +12V.
DISABLE	I	DISABLE DRIVERS INPUT – Logic level input. An input high level will cause all 4 bridge BIPOLAR Power Devices to turn off. DISABLE does not override retract.
$\overline{\text{RETRACT}}$	I	$\overline{\text{RETRACT}}$ INPUT – Logic level low will assert a forced head retraction. RETRACT will override DISABLE. $\overline{\text{RETRACT}}$ will continue to work at VCC=3.5V.
PS1	I	POWER SENSE 1 – 12V sense input to power fail comparator.
PS2	I	POWER SENSE 2 – 5V sense input to power fail comparator.
PFAIL	O	POWER FAIL – Power fail indicator open collector output. Floats if either supply goes below threshold.
1.3V	O	INTERNAL REFERENCE MONITOR - Used for testing purposes only.
A-COMP	O	AMPLIFIER A COMPENSATION - Compensation capacitor pin
B-COMP	O	AMPLIFIER B COMPENSATION - Compensation capacitor pin
C-COMP	O	AMPLIFIER C COMPENSATION - Compensation capacitor pin
D-COMP	O	AMPLIFER D COMPENSATION - Compensation capacitor pin

CONTROL (Continued)

NAME	TYPE	DESCRIPTION
SE2	I	MOTOR CURRENT SENSE INPUT - Non-inverting input to the current sense differential amplifier. It should be connected to one side of an external current sensing resistor in series with the motor. The inverting input of the differential amplifier is connected internally to SE1.

BIPOLAR DRIVE

SE3	I	MOTOR VOLTAGE SENSE INPUT - This input provides feedback to the non-inverting BIPOLAR driver amplifier. It is connected to one side of the motor. The gain to this point is: SE3-VREF = 8.5 (ERR-VREF)
SE1	I	MOTOR VOLTAGE SENSE INPUT - This input provides feedback to the inverting BIPOLAR driver amplifier. It is connected to the current sensing resistor which is in series with the motor. The gain to this point is: SE1 - VREF = -8.5 (ERR-VREF)
OUTA	O	PNP DRIVE (INVERTING) - Drive signal for a PNP power transistor connected between the current sense resistor and VCC. The PNP collector is also connected to SE1. Crossover protection circuitry ensures that the PNP and NPN devices driven by OUTA and OUTB are never simultaneously enabled.
OUTB	O	NPN DRIVE (INVERTING) - Drive signal for an NPN power transistor connected between the current sense resistor and GND. This NPN collector is also connected to SE1.
OUTC	O	PNP DRIVE (NON-INVERTING) - Drive signal for a PNP power transistor connected between one side of the motor and VCC. This PNP collector is connected to SE3. Crossover protection circuitry ensures that the PNP and NPN devices driven by OUTC and OUTD are never simultaneously enabled.
OUTD	O	NPN DRIVE (NON-INVERTING) - Drive signal for an NPN power transistor connected between one side of the motor and GND. This NPN collector is connected to SE3. Crossover protection circuitry ensures that the PNP and NPN devices driven by OUTC and OUTD are never simultaneously enabled.

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

(Maximum limits indicates where permanent device damage occurs. Continuous operation at these limits is not intended and should be limited to those conditions specified in the DC operating characteristics.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
VCC		0		16	V
VREF		0		10	V
+5V		0		7	V
SE1, SE2, SE3		-1.5		15	V
DISABLE, $\overline{\text{RETRACT}}$		-.3		+5V + .3	V
All other pins		-.3		VCC + .3	V
Storage temperature		-45		165	°C
Solder temperature	10 sec duration			260	°C

RECOMMENDED OPERATION CONDITIONS (Unless otherwise noted, the following conditions are valid throughout this document.)

VCC	Normal Mode	9	12	13.2	V
	Retract Mode	3.5V		13.2	V
+5V		4.5	5	5.5	V
VREF		4.5	5	5.5	V
Operating temperature		0		70	°C

DC CHARACTERISTICS

ICC, VCC current			13	20	mA
I5V, +5V Current			0.6	1	mA
IREF, VREF current			300		µA

A1, LOOP COMPENSATION AMPLIFIER

Input bias current				500	nA
Input offset voltage				3	mV
Voltage swing	About VREF		2		V
Common mode range	About VREF	±1			V
Load resistance	To VREF	4			kΩ
Gain			80		dB
Unity gain bandwidth			1		MHz
CMRR	f<20 kHz		60		dB
PSRR	f<20 kHz		60		dB

A2, CURRENT SENSE AMPLIFIER

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input impedance	SE1 to SE2	7.0	10		kΩ
Input offset voltage	SE1 = SE2 = VREF			2	mV
Output voltage swing		VREF-4		VCC-1.2	V
Common mode range		0		VCC-0.2	V
Load Resistance	To VREF	4			kΩ
Output impedance	f<40 kHz			20	Ω
Gain (SOUT-VREF)/(SE1-SE2)		1.95	2	2.05	V/V
Unity gain bandwidth			1		MHz
CMRR	f<20 kHz		52		dB
PSRR	f<20 kHz		60		dB

POWER SUPPLY MONITOR

1.3V pin voltage	1.3V pin open	1.18	1.25	1.31	V
PS1 threshold			1.25		V
PS2 threshold			1.25		V
PS1, PS2 Hysteresis			20		mV
PS1, PS2 Input Bias Current	PS1, PS2 = 1.3V		1		µA
PFAIL VOL	Linear mode IOC = 1mA			0.4	V
BRK VOL	Linear mode IOC = 1mA			0.4	V
PFAIL IOH	Retract mode VOH = 12V			10	µA
BRK IOH	Retract mode VOH = 12V			10	µA
DISABLE IIL	VIL = 0.8V		2	20	µA
$\overline{\text{RETRACT}}$ IIL	VIL = 0.8V		2	10	µA
DISABLE IIH	VIH = 2.4		1	10	µA
$\overline{\text{RETRACT}}$ IIH	VIH = 2.4		1	10	µA
DISABLE and $\overline{\text{RETRACT}}$ Threshold Voltage			1.4		V

BIPOLAR DRIVERS

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
SE3 Input Impedance	To VREF	10	25		kΩ
A Comp, C Comp Voltage Swing	w/ External Trans.	VCC - 1.4		VCC - .7	V
B comp, D Comp Voltage Swing	w/ External Trans.	0.7		1.4	V
Output Impedance A, B, C, D Comp	Output Off, No External Trans.		75		kΩ
Transconductance I (A, B, C, D Comp)/(ERR-VREF)			6		mA/V
Gain -(SE1-VREF)/(ERR-VREF) or (SE3-VREF)/(ERR-VREF)	Includes External Trans.	8	8.5	9	V/V
Offset Current (A2 Vos)	Rs = 0.5Ω Rf = Rin Vin = Vref		3.5		mA
Retract Motor Voltage (SE1-SE3)		0.7	1.3	1.7	V
Out B, Out D Source Current	Vout = 0.8V	20			mA
Out B, Out D Current Limit	Vcc = 10.8V, Out B, D = 0.8V Vcc = 12.0V, Out B, D = 0.8V	20 23	25 27	30 33	mA mA
Out A, Out C Sink Current	Vout = 11.2V	20			mA
B and D Output NPN Output Transistor Beta	Ic = 20mA Vce = 10V		20		V/V
A and C Output PNP Output Transistor Beta	Ic = 20mA Vce = 10V		10		V/V

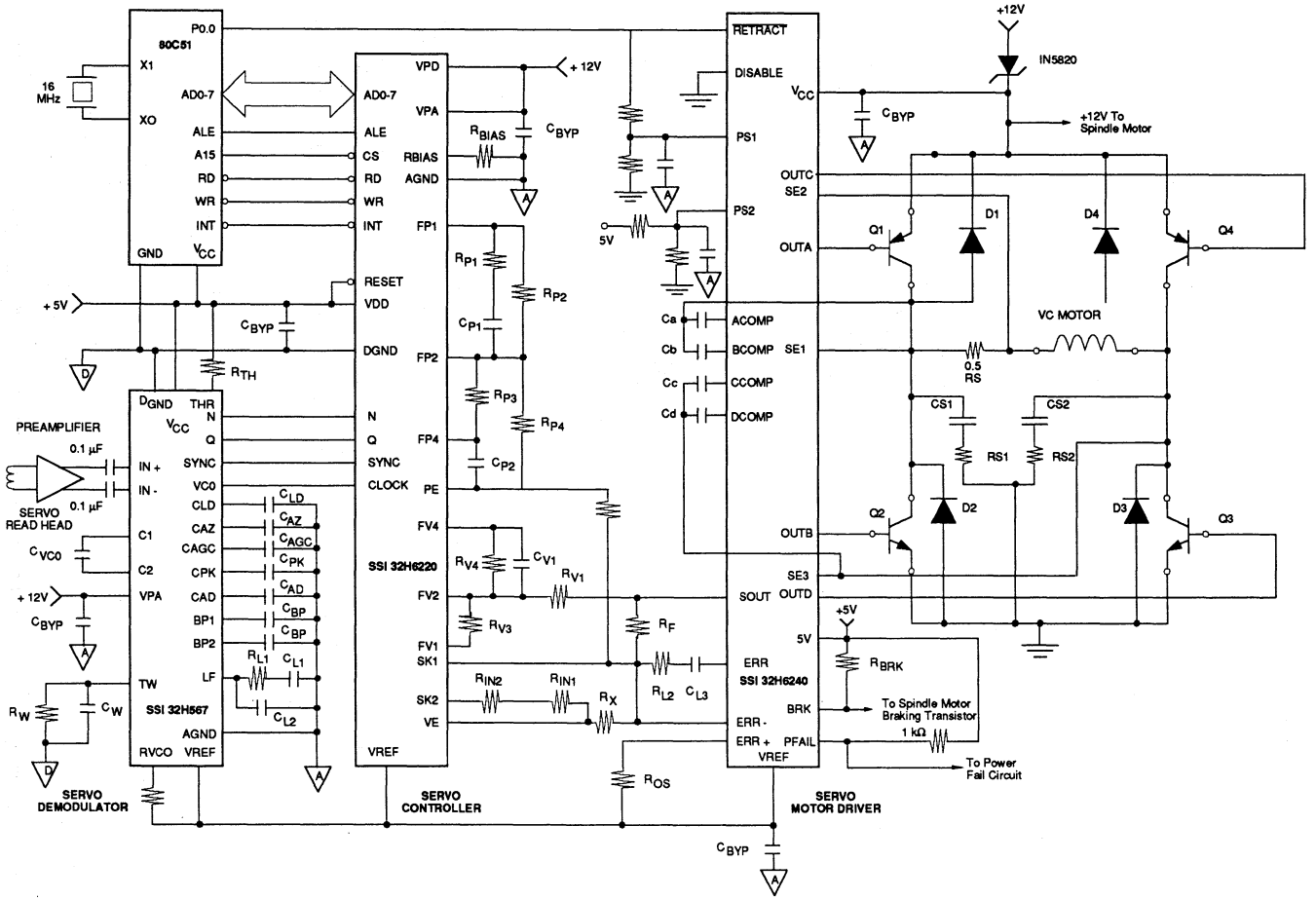
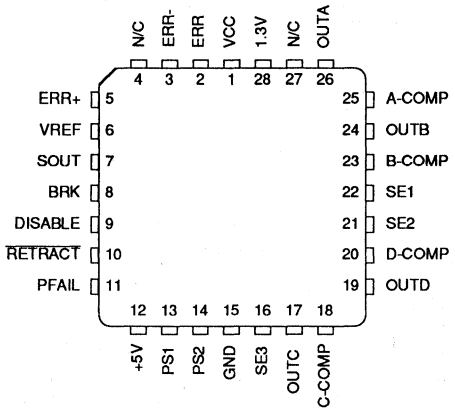


FIGURE 3: Complete Example of Servo Path Electronics using the SSI 32H567/6220/6240 Chip Set

SSI 32H6240
Servo Motor Driver

PACKAGE PIN DESIGNATIONS
(TOP VIEW)

CAUTION: Use handling procedures necessary for a static sensitive component.



28-Pin PLCC

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only. Do not use for final design.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX: (714) 731-5457

SERVO DESIGN EXAMPLE

The application of the SSI 32H568/32H6220 dedicated servo controller, SSI 32H569/32H6230 H-bridge predriver, and SSI 32H567 servo demodulator chips require both discrete component determination and microprocessor programmed register values. This section provides as a design example, a systematic method of determining both the discrete components and programmable values required in implementing a fully functional track and seek head positioning servo. This example makes use of an available Silicon Systems' program named SERVO CALC which runs on the PC/XT or PC/AT compatible personal computer. The program provides an interactive enviroment for entering target specifications, systematically proceeding through the design, and automating the calculation of components and programmable values. The program provides various tools for system performance review such as velocity profile plots, open and closed loop Bode plots, step response plot, mechanical resonances and notch filter effects.

SPECIFY SEEK PERFORMANCE REQUIREMENTS

Specifying the average seek time, total number of tracks for a full length seek, and profile characteristics will provide the basis for determining a precise head velocity profile. Profile characteristics specify the relationship between acceleration and deceleration under different conditions. The ratio of deceleration time plus settling time all divided by the acceleration time provides the profile characteristic "R." The number of tracks traveled in "triangular mode" divided by the total number of tracks for a full length seek provides the profile characteristic "BETA." These two profile characteristics may be used along with a modified square root law to determine a velocity profile which will result in satisfying the specified average seek time.

As an example, specify as design goals:

Linear actuator
1400 TPI for a G2 of 55,860 Tracks/Meter
1000 total cylinders
Average access time of 15 ms
30 gram actuator mass
R = 1.2 and BETA = 0.4

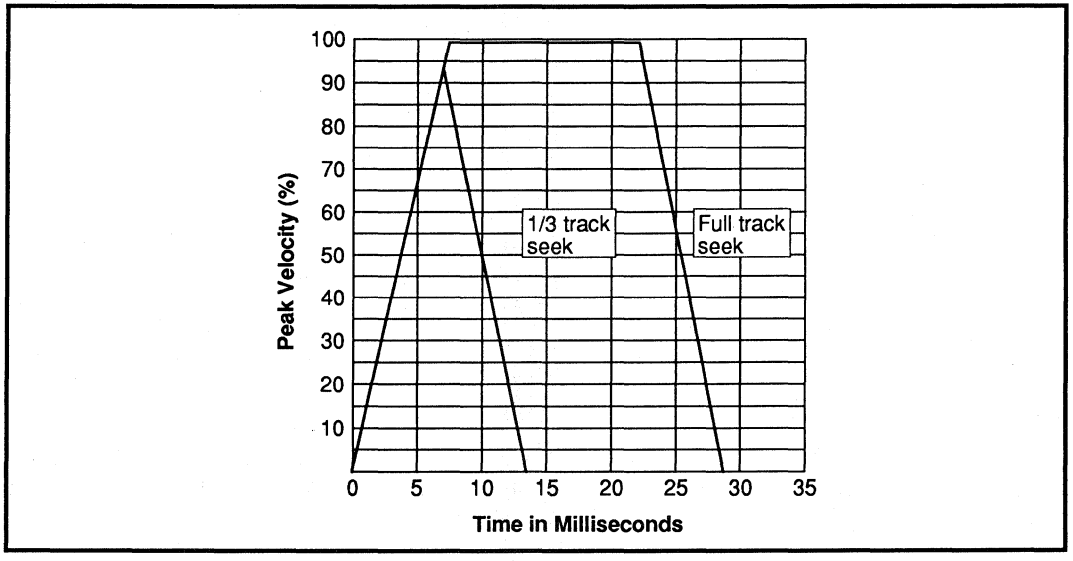


FIGURE 1: Track Seek Profile

REVIEW VELOCITY PROFILES

The deceleration profile may be reviewed and adjusted by modifying the square root law which relates profile head velocity to the number of tracks left to travel. Step-wise increasing the exponent of tracks to go from 1/2 (square root starting point) will "soften" the deceleration approach curve. As the curve softens, the settling time available decreases. The "R" value may be adjusted to match a suitable deceleration curve with the required settling time.

From the profile chosen, the following parameters may be determined for our example design:

Head acceleration of 6,175,115 tracks/sec^2

Peak head velocity of 49,699.5 tracks/sec

200 deceleration tracks required

8.05 ms of acceleration, 12.08 ms coasting, and 9.66ms decelerating full seek

Full seek time 29.8 ms

Both the average and full length seek profiles are shown in Figure 1.

SPECIFY MOTOR AND LOAD PARAMETERS

The motor and load parameters must be estimated and specified so that the power required to meet the velocity profile chosen may be computed and compared against design goals. G1 is preamplifier gain and is not dependent upon motor or load parameters. G1 is fixed at 6 VOLTS/TRACK when using the SSI 32H567. The motor resistance will introduce both a power loss and a voltage drop which must be considered. The two motor systems, namely linear and rotary, require different units of specification.

Linear Motor Specifications

G2 transport constant in Tracks/Meter

J mass in KG (kilograms)

Km motor constant in N/A (newton/amps)

Rotary Motor Specifications

G2 transport constant in Tracks/Rad

J inertia in KG m^2 (kilograms meter squared)

Km motor constant in (N • m/A)

Optionally, Km may be computed from the head velocity profile based on a specified maximum motor current IPEAK. The two specifications of IPEAK and Km are interrelated.

For our example,

IPEAK is 1 Amp and Km is calculated

Rm = 3.8Ω

Rs = 0.2Ω

REVIEW MOTOR VOLTAGE, POWER AND Km

From the motor and load specifications, the required peak current needed to satisfy the chosen head velocity profile may be calculated. Using the transport constant G2, the back EMF of the motor may be calculated at peak head velocity and added to the the voltage drop across the motor resistance Rm and sense resistor Rs. The total voltage required by the motor may be compared to the available driver voltage. Peak motor power may be computed and compared to design goals. If Km was calculated from a specification of IPEAK, the resulting value of Km may be compared against that actually attainable in the motor design. Adjustment of Km and IPEAK may be made to both satisfy the average seek time specification and general design goals.

For this example:

Km was calculated to be 3.316 N/A

Peak drive voltage required is 6.95V including the voltage across Rs

Peak coil input power is 6.75 Watt

Coil dissipation 3.8 Watt

SPECIFY POWER AMPLIFIER COMPONENTS

The power amplifier is shared by both the track following and seek servo control loops. The determination of DC gain for the power amplifier for seek will also determine some components shared with the track following servo. Referring to the example schematic of the SSI 32H567/6220/6230, RS, RF and the sum resistance of RINV1 and RINV2 (RINV) may be determined. Choosing RF to be an initial nominal value such as 10,000Ω and choosing RS as some small resistance such as 0.2Ω provides good starting points.

The DC power amplifier gain for the seek servo is calculated from the peak current required to satisfy the peak velociyy of the velocity profile and the full scale target DAC output voltage. A motor current limit may be implemented when using the SSI 32H6230 by connecting the CLAMP pin to ERR- through the RINV1 and RINV2 network as shown on the schematic. The limit voltage is programmable by setting the voltage at the 6230 VLIM pin. It is necessary to choose the limit current higher with tolerance margin above that current required to meet the maximum head velocity from the velocity profile.

In the example,

RINV total should be 5062.5Ω

RF is specified as 10,000Ω

CHOOSE DIFFERENTIATOR AND VELOCITY LOOP GAINS

The differentiator within the SSI 32H568 or 32H6220 provides a programmable corner frequency determined by servo frame rate and the two bit register ND. Having determined the maximum head velocity from the velocity profile and knowing the transport constant and servo frame rate, the maximum output voltage from the differentiator may be calculated.

The output of the differentiator is amplified by the velocity amplifier A3 and the programmable gain stage set by NVG. The velocity loop gain from the output of the differentiator to the feed back summing junction of the target DAC must be set so that the peak differentiator output voltage will result in zero VE voltage (relative to VREF) when the target DAC is at its full range of 255. Choosing a nominal NVG setting of 10 and selecting an ND which does not exceed the amplitude limit of the differentiator itself, will result in the calculation of the necessary gain in A3. The seek velocity feedback may be fine tuned by adjusting the gain of NVG as indicated in drive self-calibration.

For the example, the programmable registers are:

NVG is 10 decimal

ND will be 2 for a frame rate of 250 kHz

Gain of A3 will be 1.96 so that (RV4/RV3) = 1.96; If RV4 = 19.6K, then RV3 = 10K

RV1 and CV1 will not be used in this example

GENERATE TARGET PROFILES

The seek servo velocity loop is closed within the SSI 32H568 or 32H6220. The implementation of the velocity profile is commanded by the supporting microprocessor. The microprocessor commands target velocities by writing to the target DAC. The necessary DAC values may be derived from the velocity profile. The acceleration DAC value is determined from the peak head velocity in the velocity profile. The microprocessor writes the acceleration target velocity to the target DAC and monitors track crossings determining when to begin deceleration. Once the head has moved past the deceleration corner, the microprocessor will write the deceleration target velocities to the target DAC usually track by track thereby following the head velocity down to the transition point into track following. The number of table entries making up the deceleration table can be found from the profile data discussed in the earlier section, Review Velocity Profiles.

A fill table may be generated corresponding to the target velocity table. The fill table is usually only a few entries long. The fill table values are computed from the position error voltage available at FP1 and the step in target DAC voltage for the last few deceleration velocity targets. The fill value programs the gain of the fill amplifier which subtracts from the velocity error a portion of the position error signal. This subtraction of position error from the velocity error has the effect of smoothing the velocity error voltage at VE when the head is moving slowly and tends to insure that the head will move towards the center of the target track prior to switching on track following.

The 20 element fill value table resulting for the example is shown below in Table 1. "t" is the target track.

Target Track Lineup	
t-0: 12	t-10: 2
t-1: 5	t-11: 1
t-2: 4	t-12: 2
t-3: 3	t-13: 1
t-4: 3	t-14: 2
t-5: 3	t-15: 1
t-6: 3	t-16: 1
t-7: 2	t-17: 1
t-8: 2	t-18: 2
t-9: 2	t-19: 1

TABLE 1

The velocity target DAC values for the example are listed below in Table 2, ordered as the number of tracks remaining to go, ie: "t-n":

t-0	t-20	t-40	t-60	t-80	t-100	t-120	t-140	t-160	t-180
0	81	114	140	161	180	198	213	229	243
18	83	115	141	162	181	198	214	229	243
25	85	117	142	163	182	199	215	230	244
31	86	118	143	164	183	200	216	231	245
36	88	120	144	165	184	201	217	232	245
40	90	121	145	166	185	202	218	232	246
44	92	122	146	167	186	202	219	233	247
48	94	124	148	168	187	203	219	234	247
51	95	125	149	169	187	204	220	234	248
54	97	126	150	170	188	205	221	235	249
57	99	127	151	171	189	206	222	236	249
60	100	129	152	172	190	206	222	236	250
62	102	130	153	173	191	207	223	237	250
65	104	131	154	174	192	208	224	238	251
67	105	132	155	175	193	209	224	239	252
70	107	134	156	176	193	209	225	239	252
72	108	135	157	177	194	210	226	240	253
74	110	136	158	178	195	211	227	241	254
76	111	137	159	178	196	212	227	241	254
79	113	138	160	179	197	213	228	242	255

TABLE 2

POWER AMPLIFIER COMPENSATION

Components RL2 and CL3 set the bandwidth of the power amplifier. Specifying motor inductance Lm and power amplifier bandwidth BW while having determined RF, Rm, and Rs from seek requirements provides the means for calculating CL3 and RL2.

For the example,

Power amplifier bandwidth is specified as 10 kHz

Lm is specified as 1 mH

CL3 is calculated to be 0.005 µF

RL2 is calcuated to be 47 kΩ

TRACK FOLLOWING GAIN

Both the track following and seek loops share many of the power amplifier gain setting components. Having determined RINV, RF and Rs from velocity profile requirements, the track following power amplifier gain KP is determined entirely by RINP. The track following power amplifer gain KP is interactively set with the position loop filter gain KF. An initial KP may be chosen as 1 AMP/VOLT and the value of KF may be adjusted as needed to stabilize the track following loop. The value of RINP may be computed from RF, Rs, and KP.

In the example,

Specify KP = 1 Amp/Volt

Calculate RINP = 12.5 kΩ

POSITION LOOP FILTER

The implemented filter will take the form of a LAG-LEAD-LEAD-LAG in ascending frequency breakpoints. Due to the double integration in the motor-load mechanics going from acceleration to position, there is an initial 180 degree position phase lag which must be compensated to prevent instability and oscillation. Phase lag introduced by a pole will add additional phase lag exceeding 180 degrees while phase lead introduced by a zero will reduce phase lag. The objective of the position loop filter is to ensure that there

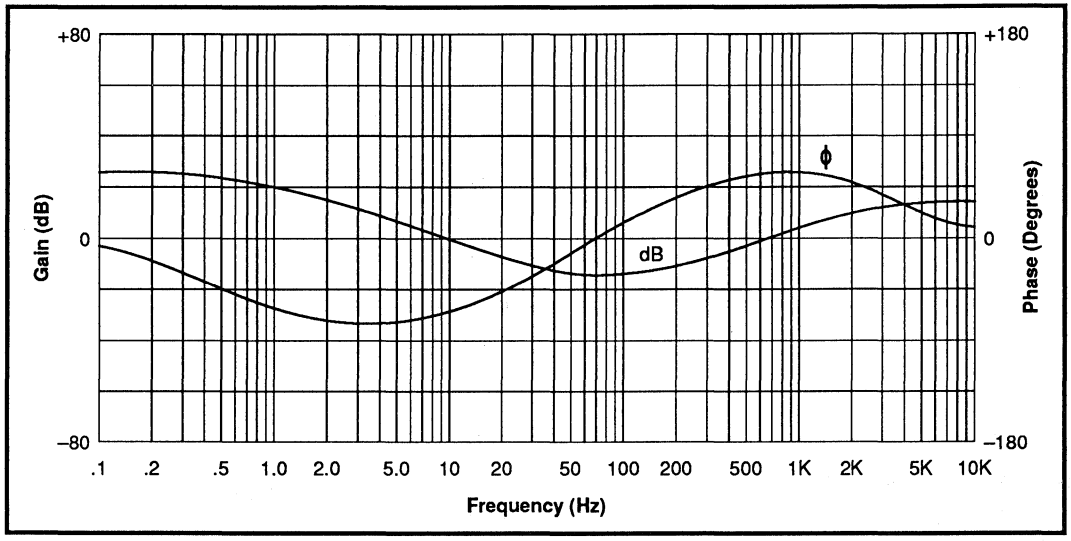


FIGURE 2: Position Loop Filter Bode Plot

is phase margin at the system unity gain crossover frequency while at the same time providing stiffness and long term tracking error cancelation.

The initial position loop filter gain KF may be estimated through a specification for DC stiffness. Specifying a stiffness in units of force per track and knowing G1, Km, and KP will provide a way to solve for KF.

DC stiffness per track is calcuated as:

STIFFNESS = G1 KF KP Km

Specifying 100 N/TRACK stiffness, KF is determined in the example to be 5.

The lowest frequency LAG time constant is referred to as bT2 and is the product CP2(RP3+RP4). This low frequency LAG serves effectively as an integrator with limited DC gain intended to minimize long term tracking error and allowing an increased DC gain improving stiffness which otherwise would not be possible due to mechanical higher frequency resonances. Time constant bT2 generally should be made as large as practically possible. Choosing a value for CP2 such as .47 µF and a pole frequency between 0.1 and 1 HZ will provide a good starting point.

The track following servo is stabilized by providing phase margin at the unity gain crossover frequency. Phase margin is obtained through the use of the two LEAD networks. The first lead breakpoint compensates for the integrator phase lag and the second lead breakpoint provides the required phase margin. Time constant T2 made up of RP3 and CP2 provides the phase lead needed to bring the phase back towards 180 degrees of phase lag. Lead time constant aT1 provides additional phase lead by reducing the phase lag less than 180 degrees at the unity gain crossover frequency. Choosing the time constant aT1 such that its break point frequency is equal to the unity gain crossover bandwidth for the system will provide approximately 45 degrees of phase margin. Time constant T2 needs to be chosen to be at least five times aT1 thereby minimizing the interactive effects of the two leads together. T2 should not be chosen so low in frequency as to cancel out the effects of the integrator lag and the low frequency gain enhancement.

Finally, the high frequency pole T1 determined by RP1 and CP1 provides a high frequency gain limit. The breakpoint frequency associated with the time constant T1 should be placed several times higher than the breakpoint frequency set by aT1. Mechanical resonances may require further adjustment of the T1 breakpoint frequency. Some systems may require additional

POSITION LOOP FILTER (Continued)

notch filters to minimize high frequency mechanical effects.

Having chosen the break point frequencies, the position filter components may all be computed having specified CP2 and KF.

For the example, the break points were initially specified as:

bT2 frequency = 0.6 Hz

T2 frequency = 60 Hz

aT1 frequency = 600 Hz (target system unity gain bandwidth)

T1 frequency = 2000 Hz

TRACK FOLLOWING SYSTEM RESPONSE REVIEW

Bode plots of the open loop response for the LAG-LEAD-LEAD-LAG position loop filter are useful in evaluating the break point frequencies chosen. More useful is the system open loop Bode plot which provides the necessary information needed to properly adjust KF to meet the desired system unity gain bandwidth. Adjusting KF will move the overall response vertically such that unity gain occurs at the desired system bandwidth frequency. The amount of vertical movement indicates how KF should change relative to its intial current value. The phase margin peak may be adjusted horizontally by changing the time constants aT1 and T2. Moving the peak phase lead to correspond to the unity gain frequency is desireable. The system unity bandwidth indicates the stability of the servo system by the amount of phase margin at the unity gain crossover point. Figure 2 shows the open loop position filter Bode plot. Notice the peaking of phase near the target system unity bandwidth frequency of 600 Hz. Figure 3 shows the overall open loop system Bode plot.

After review and adjustment, the final components were standardized as:

RP1 = 8,250Ω

RP2 = 91 kΩ

RP3 = 13 kΩ

RP4 = 680 kΩ

CP1 = 0.0075 µF

CP2 = 0.47 µF

Which resulted in actual break points of:

bT2 frequency = 0.49 Hz

T2 frequency = 26 Hz

aT1 frequency = 213 Hz

T1 frequency = 2572 Hz

And KF = 7.47 for a DC stiffness of 148 N/Track. The resulting phase margin is 51.60 degrees at 630 Hz. The gain margin is 25.2 dB at 4800 Hz.

The closed loop system step response may be obtained and examined to evaluate the overshoot and settling time. The integrator time constant bT2 will tend to control the settling time or "tail." The time constants aT1 and T2 effect the amount of ringing and overshoot. Figure 4 shows the response of the system to a position step.

For the example,

Overshoot is 30%

First zero crossing at 0.4 ms

Settling within 2 ms

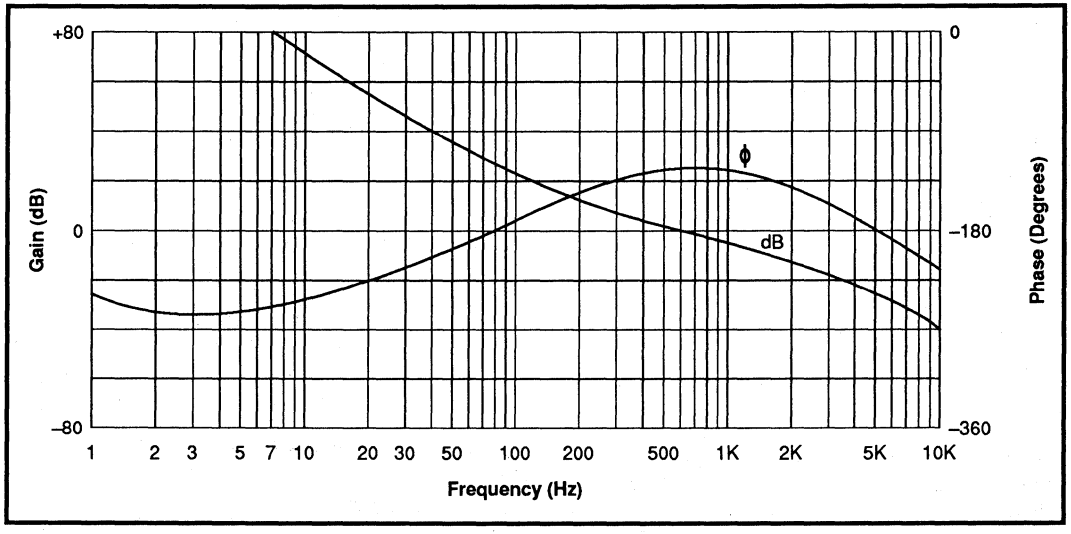


FIGURE 3: Overall Position Open Loop Bode Plot

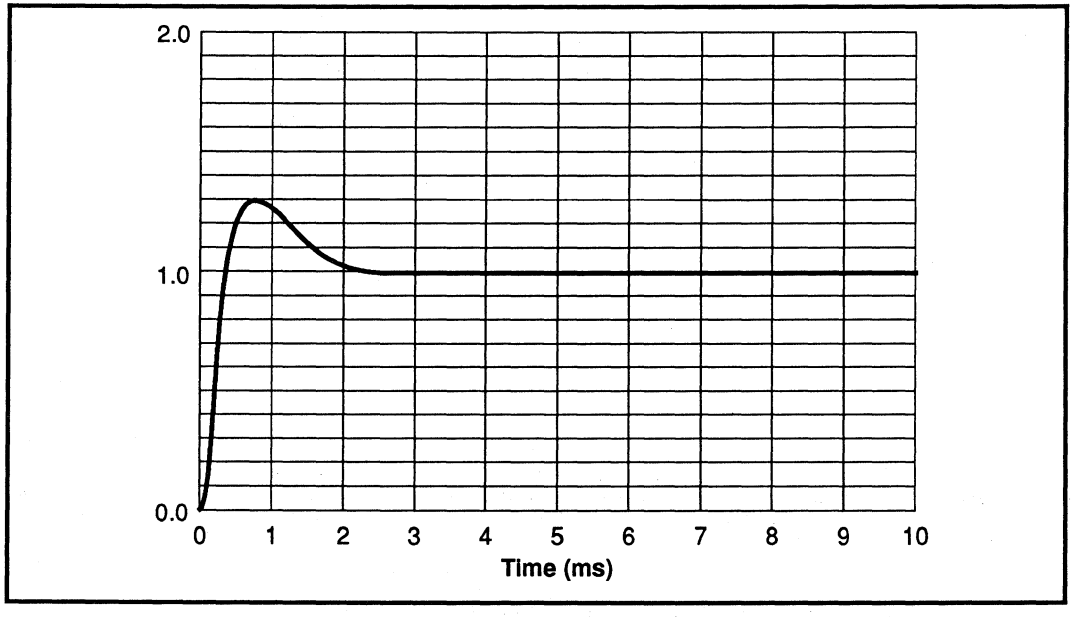


FIGURE 4: Position Closed Loop Step Response

SERVO CALC SOFTWARE

HEAD POSITIONING APPLICATIONS TOOL

DESCRIPTION

This software is an aid to disk drive head position servo design using SSI 32H568, 32H6220, 32H569, 32H6230 servo controller and servo motor driver chips. It uses block diagram algebra and transfer function analytical techniques to arrive at first order approximations for the servo design values and parameters. This software offers visual representations of block diagrams, transfer functions, schematics, as well as Bode, seek profile and step response plots. It includes design aids for the design of velocity profiles and tables for evaluation of gain and characteristics settings. It uses simple menus to choose the design screens for power amplifier and position loop filter design and design modules for seek profile/loop parameters and their components. It also has a user definable polynomial transfer function for Bode plot and step response evaluations. The effects of parameter and component changes are specially flagged and quickly displayed.

SERVO CALC PROGRAM FEATURES

- Mathematical modeling
- Polynomial transfer functions displayed/described
- Block diagrams displayed
- Individual design screens displaying design progress
- Stability analysis
- Bode and step response plots
- Mechanical resonance and notch filter effects
- Motor current and power dissipation analysis
- Velocity profile and fill table generation
- Develops design for power amplifier components
- Tabulates and displays design choices in velocity loop
- User-controllable plot and print settings

MINIMUM SYSTEM REQUIREMENTS TO RUN SERVO CALC

An IBM PC/XT/AT or compatible computer with at least 512 Kb of RAM, EGA or EGA-compatible video adapter and monitor, one 5 1/4 inch floppy disk drive. A dot matrix printer for plots and screen printings is optional. A math co-processor and a hard disk is recommended but not required.

For your copy of the SERVO CALC software and other helpful servo tools, please contact your local representative or Silicon Systems, Inc. at (714) 731-7110 ext. 3575.

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX: (714) 731-5457

Section 6

HDD SPINDLE MOTOR CONTROL

SSI 32M590-Series
5-1/4 Inch
Motor Speed Control

July, 1990

DESCRIPTION

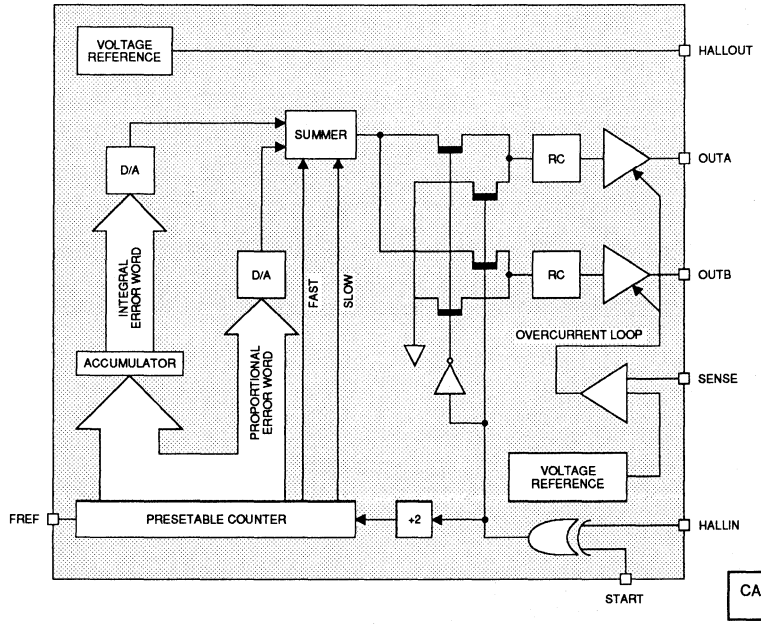
The SSI 32M590-Series consisting of SSI 32M5901 and SSI 32M5902 are motor controller ICs designed to provide all timing and control functions necessary to start, drive and brake a two-phase, four-pole, brushless DC spindle motor. The IC requires two external power transistors (such as Darlington power transistors), three external resistors, and an external frequency reference. The motor HALL sensor is directly driven and decoded by the device. The controller is optimized for a 3600 rpm disc drive motor using a 2 MHz clock. Motor protection features include stuck rotor shutdown, coil over-current detection and control, and supply fault detection. The device's linear control loop controls the power drivers using Pulse Amplitude Modulation.

FEATURES

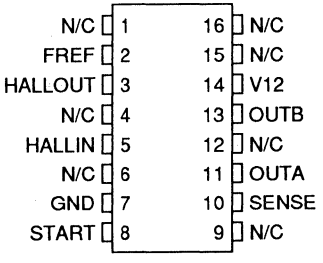
- **Available in 8-pin DIP (SSI 32M5901), 14-pin DIP (SSI 32M5902) or 16-pin SOL (SSI 32M5902)**
- **CMOS with single +12 volt power supply**
- **All motor START, DRIVE and STOP timing and control**
- **Includes HALL-Effect sensor drive and input pins**
- **Highly Accurate speed regulation of ±0.035%**
- **On-chip digital filtering requires no external compensation or adjustments**
- **Provides protection against stuck rotor, coil over-current, and supply fault**
- **Regenerative braking with shutdown**

6

BLOCK DIAGRAM



PIN DIAGRAM



SSI 32M5902

CAUTION: Use handling procedures necessary for a static sensitive component.

CIRCUIT OPERATION

The device incorporates both analog and digital circuit techniques to utilize the advantages of each. The analog portion of the loop uses switched capacitor filter technology to eliminate external components. The control loop uses a Pulse Amplitude Modulation (PAM) control scheme to avoid the switching transients and torque ripple inherent in Pulse Width Modulation (PWM) schemes.

A binary counter is preset once per motor revolution by an index signal generated by the HALL position sensor. On the next index pulse, the remaining least significant bits are loaded into the proportional D/A and accumulated by a saturation accumulator. The most significant bits are loaded into the integral D/A. The size of the accumulator and the bit locations determine the major scaling (within a factor of two) for the gain and zero location of the filter. To prevent overflow in the proportional D/A the counter is decoded to detect overflow, and the proportional D/A is saturated as needed. The overflow also generates a boost signal used in the summer. The range of the accumulator is larger than the linear range of the proportional channel to help filter small load disturbances that tend to saturate the proportional channel. The entire counter is also used to provide a time-out feature to protect the motor and external circuitry.

PIN DESCRIPTION

NAME	TYPE	DESCRIPTION
FREF	I	Frequency Reference Input. A TTL compatible input used by the device to set and maintain the desired motor speed and operate circuit blocks.
HALLOUT	O	Provides a regulated bias voltage for the HALL effect sensor inside the motor.
HALLIN	I	HALL Sensor Input. The TTL open-collector type output of the motor's Hall switch feeds this input which has a resistor pullup to the HALLOUT bias voltage. Refer to Figure 1 for input timing.
OUTA, OUTB	O	Driver Outputs. These two driver outputs drive the external power transistors, such as TIP120 NPN Darlington power transistors as shown in the typical application. The power transistors control the motor current through the current setting resistor Re. The motor current is V (sense)/Re. During normal operation, the drive voltages are adjusted as necessary to maintain the proper motor speed and drive current. Regenerative braking is accomplished with self biasing of the power transistors thru resistors Rb with power shutdown. Refer to Figure 1 for output timing.
SENSE	I	Coil Current Sense Line. Senses the coil current and limits the sense voltage to the threshold by limiting the drive to the external power transistors.
N/C	-	No Connection, 14-pin package only. These pins must remain unconnected and floating.
START	I	

PROTECTION FEATURES

LOW VOLTAGE DETECTION

If the supply drops below the detect threshold the device will turn off all of the external power transistors to prevent damage to the motor and the power devices.

STUCK ROTOR SHUTDOWN

If the delay from power onset to a positive Index transition or the time interval between successive Index transitions is greater than the prescribed time, the device interprets this delay as a stuck rotor and reduces the motor current to zero until such time as one positive HALLIN transition is detected or until power is removed and reapplied.

MOTOR COIL OVER-CURRENT

Refer to SENSE input description. Sense voltage is generated by current through Re shown in the typical application. The SENSE input threshold limits the maximum coil current.

ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNIT
Positive Supply Voltage, VDD	14	V
Storage Temperature	-65 to +125	°C
Ambient Operating Temperature	0 to 70	°C
HALLIN, FREF, and SENSE Input Voltages	-0.3 to VDD +0.3	V
HALLOUT Current	10	mA
Lead Temperature (soldering, 10 sec.)	260	°C
Power Dissipation	400	mW

6

RECOMMENDED OPERATING CONDITIONS

Unless otherwise specified, 10.8V ≤ V12 ≤ 13.2V; 0 °C ≤ Ta ≤ 70 °C; FREF = 2.00 MHz; Re = 0.4Ω ± 10% (2 watt); Rb = 4.7 kΩ ± 10% (1/4 watt); 0.8 ≤ Darlington Vbe ≤ 1.8

Motor Parameters: (1 to 3 platters)

KT	Torque constant	= 0.015 Nt-m/amp ±10%
J	Inertia	= 0.000489 Nt-m/s/s ±33%
KD	Damping factor	= 0.0000318 Nt-m/rad/s ± 33%

where: $\frac{\text{Motor Frequency (s)}}{\text{Motor Current (s)}} = \frac{KT}{J \times s + KD}$

DC ELECTRICAL CHARACTERISTICS

PARAMETERS	CONDITIONS	MIN	NOM	MAX	UNIT
POWER SUPPLY CURRENT					
ICC (Includes Drive Outputs)		(17 typ)		30	mA
FREF AND START INPUTS					
Input Low Voltage	Iil = 500 µA			0.8	V
Input High Voltage	Iih = 100 µA	2.0			V

DC ELECTRICAL CHARACTERISTICS (Continued)

PARAMETERS	CONDITIONS	MIN	NOM	MAX	UNIT
HALL SENSOR INTERFACE					
HALLOUT Bias voltage	I = 5 mA	5.0		6.8	V
HALLOUT Pullup Resistance	To HALLOUT Pin	5		20	kΩ
Input Low Voltage				1.0	V
Input High Voltage		4.0			V
DRIVER OUTPUTS					
Sink Capability	VOUTA or VOUTB = 0.5 Volts	5.0			mA
Source Capability	VOUTA or VOUTB = 3.0 Volts	-5.0			mA
Capacity Load Drive Capability				50.0	pF
SENSE INPUT					
Threshold Voltage		0.9		1.1	V
Input Current		-100		100	µA
Input Capacitance				25.0	pF
STUCK ROTOR DETECTION					
Shutdown Time	Power On To Driver	0.815		0.935	sec
LOW VOLTAGE DETECTION					
Detect Threshold		6.0		9.0	V
CONTROL LOOP - DESCRIPTION*					
Divider Ratio	FREF/Avg. Motor Frequency	16664		16672	
Index to Index Jitter	Total Jitter			8.0	µs
Loop Gain H (2 X π X f)	f = 2 Hz		0 Typical		dB
Loop Zero	Kp/Ki	0.97		1.03	Hz
CONTROL LOOP Vs SUPPLY VARIATION					
$\frac{Kp\,(V12 = 13.2V)}{Kp\,(V12 = 10.8V)}$		0.96		1.04	
$\frac{Ki\,(V12 = 13.2V)}{Ki\,(V12 = 10.8V)}$		0.96		1.04	
START/STOP VELOCITY PROFILES					
Power on Delay to FHALL Greater than FREF/16668	1 Platter	7.0		11.0	sec
	2 Platters	9.0		13.0	sec
	3 Platters	11.0		15.0	sec
Speed Overshoot $\frac{FHALL - (FREF/16668)}{(FREF/16668)}$	1 Platter	0.5		2.0	%
	2 Platters	0.5		2.0	%
	3 Platters	0.5		2.0	%

START/STOP VELOCITY PROFILES (Continued)

PARAMETERS	CONDITIONS	MIN	NOM	MAX	UNIT
Setting Time: Motor	1 Platter	9.0		13.0	sec
Frequency Settles to 0.05%	2 Platters	11.0		15.0	sec
	3 Platters	13.0		17.0	sec
Stop Time (Regenerative):	1 Platter	7.0		13.0	sec
Motor Frequency Slows to	2 Platters	8.0		15.0	sec
30% after Power is Removed	3 Platters	9.0		17.0	sec
Stop Time (Active):		4.0			sec

*The continuous Time Transfer Function of the on-chip control can be modeled as follows:

$$H(s) = \frac{Vc(s)}{F(s)} = Ki \times \frac{(1 + s/(2 \times \pi \times (Kp/Ki)))}{s}$$

Ki = Integral gain
Kp = Proportional gain

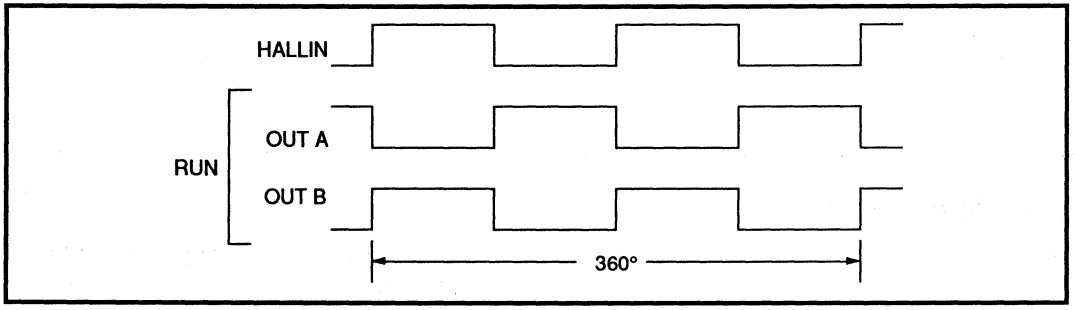


FIGURE 1: Firing Order

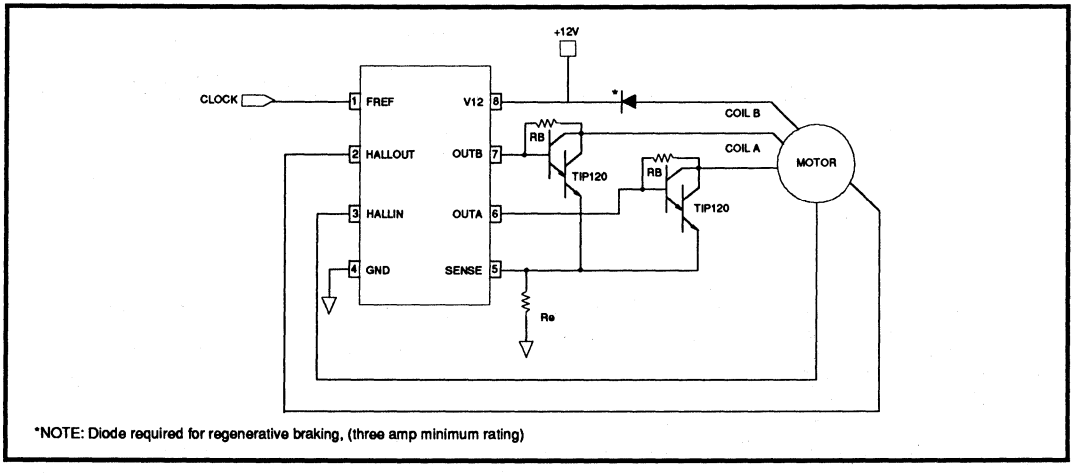
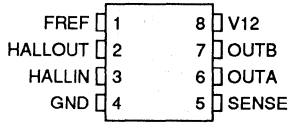


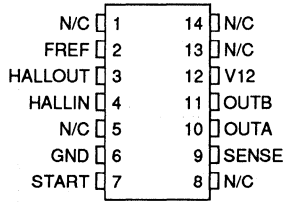
FIGURE 2: Typical Application

SSI 32M590-Series
5-1/4 Inch
Motor Speed Control

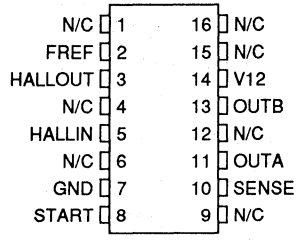
PACKAGE PIN DESIGNATIONS
(TOP VIEW)



SSI 32M5901
8-Pin PDIP



SSI 32M5902
14-Pin PDIP



SSI 32M5902
16-Pin SOL

ORDERING INFORMATION

PART DESCRIPTION	ORDERING NUMBER	PACKAGE MARK
SSI 32M590-Series		
8-Pin PDIP	SSI 32M5901-CP	32M5901-CP
14-Pin PDIP	SSI 32M5902-CP	32M5902-CP
16-Pin SOL	SSI 32M5902-CL	32M5902-CL

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32M591
Three-Phase 5-1/4 Inch Winchester Motor Speed Control

July, 1990

DESCRIPTION

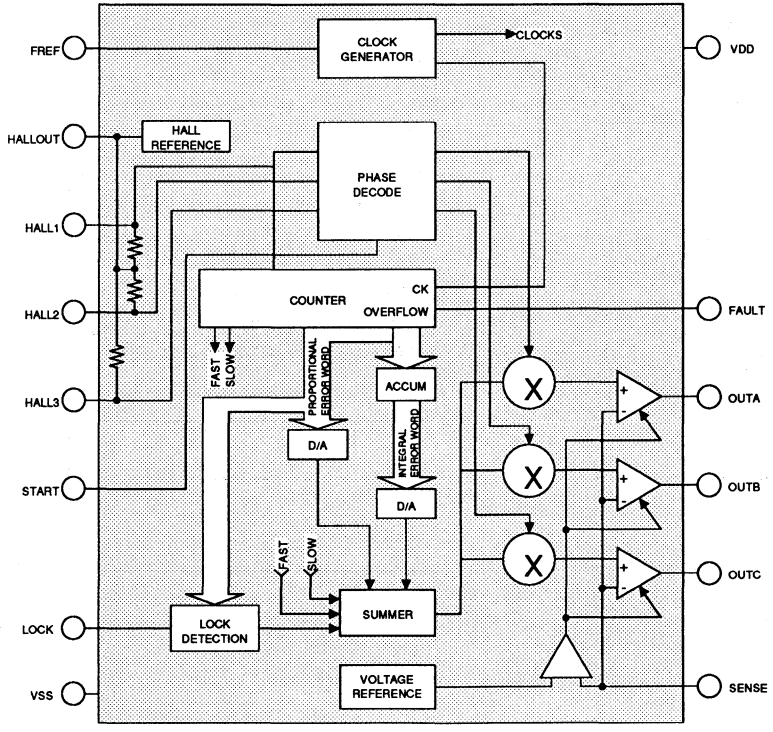
The SSI 32M591 is a motor controller IC designed to provide all timing and control functions necessary to start, drive and brake a three-phase brushless DC spindle motor. The IC requires three external power transistors (such as Darlington power transistors), one external power resistor, and an external frequency reference. The three motor HALL sensors are directly driven and decoded by the device. The controller is optimized for a 3600 rpm disk drive motor using a 2 MHz clock. Motor protection features include stuck rotor shutdown, supply and clock fault detection, all of which are indicated by a FAULT signal, and coil over-current detection and control. A LOCK signal is provided to indicate that the motor is at speed. The device's linear control loop controls the power drivers using Pulse Amplitude Modulation.

FEATURES

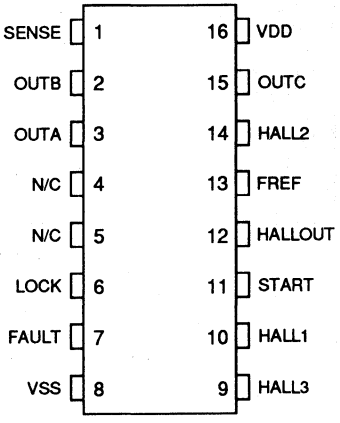
- **CMOS with TTL/LSTTL compatible control functions**
- **Single +12 volt power supply**
- **All motor START, DRIVE, and STOP timing and control**
- **Includes HALL-Effect sensor drive and input pins**
- **Highly accurate speed regulation of ±0.05 %**
- **On-chip digital filtering requires no external compensation of adjustments**
- **Provides protection against stuck rotor, motor coil over-current, supply fault, or clock fault**
- **At speed indication provided**

6

BLOCK DIAGRAM



PIN DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

CIRCUIT OPERATIONS

The device incorporates both analog and digital circuit techniques to utilize the advantages of each. The analog portion of the loop uses switched capacitor filter technology to eliminate external components. The control loop uses a Pulse Amplitude Modulation (PAM) control scheme to avoid the switching transients and torque ripple inherent in Pulse Width Modulation (PWM) schemes.

PIN DESCRIPTION

SYMBOL	I/O	DESCRIPTION
VDD	I	+12V Power supply
VSS	I	Ground
FREF	I	FREQUENCY REFERENCE INPUT: A TTL compatible input used by the device to set and maintain the desired motor speed and operate circuit blocks. This input level must not exceed VDD at any time.
HALLOUT	O	HALL SENSOR BIAS OUTPUT: Provides a regulated bias voltage for the Hall effect sensors, inside the motor.
HALL1, HALL2, HALL3	I	HALL SENSOR INPUTS: The TTL open-collector type outputs of the motor's Hall switches feed these inputs which have a resistor pullup to the HALLOUT bias voltage. The HALL1 input is used to index the control loop counter. Refer to figure 1 for input timing.
OUTA, OUTB, OUTC	O	DRIVER OUTPUTS: These three driver outputs drive the external power transistors, such as TIP120 NPN Darlington power transistors shown in the typical application. The power transistors control the motor current through the current setting resistor Re. The motor current is V(sense)/Re. During normal operation, the driver output voltages are adjusted as necessary to maintain the proper motor speed and drive current. Refer to figure 1 for output timing.
SENSE	I	COIL CURRENT SENSE INPUT: Senses the coil current and limits the sense voltage to the threshold by limiting the drive to the external power transistors.
LOCK	O	AT SPEED INDICATOR OUTPUT: An open drain LSTTL compatible output that indicates with an active low that the period of the motor is within the controller's linear range. Because of the accuracy of the loop, the LOCK pin is a good "at speed" indicator.
FAULT	O	FAULT INDICATOR OUTPUT: Goes high when the motor is determined to be stalled, VDD is low, or FREF clock is too slow.
N/C	-	NO CONNECTION: These pins must be left unconnected and floating.
START	I	

FUNCTIONAL DESCRIPTIONS

A binary counter is preset once per motor revolution by an index signal developed from the HALL1 input. On the next index pulse, the remaining least significant bits are loaded into the proportional D/A and accumulated by a saturating accumulator. The most significant bits are loaded into the integral D/A. The size of the accumulator and the bit locations determine the major scaling (within a factor of two) for the gain and zero location of the filter. To prevent overflow in the proportional D/A , the counter is decoded to detect overflow and the proportional D/A is saturated as needed. The overflow also generates a boost signal used in the summer. The range of the accumulator is larger than the linear range of the proportional channel to help filter small load disturbances that tend to saturate the proportional channel. The entire counter is also used to provide a time-out feature to protect the motor and external circuitry.

PROTECTION FEATURES

Low Voltage Detection
If the supply drops below the detect threshold, the device will turn off all of the external power transistors to prevent damage to the motor and the power devices. The FAULT pin goes high in this condition.

Stalled Rotor Shutdown
If the delay from power onset to a positive index transition or the time interval between successive index transitions is greater than the prescribed time, the device interprets this delay as a stalled rotor and reduces the motor current to zero until such time as one positive index transition is detected or until power is removed and reapplied. The FAULT output goes high when the motor is determined to be stalled.

Motor Coil Over-Current
Refer to SENSE input description. The voltage generated by motor coil current through Re is sensed as shown in the typical application. The sense input threshold limits the maximum coil current.

FREF Clock Fault
If the FREF frequency drops below the specified minimum frequency, the driver will shut down and the FAULT pin will go high.

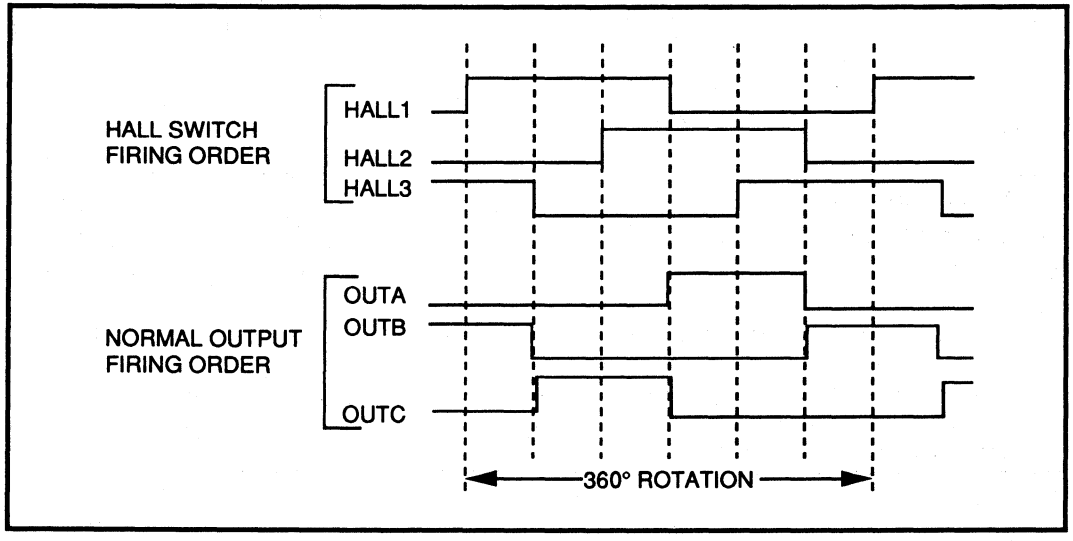


FIGURE 1: HALL Switch/Driver Timing Relationship

ELECTRICAL CHARACTERSTICS

ABSOLUTE MAXIMUM RATINGS

Maximum limits indicate where permanent device damage occurs. Continuous operation at these limits is not intended and should be limited to those conditions specified in the DC operating characteristics.

PARAMETER	RATING	UNIT
Positive Supply Voltage, VDD	14	V
Storage Temperature	-65 to + 125	°C
Pin Voltage (except FAULT and LOCK)	-0.3 to VDD +0.3	V
FAULT and LOCK Pin Voltage	-0.3 to VDD +5.0	V
HALLOUT Current	20	mA
Lead Temperature (soldering, 10 sec.)	260	°C

RECOMMENDED OPERATION CONDITIONS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
DC Supply Voltage, VDD		10.8	12.0	13.2	V
Input Clock, FREF		1.9998	2	2.0002	MHz
Ambient Temperature, Ta		0		70	°C
Emitter Resistor, Re		0.392	0.4	0.408	Ω
Power Darlington Vbe		0.8		1.8	V
Motor Parameters (1)	$\frac{\text{Motor Frequency (s)}}{\text{Motor Current (s)}} = \frac{KT}{Js + KD}$				
KT, Torque Constant Range	(0.15 Nt-m/A nom)	-10		+10	%
J, Inertia Range	(489×10^{-6} Nt-m-sec^2 nom)	-33		+33	%
KD, Damping Factor Range	(31.8×10^{-6} Nt-m/rad/s nom)	-33		+33	%
Winding resistance (2)			2.0		Ω
Winding inductance			2.0		mH
Back EMF (2)			0.0159		rad/s V

Notes:

(1) The motor parameters given are for a typical motor. The device will work for a range of motors near this nominal motor.

(2) The motor must have a back EMF less than 10 volts peak (measured from center tap to drive transistor collector/drain) at speed to insure linear operation of drive transistors and a coil resistance small enough to insure adequate start current.

DC ELECTRICAL CHARACTERISTICS.
Unless otherwise specified, 10.8V ≤ VDD ≤ 13.2V: 0°C ≤ Ta ≤ 70°C; FREF = 2.000 MHz; Re = 0.4Ω; Motor Configuration is 4-pole 3-phase center-tap "Y."

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Power Supply Current					
ICC	Clock Active 1(HALLOUT) = 15 mA 1 Driver loaded to = 5 mA 2 Drivers unloaded			30	mA
Power Dissipation				400	mW
Fault Detection					
Low Voltage Detect Threshold		6.8		9.0	V
Input Logic Signals - 'FREF' and 'START' Inputs					
Vil, Input Low Voltage				0.08	V
Iil, Input Low Current	Vin = 0	–500			µA
Vih, Input High Voltage		2.0			V
IiH, Input High Current	Vin = 5			100	µA
Output Logic Signals - 'LOCK' and 'FAULT' Pins					
Vol	Isink = 2mA			0.4	V
Ioh	Vout = VDD			10	µA
HALL Sensor Interface					
HALLOUT Bias Voltage	I = 0 to –15 mA	5.0		6.8	V
HALL1,2,3 Pullup Resistance	To HALLOUT pin	5		20	kΩ
Input Low Voltage				1.0	V
Input High Voltage		4.0			V
Driver Outputs					
Sink Capability	Vol = 0.5V	1.0			mA
Source Capability	Voh = 3.0V	–5.0			mA
Capacitive Load Drive Capability			50.0		pF
Sense Input And Over-Current Control					
Threshold Voltage		0.9		1.1	V
Input Current		–100		100	µA

AC ELECTRICAL CHARACTERISTICS

Unless otherwise specified, 10.8V ≤ VDD ≤ 13.2V; 0°C ≤ Ta ≤ 70°C; FREF = 2.000 MHz; Re=0.4Ω.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNITS
Fault Detection					
Stalled Rotor Shutdown Time	Power On to driver	0.850		0.900	sec
Low FREF Shutdown Threshold				100	Hz
Lock Indication					
Lock Range	Motor Speed	3585		3615	Hz
Control Loop Parameters*					
Divider Ratio	FREF/Fmotor		33,336		
Instantaneous Speed Error	Referenced to 60Hz	–0.035	0.01	0.015	%
Index to Index Jitter (16/FREF)	Total jitter			8	µs
Loop Bandwidth	Nominal motor Re = 0.40Ω		2		Hz
Loop Zero	Ki/Kp		1.0		Hz
Maximum Running Current	Re = 0.40Ω	1.50			Amps
Minimum Running Current	Re = 0.40Ω			0	Amps
Start Current	Re = 0.40Ω	2.25		2.75	Amps
Input Logic Signals-'FREF' and 'START' Pins					
Input Capacitance				25	pF
Hall Sensor Interface					
Input Capacitance				25	pF
Sense Input and Over-current Control					
Input Capacitance				25	pF

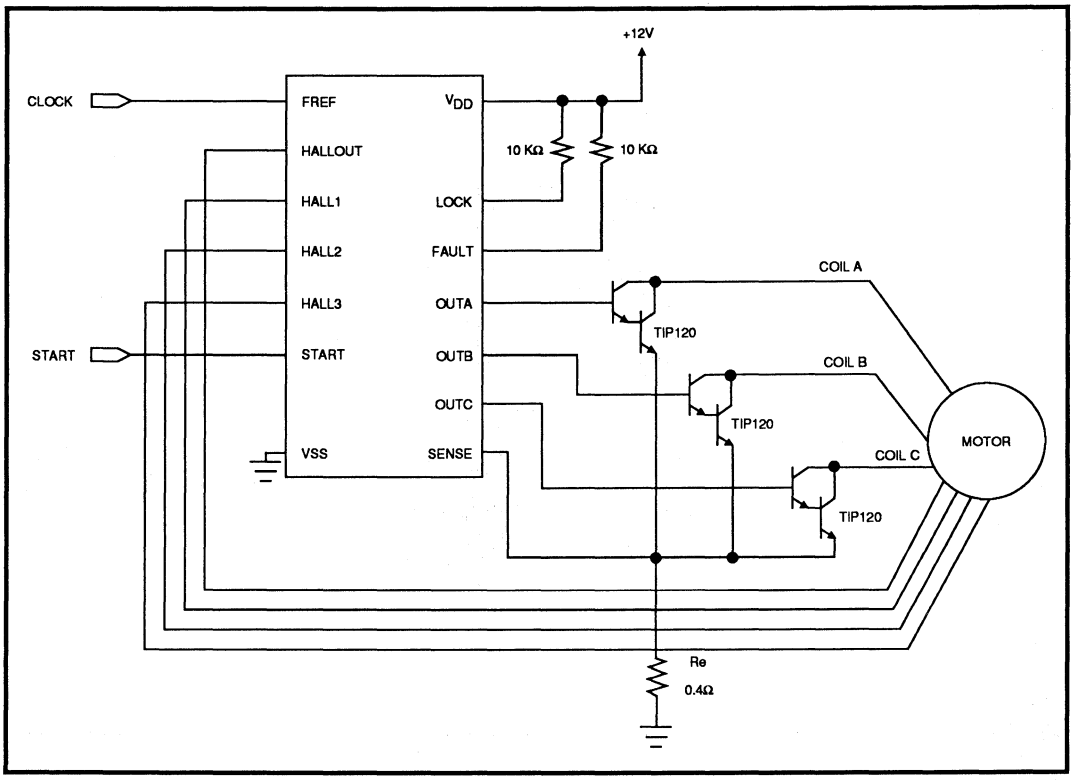
*Control Loop Notes:

Running current limits refer to capabilities during speed correction.

The motor control loop consists of counters, logic, and digital-to-analog converters that provide loop time constants. The continuous time transfer function of the on chip control can be modeled as follows:

$$H(s) = \frac{Vc(s)}{Fm(s)} = \frac{Ki}{s} + Kp$$

Vc(s) is the voltage applied to the external setting resistor Re by the modulator. By adjusting the value of Re the gain the motor sees can be adjusted, as can the starting current.



Typical Application Diagram

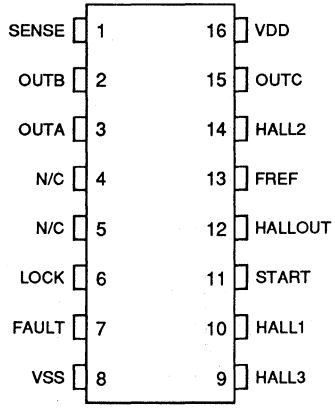
6

SSI 32M591
Three-Phase 5-1/4 Inch
Winchester Motor Speed Control

PIN DIAGRAM
(TOP VIEW)

THERMAL CHARACTERISTICS: Øja

16-Pin DIP	75°C/W
16-Pin SOL	105°C/W



16-Pin DIP

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32M591 16-Pin Plastic DIP	SSI 32M591-CP	32M591-CP
SSI 32M591 16-Pin SOL	SSI 32M591-CL	32M591-CL

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680 (714) 731-7110, FAX (714) 731-5457

SSI 32M593A
Three-Phase Delta Motor Speed Controller

July, 1990

DESCRIPTION

The SSI 32M593A is a motor speed control IC designed to provide all timing and control functions necessary to start, drive, and brake a 3-phase, 4 or 8 pole brushless DC spindle motor. External Darlington power transistors or external power FETs may be used by the SSI 32M593A to drive the spindle motor.

The motor Hall sensors are directly driven and decoded by the device. The controller is optimized for a 3600 rpm motor using a 2 MHz clock. Motor protection features include jammed platter shutdown, supply and clock fault detection, all of which are indicated by a FAULT signal, and coil over-current detection and control. A LOCK signal is provided to indicate that the motor is at speed. The device's linear control loop controls the power drivers using Pulse Amplitude Modulation.

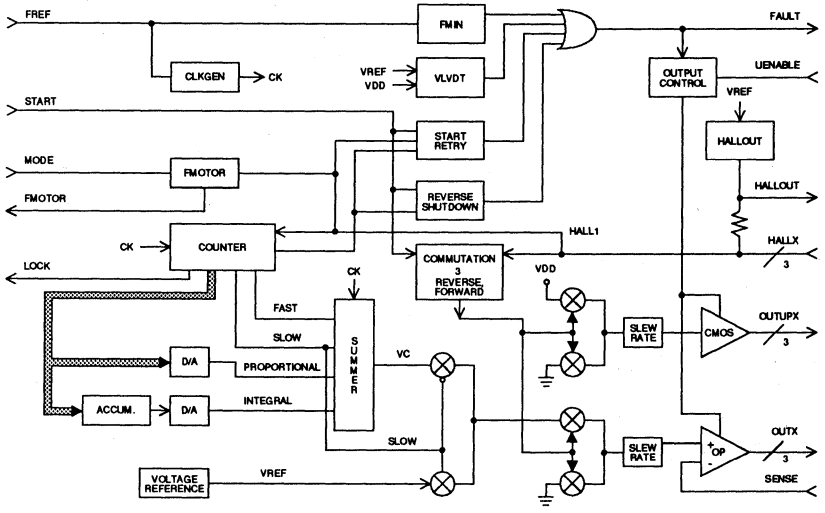
The SSI 32M593A requires a +12V power supply, and is available in 20-pin DIP or SO packages.

FEATURES

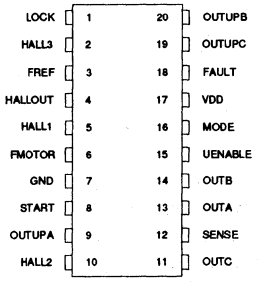
- **3-phase bipolar or unipolar operation**
- **4 or 8-pole operation**
- **3600 rpm speed control using a 2 MHz clock**
- **Highly accurate speed regulation of ±0.037%**
- **At speed indication provided**
- **Active braking function**
- **Output pre-driver for center tap or non-center tap windings**
- **Drives complementary Darlington power transistors or complementary power FETs**
- **Power supply fault protection**
- **Motor over-current protection**
- **Multiple retry on jammed spindle**
- **Single +12 volt power supply**

6

BLOCK DIAGRAM



PIN DIAGRAM



20-PIN DIP or SOL

CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 32M593A
Three-Phase Delta
Motor Speed Controller

FUNCTIONAL DESCRIPTION

The SSI 32M593A uses a mix of analog and digital techniques to accomplish speed control. The control signal is generated by analog conversion of a digital speed error term developed by examining the contents of a count-down counter once per motor revolution. The sign and magnitude of the remainder controls the amplitude of a correction signal applied to the motor. Commutation timing, developed from motor generated HALL signals, applies the correction in the proper phase sequence.

The device uses a Pulse Amplitude Modulation (PAM) scheme rather than Pulse Width Modulation (PWM) to avoid the switching transients and torque ripple inherent in PWM.

In operation, the SSI 32M593A is installed in a closed loop control system that maintains the speed of a 3-Phase Brushless DC motor. By monitoring the HALL signal outputs of the motor, a control voltage is developed using both digital and analog techniques. The analog portion of the control loop uses switched capacitor techniques to eliminate the need for any external passive components required for loop compensation. An operation description of the circuit follows.

CONTROL LOOP

Referring to the block diagram, the major sections of the control loop are a 19-stage Counter, Integral and Proportional channels, D/A's and a Summer.

The speed error is determined by examining the contents of the counter once per revolution. The counter is preset once per revolution by an INDEX signal developed from the HALL1 input, at the same time any remainder resulting from a 500 kHz count-down rate is loaded into a latch.

The lower LSB's of the latch, except for the LSB, are used to drive the Proportional D/A while the entire contents of the latch are accumulated to control the Integral Channel. The MSB's of the accumulator drive the Integral D/A.

If the contents of the counter indicate that the speed is outside the linear regulation range (±0.037%), this is decoded as a "FAST" or "SLOW" condition. Under these conditions the Proportional D/A output is driven to either end of its range, as appropriate. Under a slow condition, a fixed reference voltage is supplied to the output drives.

The Summer then outputs a control voltage (VC) consisting of a bias voltage plus or minus the sum of the two D/A outputs.

The Integral and Proportional channels perform several functions related to the operation of the control loop. One function is to control loop stability by maintaining the loop zero at 1 Hz. In operation this translates to the Integral channel responding to major bias point changes while the Proportional channel takes care of minor perturbations to the loop.

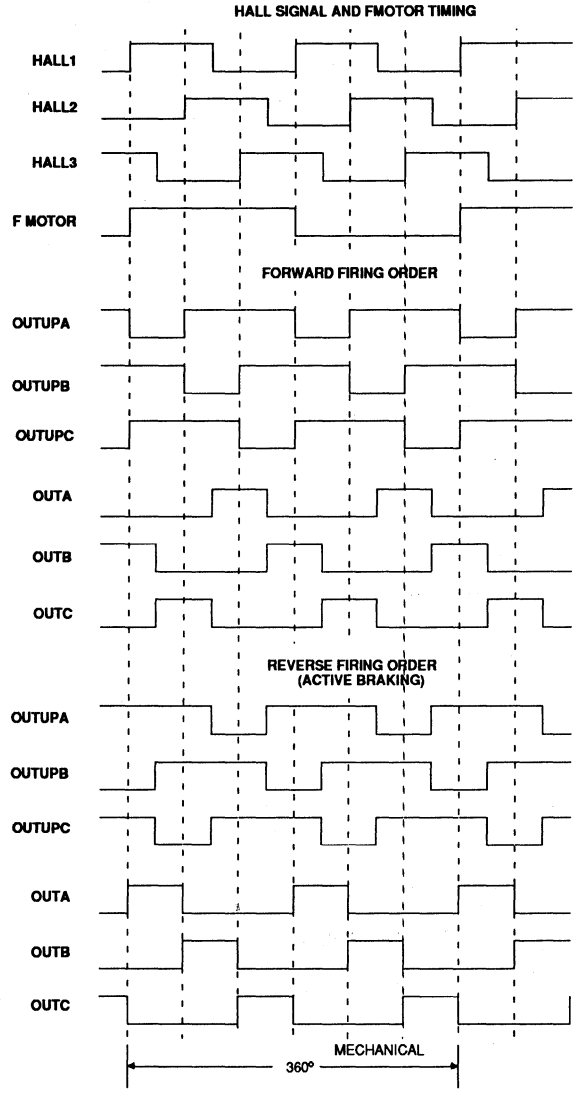
COMMUTATION

The summer output is channeled to the appropriate OUTA, B, C output according to the timing shown in Figure 1. To reduce switching transients, the outputs are slew rate controlled during each transition.

OUTUPA, B, C outputs cycle between approximately VDD in the OFF state and GND in the ON state also according to Figure 1. Again, rise and fall times are controlled during transitions.

MOTOR COIL OVER-CURRENT

Refer to SENSE input description. Sense voltage is generated by current through Re shown in the typical application. The SENSE input threshold limits the maximum coil current.



NOTE: Figure shows commutation of a 4-pole device. 8-pole devices apply same firing order twice per revolution.

FIGURE 1: Commutation Timing Diagram

FUNCTIONAL DESCRIPTION (Continued)

FAULT CONDITIONS

Four conditions cause an active high on the FAULT output pin, also disabling all drivers except as noted :

(1) Low power supply - VDD < Vlvdt

(2) No FREF clock - FREF < Fmin

(3) Stalled motor. If the delay from power onset to a positive HALL index transition or the time interval between successive HALL index transitions is greater than the specified time, the device interprets this delay as a stalled motor, reduces the motor current to zero and performs three retry cycles. If the motor continues to be stalled after three retries, then motor current is reduced to zero until such time as one positive HALL index transition is detected, the START pin is toggled, or power or FREF is removed and re-applied. After the fourth try, FAULT goes high. (See Figure 2.)

(4) Reverse shutdown speed. During active braking (START=0) the HALL sensor's phasing is changed to apply a reverse torque to the motor until the motor speed drops below the reverse shutdown speed at which time the drivers turn off to deny power to the motor and FAULT goes high. If UENABLE is high (non-center tapped motor) the device will perform passive braking after the motor speed drops below the reverse shutdown speed by enabling the lower drivers, OUTX, to dissipate any remaining coil energy. The upper drivers OUTUPX are off. (See Figure 3.)

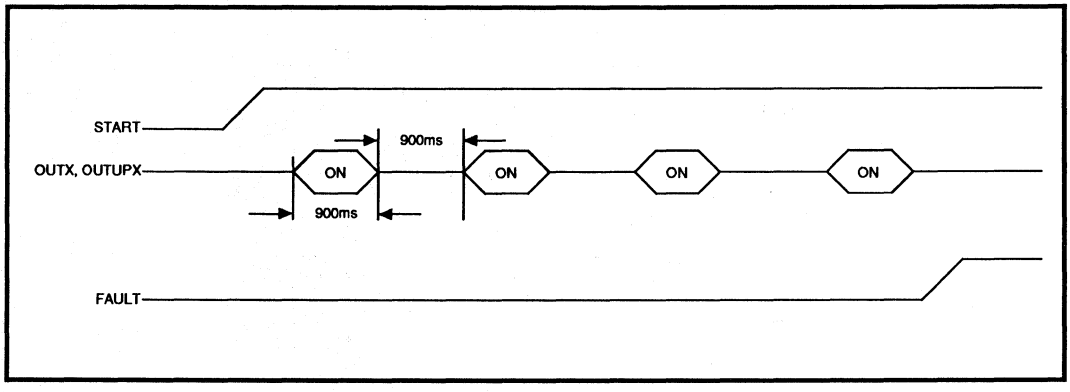


FIGURE 2: Jammed Platter Sequence

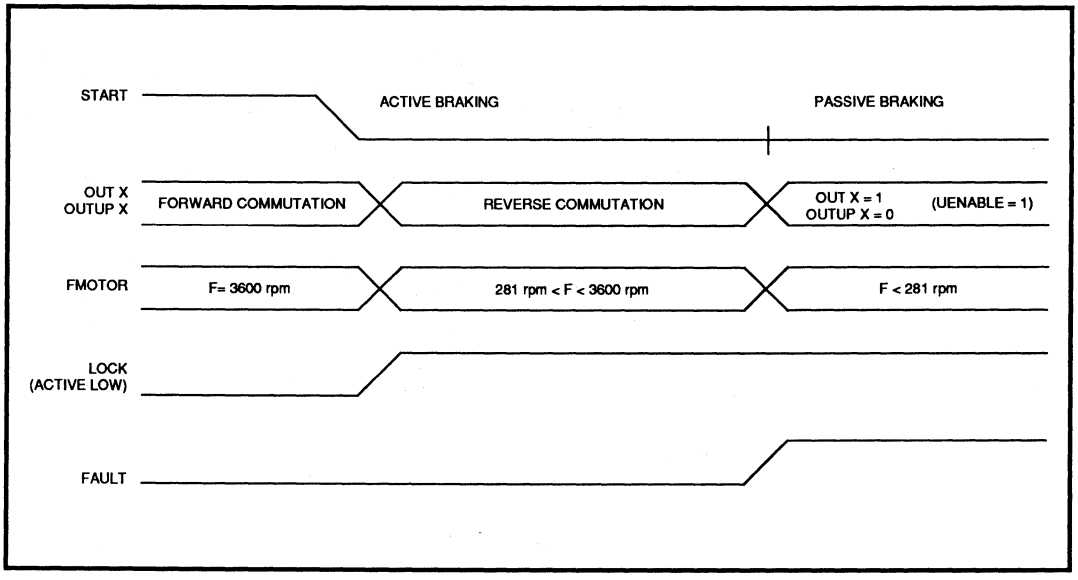


FIGURE 3: Active Braking Sequence

PIN DESCRIPTION

NAME	TYPE	DESCRIPTION
VDD	I	+12V Power Supply
GND	I	Ground
FREF	I	The reference clock input used to set motor speed and operate circuit blocks.
START	I	A high level on this pin enables the motor. The START input must be low during power-up and should conform to Ts set-up time. Active braking is enabled by applying a logic "zero". During active braking the commutation is changed to apply a reverse torque to the motor until the motor velocity drops below 281 rpm.
MODE	I	Mode Control. When tied high (to VDD) selects 8-pole operation where HALL1 signal is divided by four to generate an index signal. When left open, 4-pole operation is selected and HALL1 is divided by two.
UENABLE	I	Tying UENABLE to GND forces all upper outputs to their off state and disables passive braking. UENABLE must be tied to GND for unipolar center-tapped motors. Tied high or floating, UENABLE = 1 and drives bipolar motors.
FAULT	O	FAULT goes active high indicating low VDD, no FREF, a stalled motor, or motor velocity below the reverse shutdown speed.
LOCK	O	LOCK goes active low when the motor frequency is within a specified lock range.
FMOTOR	O	FMOTOR frequency indicates the motor speed, nominally 3600 rpm. FMOTOR is derived from HALL1.
SENSE	I	Coil Current Sense Input. Senses the coil current and limits the sense voltage to the specified threshold by limiting the voltage from the lower drivers. (OUTX)
HALLOUT	O	Hall Sensor Bias Output. Provides a regulated bias voltage for the hall effect sensors.
HALL1, 2, 3	I	Hall Sensor inputs that determine commutation. The TTL open-collector type motor outputs drive these inputs, which have internal resistor pullups referenced to the HALLOUT bias voltage.
OUTUPA, B, C	O	Upper motor CMOS level outputs that drive either Darlingtons or PFETs.
OUTA, B, C	O	Lower Driver Outputs. These three driver outputs drive external Bipolar or NFET power transistors to control the motor current through the current setting resistor Re. The motor current is V(sense)/Re. During normal operation, the drive voltages are adjusted as necessary to maintain the proper motor speed and drive current.

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNIT
VDD Supply Voltage	-0.5 to +14	V
Storage Temperature	-65 to +150	°C
Lead Temperature, PDIP (10 sec. soldering)	260	°C
Package Temperature, SO (20 sec. reflow)	215	°C
Input, Output pins	-0.3 to VDD +0.3	V
Inputs and outputs are protected from static charge using built-in ESD and Latchup protection devices.		

ELECTRICAL CHARACTERISTICS (Unless otherwise specified Vlvdt <Vdd<13.2V.)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VDD supply voltage		10.8	12	13.2	V
IDD supply current	includes output driver current	-	20	38	mA
PDD power dissipation	IoutA or B, or C = -10 mA IoutupA, or B, or C = 10 mA IHALLOUT = -10 mA	-	240	375	mW
FREF clock frequency		1.998	2	2.002	MHz
TA ambient temperature		0	-	70	°C
TTL Inputs START, FREF, UENABLE					
Vil input low voltage	Iil ≤500 µA	-	-	0.8	V
Vih input high voltage	Iih ≤100 µA	2.0	-	-	V
START set-up time (Ts)	FREF active to START ↑	100			µs
MODE Input					
Vil input low voltage		-	-	0.5	V
Vih input high voltage	Iih ≤500 µA	VDD-.5	-	-	V
HALLX Input					
Vil input low voltage		-	-	0.8	V
Vih input high voltage	External pullup current ≤1.7 mA	3.0	-	-	V
Input Pullup-Pulldown Resistance					
Internal pullup resistance	START, FREF, UENABLE	40	-	-	kΩ
Internal pullup resistance	HALLX inputs	5	-	20	kΩ
Internal pulldown resistance	MODE input	40	-	-	kΩ
Input capacitance	All inputs	-	-	25	pF

ELECTRICAL CHARACTERISTICS (Continued)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
SENSE Input						
SENSE voltage threshold		if exceeded, driver voltage is limited	0.9	1.0	1.1	V
Input current			-100	-	+100	µA
Open Drain Outputs LOCK, FMOTOR, FAULT						
Vol output low voltage		I_{OL} = 2 mA	-	-	0.5	V
Typical external pullup resistor			-	10	-	kΩ
FAULT Indication						
Vlvdt, low voltage			7.0	-	9.5	V
Fmin, loss of FREF			-	-	100	Hz
Stuck motor, start pulses		drivers on, drivers off	-	0.90	-	sec
Number of start pulses			-	4	-	-
Reverse shutdown speed		START = 0	-	281	-	rpm
LOCK Indication						
Lock range		Measure at FMOTOR, FREF =	3594	3600	3607	rpm
Speed error		2 MHz, 10.8 < V_{DD} < 13.2	-.037		+.037	%
HALL Sensor Interface						
HALLOUT bias voltage		10.8 < VDD < 13.2, Iload = -5 mA	5.0		6.8	V
		10.8 < VDD < 13.2, Iload = -10 mA	5.0			V
Driver Outputs (FHALLX ≥ 100 Hz, Vlvdt < VDD ≤ 13.2, CL ≤ 500 pF unless otherwise specified.)						
Slew rate		All driver outputs	150	-	500	V/msec
OUTX	Voh	Iload = -5.0 mA	3.75	-	-	V
	Voh	Iload = -100 µA, 10.8 ≤ V_{DD} ≤ 13.2	8.0	-	-	V
	Vol off state	Iload = 3.4mA, 5.0 ≤ V_{DD} ≤ 13.2	-	-	0.5	V
OUTUPX	Vol	Iload = 10 mA	-	-	3.0	V
	Voh off state	Iload = -5 mA	V_{DD}-0.5	-	-	V
	Voh off state	Iload = -2 mA, 5.0 ≤ VDD ≤ Vlvdt	V_{DD}-0.5	-	-	V

APPLICATION INFORMATION

PARAMETER	RECOMMENDED	MIN	NOM	MAX	UNIT
Power Transistors					
Re, Emitter Resistor		.392	.4	.408	Ω
Power Darlington Vbe	Typical device: TIP 125, TIP 120	0.8	-	1.8	V
Power FET Vth	Typical device: IRFT 001	2	-	6	V
Power FET Rds (on)		-	-	0.4	Ω
Power FET BVds		30	-	-	V

Motor Parameters

The SSI 32M593A MSC is optimized for use with a 5 1/4" three-platter Winchester motor. The device will work for a range of motors near this nominal motor. Attempts to use a significantly different motor may require careful choice of a sense resistor for good spin-up and regulation.

KT, Torque Constant Range	(0.015 Nt-m/A nom.)	-10	-	+10	%
J, Inertia Range	(489 x 10^{-6} Nt-m-sec ^{2} nom.)	-33	-	+33	%
KD, Damping Factor Range	(31.8 x 10^{-6} Nt-m/rad/sec nom.)	-33	-	+33	%
Note: $\frac{\text{Motor Frequency (s)}}{\text{Motor Current (s)}} = \frac{KT}{Js + KD}$					

Control Loop Parameters

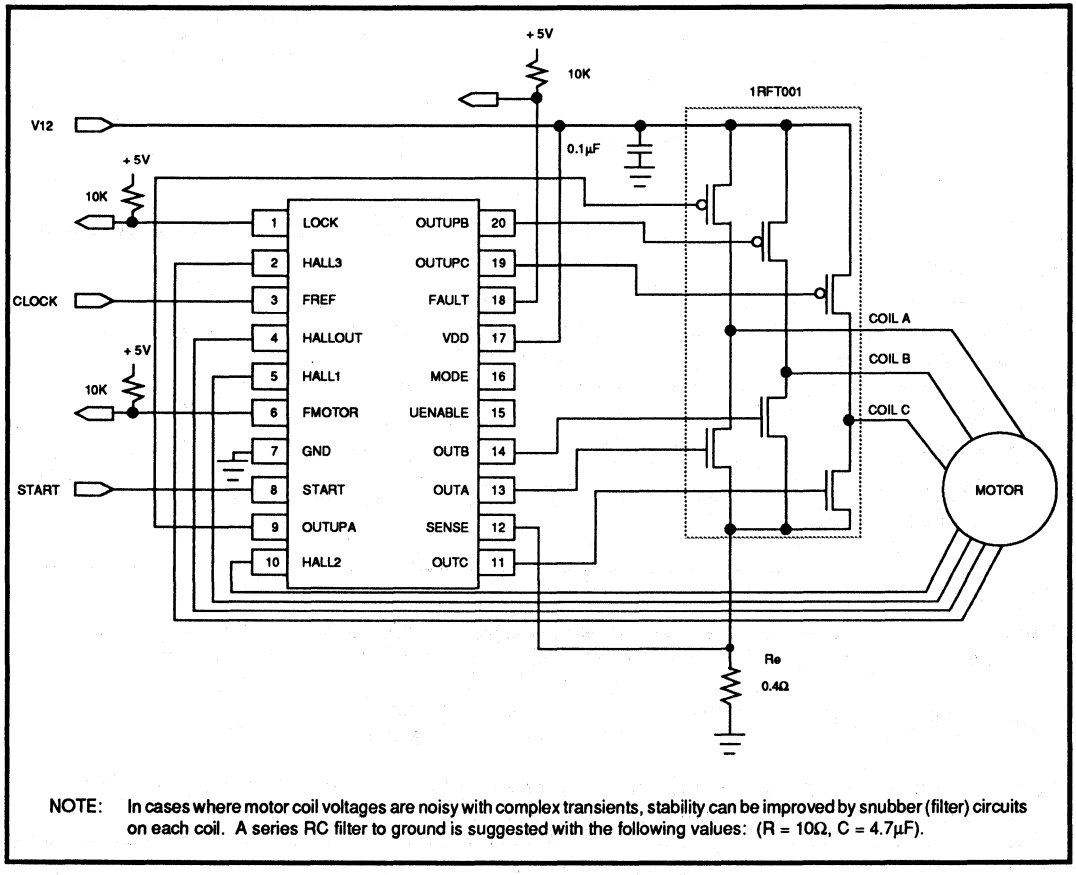
The motor control loop consists of counter, logic, and digital-to-analog converters that provide loop time constants. The continuous time transfer function of the on-chip control can be modeled as follows:

$$H(s) = \frac{Vc(s)}{Fm(s)} = \frac{Ki}{s} + Kp$$

Where: Ki = Integral Channel Gain
Kp = Proportional Channel Gain

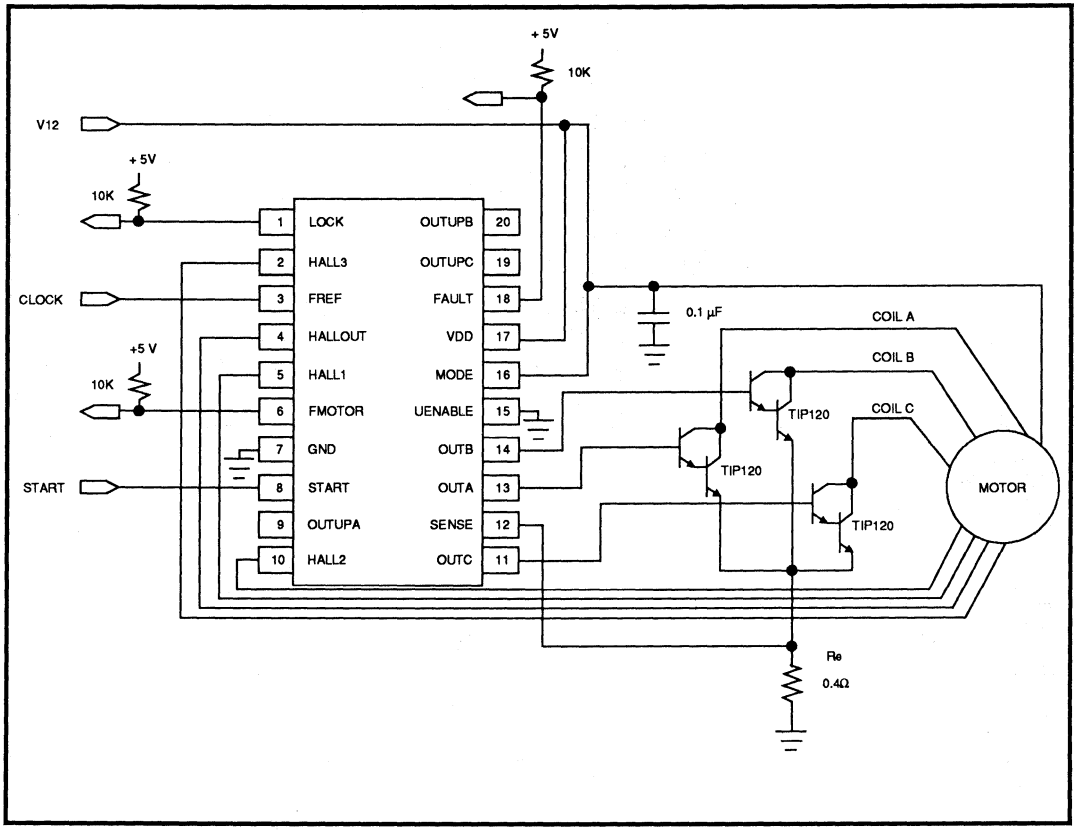
Vc(s) is the voltage applied to the external sense resistor (Re) by the modulator. By adjusting the value of Re, the gain the motor sees can be adjusted as can the starting current.

Loop Bandwidth	Nominal motor, Re= 0.40Ω		2		Hz
Loop Zero	Ki/Kp		1.0		Hz
Kp, Proportional Channel Gain		0.198	0.213	0.227	V/rad/s
Ki, Integral Channel Gain		1.23	1.33	1.42	V/rad
Start current	Re = 0.40Ω		2.5		Amps
Running current	Re = 0.40Ω		1.5		Amps



NOTE: In cases where motor coil voltages are noisy with complex transients, stability can be improved by snubber (filter) circuits on each coil. A series RC filter to ground is suggested with the following values: (R = 10Ω, C = 4.7µF).

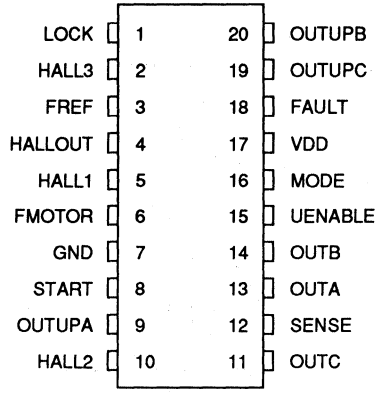
**Typical Three-Phase, 4-Pole, Bipolar,
Non-Center Tapped Motor Using A Power FET Module**



**Typical Three-Phase, 8-Pole, Unipolar,
Center Tapped Motor Using A Power Darlington. UENABLE Must be Tied to GND.**

SSI 32M593A
Three-Phase Delta
Motor Speed Controller

PACKAGE PIN DESIGNATIONS
(TOP VIEW)



20-Pin DIP or SOL

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32M593A Three-Phase SOL	SSI 32M593A-CL	32M593A-CL
SSI 32M593A Three-Phase PDIP	SSI 32M593A-CP	32M593A-CP

Silicon Systems, Inc. 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX (714) 731-5457

SSI 32M594
Three-Phase Delta Motor Speed Controller
Preliminary Data

July, 1990

DESCRIPTION

The SSI 32M594 is a motor speed control IC designed to provide all timing and control functions necessary to start, drive, and brake a 3-phase, 4 or 8 pole brushless DC spindle motor. External Darlington power transistors or external power FETs may be used by the SSI 32M594 to drive the spindle motor.

The motor Hall sensors are directly driven and decoded by the device. The controller is optimized for a 3600 rpm motor using a 2 MHz clock. Motor protection features include jammed platter shutdown, supply and clock fault detection, all of which are indicated by a FAULT signal, and coil over-current detection and control. A $\overline{\text{LOCK}}$ signal is provided to indicate that the motor is at speed. The device's linear control loop controls the power drivers using Pulse Amplitude Modulation.

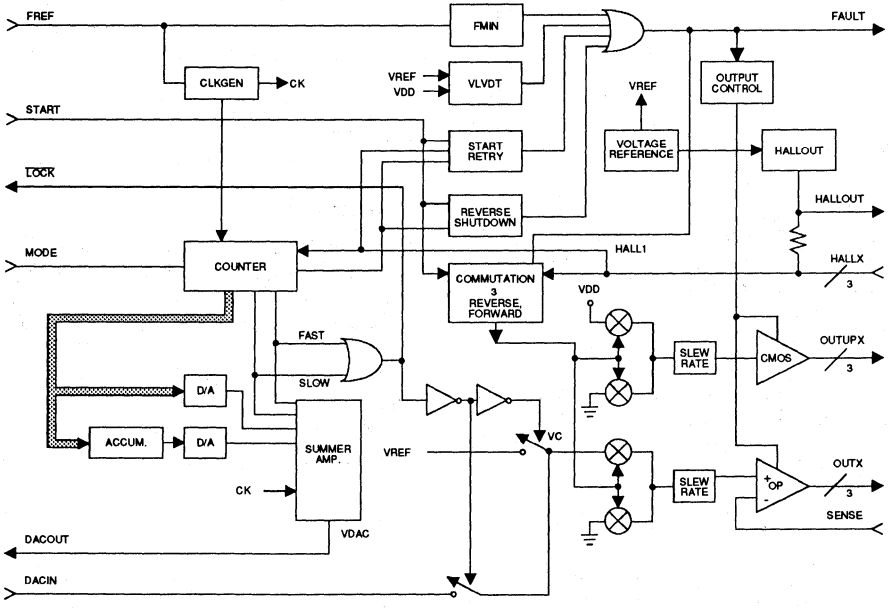
The SSI 32M594 requires a +12V power supply, and is available in 20-pin DIP or SO packages.

FEATURES

- **Supports wide range of DC brushless 3-phase motors, including 3 1/2" motors**
- **4 or 8-pole operation**
- **3600 rpm speed control using a 2 MHz clock**
- **Highly accurate speed regulation of ±0.037%**
- **Provides for gain scaling of the motor current voltage**
- **On-chip digital filter**
- **At speed indication provided**
- **Active braking function**
- **Output pre-driver for center tap or non-center tap windings**
- **Drives complementary Darlington power transistors or complementary power FETs**
- **Power supply fault protection**
- **Motor over-current protection**
- **Multiple retry on jammed spindle**
- **Single +12 volt power supply**

6

BLOCK DIAGRAM



SSI 32M594
Three-Phase Delta
Motor Speed Controller

FUNCTIONAL DESCRIPTION

The SSI 32M594 uses a mix of analog and digital techniques to accomplish speed control. The control signal is generated by analog conversion of a digital speed error term developed by examining the contents of a count-down counter once per motor revolution. The sign and magnitude of the remainder controls the amplitude of a correction signal applied to the motor. Commutation timing, developed from motor generated HALL signals, applies the correction in the proper phase sequence.

The device uses a Pulse Amplitude Modulation (PAM) scheme rather than Pulse Width Modulation (PWM) to avoid the switching transients and torque ripple inherent in PWM.

The SSI 32M594 generates a motor current voltage which is related to the motor speed error. This is implemented on the IC by digital/analog techniques, converting a motor frequency error derived from a reference clock and digital counter into a voltage using switched capacitor D/A's. The voltage Vc translates into a motor current across Re regulating motor speed.

In operation, the SSI 32M594 is installed in a closed loop control system that maintains the speed of a 3–Phase Brushless DC motor. By monitoring the HALL signal outputs of the motor, a control voltage is developed using both digital and analog techniques. The analog portion of the control loop uses switched capacitor techniques to eliminate the need for any external passive components required for loop compensation. An operation description of the circuit follows.

CONTROL LOOP

Referring to the block diagram, the major sections of the control loop are a 19-stage Counter, Integral and Proportional channels, D/A's and a Summer.

The speed error is determined by examining the contents of the counter once per revolution. The counter is preset once per revolution by an INDEX signal developed from the HALL1 input, at the same time any remainder resulting from a 500 KHz count-down rate is loaded into a latch.

The lower LSB's of the latch, except for the LSB, are used to drive the Proportional D/A while the entire contents of the latch are accumulated to control the Integral Channel. The MSB's of the accumulator drive the Integral D/A.

If the contents of the counter indicate that the speed is outside the linear regulation range (±0.037%), this is decoded as a "FAST" or "SLOW" condition. Under these conditions the Proportional D/A output is driven to either end of its range, as appropriate. Under a slow condition, a fixed reference voltage is supplied to the output drives resulting in a start current of Vref/Re.

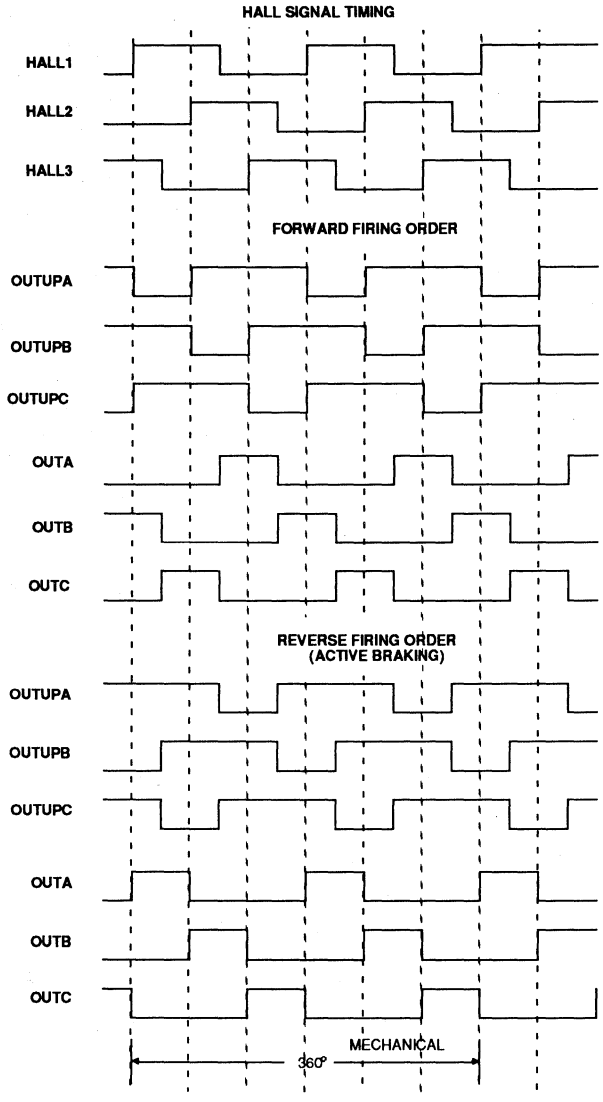
When $\overline{LOCK}$ is low, the control voltage, VDAC, from the summer is used to generate the motor running current. VDAC is a summation of integral channel voltage which cancels out offsets in the loop and motor losses, and a proportional channel voltage which tracks speed variations from the counter. The two channel voltages are then summed and weighted. The control voltage applied is externally scaleable by resistors R1 and R2 at DACOUT and DACIN (see Typical Application diagram) to fit a wide range of motors including those used in 3 1/2" drives. Note that Re affects start current while R1 and R2 affect running current as Irunning = V_{DACIN}/Re.

The Integral and Proportional channels perform several functions related to the operation of the control loop. One function is to control loop stability by maintaining the loop zero at 1 Hz. In operation this translates to the Integral channel responding to major bias point changes while the Proportional channel takes care of minor perturbations to the loop.

COMMUTATION

The summer output is channeled to the appropriate OUTA, B, C output according to the timing shown in Figure 1. To reduce switching transients, the outputs are slew rate controlled during each transition.

OUTUPA, B, C outputs cycle between approximately VDD in the OFF state and GND in the ON state also according to Figure 1. Again, rise and fall times are controlled during transitions.



NOTE: Figure shows commutation of a 4-pole device. 8-pole devices apply same firing order twice per revolution.

FIGURE 1: Commutation Timing Diagram

FUNCTIONAL DESCRIPTION (Continued)

MOTOR COIL OVER-CURRENT

Refer to SENSE input description. Sense voltage is generated by current through Re shown in the typical application. The SENSE input threshold limits the maximum coil current.

FAULT CONDITIONS

Four conditions cause an active high on the FAULT output pin, also disabling all drivers except as noted :

(1) Low power supply - VDD < Vlvdt

(2) No FREF clock - FREF < Fmin

(3) Stalled motor. If the delay from power onset to a positive HALL index transition or the time interval between successive HALL index transitions is greater than the specified time, the device interprets this delay as a stalled motor, reduces the motor current to zero and performs three retry cycles. If the motor continues to be stalled after three retries, then motor current is reduced to zero until such time as one positive HALL index transition is detected, the START pin is toggled, or power or FREF is removed and re-applied. After the fourth try, FAULT goes high. (See Figure 2)

(4) Reverse shutdown speed. During active braking (START = 0) the HALL sensor's phasing is changed to apply a reverse torque to the motor until the motor speed drops below the reverse shutdown speed at which time the drivers turn off to deny power to the motor and FAULT goes high. (See Figure 3)

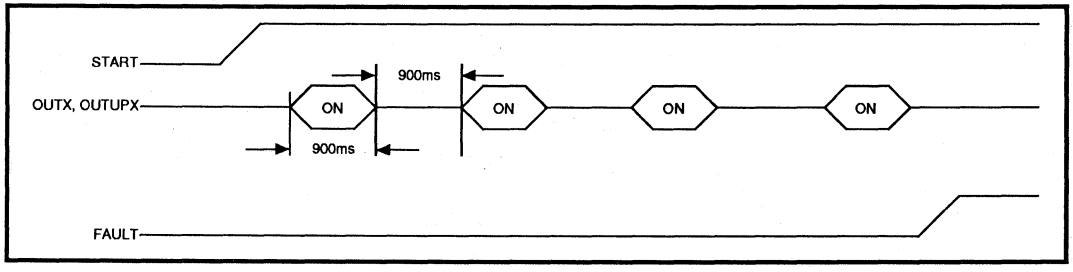


FIGURE 2: Jammed Platter Sequence

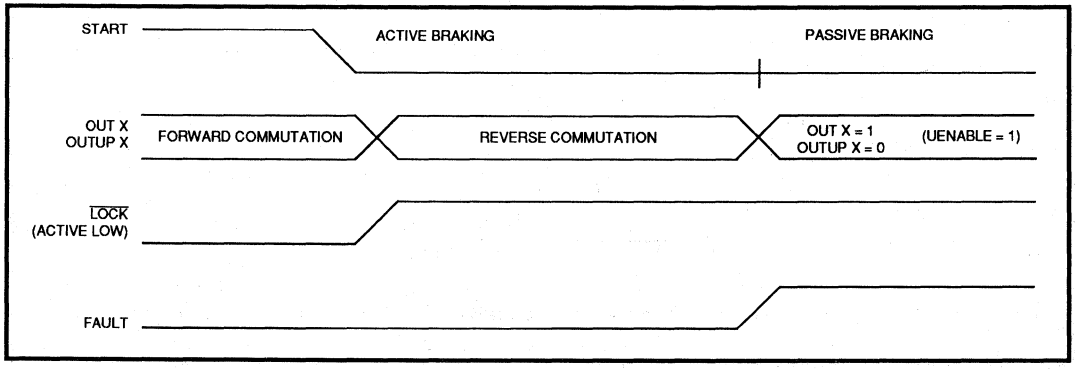


FIGURE 3: Active Braking Sequence

PIN DESCRIPTION

NAME	TYPE	DESCRIPTION
VDD	I	+12V Power Supply
GND	I	Ground
FREF	I	The reference clock input used to set motor speed and operate circuit blocks.
START	I	A high level on this pin enables the motor. The START input must be low during power-up and should conform to Ts set-up time. Active braking is enabled by applying a logic "zero". During active braking the commutation is changed to apply a reverse torque to the motor until the motor velocity drops below 281 rpm.
MODE	I	Mode Control. When tied high (to VDD) selects 8-pole operation where HALL1 signal is divided by four to generate an index signal. When left open, 4-pole operation is selected and HALL1 is divided by two.
FAULT	O	FAULT goes active high indicating low VDD, no FREF, a stalled motor, or motor velocity below the reverse shutdown speed.
$\overline{\text{LOCK}}$	O	$\overline{\text{LOCK}}$, open drain active low, goes active low when the motor frequency is within a specified lock range.
SENSE	I	Coil Current Sense Input. Senses the coil current and limits the sense voltage to the specified threshold by limiting the voltage from the lower drivers. (OUTX)
HALLOUT	O	Hall Sensor Bias Output. Provides a regulated bias voltage for the hall effect sensors.
HALL1, 2, 3	I	Hall Sensor inputs that determine commutation. The TTL open-collector type motor outputs drive these inputs, which have internal resistor pullups referenced to the HALLOUT bias voltage.
OUTUPA, B, C	O	Upper motor CMOS level outputs that drive either Darlingtons or PFETs.
OUTA, B, C	O	Lower Driver Outputs. These three driver outputs drive external Bipolar or NFET power transistors to control the motor current through the current setting resistor Re. During normal operation, the drive voltages are adjusted as necessary to maintain the proper motor speed and drive current.
DACIN	I	Reference voltage for motor current.
DACOUT	O	Summer Output (VDAC). The summation of integral and proportional channel voltages.

ABSOLUTE MAXIMUM RATINGS

Maximum limits indicate where permanent device damage occurs. Continuous operation at these limits is not intended and should be limited to those conditions specified in the DC Operating Characteristics.

PARAMETER	RATING	UNIT
VDD Supply Voltage	-0.5 to +14V	V
Storage Temperature	-65 to +150	°C
Lead Temperature, PDIP (10 sec. soldering)	260	°C
Package Temperature, SO (20 sec. reflow)	215	°C
Input, Output pins	-0.3 to VDD +0.3	V
Inputs and outputs are protected from static charge using built-in ESD and Latchup protection devices.		

ELECTRICAL CHARACTERISTICS (Unless otherwise specified Vlvdt <VDD<13.2V.)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VDD supply voltage		10.8	12	13.2	V
IDD supply current	includes output driver current	-	20	38	mA
PDD power dissipation	IoutA or B, or C = -10 mA IoutupA, or B, or C = 10 mA IHALLOUT = -10 mA	-	240	375	mW
FREF clock frequency		1.998	2	2.002	MHz
TA ambient temperature		0	-	70	°C
TTL Inputs START, FREF					
VIL Input Low Voltage	IIL ≤500 µA	-	-	0.8	V
VIH Input High Voltage	IIH ≤100 µA	2.0	-	-	V
START Set-up time (Ts)	FREF active to START ↑	100			µs
MODE Input					
VIL Input Low Voltage		-	-	0.5	V
VIH Input High Voltage	IIH ≤500 µA	VDD-.5	-	-	V
HALLX Input					
VIL Input Low Voltage		-	-	1.0	V
VIH Input High Voltage	External pullup current ≤1.7 mA	3.0	-	-	V
Input Pullup-Pulldown Resistance					
Internal pullup resistance	START, FREF	40	-	-	KΩ
Internal pullup resistance	HALLX inputs	5	-	20	KΩ
Internal pulldown resistance	MODE input	40	-	-	KΩ
Input capacitance	All inputs	-	-	25	pF

ELECTRICAL CHARACTERISTICS (Continued)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
SENSE Input						
SENSE voltage threshold		if exceeded, driver voltage is limited	0.9	1.0	1.1	V
Input current			-100	-	+100	µA
Open Drain Outputs $\overline{LOCK}$, FAULT						
VOL Output Low Voltage		IOL = 2 mA	-	-	0.5	V
Typical external pullup resistor			-	10	-	KΩ
FAULT Indication						
Vlvdt, low voltage			7.0	-	9.5	V
Fmin, loss of FREF			-	-	100	Hz
Stuck motor, start pulses		drivers on, drivers off	-	0.90	-	sec
Number of start pulses			-	4	-	-
Reverse shutdown speed		START = 0	-	281	-	rpm
$\overline{LOCK}$ Indication						
Lock range		FREF = 2 MHz	3594	3600	3607	rpm
Speed error		10.8 < VDD < 13.2	-0.037		+0.037	%
HALL Sensor Interface						
HALLOUT bias voltage		10.8 < VDD < 13.2, Iload = -5 mA	5.0		6.8	V
		10.8 < VDD < 13.2, Iload = -10 mA	5.0			V
Driver Outputs (FHALLX ≥ 100 Hz, Vlvdt < VDD ≤ 13.2, CL ≤ 500 pF unless otherwise specified.)						
Slew rate		All driver outputs	150	-	500	V/msec
OUTX	VOH	Iload = -7.5 mA	3.75	-	-	V
	VOH	Iload = -100 µA, 10.8 ≤ VDD ≤ 13.2	8.0	-	-	V
	VOL off state	Iload = 3.4mA, 5.0 ≤ VDD ≤ 13.2	-	-	0.5	V
OUTUPX	VOL	Iload = 10 mA	-	-	3.0	V
	VOH off state	Iload = -5 mA	VDD-0.5	-	-	V
	VOH off state	Iload = -2 mA, 5.0 ≤ VDD ≤ Vlvdt	VDD-0.5	-	-	V

6

APPLICATION INFORMATION

PARAMETER	RECOMMENDED	MIN	NOM	MAX	UNIT
Power Transistors					
Power Darlington Vbe	Typical device: TIP 125, TIP 120	0.8	-	1.8	V
Power FET Vth	Typical device: IRFT 001	2	-	6	V
Power FET Rds (on)		-	-	0.4	Ω
Power FET BVds		30	-	-	V

R1, R2

R1/(R1 + R2)		0.02	0.2	1.0	
R1 + R2		20	50	200	KΩ

$$I_{running} = \frac{R1}{R1 + R2} \times \frac{VDAC}{Re}$$

Where $VDAC = Kp * \Delta f + Ki * \int \Delta f * \Delta t$

Kp = Proportional constant = .213 V/rad/sec

Ki = Integral constant = 1.33 V/rad

Δf = Frequency error

Motor Parameters

The SSI 32M594 MSC is optimized for use with a wide range of Winchester motors including 3 1/2" motors. Torque Constant Range (KT) of 0.01 to 0.02 Nt - m/A and an Inertia Range (J) from 0.5 to 6.5 x 10^{-4} Nt – m – sec^2. The choice of R1, R2 and Re will be affected by motor parameters, so some care in their selection is recommended.

Control Loop Parameters

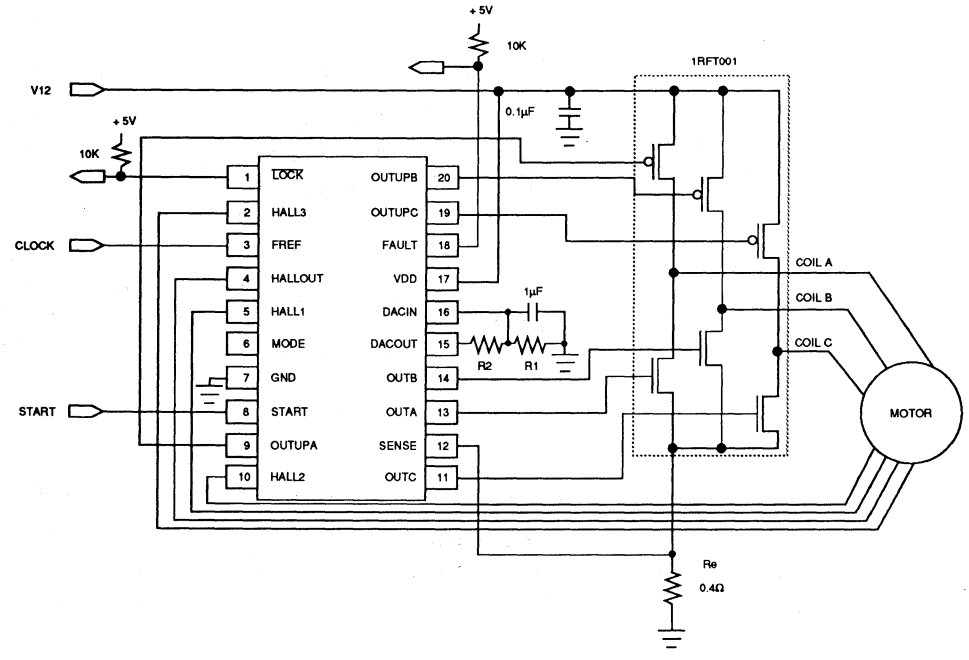
The motor control loop consists of counter, logic, and digital-to-analog converters that provide loop time constants. The continuous time transfer function of the on-chip control can be modeled as follows:

$$H(s) = \frac{Vc(s)}{Fm(s)} = \frac{Ki}{s} + Kp$$

Vc(s) is the voltage applied to the external sense resistor (Re) by the modulator. By adjusting the value of Re, the gain the motor sees can be adjusted as can the starting current.

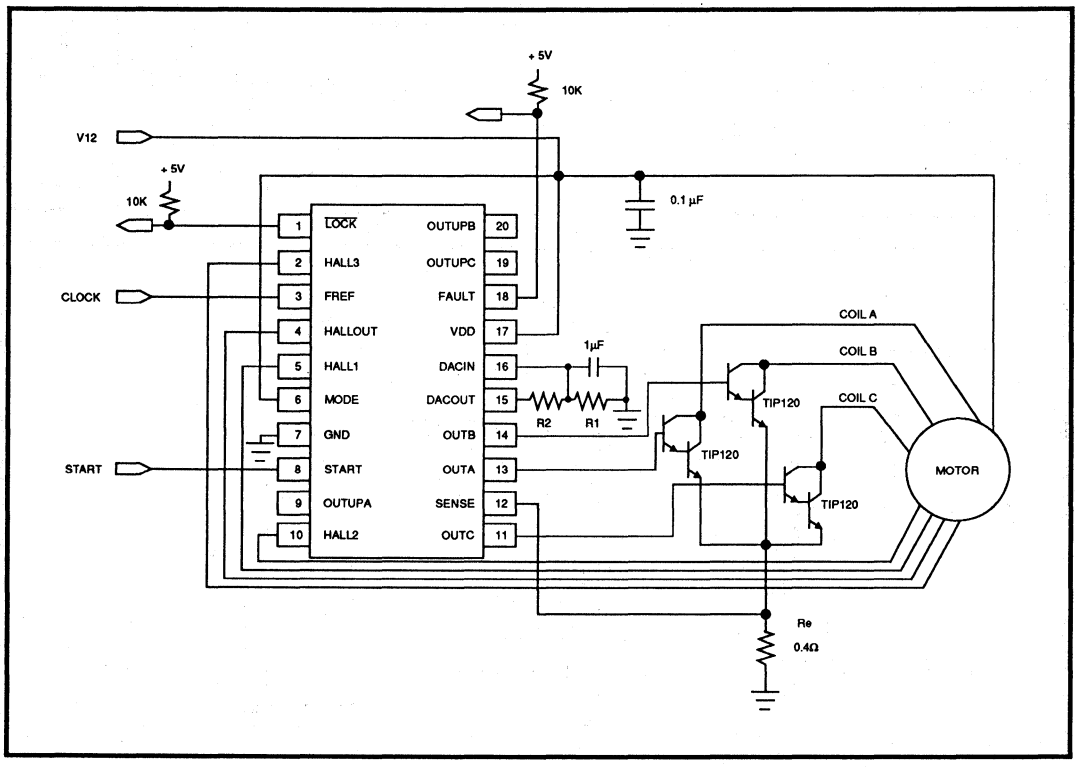
Control Loop Parameters (Continued)

PARAMETER	RECOMMENDED	MIN	NOM	MAX	UNIT
Loop Bandwidth	Nominal motor, Re = 0.4Ω		2		Hz
Loop Zero	Ki/Kp		1.0		Hz
Kp, Proportional Channel Gain		0.198	0.213	0.227	V/rad/s
Ki, Integral Channel Gain		1.23	1.33	1.42	V/rad
Start current		1.0	2.0	3.0	Amps
Running current		0.1	0.2	0.3	Amps



NOTE: In cases where motor coil voltages are noisy with complex transients, stability can be improved by snubber (filter) circuits on each coil. A series RC filter to ground is suggested with the following values: (R = 10Ω, C = 4.7 µF).

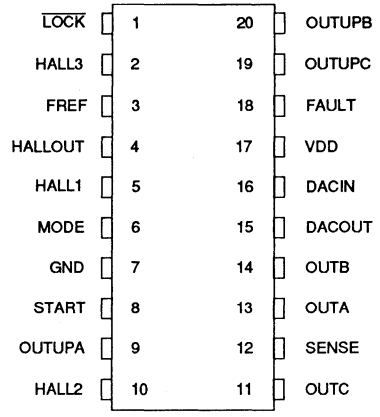
**Typical Three-Phase, 4-Pole, Bipolar,
Non-Center Tapped Motor using a Power FET Module**



**Typical Three-Phase, 8-Pole, Unipolar,
Center Tapped Motor using a Power Darlington. UENABLE must be tied to GND.**

PACKAGE PIN DESIGNATIONS
(TOP VIEW)

CAUTION: Use handling procedures necessary for a static sensitive component.



20-Pin PDIP or SOL

6

ORDERING INFORMATION

PART DESCRIPTION	ORDERING NUMBER	PACKAGE MARK
SSI 32M594 Three-Phase Delta Motor Speed Controller		
20-Pin SOL	SSI 32M594-CL	32M594-CL
20-PIN PDIP	SSI 32M594-CP	32M594-CP

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc. 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX (714) 731-5457

Notes:

silicon systems®

SSI 32M595
Hall Sensor-Less Motor Speed Controller
Advance Information

July, 1990

DESCRIPTION

The SSI 32M595 is a motor speed control IC designed to provide all timing and control functions necessary to start, drive and brake a 3-phase, 4, 8 or 12 pole brushless DC spindle motor. External Darlington power transistors or external power FETs may be used by the SSI 32M595 to drive the spindle motor.

The SSI 32M595 implements a back EMF sensing circuit which determines when to advance the commutation state of the motor. No external sensors are required when using the 32M595. The drive controlling microprocessor initially starts the motor enabling motor current by asserting the ENABLE pin. The microprocessor then generates a stream of START pulses which initially advances the motor and examines the COMCLK pin for back EMF induced self-commutation. Once the motor has advanced with sufficient speed (usually within one revolution) for the back EMF sense logic to detect motion, the microprocessor work is done. The 32M595 will spin the motor up and regulates the speed all without microprocessor involvement.

Along with the back EMF sensing and commutation is a precise speed regulation control loop which regulates the motor speed. Speed regulation is accomplished with a hardware control loop. The control signal is generated by analog conversion of a digital speed error term developed by examining the contents of a count-down counter once per motor revolution. The Integral and Proportional channels have individual external gain setting resistors which provide flexible adjustment of the control loop compensation. The Proportional and Integral channels are then summed forming an analog control variable. In operation this translates to the Integral channel responding to major bias point change while the proportional channel takes care of minor perturbations to the loop.

The 32M595 provides both braking on command and power supply fault braking. The ENABLE pin when asserted TRUE enables motor current to flow and proper operation of the back EMF commutation and speed regulation circuits. When ENABLE is FALSE, the 32M595 predrivers are configured for dynamic braking. During dynamic braking, the upper power drivers are turned off while the lower power drivers are turned on thereby shorting the motor windings. The BRAKEMODE pin determines the brake response when a power fault is detected. If BRAKEMODE is strapped to ground, dynamic braking will be initiated immediately on power fault. Connecting BRAKEMODE through an RC network can provide a delayed dynamic brake. While the BRAKEMODE voltage remains above a threshold, the power drivers will be turned off enabling free spin. Once below the BRAKEMODE threshold, dynamic braking will occur.

FEATURES

- **Sensor-less motor commutation**
- **3-phase, 4, 8 or 12 pole bipolar motor operation**
- **Compatible with 5 and 12 volt, DELTA/Y/ STAR motors**
- **3600 rpm precise speed control using 2 MHz clock**
- **External two resistor loop compensation**
- **Drives complementary Darlington power transistors or complementary power FETs**
- **At speed and power supply fault indicators**
- **Dynamic braking on power fault or on command**
- **Motor current limiting**
- **Single +5V power supply**

PIN DESCRIPTION

NAME	TYPE	DESCRIPTION
VDD	I	+5V Power Supply
GND	I	Ground
FREF	I	Frequency Reference Input. A TTL compatible input used by the device to set and maintain the desired spindle speed. A 2 MHz clock should be applied to this input.
INDEX	I	External index signal indicating revolution speed of motor. If the SOURCE pin is high, this INDEX signal will be used as feed back of motor speed.
SENSE	I	Coil Current Sense Input. The input senses the coil current and limits the sense voltage to the specified threshold by limiting the voltage on the lower predriver outputs.
OUTUPA,B,C	O	Upper predriver outputs. These three predriver outputs are used to activate external PFET power transistors.
OUTA,B,C	O	Lower predriver outputs. These three predriver outputs drive external Bipolar or NFET power transistors to control the motor current sensed across resistor Re. The motor current is equal to the voltage at SENSE divided by Re. When the motor is at speed, the drive voltages are adjusted as necessary to maintain the proper motor speed with a proper motor current.
BEMF A,B,C	I	Back EMF sense voltage inputs which are connected directly (for a 5 volt motor) or through external resistors (for a 12 volt motor) to the three motor terminals.
8-POLE	I	Sets internal divider to 24 corresponding to an 8-pole motor when logically high. Sets divider to 12 when logically low for a 4 pole motor.
FAULT	O	Open drain output active low asserted when VDD is below the power supply fault threshold.
PROP	O	Proportional channel output to be connected in series with an external proportional gain setting resistor and summed at the IN pin.
INTEG	O	Integral channel output to be connected in series with an external proportional gain setting resistor and summed at the IN pin.
SOURCE	I	Selects source which indicates revolution rate of the motor. If logically high, INDEX is used as motor speed feed back. If logically low, the internally derived back EMF is used as motor speed feedback.
RC	I	Timing RC network used to delay the actual motor commutation time from the back EMF derived commutation time. This optional delay may be used to optimize motor efficiency at the target speed. This pin may be left disconnected.
COMCLK	O	Back EMF commutation sense clock divided by 2. Each change in level corresponds to an advancement in back EMF sensed commutation state. This signal is used during initial startup by the microprocessor to sense the advancement and initial spin up of the motor.
OUT	O	Summing amplifier output pin intended to be connected in series with an external gain setting resistor to the IN pin.

PIN DESCRIPTION (continued)

NAME	TYPE	DESCRIPTION
IN	I	Input to the summing amplifier, connected through external resistors to the PROP, INTEG, and OUT pins.
CT	I	Neutral or center tap connection used by the back EMF sense circuit. For a STAR configured motor, CT is connected directly to the center tap (through a resistor for a 12 volt STAR motor). For DELTA or Y configured motors, three external resistors forming a DELTA to Y transformation network generate a neutral which is then connected directly to CT (through a resistor for a 12 volt motor).
BRAKEMODE	I	Mode control determining how the SSI 32M595 will respond to a power down fault. An internal threshold is compared to the voltage on the BRAKEMODE pin. When the BRAKEMODE voltage is above the threshold and a fault is active, the motor will free spin. When the voltage on BRAKEMODE drops below the threshold, dynamic braking will be implemented. This pin may be strapped to ground or tied to an RC network.
$\overline{\text{LOCK}}$	O	Open drain output active low when the motor speed is within the specified range.
ENABLE	I	Power enable. When ENABLE is low, the motor predriver is configured for dynamic braking, the internal FREF clock is gated off, and the component enters a low power state. When ENABLE is high, the FREF clock is enabled, the commutation and speed control circuits are enabled, and motor current will flow corresponding to the commutation state in effect.
START	I	Start clock generated by the supporting microprocessor when initially starting the motor. Each low to high transition advances the commutation state by one. While START is active high, back EMF commutation clocks are ignored. START may be applied regardless of the state of ENABLE since the commutation state counter is not powered down.

Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only. Do not use for final design.

Silicon Systems, Inc. 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX (714) 731-5457

Notes:

Section 7

HDD CONTROLLER/ INTERFACE

SSI 32B451
SCSI Controller

July, 1990

DESCRIPTION

The SSI 32B451 SCSI bus interface device is designed to adapt a peripheral controller (target) system to a small computer system interface (SCSI) bus.

As a target adapter, the SSI 32B451 contains circuitry to complement the logic of the SSI 32C453 Dual Port Buffer Controller for SCSI arbitration; SCSI REQ/ACK handshake; and parity generation and checking. In its role as a target SCSI adapter, the circuitry on the device maximizes SCSI bus performance in all phases and ensures conformance with the SCSI specification.

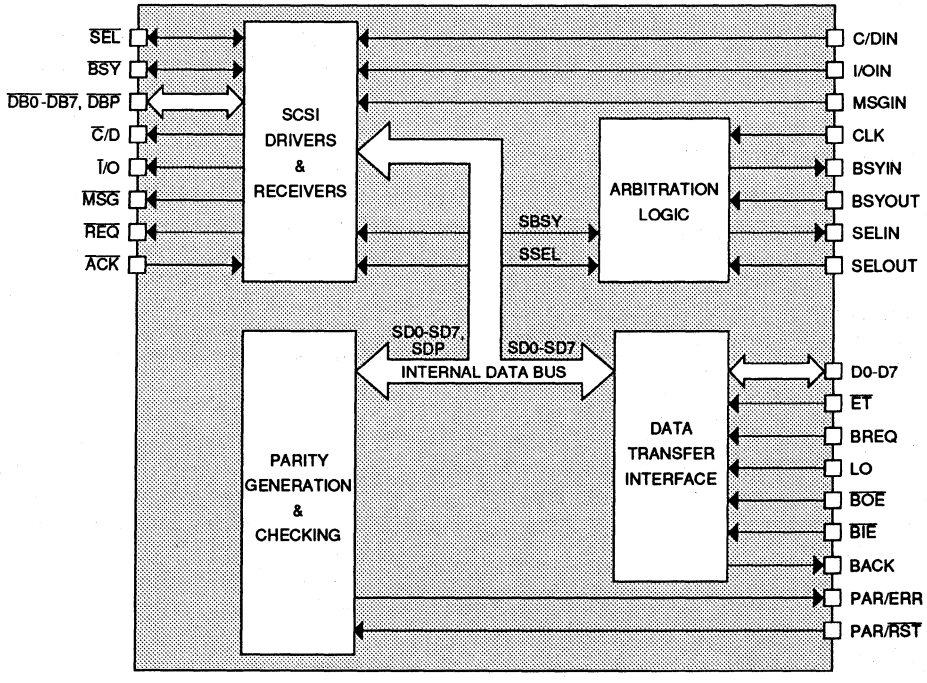
The SSI 32B451 includes high current drivers and Schmitt trigger receivers which allow for direct connection to the SCSI bus for the single ended interfacing option. The SSI 32B451 is intended for use in designs based around the SSI 32C452 storage controller and the SSI 32C453 Dual Port Buffer Controller.

FEATURES

- **Supports asynchronous data transfer up to 1.5 Mbytes/sec**
- **Supports target role in SCSI applications**
- **Includes high current drivers and Schmitt trigger receivers for direct connection to the SCSI bus**
- **Full hardware compliance to ANSI X3T9.2 Rev. 17B specification as a target peripheral adapter**
- **Contains circuitry to support SCSI arbitration, (re)selection and parity features**
- **Complements the SSI 32C453 Buffer controller**
- **Plug compatible with AIC 500L**
- **Available in 44 pin PLCC**
- **Single +5V supply**

7

BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

The purpose of the SSI 32B451 is to fulfill a support role within a hardware design. The device contains four circuit functions which interact within the overall design. The partial schematic in Figure 10 illustrates this interaction. This section describes each of the functional circuits.

DATA TRANSFER INTERFACE

The data transfer interface logic coordinates the transfer of data between the data transfer logic and the SCSI bus. Standard two-wire DMA handshaking is supported by the BREQ and BACK signals. This section is organized to connect directly with the SSI 32C453, Dual Port Buffer Controller, but is easily connected to any other data transfer control device. Before DMA controlled information transfer can begin, a valid connection must exist to the SCSI bus with BSY active and no phase error. The direction of information flow is controlled by the I/O In signal from the storage controller or a latch.

The device complements the buffer controller handshake timing by latching the SCSI data before transferring into the controller buffer. This speeds the data transfer across the bus by reducing the $\overline{REQ}/\overline{ACK}$ timing restraints for the SCSI bus transfers.

In the target-in state (read operation), the data is being transferred from the peripheral controller to the initiator or the host. The buffer controller device controls when the buffer is accessed to pass on to the device. Once valid data is present on D0-D7 of the buffer data, LO is asserted, latching data into the device. The buffer controller then asserts BREQ, indicating to the device that valid data is in the internal latch ready to be transferred over the SCSI bus. The device then places data on the SCSI bus and then asserts $\overline{REQ}$. The data setup time required by SCSI specification is dictated primarily by the buffer controller. The host (initiator) asserts $\overline{ACK}$ indicating acceptance of the SCSI data transfer cycle. The device asserts BACK to the buffer controller logic indicating completion of that cycle. Refer to Read Operation timing diagram (Figure 4) for an illustration of this handshake.

In the target-out state (write operation), the data is being transferred from the initiator to the buffer upon the control of the buffer controller. The buffer controller asserts BREQ requesting transfer of a byte of data from the initiator. The device, in turn, asserts $\overline{REQ}$ and the initiator responds by driving the SCSI data bus and asserting $\overline{ACK}$ which latches data into the device. BACK is asserted by the device indicating that the byte is latched inside the device and is available to be transferred to the buffer RAM. The buffer controller then asserts $\overline{BIE}$ to enable output of the data to the RAM. When the buffer controller has completed transferring the data it negates $\overline{BIE}$ and BREQ indicating to the device that the cycle is complete. Refer to Write Operation timing diagram (Figure 3) for an illustration of this handshake.

ARBITRATION

The purpose of this block is to complement the logic in the SSI 32C453, buffer controller device, for SCSI bus arbitration during selection of the target controller or reselection of the initiator phases. The device simply passes along the $\overline{SEL}$ and $\overline{BSY}$ signals as SEL IN and BSY IN, respectively. It also monitors the control line BSYOUT received from the buffer controller chip for a minimum of three clock periods and a maximum of four clock periods (Bus-Free Delay) after which time it outputs $\overline{BSY}$.

Once the device has performed these functions it leaves the actual arbitration activity to the local microcontroller and the buffer controller. Refer to the SSI 32C453 specification for details of this activity.

The SCSI signals $\overline{SEL}$, SELOUT, $\overline{BSY}$ and BSYOUT received from the buffer controller are internally inverted and become SELIN, $\overline{SEL}$, BSYIN and $\overline{BSY}$, respectively. The actual monitoring of these lines for SCSI timing specification is accomplished by the buffer controller. The actual arbitration activity for the SCSI bus is performed by the buffer controller device and the local microcontroller. Refer to the SSI 32C453 specification for the timing of this activity.

PARITY GENERATION

Parity functions as 'Odd' parity only. For incoming data, the SSI 32B451 checks parity or computes and passes the computed bit to the buffer RAM depending upon the condition of PAR/$\overline{RST}$ line. For outgoing data, the device always computes parity on the data and presents to the SCSI bus.

For the incoming SCSI data, the device generates parity internally and compares it against the parity bit received if the PAR/$\overline{RST}$ line is high. The result of this comparison is latched at the PAR/ERR output signal. An error is indicated by a high signal at this output. To clear the error condition, the PAR/$\overline{RST}$ line must be driven to a low level.

Alternatively, if PAR/$\overline{RST}$ is held low, the device computes parity on incoming SCSI data and presents this parity bit at the PAR/ERR output. This value can be stored in the buffer RAM for parity checking at a later time.

For outgoing data, parity is always generated and presented for the SCSI bus on the $\overline{DBP}$ line by the device.

NOTE: Parity, as a function of SCSI, is optional. However, the SSI 32B451 ignores this and works parity continuously. The surrounding design has responsibility of either monitoring parity or ignoring it.

SCSI INTERFACE

Drivers and receivers are provided internally to the SSI 32B451 for direct connection to the SCSI bus. The only components necessary outside of the chip are the pull-up and pull-down resistors for the interface and receivers for SCSI Attention and Reset signals. The data and parity signals received from the SCSI bus are passed along to the Data Transfer Interface and parity circuits described above. The data and parity bits to be sent over to the SCSI bus are buffered by this circuit.

PIN DESCRIPTION

This section describes the names of pins, their symbols, their functions and their active states. The signals are grouped in four categories according to their interface to other components on the board. The four categories area:

* SCSI Bus Interface
* Buffer Controller/Buffer RAM Interface
* Storage Controller Interface
* Others

7

SCSI BUS INTERFACE

The following group of signals interface directly to the SCSI bus. All output and bi-directional lines have 48 mA sinking current capability. All input buffers are Schmitt trigger inputs and all outputs have high current open drain buffers to allow direct connection to the SCSI bus.

NAME	PIN #	TYPE	I/O	DESCRIPTION
$\overline{DB0}$-$\overline{DB7}$	13-17 19-21	SCSI	I/O	Data Bus. Buffered data bus signals interface directly to SCSI bus.
$\overline{DBP}$	10	SCSI	I/O	Data Bus Parity. Parity bit for the SCSI data bus signals. It is always generated when data is transferred on the SCSI bus. It can be ignored on reception. Active low.
$\overline{ACK}$	7	SCSI	I	Acknowledge. This signal is an input from the initiator in response to the SSI 32B451's $\overline{REQ}$, and indicates valid data on the SCSI bus. Active low.
$\overline{SEL}$	23	SCSI	I/O	Select. Active low signal used by an initiator (the host) to select a target or by a target to reselect an initiator.

SCSI BUS INTERFACE (Continued)

NAME	PIN #	TYPE	I/O	DESCRIPTION
$\overline{BSY}$	25	SCSI	I/O	Busy. Active low. An "OR-tied" signal that indicates the bus is being used.
$\overline{MSG}$	11	SCSI	O	Message. Open drain SCSI signal. Signal driven by the device to indicate that the SCSI communication is in the message phase. Active low.
$\overline{C}$/D	27	SCSI	O	Command/Data. Open drain SCSI signal driven by the device that indicates control or data information is on the data bus.
$\overline{REQ}$	22	SCSI	O	Request. Active low true signal driven to request data byte transfers. Also, used to "Acknowledge" at completion of transfer.
$\overline{I}$/O	26	SCSI	O	Input/Output. SCSI signal that controls the direction of data movement on the SCSI bus with respect to the initiator.

BUFFER CONTROLLER/BUFFER RAM INTERFACE

The following group of signals are associated with buffer data and control. All signals except the buffer data signals interface to the SSI 32C453, Dual Port Buffer Controller.

NAME	PIN #	TYPE	I/O	DESCRIPTION
BREQ	35	TTL	I	Buffer Request. When asserted, this signal indicates that the peripheral buffer controller is requesting to transfer a byte of data. Active high input.
BACK	6	TTL	O	Buffer Acknowledge. When asserted this signal indicates acceptance of data transfer. Active high output.
LO	38	TTL	I	Latch Out. Latches data into the device to be presented to the SCSI bus. Active high.
$\overline{BIE}$	39	TTL	I	Bus In Enable. Active low. A strobe from the data transfer control logic which indicates it is transferring data from the SCSI bus to the local buffer.
$\overline{BOE}$	5	TTL	I	Bus Out Enable. Active low. A strobe from the data transfer control logic which indicates it is transferring data from the local buffer to the SCSI bus.
$\overline{ET}$	8	TTL	I	Target Enable. Active low. A signal connected to the SSI 32C453. When this signal is active it provides microcode and hardware control to enable all drivers except Busy on the SCSI bus.

BUFFER CONTROLLER/BUFFER RAM INTERFACE (Continued)

NAME	PIN #	TYPE	I/O	DESCRIPTION
SEL IN	29	TTL	O	Select In. Active high. Used to pass the select line from the SCSI bus to the buffer controller.
SEL OUT	28	TTL	I	Select Out. Active high. Used as an input from the buffer controller to indicate when to drive the select line on the SCSI bus.
BSY IN	31	TTL	O	Busy In. Active high. Used to pass busy from the SCSI bus to the buffer controller. Indicates other devices are actively accessing the bus.
BSY OUT	32	TTL	I	Busy Out. Active high. Used as an input from the buffer controller to indicate when to drive the busy line on the SCSI bus.
D0-D7	2-4 40-44	TTL	I/O	Buffer Data. These lines connect to buffer RAM data pins.

STORAGE CONTROLLER INTERFACE

The following group of pins interface with the SSI 32C452, Storage Controller. These lines may also be connected to an output port of a microcontroller or a latch.

NAME	PIN #	TYPE	I/O	DESCRIPTION
MSG IN	9	TTL	I	Message In. Active high signal from the storage controller drives the SCSI $\overline{MSG}$ signal low.
I/O IN	33	TTL	I	I/O In. A high signal from the storage controller drives the SCSI $\overline{I/O}$ signal low.
C/D IN	30	TTL	I	C/D In. A high signal from the storage controller drives the SCSI $\overline{C/D}$ signal low.

OTHERS

The following group of lines are the miscellaneous signals.

NAME	PIN #	TYPE	I/O	DESCRIPTION
CLK	34	TTL	I	Clock. Used for clock input between 2.5 MHz and 5 MHz. This signal is used internally during the arbitration phase only.
PAR/ERR	37	TTL	O	Parity/Error. Logic 1 indicates a parity error detected on the SCSI bus when PAR/$\overline{RST}$ is held high. When the PAR/$\overline{RST}$ line is held low, parity will be passed to the controller buffer by using the PAR/ERR line as the parity bit for each byte.

OTHERS (Continued)

NAME	PIN #	TYPE	I/O	DESCRIPTION
PAR/$\overline{RST}$	36	TTL	I	Parity/Reset. When held high, the device checks SCSI bus parity error by setting logic 1 (high) on the PAR/ERR pin. When held low, parity is passed through the device to the controller buffer with the PAR/ERR line being the parity bit.
GND	12, 18, 24			Ground. Device system ground.
VCC	1			Power Supply. +5V input for power to the device.

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

(Maximum limits indicate where permanent device damage occurs. Continuous operation at these limits is not intended and should be limited to those conditions specified in the DC Operating Characteristics.)

PARAMETER	RATING	UNIT
VCC with respect to VSS (GND)	+7	V
Max. voltage on any pin with respect to VSS	-0.5 to +7	V
Operating temperature	0 to 70	°C
Storage temperature	-55 to +125	°C

DC OPERATING CHARACTERISTICS

(Ta = 0 to 70°C, VCC = +5V ± 5%, VSS = 0V)

PARAMETER		CONDITION	MIN	MAX	UNITS
IIL	Input Leakage ($\overline{BREQ}$, LO, $\overline{BOE}$, $\overline{BIE}$, $\overline{ET}$ SELOUT, BSYOUT, CDIN, I/OIN, $\overline{MSGIN}$, PAR/$\overline{RST}$, CLK, $\overline{ACK}$)	0 < Vin < VCC	-10	+10	µA
IOL	SCSI Output Leakage ($\overline{SEL}$, $\overline{BSY}$, $\overline{DB0}$-$\overline{DB7}$, $\overline{DBP}$, $\overline{MSG}$, $\overline{C}$/D, $\overline{I}$/O)	0.5 < Vout < VCC	-50	+50	µA
IOL	D0-D7	0.45 < Vout < VCC	-10	+10	µA
VIL	Input Low Voltage		0	0.8	V

DC OPERATING CHARACTERISTICS (Continued)

PARAMETER		CONDITION	MIN	MAX	UNITS
VIH	Input High Voltage		2.0		V
VOH	Output High Voltage	IOH = -400 µA	2.4		V
VOL	SCSI Output Low Voltage	IOL = 48 mA		0.5	V
VOL	All others	IOL = 2 mA		0.4	V
	Power Dissipation			500	mW
Vhsy	Hysteresis Voltage (all SCSI signals)		200		mV
Iccs	Standby Current	Ta = 70°C		600	µA
Icc	Supply Current	Ta = 70°C		30	mA
Cin	Input Capacitance			15	pF

AC CHARACTERISTICS

The following sections list the timing characteristics necessary for the proper operation of the device. Unless otherwise specified, all timing parameters pertain to input clock frequency (2.5 MHz min. to 5.0 MHz max.).

7

Note: AC timing is measured at Voh = 2.0V, Vol = 0.8V, Cin = 50 pF. Timing characteristics are valid over the entire operating temperature, 0 to 70°C, and voltage range, 4.75 to 5.25 volts.

CLOCK AND PARITY TIMING (See Figures 1 & 2)

SYMBOL	PARAMETER	MIN	MAX	UNITS
TICLK/2	Input Clock Half-Cycle	100	200	ns
TICLK	Input Clock Width	200	400	ns
DPV	Data Valid to Parity Detect		100	ns

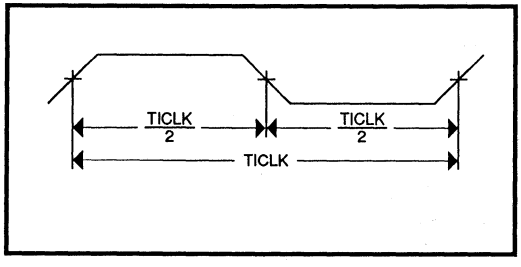


FIGURE 1: Input Clock Timing

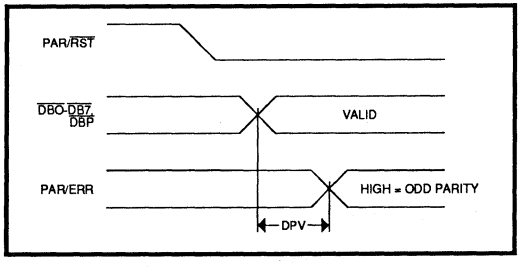
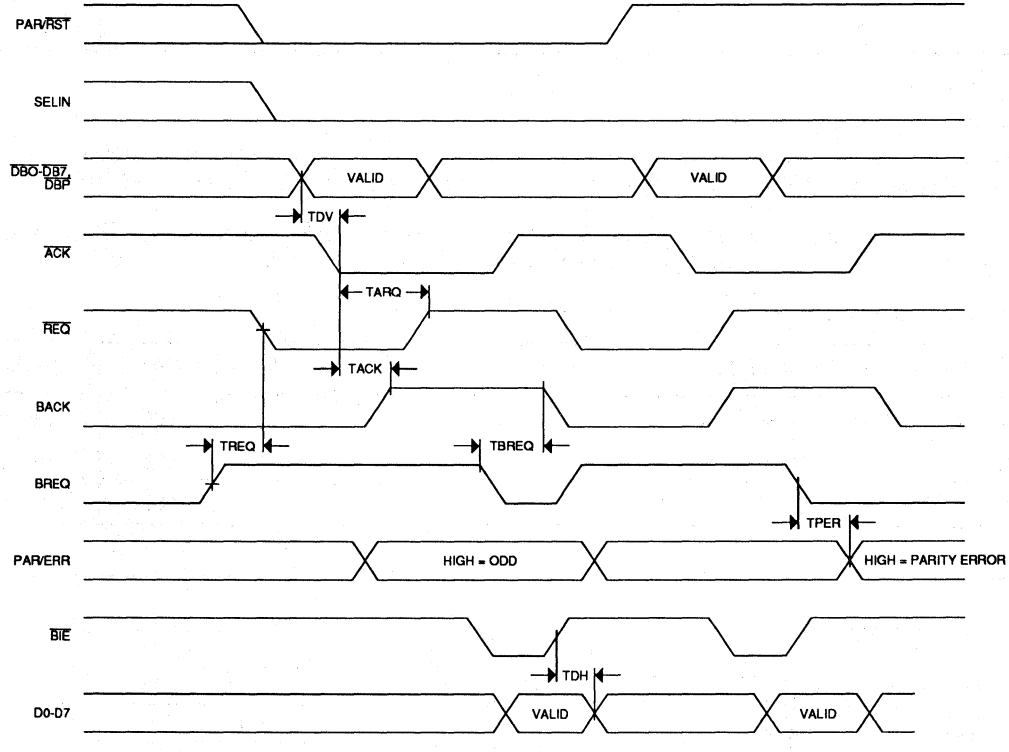


FIGURE 2: SCSI Bus Parity Timing

WRITE OPERATION TIMING (See Figure 3)

SYMBOL	PARAMETER	MIN	MAX	UNITS
TREQ	BREQ ↑ to $\overline{REQ}$ ↓		21	ns
TARQ	$\overline{ACK}$ ↓ to $\overline{REQ}$ ↑		55	ns
TACK	$\overline{ACK}$ ↓ to BACK ↑		50	ns
TBREQ	BREQ ↓ to BACK ↓		25	ns
TDH	$\overline{BIE}$ ↑ to Data Invalid		40	ns
TDV	SCSI Data Valid to $\overline{ACK}$ ↓	55		ns
TPER	BREQ ↓ to Parity Error Valid		45	ns

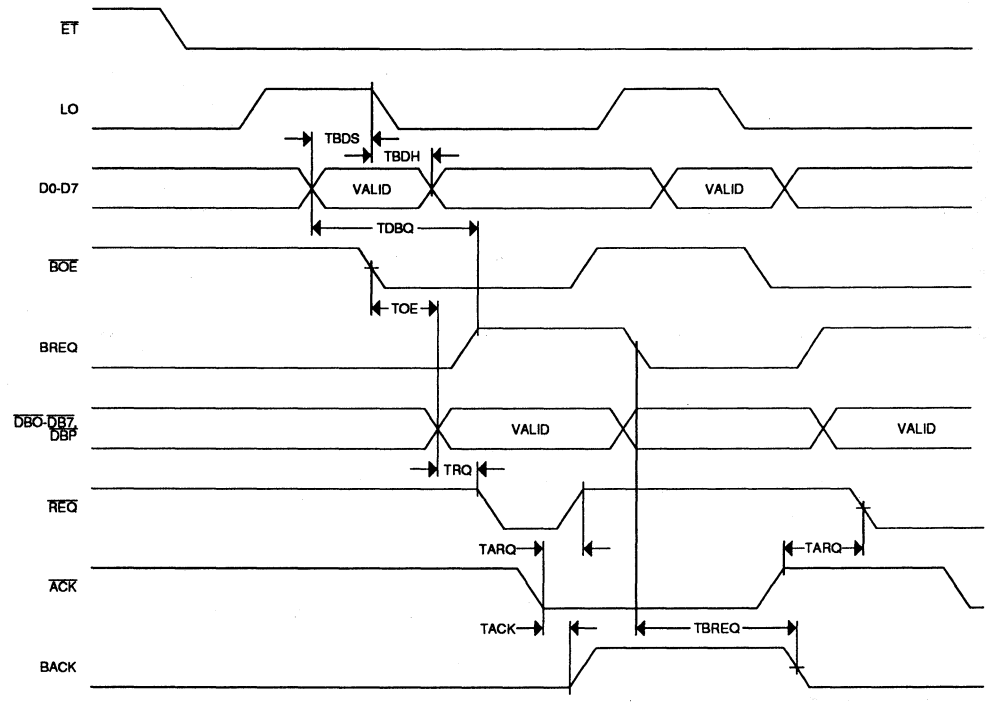


Note: Data from host - SCSI initiator - is transferred to buffer RAM.

FIGURE 3: Write Operation Timing

READ OPERATION TIMING (See Figure 4)

SYMBOL	PARAMETER	MIN	MAX	UNITS
TBDS	Buffer Data Valid to LO ↓	0		ns
TBDH	LO ↓ to Buffer Data Invalid	25		ns
TDBQ	Buffer Data Valid to BREQ ↑	90		ns
TRQ	SCSI Bus Data Valid to $\overline{REQ}$ ↓	55		ns
TARQ	$\overline{ACK}$ ↓ to $\overline{REQ}$ ↑		55	ns
TACK	$\overline{ACK}$ ↓ to BACK ↑		55	ns
TARQ	$\overline{ACK}$ ↑ to $\overline{REQ}$ ↓		55	ns
TBREQ	BREQ ↓ to BACK ↓		25	ns
TOE	$\overline{BOE}$ to SCSI Data Valid		35	ns



Note: Data read from peripheral drive is transferred to the host - SCSI initiator

FIGURE 4: Read Operation Timing

ARBITRATION AND CONTROL SIGNAL TIMING (See Figures 5 & 6)

SYMBOL	PARAMETER	MIN	MAX	UNITS
TSELO	SELOUT ↑ or ↓ to $\overline{SEL}$ ↓ or ↑		35	ns
TBOT	BSYOUT ↑ or ↓ to $\overline{BSY}$ ↓ or ↑	3 x TICLK	4 x TICLK + 40	ns
TCNT	MSGIN, I/OIN, CDIN to $\overline{MSG}$, $\overline{I}$/O, $\overline{C}$/D		35	ns

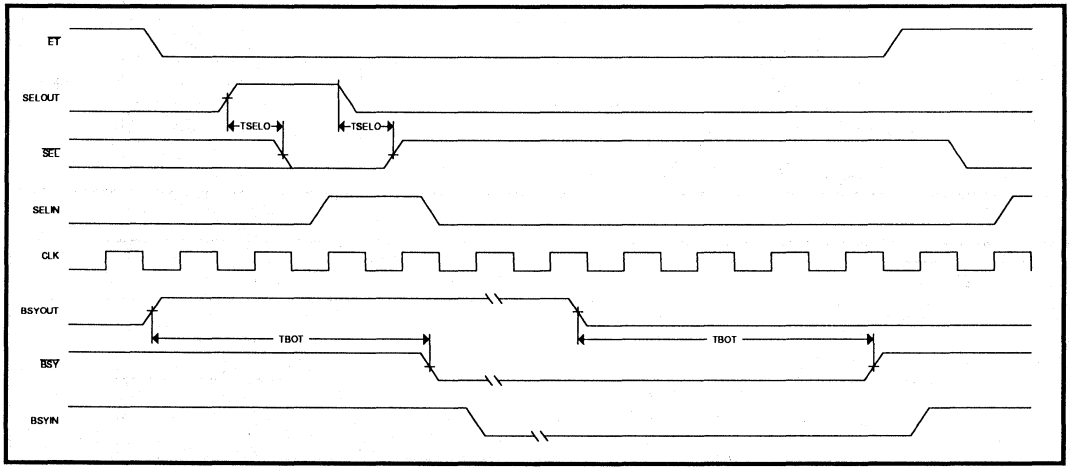


FIGURE 5: Arbitration Signals Timing

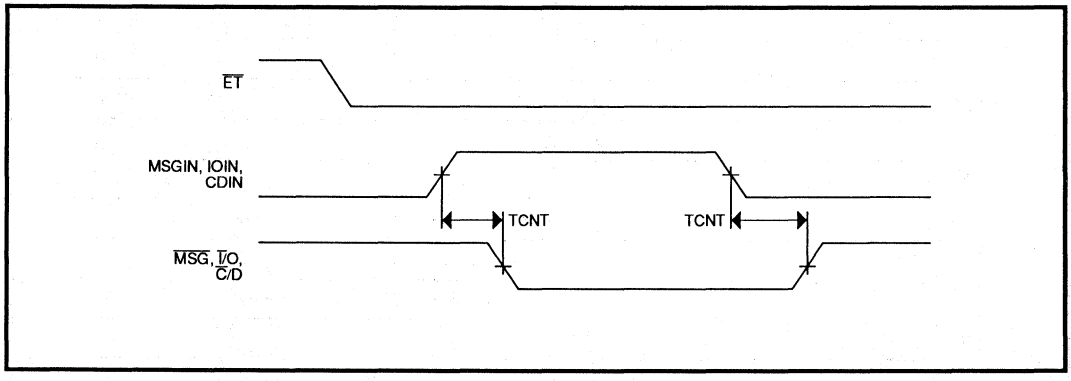


FIGURE 6: SCSI Control Signal Timing

APPLICATION NOTES

The SSI 32B451 supports the SSI 32C453 and the local microprocessor in performing all the SCSI target controller functions. For successful SCSI bus operation, the target controller must follow all the requirements of the SCSI protocol defined by ANSI specification X3T9.2 Rev. 17B. An overview of a typical SCSI signal sequence is shown in Figure 7.

Before any SCSI operations can begin, the local microprocessor polls the $\overline{BSY}$ line through the SSI 32C453 (BSYIN signal). When this signal is asserted, the microprocessor checks the arbitration I.D. asserted by the initiator.

Following the Arbitration phase, the SCSI bus enters the Selection phase. SSI 32B451 assists the Arbitration and Selection phases by passing the two control signals, BSY and SEL, and the SCSI I.D. to the SSI 32C453 and the local buffer, respectively. Other phases following Arbitration and Selection are command, data in, data out, status, message in and message out. Table 1 shows the various phases and their sources.

Table 2 shows the various control signal status during different SCSI phases. Being a target device, the SSI 32B451 drives these control lines out on the SCSI bus.

The SSI 32B451 requires local microprocessor supervision for successful operation over the SCSI bus. Firmware support for the local microprocessor consists of various routines. Flow charts for these routines are shown in Figures 8 and 9.

SCSI SPECIFIC INFORMATION

This information from the ANSI Standard for the Small Systems Computer Interface is provided to assist in implementing a SCSI based controller with the SSI 32B451.

TABLE 1: Bus Phase Signal Sources

BUS PHASE	SIGNALS				
	$\overline{BSY}$	$\overline{SEL}$	$\overline{C/D}$, $\overline{I/O}$, $\overline{MSG}$, REQ	ACK/ATN	DB7-DB0
Bus Free	None	None	None	None	None
Arbitration	All	Winner	None	None	SCSI ID
Selection	I & T	Initiator	None	Initiator	Initiator
Reselection	I & T	Target	Target	Initiator	Target
Command	Target	None	Target	Initiator	Initiator
Data In Target	Target	None	Target	Initiator	Target
Data Out	Target	None	Target	Initiator	Initiator
Status Target	Target	None	Target	Initiator	Target
Message In	Target	None	Target	Initiator	Target
Message	Target	None	Target	Initiator	Initiator

7

DEFINITIONS FOR TABLE 1

All: The signal is driven by all SCSI devices which are actively arbitrating.

SCSI ID: The SCSI ID is a unique data bit (DB) for each of the SCSI devices in the system and is driven onto the SCSI bus by each device that is actively arbitrating. The other seven data bits shall not be driven by the SCSI device. The parity bit may be asserted or undriven during arbitration but can't be driven false.

I & T: This signal is driven by the initiator, target or both as specified in the selection or reselection phase.

Initiator: If this signal is driven it can be driven only by the active initiator.

None: The signal is released meaning it is not driven by any SCSI device.

Winner: The signal shall be driven by the one SCSI device that wins arbitration.

Target: If the signal is driven it can be driven only by the active target.

TABLE 2: Signal Status, Information Transfer Phases

SIGNALS			PHASE NAME	DIRECTION OF TRANSFER
$\overline{MSG}$	$\overline{C}$/D,	$\overline{I}$/O		
1	1	1	Data Out	Initiator to Target
1	1	0	Data In	Initiator from Target
1	0	1	Command	Initiator to Target
1	0	0	Status	Initiator from Target
0	1	1	#	
0	1	0	#	
0	0	1	Message Out	Initiator to Target
0	0	0	Message In	Initiator from Target
# = Reserved for future standardization				

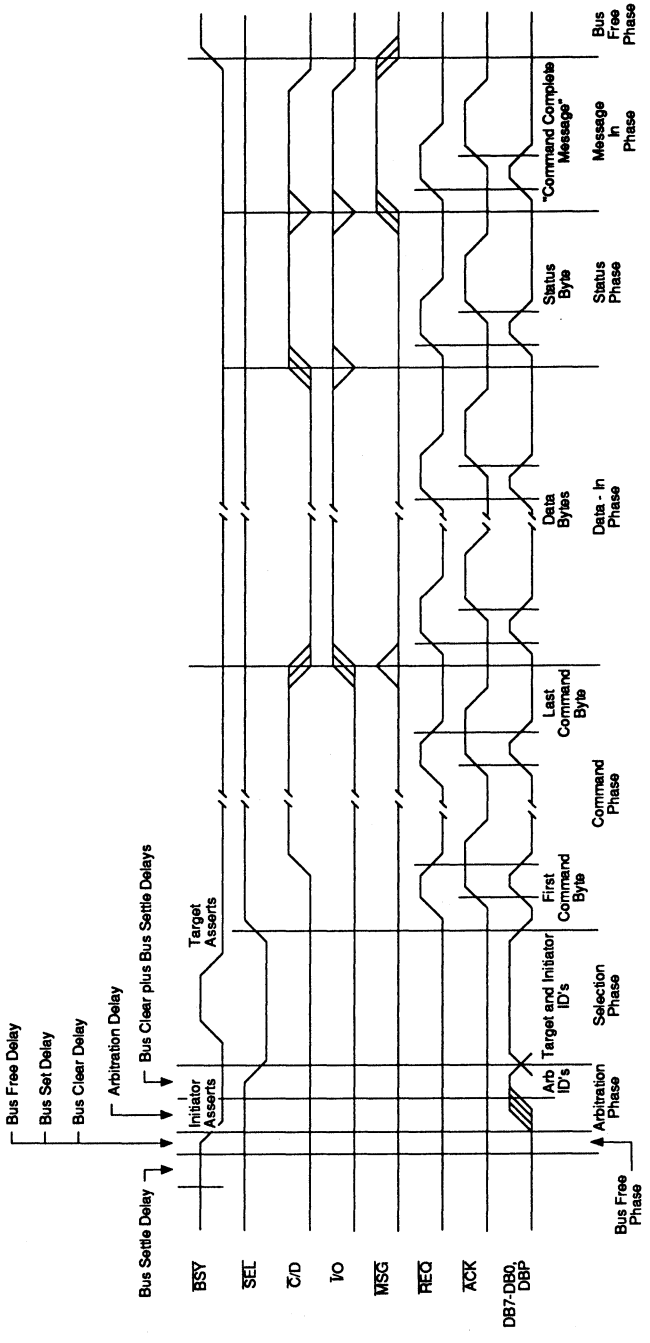


FIGURE 7: SCSI Signal Sequence Example

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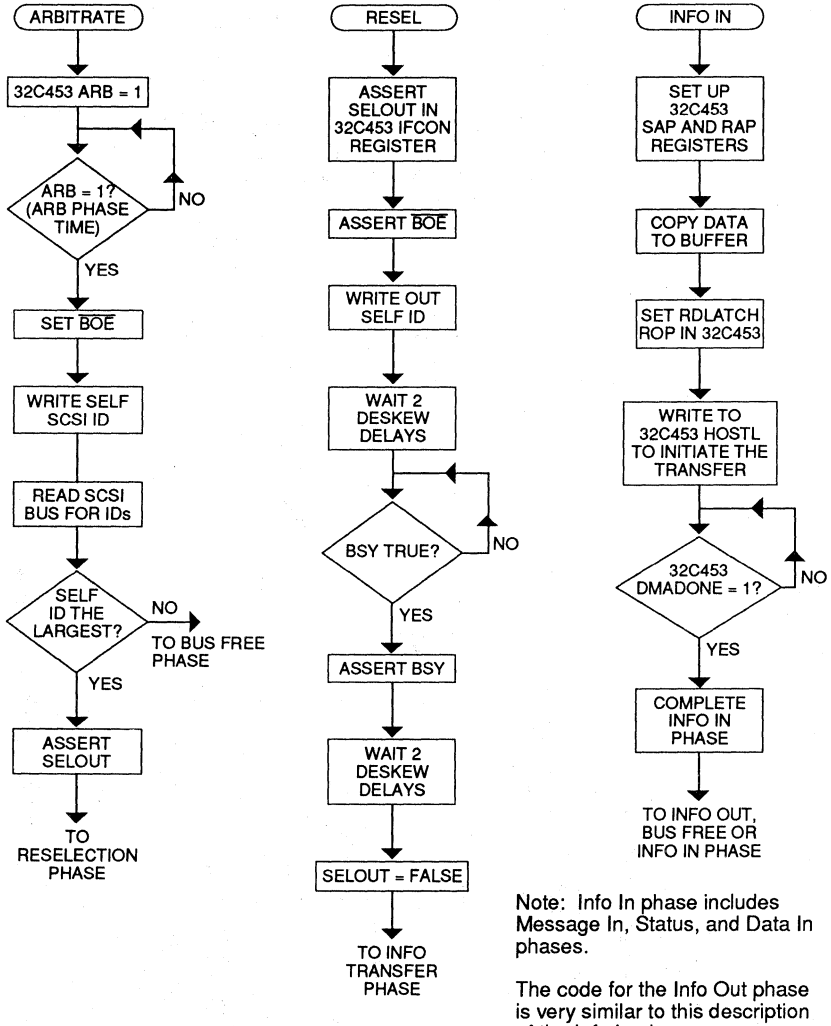


Note: Info In phase includes Message In, Status, and Data In phases.

The code for the Info Out phase is very similar to this description of the Info In phase.

FIGURE 8: Flow Charts for Various SSI 32B451 Routines

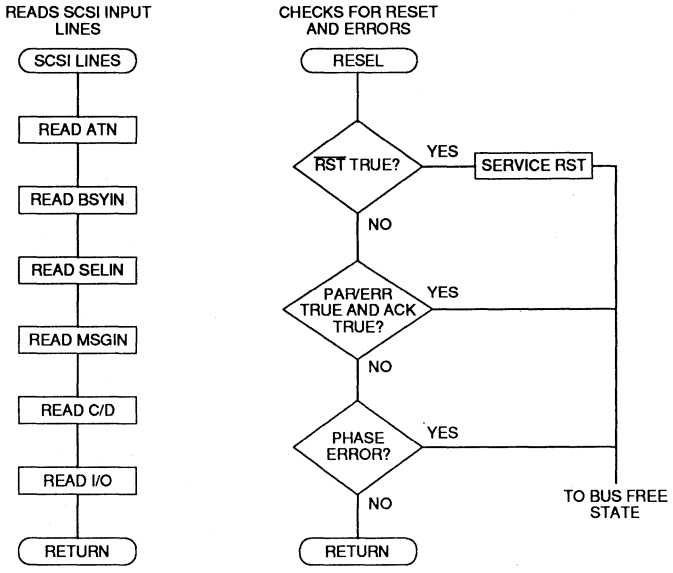


FIGURE 9: SCSI Background Routines Using SSI 32B451

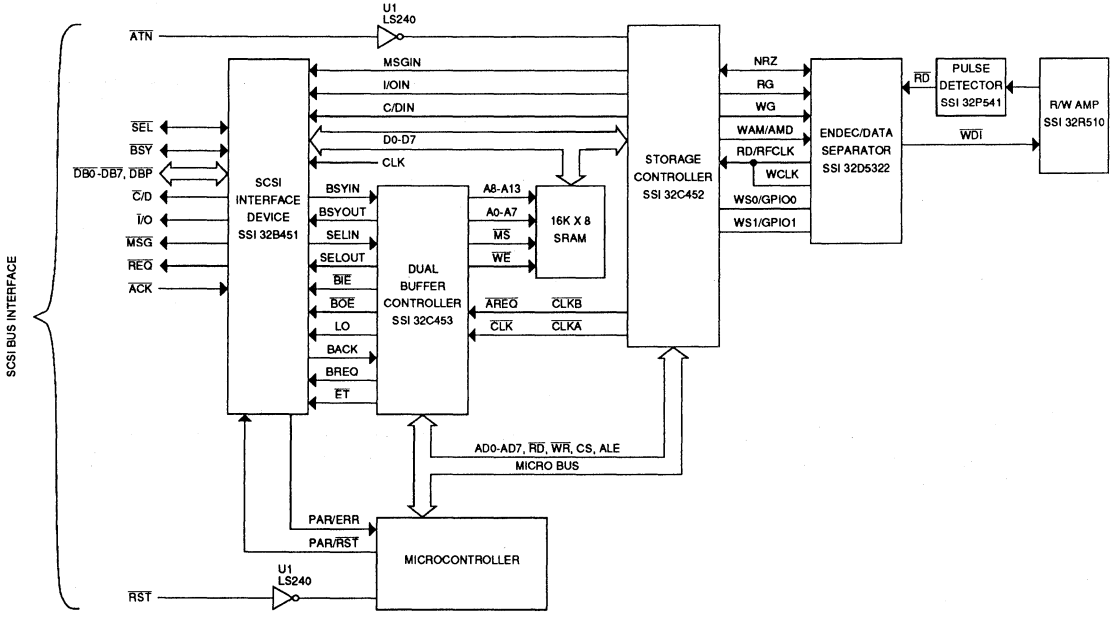
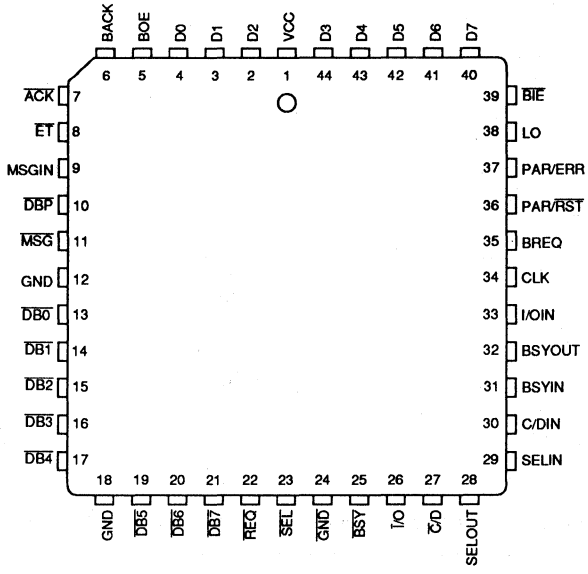


FIGURE 10: Partial Schematic for SCSI Implementation with Arbitration Support Using SSi Devices

PACKAGE PIN DESIGNATIONS
(TOP VIEW)

CAUTION: Use handling procedures necessary for a static sensitive component.



44-pin PLCC

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32B451 44-pin PLCC	SSI 32B451-CH	32B451-CH

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX: (714) 731-5457

SSI 32C260
PC AT/XT Combo Controller

Advance Information

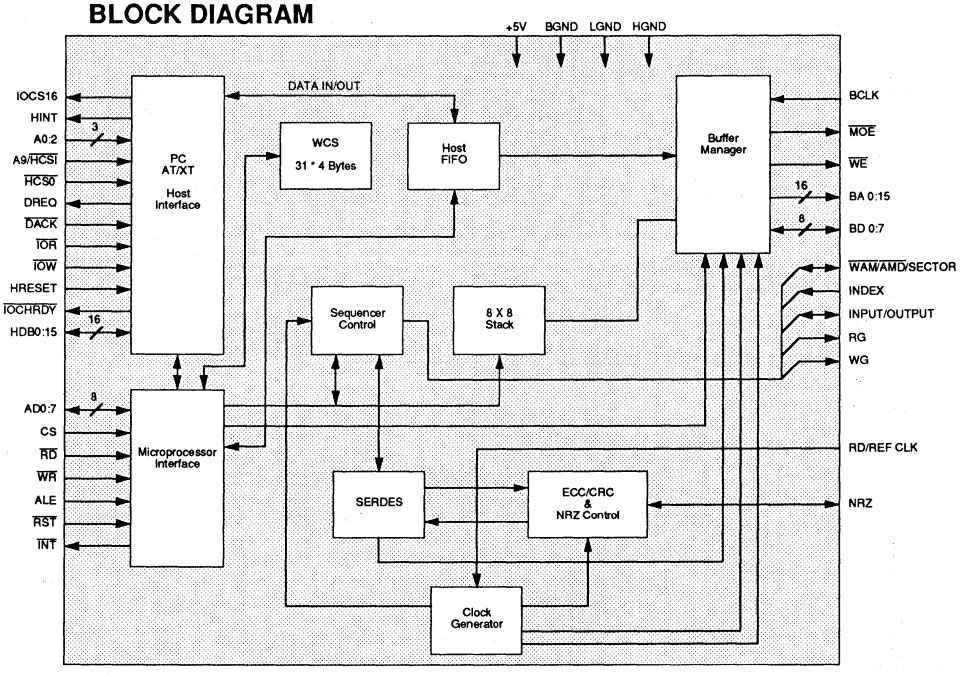
July, 1990

FEATURES

- PC AT/XT Bus Interface
  - Single Chip PC AT/XT Controller
  - Supports ST506/412, ST412HP, ESDI, and SMD disk interfaces
  - Direct bus interface logic with on-chip 24 mA drivers
  - Logic for daisy chaining 2 embedded controller drives on a PC AT
  - Supports 15 Mbit/s concurrent disk transfer on a 12 MHz PC AT without wait states
- Buffer Manager
  - Supports Buffer Memory throughput to 6 MB/s
  - Direct Buffer Memory addressing up to 64 kB static RAM
  - Dual port circular buffer control
- Storage Controller
  - NRZ Data rate up to 15 Mbit/s
  - Selectable 16-bit CRC or 56-bit ECC polynomial with fast hardware correction circuitry
  - Support sector level defect management
  - Support 1:1 interleaved operation
- Microprocessor Interface
  - Supports both Intel 8051, and Motorola 68HC11 family of microprocessors
  - Interrupt or polled microprocessor interface
- Others
  - Low power CMOS technology
  - Plug and Play compatible with Cirrus CL-SH 260 chip
  - Available in 84-pin PLCC or 100-pin QFP

7

BLOCK DIAGRAM



SSI 32C260
PC AT/XT Combo Controller

DESCRIPTION

The SSI 32C260 is a CMOS VLSI device which integrates the major portion of the hardware needed to build a PC AT/XT driven hard disk controller. The 32C260 is capable of supporting interleaved data transfer rate up to 15 Mbit/s. This chip represents a major reduction in part count when used with the SSI 32D5322 Data Separator, 32P541 Pulse Detector, the SSI 32R4610 Read/Write device, and the SSI 32H4631 Servo and Motor Speed Controller device, implementing a powerful and cost efficient 5-chip set intelligent drive solution. It also has the flexibility to be used as a stand-alone combo controller.

The SSI 32C260 includes a dual port Buffer Manager, a storage controller and a extensive hardware support, including 24 mA drivers, for the PC AT/XT and other compatible interfaces.

The SSI 32C260 performs all the controller functions for the peripheral device, such as serialization/ deserialization, ECC generation and checking on the data stream, and CRC generation and checking on the header of the data stream.

PIN DESCRIPTION

NAME	TYPE	DESCRIPTION
GENERAL		
+5V		POWER SUPPLY pin, VCC
BGND		BUFFER BUS GROUND
LGND		LOGIC GROUND
HGND		HOST GROUND
HOST INTERFACE		
A0:2	I	HOST ADDRESS LINES. These pins are used to address the internal registers by the AT bus.
A9/$\overline{HCS1}$	I	HOST ADDRESS LINE 9/ HOST CHIP SELECT 1. A9, this pin is used in conjunction with the A0:2 address lines to address the internal task file registers. HCS1 is an active low pin, used to qualify Host access.
$\overline{HCS0}$	I	HOST CHIP SELECT 0. Active low, this pin selects access to the control, status and data registers.
$\overline{IOCS16}$	O	I/O SELECT 16. An open drain output that indicates that a 16-bit sector buffer transfer is active.
HINT	O	HOST INTERRUPT. Asserted to indicate to the Host that the controller needs attention.
$\overline{IOCHRDY}$	O	I/O CHANNEL READY. Active low, this signal is asserted whenever that internal host FIFO is not ready to transfer data.
DREQ	O	DMA REQUEST. This pin is programmed to function as the PC/AT bus signal in the PC/ AT DMA mode.
$\overline{DACK}$	I	DMA ACKNOWLEDGE. Active low, in the PC/AT DMA mode this pin is programmed to be the PC/AT channel signal - DACK.
$\overline{IOR}$	I	INPUT READ SELECT. Active low, this pin is asserted by the Host during a Host read operation.
$\overline{IOW}$	I	INPUT WRITE SELECT. Active low, asserted by the HOST during a HOST write operation.

NAME	TYPE	DESCRIPTION
HOST INTERFACE (Continued)		
HRESET	I	HOST RESET. This signal resets all commands in progress when active, and initializes the control/status registers.
HDB 15:0	I/O	HOST DATA BUS. Active high bi-directional pins. These bits are used for data transfers between the Host and the Buffer Manager.
DISK INTERFACE		
INDEX	I	INDEX. Input for index pulse received from the drive
INPUT/ OUTPUT	I/O	INPUT/OUTPUT. A general purpose control and status pin. It can be either an input or an output. At power-on, this pin is an input.
$\overline{WAM}$/ $\overline{AMD}$/ SECTOR	I/O	WRITE ADDRESS MARK/ADDRESS MARK DETECT/SECTOR. This pin becomes an active low address mark detect if the read gate is on, or write address mark if write gate in on. It operates in hard or soft sector modes. The default is soft sector. In hard sector mode this is the input for the sector pulse.
RG	O	READ GATE. During NRZ data read, this pin is asserted. Active high.
WG	O	WRITE GATE. During NRZ data write, this pin is asserted. Active high.
RD/REF/ CLK	I	READ/REFERENCE CLOCK. This pin is used in conjunction with the NRZ pin to clock data in and out of the SSI 32C260 device.
NRZ	I/O	NRZ. This pin is used in conjunction with the RG and WG when reading and writing from and to the disk.
MICROPROCESSOR INTERFACE		
$\overline{RST}$	I	RESET. Active low input, when pulled low, the internal registers of the SSI 32C260 are held at reset.
ALE	I	ADDRESS LATCH ENABLE. This control signal latches the address on the address/data lines.
CS	I	CHIP SELECT. Active high signal, when asserted, the internal registers of the SSI 32C260 can be accessed.
$\overline{WR}$	I	WRITE. Active low input, when active the data is written to the internal registers.
$\overline{RD}$	I	READ. Active low input, when active the data is read from the internal registers.
$\overline{INT}$	O	INTERRUPT. An open drain output, when active, the microprocessor is requesting controller service.
AD7:0	I/O	ADDRESS/DATA BUS. 8-bit bus for both microprocessor register address and data.
BUFFER MANAGER INTERFACE		
BA0:15	O	BUFFER MANAGER ADDRESS LINES. Active high, for direct connection to a static RAM.
BD0:7	I/O	BUFFER MANAGER DATA BUS. 7 through 0. Active high, buffer data bus that connects directly to the buffer RAM.
$\overline{MOE}$	O	MEMORY OUTPUT ENABLE. Active low select for the buffer RAM.
$\overline{WE}$	O	WRITE ENABLE. Active low, write enable for the buffer RAM.
BCLK	I	SYSTEM CLOCK. This signal is used to synchronize the buffer RAM access, including the generation of memory address bits, write enable $\overline{WE}$, and memory output enable $\overline{MOE}$.

ABSOLUTE MAXIMUM RATINGS

Maximum limits indicate where a permanent device damage occurs. Continuous operation at these limits is not intended and should be limited to those conditions specified in the DC operating characteristics

PARAMETER	RATING	UNITS
Power Supply Voltage, VCC	7	V
Ambient Temperature	0 to 70	°C
Storage Temperature	-65 to 150	°C
Power Dissipation	750	mW
Input, Output pins	-0.5 to VCC+0.5	V

ELECTRICAL CHARACTERISTICS

PARAMETER	CONDITION	MIN	NOM	MAX	UNITS
VCC Power Supply Voltage		4.75		5.25	V
VIL Input Low Voltage		-0.5		0.8	V
VIH Input High Voltage		2.0		VCC+0.5	V
VOL Output Low Voltage	All pins except PC interface, IOL = 2 mA			0.4	
VOL Output Low Voltage	PC interface pins, IOL = 24 mA			0.5	V
VOH Output High Voltage	IOH = -400 µA			2.4	V
ICC Supply Current				50	mA
ICCS Supply Current Standby	All Inputs at GND or VCC	250			µA
IL Input Leakage Current	0 < VIN < VCC	-10		10	µA
CIN Input Capacitance				10	pF
COUT Output Capacitance				10	pF

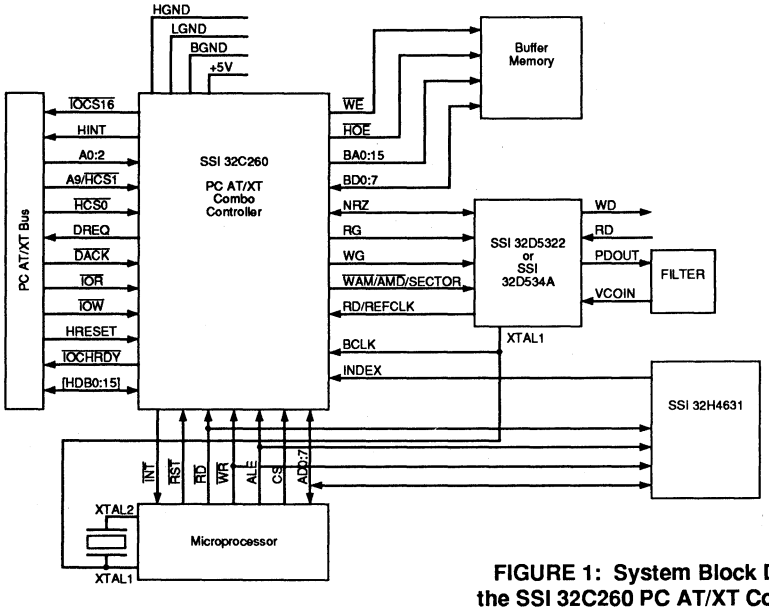
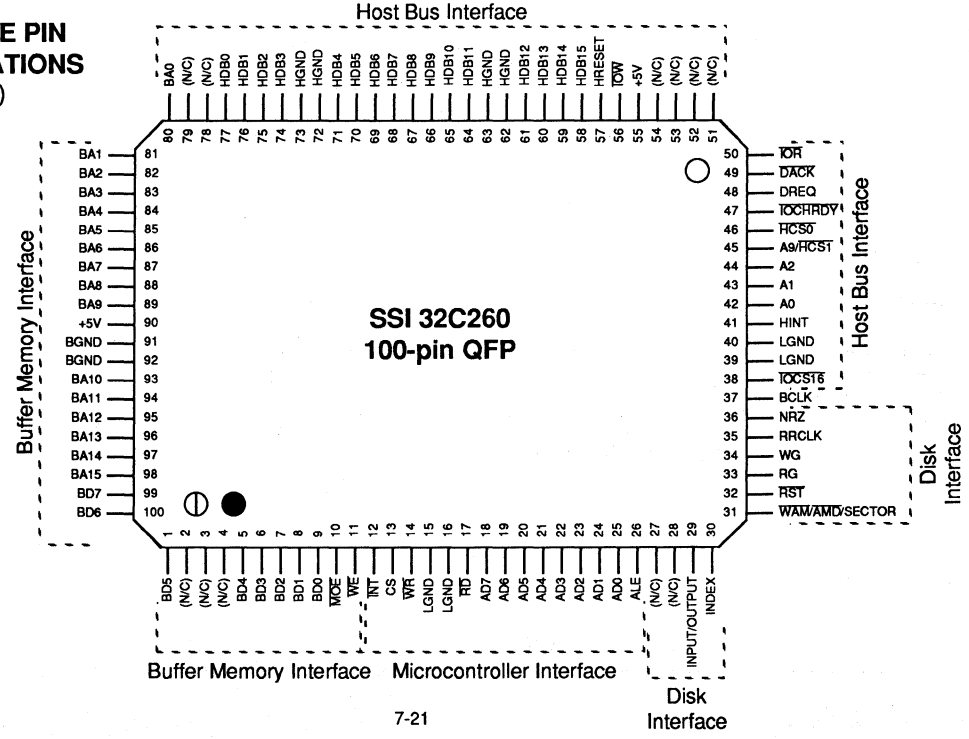


FIGURE 1: System Block Diagram using the SSI 32C260 PC AT/XT Combo Controller

7

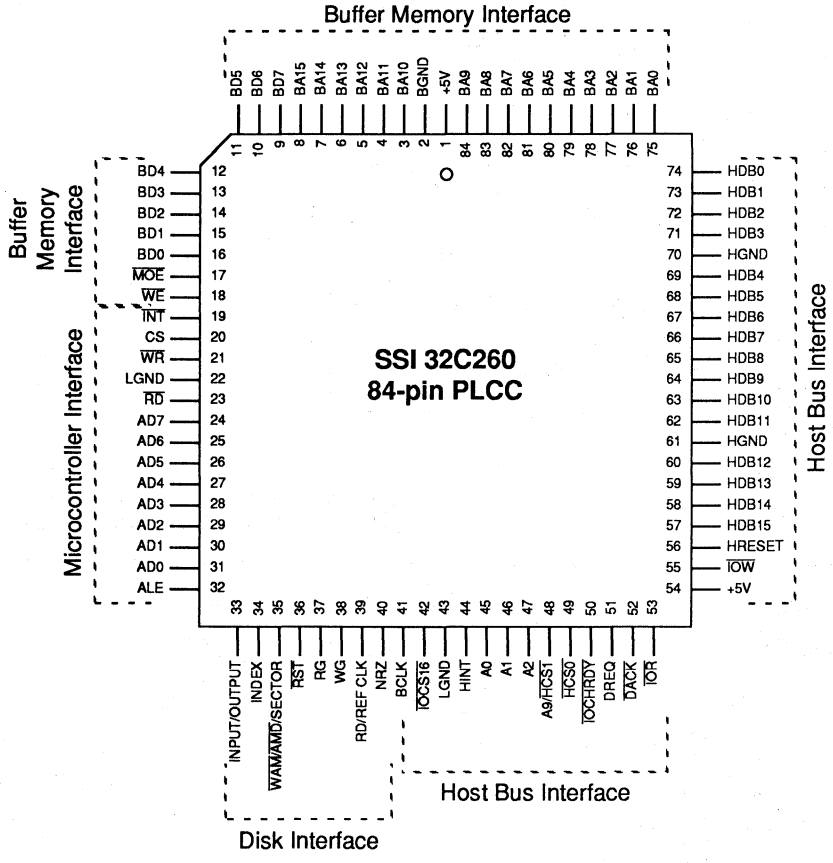
PACKAGE PIN DESIGNATIONS
(TOP VIEW)



PACKAGE PIN DESIGNATIONS (Continued)

(TOP VIEW)

CAUTION: Use handling procedures necessary for a static sensitive component.



Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only. Do not use for final design.

Silicon Systems, Inc. 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX (714) 731-5457

SSI 32C452
Storage Controller

Preliminary Data

July, 1990

DESCRIPTION

The SSI 32C452 Storage Controller is a CMOS device that provides the basis for an intelligent Winchester disk drive controller capable of non-interleaved data transfers at rates up to 20 Mbit/s. When combined with a microprocessor, memory and a buffer management device such as the SSI 32C453, the SSI 32C452 implements a powerful and cost-efficient peripheral controller solution. It also has the flexibility to be used in SCSI systems.

The SSI 32C452 includes a control sequencer with a writeable control store, and configuration/status registers which can be programmed to support standard and custom interface protocols for storage controllers. Access to the control store and registers is accomplished through the microprocessor interface which is optimized for 8 bit, multiplexed address/data bus processors such as the 8085 . It also has the flexibility to interface with most standard 8-bit microprocessors. This organization allows the controller firmware to be stored in an EPROM or the host and down-loaded to the SSI 32C452, and means wide flexibility of the control functions performed by the device.

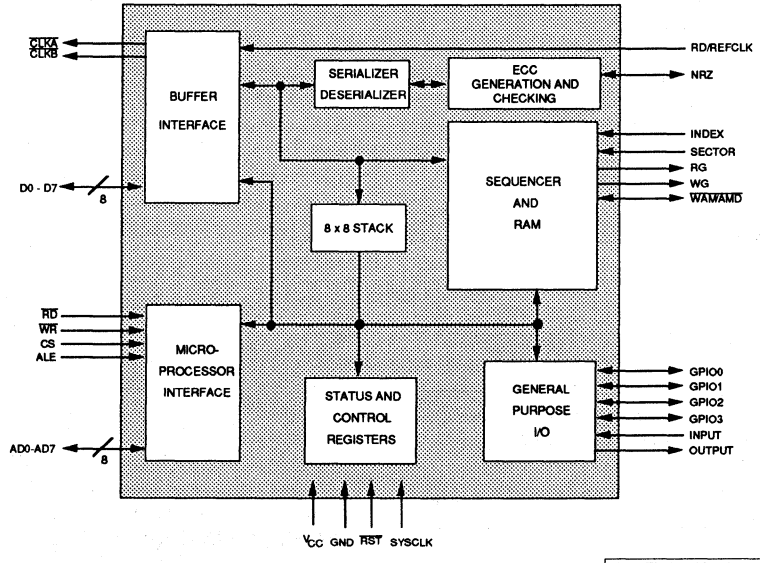
(Continued)

FEATURES

- **Supports ST506/412, ST412HP, SA100, SMD, ESDI and custom interfaces**
- **Operates with 16 MHz microprocessors**
- **Internal RAM-based control sequencer**
- **Internal user programmable ECC to 32 bits**
- **Non-interleaved data transfer to 20 Mbit/s**
- **Hard or soft sector formats**
- **Programmable sector lengths up to a full track**
- **High performance, low power CMOS device**
- **Plug and software compatible with AIC-010F Storage Controller**
- **Single 5 volt supply**
- **Available in 44-pin PLCC or 40-pin DIP package**

7

BLOCK DIAGRAM



DESCRIPTION (Continued)

The SSI 32C452 performs all the controller functions for the peripheral device, such as serialization/deserialization, ECC generation and checking on the data stream. It also handles overhead information such as address marks, gaps and sector ID fields. If an ECC error is detected during a read, the syndrome is saved so that defects can be corrected. The ECC polynomial and register length can be programmed or bypassed entirely so that external ECC hardware can be used.

FUNCTIONAL DESCRIPTION

The major functional elements and data paths of the SSI 32C452 are shown in the block diagram.

The SSI 32C452 performs the functions to interface a serial data storage device such as a Winchester disk drive, to a parallel bus interface for data processing on a byte wide basis. The functions necessary to accurately make this conversion are serialization/deserialization, error detection and correction, and data path control. The SSI 32C452 also has general purpose interface lines to further facilitate control of the data storage device or parallel interface. An eight byte stack allows data to be saved and reviewed by the microprocessor for error handling purposes. The internal sequencer performs most of the operations in conjunction with the control and status registers. The sequencer program is contained in internal sequencer RAM, which is easily (re)programmed providing almost infinite flexibility in communcations protocols and control features. A microprocessor effects both initialization and control of the SSI 32C452 by writing to and reading from the internal registers, sequencer RAM, stack and general purpose I/O circuitry. The microprocessor interface block of the SSI 32C452 provides the communication and control for the SSI 32C452 to the microprocessor.

The **buffer interface** includes a bidirectional data bus that exchanges data bytes between an external buffer memory and the serializer/deserializer. It generates two clocks, $\overline{\text{CLKA}}$ and $\overline{\text{CLKB}}$ which control all accesses to the buffer memory. All buffer memory cycles must be synchronous with $\overline{\text{CLKA}}$, which is derived from the RD/REFCLK input during data transfers and from SYSCLK otherwise. The internal register CLKCON contains control bits which define the relationship between these source clocks and $\overline{\text{CLKA}}$. The $\overline{\text{CLKB}}$ signal is asserted whenever a new data byte must be transferred (ie. when the serializer/deserializer is full during a read operation or empty during a write operation). The direction of the transfer is determined from the state of the read gate (RG) and write gate (WG) lines. A $\overline{\text{CLKB}}$ cycle is used to force the buffer control device (eg. an SSI 32C453) to reserve the next buffer memory access for the SSI 32C452, since peripheral transfers take precedence over the asynchronous host transfers. In order to allow host transfers to keep up with peripheral transfers, the $\overline{\text{CLKA}}$ rate selected should be at least twice the word transfer rate of the peripheral.

The **microprocessor interface** decodes microprocessor read and write requests and provides access to the appropriate register or internal memory location. Since both data and address information are carried on the multiplexed bus lines AD0-AD7, address information is latched from the bus on the falling edge of the microprocessor signal ALE (address latch enable). When $\overline{\text{CS}}$ is asserted along with either $\overline{\text{RD}}$ or $\overline{\text{WR}}$, the register whose address was previously latched is selected. The addresses and names of all the accessible registers are shown in the Register Address Map, Figure 1. The microprocessor should not read or write the sequencer RAM while the sequencer is running, since there is no circuitry to resolve conflicting accesses and incorrect sequencer operation will result.

The **status and control registers** make status information available to the microprocessor and allow the device to be configured for a wide variety of peripheral control applications. The microprocessor can monitor the status of transfers in progress and control the ECC register operation, the ECC polynomial, the clock generation hardware and the sequencer program execution. The microprocessor also has access to the sequencer's microprogram RAM so that it loads the microcode for all controller operations.

The **serializer/deserializer** circuit interfaces the parallel buffer memory bus to the serial NRZ data stream of the peripheral device. Byte synchronism is maintained with a bit ring, which is an 8 bit recirculating shift register clocked by the peripheral bit clock. During a sector write, the bit ring is initialized explicitly with a sequencer instruction. The bit ring continues to operate until the end of the field (ECC written or read) and causes $\overline{\text{CLKB}}$ to be asserted once for each data byte to be transferred. During write operations, the sequencer

may cause address marks and sync patterns to be loaded into the serializer instead of data bytes. These special patterns are contained in a sequencer instruction and are transferred to the serializer over an internal byte wide data path. During read operations, bytes of overhead information may be routed to the stack or sequencer for comparison against target values. This process is controlled by the control field (SEQCONF) in each sequencer instruction.

The eight byte recirculating **stack** may be used to capture read data for later examination by the microprocessor. Data is pushed onto the stack under sequencer control. The control bit STACKEN in the sequencer instruction field SEQCONF directly controls the stack. If more than 8 bytes are written to the stack, only the last 8 will be saved. When a data byte is read from the top of the stack by the microprocessor via the STACK register, the data is recirculated to the bottom of the stack, allowing the stack contents to be examined more than once without the use of temporary storage in the microprocessor or buffer.

Serial peripheral data is passed through a variable length shift register with programmable exclusive OR feedback that performs **ECC generation and checking**. The feedback taps for the desired ECC polynomial are selected in the four registers POLY0 - POLY24 and the polynomial length is determined by the LEN bits in ECCCON. In addition, the ECC register may be operated either under sequencer or microprocessor control. During read operations, the contents of the ECC register are compared to the actual ECC field read from the peripheral. If there is a mismatch, the error syndrome is available for error correction. The ECC polynomial may be reversed to allow hardware computation of the error location, relieving the microprocessor of the burden of this lengthy calculation. During writes to the peripheral, the computed ECC word can be appended to each data or address field. The sequencer data type field (SEQDATF) indicates when ECC bytes are to be written or checked during a peripheral transfer.

The **sequencer** controls the time critical operations of the SSI 32C452. It executes programs stored in the 28 word by 32 bit sequencer RAM, and can be pro-

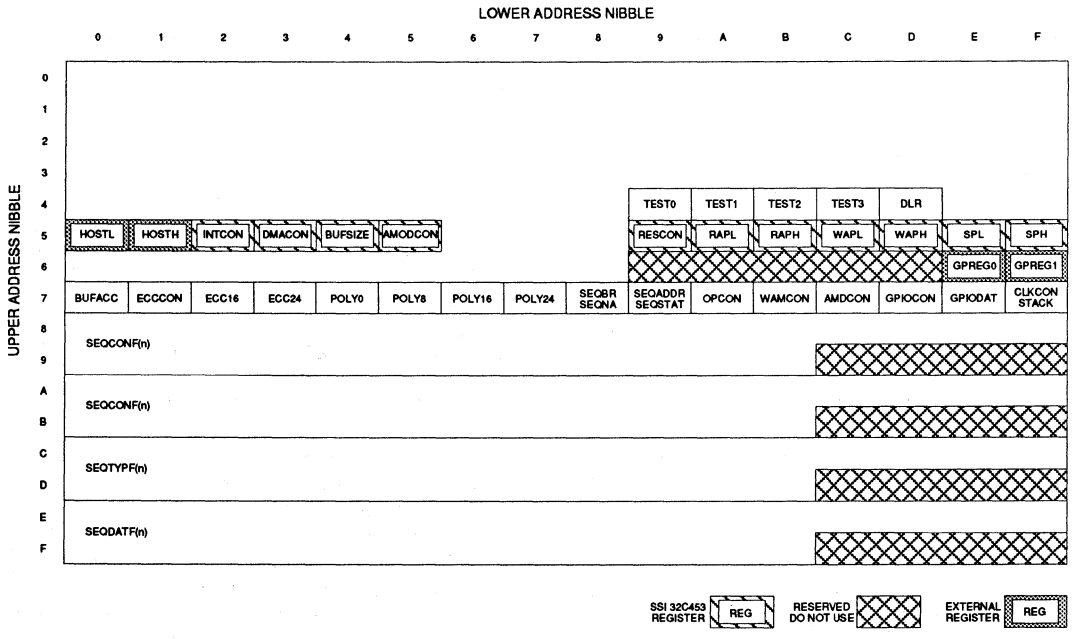


FIGURE 1: Register Address Map

FUNCTIONAL DESCRIPTION (continued)

grammed to support hard and soft sectored read, write, search and verify operations for a wide variety of Winchester disk drives and other peripherals. The sequencer RAM is loaded by writing to the sequencer instruction registers as outlined in the Sequencer Instructions section of this data sheet. Each instruction is comprised of four bytes. Each of the four bytes represents a function of the sequencer operation. They are address field, control field, data type field, and data field. The organization of these fields is shown in the Register Bit Map, Figure 2. The Sequencer Registers provide control from and status to the microprocessor and sequencer. They contain branch, next and start addresses, and sequencer status information. The SEQUENCER STATUS register provides informaton on the sequencer state such as whether an ECC error occurred, a compare equal or low occurred, if the branch condition or address mark is active, or whether the sequencer is halted.

The **general purpose I/O** section has four general purpose I/O lines GPIO0 - GPIO3, and the INPUT pin which are accessible through the internal general purpose input/output registers. They are available for user defined functions such as Winchester disk or host interface control. The functionality of the GPIO0 - GPIO3 pins is programmed in the GPIOCON and GPIODAT registers. They can act as I/O's asserted or read through the GPIODAT register, or they can be programmed to decode microprocessor access to addresses 6EH and 6FH eliminating the need for external decode. The INPUT signal can be programmed in the SEQADRF RAM (registers) to affect sequencer operation and the state of the pin read from the GPIODAT register. The other general purpose line, OUTPUT is controlled directly by the sequencer to synchronize it with external circuitry. The OUT bit of the GPIODAT register reflects the state of the output pin.

PIN DESCRIPTION

GENERAL

NAME	DIP	PLCC	TYPE	DESCRIPTION
VCC	40	1		POWER SUPPLY +5 volts
GND	20-21	22		GROUND
$\overline{RST}$	12	13	I	RESET - Active low signal halts the sequencer, sets output pins RG, WG, $\overline{WAM}$ and NRZ low, forces the GPIO pins into a high impedance state and resets a number of the registers as described below.
SYSCLK	13	14	I	SYSTEM CLOCK - Clock input in the range of 1.5 MHz to 16 MHz

MICROPROCESSOR INTERFACE

ALE	1	2	I	ADDRESS LATCH ENABLE - Falling edge latches register address from AD0-7 pins.
CS	29	33	I	CHIP SELECT- Active high signal enables device to respond to microprocessor read or write.

PIN DESCRIPTION (continued)

NAME	DIP	PLCC	TYPE	DESCRIPTION
$\overline{WR}$	30	34	I	WRITE STROBE - Active low signal causes the data on the address/data bus to be written to the addressed register if CS is also active.
$\overline{RD}$	31	35	I	READ STROBE - Active low signal causes the contents of the addressed register to be placed on the address/ data bus if CS is also active.
AD0-AD7	39-32	43-36	I/O	ADDRESS/DATA BUS - 8 bit bus which carries register address information and bi-directional data. These pins are high impedance when not in use.
GENERAL PURPOSE I/O				
GPIO0-3	4-7	5-8	I/O	GENERAL PURPOSE I/O LINES - These lines can be programmed as an inputs or outputs which are accessed though the GPIODAT register. They may also be programmed to serve as active low outputs which decode microprocessor accesses to the following locations: I/O pin — Alternate output decode GPIO0 — Write to 6EH GPIO1 — Read from 6EH GPIO2 — Write to 6FH GPIO3 — Read from 6FH
INPUT	8	9	I	INPUT PIN - This dedicated input line may be read through the GPIODAT register or tested directly by the control sequencer.
OUTPUT	9	10	O	OUTPUT PIN - Dedicated output line which is derived directly from the control sequencer instruction field.
DISK DRIVE INTERFACE				
INDEX	10	11	I	INDEX PULSE - Active high disk drive index pulse input, must be at least one byte time long.
SECTOR	11	12	I	SECTOR PULSE - Active high sector pulse input from disk drives that are hard sectored, must be at least one byte time long.
RG	14	15	O	READ GATE - Active high output from control sequencer enables external phase-locked loop (PLL) to synchronize to read data stream from the storage device.

PIN DESCRIPTION (continued)

DISK DRIVE INTERFACE (continued)

NAME	DIP	PLCC	TYPE	DESCRIPTION
WG	15	16	O	WRITE GATE - Active high output from control sequencer indicates valid write data to the storage device.
RD/REFCLK	26	30	I	READ/REFERENCE CLOCK - This input must be externally multiplexed to provide the PLL clock when read gate is active and the write oscillator clock at all other times. This pin must always be driven with a clock signal, even when $\overline{RST}$ is active.
NRZ	27	31	I/O	NRZ DATA - This bi-directional pin provides write data when WG is active, and must be driven with read data when RG is active. Data must be in the NRZ format.
$\overline{WAM/AMD}$	28	32	I/O	WRITE ADDRESS MARK/ADDRESS MARK DETECT - This bi-directional pin is used to write and detect address marks. When WG is active, a low level output of one bit time on this pin indicates that an address mark must be written. When RG is active, the peripheral must provide an active low input to indicate the detection of an address mark.

BUFFER INTERFACE

$\overline{CLKA}$	2	3	O	CLOCK A - Clock signal which initiates host or controller accesses to the buffer memory on its falling edge. When either RG or WG is active, this output is derived from RD/REFCLK. At all other times it is derived from SYSCLK. The clock source is divided by 2 or 4 as programmed in the CLKCON register.
$\overline{CLKB}$	3	4	O	CLOCK B - This clock is used to reserve $\overline{CLKA}$ cycles for SSI 32C452 data transfers. An active low pulse spanning a falling edge of $\overline{CLKA}$ indicates that the next falling edge on $\overline{CLKA}$ will be used by the SSI 32C452 to access the buffer memory.
D0-D7	16-19 22-25	18-21 25-28	I/O	BUFFER DATA BUS - Bi-directional data bus that carries data to and from the buffer memory. Bus cycles are controlled by $\overline{CLKA}$ and $\overline{CLKB}$. Direction of the transfer is determined by RG and WG. Note: refer to pin diagram for exact ordering of the pins.
No connects on PLCC package: 17, 23, 24, 29, 44				

REGISTER	ADDRESS	D7	D6	D5	D4	D3	D2	D1	D0	READ/ WRITE
TEST0	49H	SEQUENCER NEXT ADDRESS FIELD								R
TEST1	4AH	SEQUENCER CONTROL FIELD								R
TEST2	4BH	SEQUENCER COUNT/DATA TYPE FIELD								R
TEST3	4CH	SEQUENCER DATA FIELD								R
DLR	4DH	DATA LATCH REGISTER								R
BUFACC	70H	BUFFER MEMORY BYTE								R/W
ECCCON	71H	LEN1	LEN0	RESET	SECTBR	CLRECC	FEEDINH	ECCSHIFT	ECCIN	R/W
ECC16	72H	ECC23	ECC22	ECC21	ECC20	ECC19	ECC18	ECC17	ECC0/16	R
ECC24	73H	ECC31	ECC30	ECC29	ECC28	ECC27	ECC26	ECC25	ECC24	R
POLY0	74H	F7	F6	F5	F4	F3	F2	F1	F0	R/W
POLY8	75H	F15	F14	F13	F12	F11	F10	F9	F8	R/W
POLY16	76H	F23	F22	F21	F20	F19	F18	F17	F16	R/W
POLY24	77H	UNUSED	F30	F29	F28	F27	F26	F25	F24	R/W
SEQBR	78H	UNUSED			BRADR4	BRADR3	BRADR2	BRADR1	BRADR0	W
SEQNA	78H	TEST POINTS			NADR4	NADR3	NADR2	NADR1	NADR0	R
SEQADDR	79H	UNUSED			STADR4	STADR3	STADR2	STADR1	STADR0	W
SEQSTAT	79H	AMACTIVE	DATATRANS	BRACTIVE	STOPPED	UNUSED	ECCERR	COMPLO	COMPEQ	R
OPCON	7AH	CARRYINH	UNUSED	TRANSINH	SEARCHOP	SYNDET	NRZDAT	SECTORP	INDEXP	R/W
WAMCON	7BH	AM7 - AM0								R/W
AMDCON	7CH	AMD7 - AMD0								R/W
GPIOCON	7DH	RGFSEL	WGFSEL	RGESEL	WGESEL	GPDIR3	GPDIR2	GPDIR1	GPDIR0	R/W
GPIODAT	7EH	UNUSED		OUT	INP	GP3	GP2	GP1	GP0	R/W
CLKCON	7FH	CLKF2	CLKF1	UNUSED	CLKFO	CLKINH	SYN2	SYN1	SYN0	W
STACK	7FH	TOP OF STACK								R
SEQADDRF	80H 9BH	BRCON2	BRCON1	BRCON0	NEXT4	NEXT3	NEXT2	NEXT1	NEXT0	R/W
SEQCONF	A0H BBH	SETWG	SETRG	RESWG	STACKEN	NRZINH	OUTPIN	COMPEN	DATEN	R/W
SEQTYPF	C0H DBH	CNT7/ DTYP2	CNT6/ DTYP1	CNT5/ DTYP0	CNT4	CNT3	CNT2	CNT1	CNTO	R/W
SEQDATF		DATA FIELD								R/W

FIGURE 2: Register Bit Map

REGISTER DESCRIPTION

The microprocessor which controls the system has access to all the SSI 32C452 registers and sequencer RAM through its external memory address space. The SSI 32C452 and its companion device, the SSI 32C453 Dual Port Buffer Controller, are designed to occupy a single 256 byte page. The 8 bit page address is latched from pins AD0-AD7 on a falling edge of ALE and remains valid until the next ALE falling edge.

The external registers described at the end of this section are not implemented in either the SSI 32C452 or SSI 32C453, and are assumed to be implemented in external hardware. These external registers are not required for use with the SSI 32C452, but are included as applications information.

ECC REGISTERS

The core of the ECC circuit is a 32 bit shift register whose effective length may be programmed to be 16, 24 or 32 bits. This is accomplished in hardware by directing the input data to stage 16, 8 or 0 of the ECC shift registers, ECC16 and ECC24, while its output is always bit 31, which is bit ECC31 of register ECC24.

The ECC polynomial to be implemented is programmed by the user into the ECC feedback registers, POLY0, POLY8, POLY16 and POLY24. Each bit in these registers enables or disables exlusive OR feedback to the output of the corresponding shift register stage. The feedback signal is the exclusive OR of the serial data stream with the output of shift register stage 31. An override bit in ECCCON forces normal shift register operation, regardless of the settings of the feedback control bits.

When WG or RG are active, the ECC shift register input is the serial read or write data and the shift clock is RD/REFCLK. When an ECC word is being written, feedback is disabled and the shift register output is substituted for the data stream. At other times the microprocessor may set the ECCIN bit explicitly and cause a single shift register clocking to occur. For further information on implementing an ECC polynomial see the Applications Information Section at the end of this data sheet.

ECCCON **71H** **Read/Write**

ECC CONTROL WORD		
BIT	**NAME**	**DESCRIPTION**
0	ECCIN	ECC SERIAL INPUT - When both RG and WG are inactive, this bit becomes the input bit for the ECC shift register. The RD/REFCLK must always be active for correct operation of the device.
1	ECCSHIFT	ECC SHIFT CONTROL - When both RG and WG are inactive, a single shift of the ECC register will occur when this bit is set. It is automatically cleared again when the shift is complete.
2	FEEDINH	ECC FEEDBACK INHIBIT - When this bit is set all feedback is inhibited and the ECC register functions as a simple shift register of the selected length.
3	CLRECC	CLEAR ECC - If this bit is set when either RG or WG are active, the ECC syndrome will be cleared at the end of the read/write operation. If both are inactive, the syndrome will be cleared immediately.
4	SECTBR	ENABLE SECTOR BRANCH - If the sequencer "branch on index or sector" instruction is executed and SECTBR is set, the sequencer will recognize the branch condition as true if either the INDEX or the SECTOR pin is active. If SECTBR is cleared, then the sequencer will only recognize the branch condition if the INDEX pin is active.

ECC REGISTERS (continued)

BIT	NAME	DESCRIPTION
5	RESET	CHIP RESET - When this bit is set, the SSI 32C452 will be held in its reset state. This bit is set when $\overline{RST}$ is true.
6-7	LEN0-LEN1	ECC REGISTER LENGTH - These two bits select the ECC register length as follows: LEN1 LEN0 0 0 16 bit register 0 1 24 bit register 1 0 illegal combination 1 1 32 bit register
Reset State: ECCCON= 20H (ie. RESET=1)		

ECC16 **72H** **Read only**

ECC DATA		
BIT	**NAME**	**DESCRIPTION**
0	ECC0/16	ECC REGISTER LEADING BITS - This bit reflects the OR of all the ECC register bits from the input stage through bit 16. For 16 bit operation, this is bit 16. For 24 bit operation this is bit 8 + bit 9 + .. + bit 16. For 32 bit operation, this is bit 0 + bit 1 + ... + bit 16.
1-7	ECC17-ECC23	ECC REGISTER BITS - These bits reflect the output of ECC shift register stages 17 to 23.
Reset State: Unknown		

ECC24 **73H** **Read only**

ECC DATA		
BIT	**NAME**	**DESCRIPTION**
0-7	ECC24-ECC31	ECC REGISTER BITS - These bits reflect the output of ECC shift register stages 24 to 31.
Reset State: Unknown		

ECC REGISTERS (continued)

POLY0 **74H** **Read/Write**

ECC POLYNOMIAL		
BIT	**NAME**	**DESCRIPTION**
0-7	F0-F7	ECC POLYNOMIAL FEEDBACK - These bits enable or disable exclusive OR feedback of both the shift register output (bit 31) and the serial input to the output of shift register stages 0 to 7. These settings may be overriden by the FEEDINH bit in ECCCON. For ECC register lengths of 16 or 24 bits, F0-F7 are irrelevant.
Reset State: POLY0=00H		

POLY8 **75H** **Read/Write**

ECC POLYNOMIAL		
BIT	**NAME**	**DESCRIPTION**
0-7	F8-F15	ECC POLYNOMIAL FEEDBACK - These bits enable or disable exclusive OR feedback to the output of shift register stages 8 to 15. For register lengths of 16 bits, F8-F15 are irrelevant.
Reset State: POLY8=00H		

POLY16 **76H** **Read/Write**

ECC POLYNOMIAL		
BIT	**NAME**	**DESCRIPTION**
0-7	F16-F23	ECC POLYNOMIAL FEEDBACK - These bits enable or disable exclusive OR feedback to the output of shift register stages 16 to 23.
Reset State: POLY16=00H		

POLY24 **77H** **Read/Write**

ECC POLYNOMIAL		
BIT	**NAME**	**DESCRIPTION**
0-6	F24-F30	ECC POLYNOMIAL FEEDBACK - These bits enable or disable exclusive OR feedback to the output of shift register stages 24 to 30.
7	unused	
Reset State: POLY24=00H		

SEQUENCER STATUS AND CONTROL REGISTERS

The sequencer controls all the time-critical interactions with the peripheral storage device being controlled by the SSI 32C452. The instructions directly control disk drive interface lines, provide data for writing or comparison, determine the number of bytes handled and control the sequence of instruction execution. It is programmed by the user for maximum capability and variability. There are 28 instructions which are 32 bits wide. They are divided in to 4 byte wide fields. These fields are sequencer address, control, data type and data fields. These may be further divided into subfields as described in detail below. Examples are shown in the Applications Information section at the end of this data sheet.

The next address field of the sequencer instruction contains address and branching information. Each instruction is executed for the duration of the number of byte times specified in its count field. The specified count is loaded into a down counter which clocks every 8 bit times. When the counter underflows execution of that instruction is terminated. A carry inhibit feature allows the counter to wrap around to a full count for fields which are more than 256 bytes long. Execution is passed to the instruction at the specified next address, unless a branch condition is specifed in the instruction (e.g., ECC error or successful data comparison). In that case, execution passes to the address specified in the SEQBR register. Sequencer operation may also be conditionally stopped. The sequencer will always stop if execution passes to address 1FH, which is outside of the 28 word instruction control store.

The control field of the sequencer instruction is used to specify the state of RG and WG, to move data to the stack and to select data transfer or data comparison operations. The count field sets the duration of each instruction in byte times and is also used to select the type of data written, such as address marks or ECC bytes.

SEQBR **78H** **Write only**

SEQUENCER BRANCH ADDRESS		
BIT	**NAME**	**DESCRIPTION**
0-4	BRADR0 - BRADR4	BRANCH ADDRESS BITS - When a sequencer instruction with a branch condition is finished (i.e., the specified number of byte times have elapsed) and the specified condition did occur, execution will resume at this 5 bit address.
5-7	unused	
Reset State: Unknown		

SEQNA **78H** **Read only**

SEQUENCER NEXT ADDRESS		
BIT	**NAME**	**DESCRIPTION**
0-4	NADR0 - NADR4	NEXT ADDRESS BITS- This reflects the 5 bit next address field of the sequencer instruction currently being executed. After the specified byte count, execution will proceed at this address provided no branch conditions occur.
5-7		Internal test points
Reset State: Unknown		

SEQUENCER STATUS AND CONTROL REGISTERS (continued)

SEQADDR 79H Write only

SEQUENCER START ADDRESS		
BIT	**NAME**	**DESCRIPTION**
0-4	STADR0 - STADR4	SEQUENCER START ADDRESS BITS - If the sequencer is currently halted, writing this register with an address in the range 00H to 1BH will cause sequencer execution to commence at that address. If this register is written with 1FH , the sequencer will halt.
5-7	unused	
Reset State: 00H		

SEQSTAT 79H Read only

SEQUENCER STATUS		
BIT	**NAME**	**DESCRIPTION**
0	COMPEQ	COMPARE EQUAL - When a sequencer instruction enables the comparison operation, this bit reflects the result of all the byte comparisons performed (i.e., if it is set then all bytes compared so far have been equal.) If RG is enabled, the comparisons occur between the instruction's data field and the data bytes being read (or buffer memory if the SEARCHOP bit in OPCON is true as well).
1	COMPLO	COMPARE LOW - Similar to COMPEQ, except that it indicates that in all comparisons the data field was smaller than the compared byte.
2	ECCERR	ECC ERROR - This bit is set during RG active, upon reading the last ECC bit, if there was an error in the data read. The error syndrome will be stored in the ECC registers.
3	not used	
4	STOPPED	SEQUENCER STOPPED - This bit is set when the sequencer is stopped and its instruction address is 1FH.
5	BRACTIVE	BRANCH ACTIVE - This is set when the branch condition specified in the current instruction has been satisfied. This means that the next address used will be taken from the SEQBR register. This bit is reset when the microprocessor reads this register.
6	DATATRANS	DATA TRANSFER - This bit is set when the current sequencer instruction is causing data to be transferred between the buffer memory and the peripheral device. This distinguishes the activity from a search or verification operation.
7	AMACTIVE	ADDRESS MARK ACTIVE - This bit is set when the controller reads or writes an address mark or sync byte. It is reset after the ECC bytes are read or written, or when the sequencer is halted.
Reset State: 00H		

SEQUENCER INSTRUCTION REGISTERS

The 4 fields of 8 bits comprising a single sequencer instruction are detailed below. They are presented as arrays of 28 bytes each, corresponding to the 28 instructions at sequencer addresses 0 to 1BH.

SEQADRF(n) 80H-9BH Read/Write

SEQUENCER ADDRESS FIELD ARRAY			
BIT	**NAME**	**DESCRIPTION**	
0-4	NEXT0-NEXT4	NEXT ADDRESS FIELD - This 5 bit field specifies the address of the next instruction to be executed when the current instruction has continued for the specified number of bytes.	
5-7	BRCON0 -BRCON2	BRANCH CONTROL FIELD - This 3 bit field specifies the branch condition for the current instruction. When a branch condition is satisfied, execution of the current instruction is not curtailed. It continues to execute for the full byte count specifed, and then the sequencer proceeds with execution of the address specified in SEQBR. The branch condition used depends on the state of RG and data type field (see SEQTYPF). If RG is true and ECC bytes are being read, the following branch conditions apply:	
		BRCON2/1/0=	000 No branch
			001 Stop on ECC error
			010 Stop on comparison error
			011 Stop on ECC or comparison error
			100 Branch on good ECC and comparison
			101 Branch on ECC error
			110 Branch on comparison error
			111 Branch on ECC or comparison error
		Otherwise, the branch conditions are:	
		BRCON2/1/0=	000 No branch
			001 Stop if INPUT pin active
			010 Stop if INDEX or SECTOR pin active (see SECTBR bit of register ECCCON).
			011 Stop if comparison error
			100 Branch on carry (from byte counter).
			101 Branch on ECC error
			110 Branch if INDEX or SECTOR pin active (see SECTBR bit of register ECCCON).
			111 Branch on comparison error
Reset State: The contents of the sequencer RAM are unchanged.			

7

SEQUENCER INSTRUCTION REGISTERS (continued)

SEQCONF(n) A0H-BBH Read/Write

SEQUENCER CONTROL FIELD ARRAY		
BIT	**NAME**	**DESCRIPTION**
0	DATEN	DATA TRANSFER ENABLE - When this bit is set, the SSI 32C452 will generate $\overline{\text{CLKB}}$ requests to transfer data bytes to or from buffer memory, depending on whether WG or RG is active.
1	COMPEN	COMPARE ENABLE - When this bit is set and RG is active, read data bytes from the peripheral will be compared with the instruction data field (SEARCHOP reset in the OPCON register) or the buffer memory data (SEARCHOP set). The results of the comparisons are OR'ed together for the duration of the instruction and can be used for a branch condition or tested by the microprocessor.
2	OUTPIN	OUPUT PIN CONTROL - This bit appears on the OUTPUT pin and may be used to synchronize external circuitry to the sequencer.
3	NRZINH	NRZ DATA INHIBIT - When RG is active and this bit is set, the NRZ data input will be ignored. This is useful while external data recovery circuits start up.
4	STACKEN	STACK WRITE ENABLE - While this bit is set, bytes of NRZ data are pushed onto the recirculating stack.
5	RESWG	RESET WRITE GATE - This bit causes the WG line to go inactive 4 bit times after the current instruction is finished (byte counter reaches 0).
6	SETRG	SET READ GATE - Provided WG is inactive, this bit sets RG, which will remain active until the ECC information is read or the sequencer is halted.
7	SETWG	SET WRITE GATE - When this bit is set and an instruction executed, the WG line will be activated after a delay of 4 bit times. WG will remain active until cleared by the RESWG bit or the sequencer is halted. WG will not be activated if RG is already active.
Reset State: The contents of the sequencer RAM are unchanged.		

SEQTYPF(n) C0H-DBH Read/Write

SEQUENCER DATA TYPE FIELD ARRAY		
BIT	**NAME**	**DESCRIPTION**
0-4	CNT0-CNT4	COUNT FIELD - The current sequencer instruction is executed for the number of byte times specified by the count field. If the DATEN bit is set, the count is specified as an 8 bit quantity (CNT0-CNT7). If DATEN is reset, the count is specified as a 5 bit quantity (CNT0-CNT4), and the upper three bits of this instruction field are interpreted as data type bits, described below.

SEQUENCER INSTRUCTION REGISTERS (continued)

BIT	NAME	DESCRIPTION
5	CNT5/DTYP0	COUNT BIT 5 OR DATA TYPE 0 - When this bit is interpreted as a data type bit, it is used to initialize the bit ring with a single 1. This will occur at the next $\overline{CLKA}$ cycle. This starts $\overline{CLKB}$ so that write data bytes will be fetched from buffer memory. The bit ring will be cleared after the ECC is written.
6	CNT6/DTYP1	COUNT BIT 6 OR DATA TYPE BIT 1 - When this bit is interpreted as a data type bit, it indicates that ECC information is being read or written.
7	CNT7/DTYP2	COUNT BIT 7 OR DATA TYPE BIT 2 - When this bit is being interpreted as a data type bit it indicates that an address mark is being written.
Note: When DATEN is reset, and CNT5/DTYP0, CNT6/DTYP1 and CNT7/DTYP2 are being interpreted as data type select bits, the upper 3 bits of the byte counter are forced to 0 regardless of the settings of the data type bits. When all 3 data type bits are 0, the data field is interpreted as normal binary data.		
Reset State: The contents of the sequencer RAM are unchanged		

SEQDATF **E0H-FBH** **Read/Write**

SEQUENCER DATA FIELD ARRAY		
BIT	**NAME**	**DESCRIPTION**
0-7	DAT0-DAT7	DATA FIELD - When RG is active, the byte in this field is used for comparison operations. If WG is active, DATATRANS is set and TRANSINH (Transfer Inhibit bit in OPCON register) is set, the write data will come from this field. This allows the sequencer to generate the necessary overhead bytes while writing a sector.
Reset State: The contents of the sequencer RAM are unchanged.		

DISK DRIVE INTERFACE REGISTERS

The disk drive interface registers provide control and status for the interface of the SSI 32C452 to the disk drive (peripheral device), and for data transfer to the buffer or host.

OPCON **7AH** **Read/Write**

OPERATION CONTROL WORD		
BIT	**NAME**	**DESCRIPTION**
0	INDEXP	INDEX PULSE DETECTED - This bit is set when an index pulse is encountered and reset each time the register is read. The bit will be reset even if the INDEX pin is true during the access.
1	SECTORP	SECTOR PULSE DETECTED - This bit is set when a sector pulse is encountered and cleared each time the register is read. The bit will be cleared even if the SECTOR pin is true during the read access. This bit is only used with hard-sectored disk drives.

DISK DRIVE INTERFACE REGISTERS (continued)

BIT	NAME	DESCRIPTION
2	NRZDAT	NRZ DATA IN - This bit is set when a rising edge is detected on the NRZ pin and RG is active. It is reset when the register is read.
3	SYNDET	SERIAL DATA SYNCHRONIZATION DETECT - Indicates that the bit ring is synchronized on byte boundaries, following detection of an address mark.
4	SEARCHOP	SEARCH OPERATION - Setting this bit will cause comparisons to occur between the contents of the buffer memory and the read data bytes from the peripheral. If SEARCHOP is reset, then read data bytes will be compared to the sequencer instruction data field.
5	TRANSINH	DATA TRANSFER INHIBIT - If WG is active and this bit is set, then the write data will come from the sequencer instruction data field instead of the buffer memory. If RG is active and this bit is set, then the read data bytes are used for comparisons only and are not written to buffer memory. Setting this bit will suppress $\overline{CLKB}$ so that no buffer memory transfers occur.
6	Unused	
7	CARRYINH	SEQUENCER COUNTER CARRY INHIBIT - When this bit is set, the sequencer will not detect a carry (underflow) in its byte counter. This bit is reset when a carry occurs.
Reset State: Unknown		

WAMCON **7BH** **Read/Write**

WRITE ADDRESS MARK CONTROL		
BIT	**NAME**	**DESCRIPTION**
0-7	AM0-AM7	ADDRESS MARK BITS - When WG is active and the sequencer instruction specifies that an address mark is to be written (DATATRANS is reset, DTYP2 is set) the bits AM0-AM7 will be shifted out on the $\overline{WAM}/\overline{AMD}$ pin. The pattern is delayed by two bit times to compensate for the encoder delay.
Reset State: Unknown		

AMDCON **7CH** **Read/Write**

ADDRESS MARK DETECT CONTROL		
BIT	**NAME**	**DESCRIPTION**
0-7	AMD0-AMD7	ADDRESS MARK DETECT CONTROL - When RG and the $\overline{WAM}/\overline{AMD}$ input are active, the NRZ data stream is compared to the contents of this register. Byte synchronization is established when a match occurs. The number of bits used in the comparison is determined in the CLKCON register.
Reset State: Unknown		

DISK DRIVE INTERFACE REGISTERS (continued)

CLKCON 7FH Write only

CLOCK CONTROL

BIT	NAME	DESCRIPTION
0-2	SYN0-SYN2	SYNC COMPARE CONTROL - These 3 bits determine which bits in register AMDCON are used when looking for the sync byte, as follows:
		SYN2/1/0 = 000 Bit 7 used
		001 Bits 7,6 used
		010 Bits 7,6,5 used
		011 Bits 7,6,5,4 used
		100 Bits 7,6,5,4,3 used
		101 Bits 7,6,5,4,3,2 used
		110 Bits 7,6,5,4,3,2,1 used
		111 All bits used
3	CLKINH	CLOCK INHIBIT - When this bit is set, $\overline{CLKA}$ and $\overline{CLKB}$ are forced to a high impedance state.
4	CLKF0	CLOCK FREQUENCY SELECT - This bit sets the relationship between $\overline{CLKA}$ and RD/REFCLK when data transfers are in progress. When it is set, $\overline{CLKA}$ will be 1/4 the RD/REFCLK frequency and when it is reset, $\overline{CLKA}$ will be 1/2 the RD/REFCLK frequency.
5	Unused	
6-7	CLKF1-CLKF2	CLOCK FREQUENCY SELECT - These bits determine the relationship between the frequency of $\overline{CLKA}$ and SYSCLK when no data transfers are in progress, as follows:
		CLKF2/CLKF1= 00 1/4 frequency
		01 1/2 frequency
		10 same frequency
		11 illegal combination

Reset State: Unknown

STACK 7FH Read only

TOP OF STACK

This register provides the microprocessor read access to the top of the 8 byte stack. Each read operation causes the stack data to recirculate, with the top of the stack moving to the bottom. When the sequencer writes data to the stack, the byte on the bottom of the stack is lost.

7

GENERAL PURPOSE INPUT/OUTPUT REGISTERS

GPIOCON 7DH Read/Write

GENERAL PURPOSE I/O CONTROL		
BIT	**NAME**	**DESCRIPTION**
0-3	GPDIR0 -GPDIR3	GENERAL PURPOSE I/O LINE DIRECTION- These bits program the direction of lines GPIO0 to GPIO3. The direction bits are set for outputs and reset for inputs.
4	W6ESEL	$\overline{W6E}$ SELECT - If this bit is set along with GPDIR0, the GPIO0 pin becomes an active low output signal decoding a microprocessor write to location 6EH.
5	R6ESEL	$\overline{R6E}$ SELECT - If this bit is set along with GPDIR1, the GPIO1 pin becomes an active low output signal decoding a microprocessor read from location 6EH.
6	W6FSEL	$\overline{W6F}$ SELECT - If this bit is set along with GPDIR2, the GPIO2 pin becomes an active low output signal decoding a microprocessor write to location 6FH.
7	R6FSEL	$\overline{R6F}$ SELECT - If this bit is set along with GPDIR3, the GPIO3 pin becomes an active low output signal decoding a microprocessor read from location 6FH.
Reset State: Unknown		

GPIODAT 7EH Read/Write

GENERAL PURPOSE I/O DATA		
BIT	**NAME**	**DESCRIPTION**
0-3	GP0-GP3	GENERAL PURPOSE I/O PIN STATUS - These bits represent the state or output data for the GPIO0 to GPIO3 pins, depending on the direction programmed in the GPIOCON register.
4	INPUT	INPUT PIN STATUS - This bit reflects the data on the INPUT pin.
5	OUT	OUTPUT PIN STATUS - This bit reflects the data on the OUTPUT pin. The OUTPUT pin is actually written to by the sequencer.
6-7	Unused	
Note: The GPIOCON register must be initialized before GPIODAT is accessed.		
Reset State: Unknown		

MICROPROCESSOR INTERFACE REGISTERS

DLR **4DH** **Read only**

DATA LATCH REGISTER
When a microprocessor read from location 70H is detected, the data on the buffer memory bus (D0-D7) is latched by the SSI 32C452 into the DATA LATCH REGISTER. When the microprocessor accesses DLR this data is placed on the address/data bus (AD0-AD7).

SPECIAL ADDRESS DECODES 50H-51H **Read/Write**

Special decodes
Microprocessor accesses to these locations will cause the address/data bus (AD0-AD7) and the buffer data bus (D0-D7) to be bridged together internally (see external register description).

BUFACC **70H** **Read/Write**

BUFFER ACCESS
Microprocessor accesses to this location cause the address/data bus (AD0-AD7) and the buffer data bus (D0-D7) to be bridged together internally. If a read cycle is performed, the data present will be latched into register DLR as well.

TEST REGISTERS
These registers may not be accessed while the sequencer is running.

TEST0 **49H** **Read only**

TEST REGISTER 0
Access to the Next Address field of the current sequencer instruction.

TEST1 **4AH** **Read only**

TEST REGISTER 1
Access to the Control field of the current sequencer instruction.

TEST2 **4BH** **Read only**

TEST REGISTER 2
Access to the Count/Data Type field of the current sequencer instruction.

TEST3 **4CH** **Read only**

TEST REGISTER 3
Access to the Data field of the current sequencer instruction.

EXTERNAL REGISTERS (for reference only)

HOSTL **50H** **Read/Write**

HOST BUS (LOWER BYTE)
External hardware may be used to connect the lower byte of the host bus to the buffer memory when this address is accessed.

HOSTH **51H** **Read/Write**

HOST BUS (UPPER BYTE)
External hardware may be used to connect the upper byte of the host bus to the buffer memory when this address is accessed.

GPREG0 **6EH** **Read/Write**

GENERAL PURPOSE REGISTER 0
Systems which need extra I/O on the microprocessor data bus may take advantage of the strobes available on pins GPIO0 (write) and GPIO1 (read) to add an expansion port at this address.

GPREG1 **6FH** **Read/Write**

GENERAL PURPOSE REGISTER 1
Systems which need extra I/O on the microprocessor data bus may take advantage of the strobes available on pins GPIO2 (write) and GPIO3 (read) to add an expansion port at this address.

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNIT
Ambient Temperature Under Bias	0 to 70	°C
Storage Temperature	-65 to 150	°C
Voltage On Any Pin With Respect To Ground	GND -0.5 or VCC + 0.5	V
Power Supply Voltage	7.0	V
Max Current Injection	25	mA

NOTE: Stress above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VCC Supply Voltage		4.75		5.25	V
TA Operating Free Air Temp.		0		70	°C
Input Low Voltage		0		0.4	V
Input High Voltage		2.4		VCC	V

7

D. C. CHARACTERISTICS

TA = 0°C to 70°C, VCC = 5V ± 5%, unless otherwise specified.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VIL Input Low Voltage		-0.5		0.8	V
VIH Input High Voltage		2.0		VCC + .5	V
VOL Output Low Voltage	IOL = 4 mA for RG and WG			0.45	V
	IOL = 2 mA all others				
VOH Output High Voltage	IOH = 400 mA			2.4	V
ICCS Supply Current Standby	Inputs at GND or VCC			25	mA
ICC Supply Current				85	mA
Power Dissipation				500	mW

D. C. CHARACTERISTICS (continued)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
IL	Input Leakage	0V < Vin < VCC	-10		10	µA
IOL	Output Leakage	0.45V < Vout < VCC	-10		10	µA
Cin	Input Capacitance				10	pF
Cout	Output Capacitance				10	pF

A. C. TIMING CHARACTERISTICS

TA = 0°C to 70°C, VCC = 5v ± 5%, unless otherwise specified.
Load conditions for all pins - 30pF. Timing measurements are made at 50% of rising or falling edge.
Note: ↓ indicates falling edge; ↑ indicates rising edge.

MICROPROCESSOR INTERFACE TIMING (See Figure 3)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
S	SYSCLK Period		50			ns
S/2	SYSCLK Assert to De-assert		18			ns
S/2	SYSCLK Rise and fall	Sr = Sf, S = 60 ns			5	ns
Ta	ALE Width		45			ns
Taw	ALE ↓ to $\overline{WR}$ ↓		25			ns
Tar	ALE ↓ to $\overline{RD}$ ↓		25			ns
Tw	$\overline{WR}$ Width		200			ns
Tr	$\overline{RD}$ Width		200			ns
As	AD0 - AD7 in Valid to ALE ↓		7.5			ns
Ah	ALE ↓ to AD0 - AD7 in Invalid		20			ns
Cs	CS ↑ to ALE ↓		7.5			ns
Ch	$\overline{RD}$ ↑ or $\overline{WR}$ ↑ to CS ↓		0			ns
Wds	AD0 - AD7 in Valid to $\overline{WR}$ ↑		70			ns
Wdh	$\overline{WR}$ ↑ to AD0 - AD7 in Invalid		10			ns
Tda	$\overline{RD}$ ↓ to AD0 - AD7 out Valid				145	ns
Tdh	$\overline{RD}$ ↑ to AD0 - AD7 out Invalid				50	ns

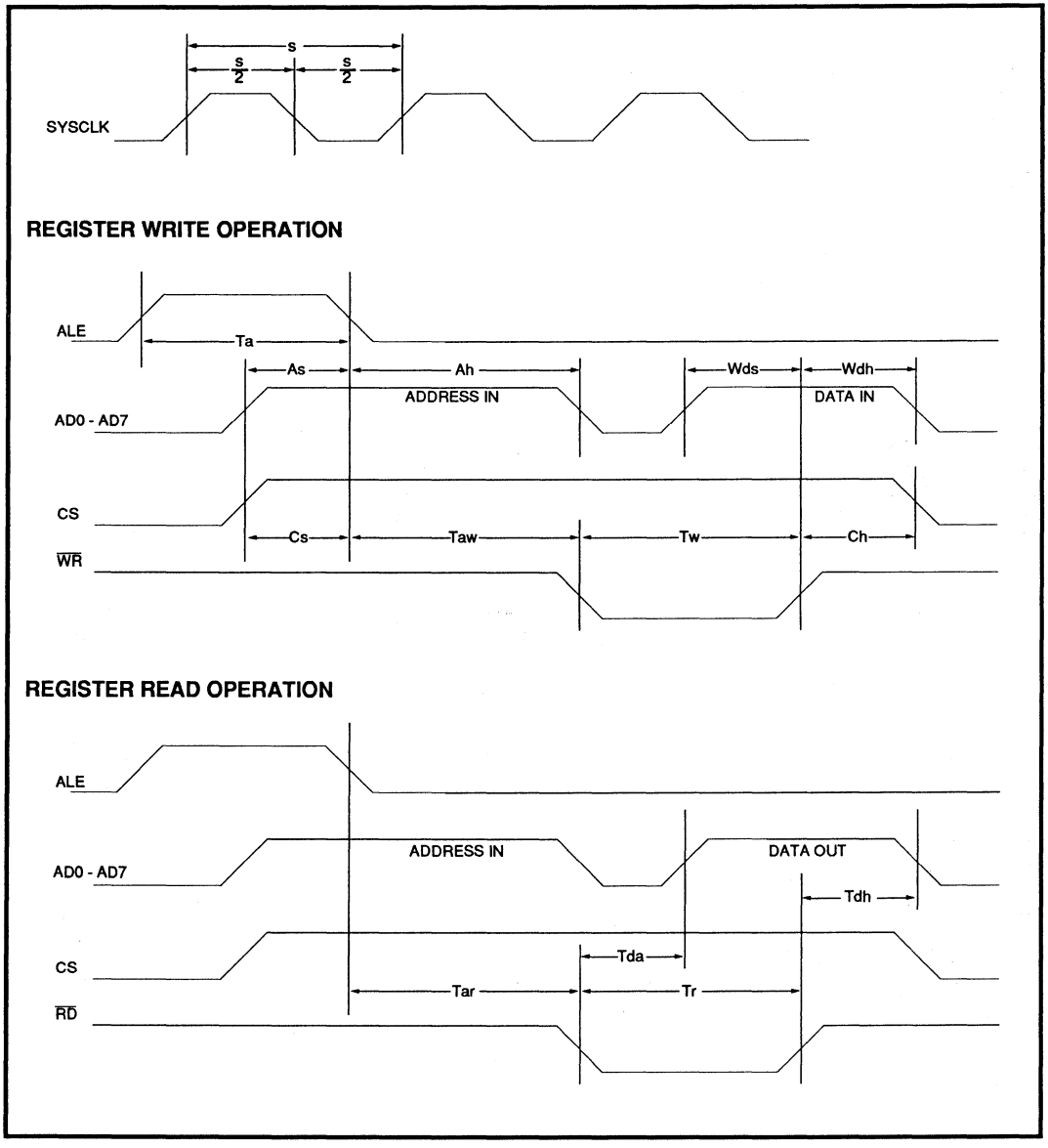


FIGURE 3: Microprocessor Interface Timing

A. C. TIMING CHARACTERISTICS (continued)

PERIPHERAL DEVICE INTERFACE TIMING (See Figure 4)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
T	RD/REFCLK Period		50			ns
T/2	RD/REFCLK Assert to De-assert		18			ns
Tr	RD/REFCLK Rise Time	T = 62.5 ns			5	ns
Tf	RD/REFCLK Fall Time	T = 62.5 ns			5	ns
Ds	NRZ in Valid to RD/REFCLK ↑	Set-up time	10			ns
Dh	RD/REFCLK ↑ to NRZ in Invalid	Hold time	7			ns
As	$\overline{AMD}$ ↓ to RD/REFCLK ↑	Set-up time	10			ns
Dv	RD/REFCLK ↑ to NRZ out		10		40	ns
Wv	RD/REFCLK ↑ to $\overline{WAM}$ ↓		10		40	ns
Wvr	RD/REFCLK ↑ to $\overline{WAM}$ ↑		10		40	ns

BUFFER INTERFACE TIMING (See Figure 5)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
T	$\overline{CLKA}$ Period		100			ns
T/2	$\overline{CLKA}$ Assert to De-assert		40			ns
Tba	$\overline{CLKB}$ ↓ to $\overline{CLKA}$ ↓		40			ns
Tab	$\overline{CLKA}$ ↓ to $\overline{CLKB}$ ↑		40			ns
Dov	$\overline{CLKA}$ ↑ to D0 - D7 out Valid		0		50	ns
Doh	$\overline{CLKA}$ ↑ to D0 - D7 out Invalid		0		50	ns
Dis	D0 - D7 in Valid to $\overline{CLKA}$ ↓		25			ns
Dih	$\overline{CLKA}$ ↓ to D0 - D7 in Invalid		10			ns

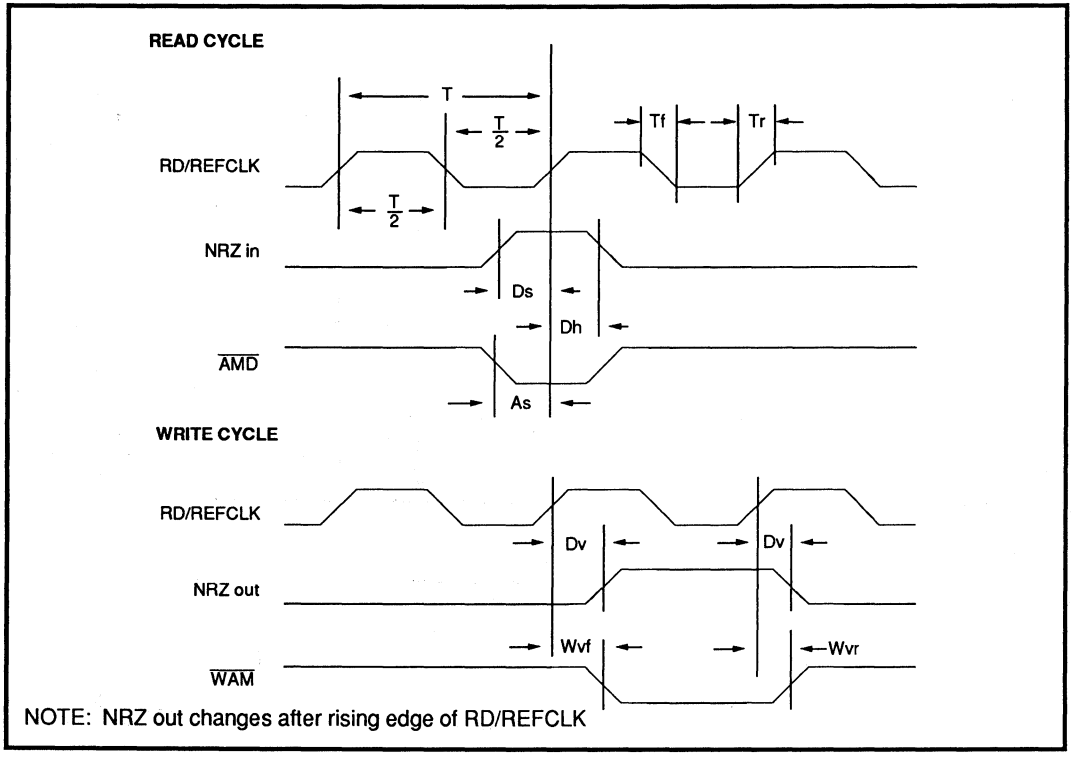


FIGURE 4: Peripheral Device Interface Timing

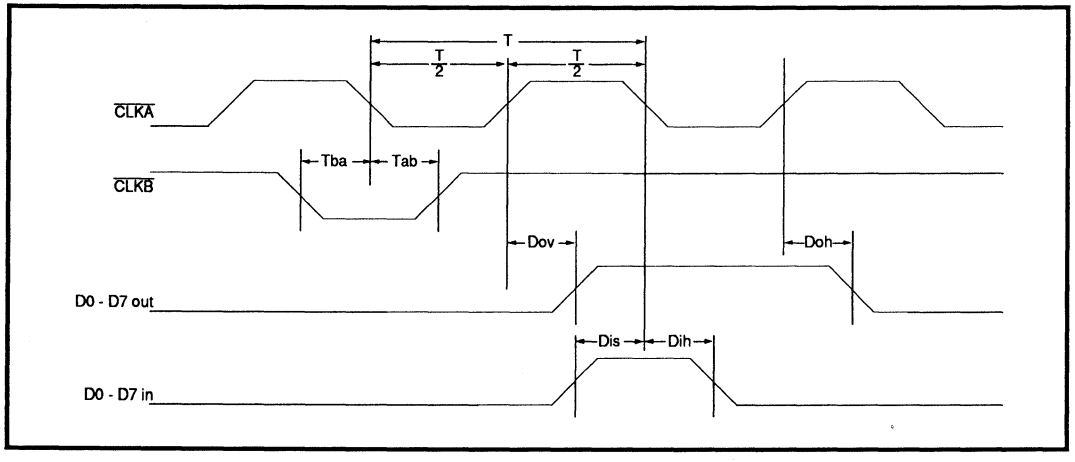


FIGURE 5: Buffer Interface Timing

A. C. TIMING CHARACTERISTICS (continued)

EXTERNAL REGISTER TIMING (See Figure 6)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
Tda	D0 - D7 in Valid to AD0 - AD7 out Valid				55	ns
Tra	$\overline{RD}$ ↓ to AD0 -AD7 out Valid	D0-D7 setup before $\overline{RD}$ ↓			85	ns
Trh	$\overline{RD}$ ↑ to AD0 - AD7 out Invalid				50	ns
Tad	AD0 - AD7 in Valid to D0 - D7 out Valid				59	ns
Twd	$\overline{WR}$ ↓ to D0 - D7 out Valid	AD0-AD7 setup before $\overline{WR}$ ↓			60	ns
Twh	$\overline{WR}$ ↑ to D0 - D7 out Invalid		45			ns

ADDRESS DECODE 6E AND 6F TIMING (See Figure 7)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
Tdf	$\overline{RD}$ or $\overline{WR}$ ↓ to Strobe ↓				40	ns
Tdr	$\overline{RD}$ or $\overline{WR}$ ↑ to Strobe ↑				40	ns

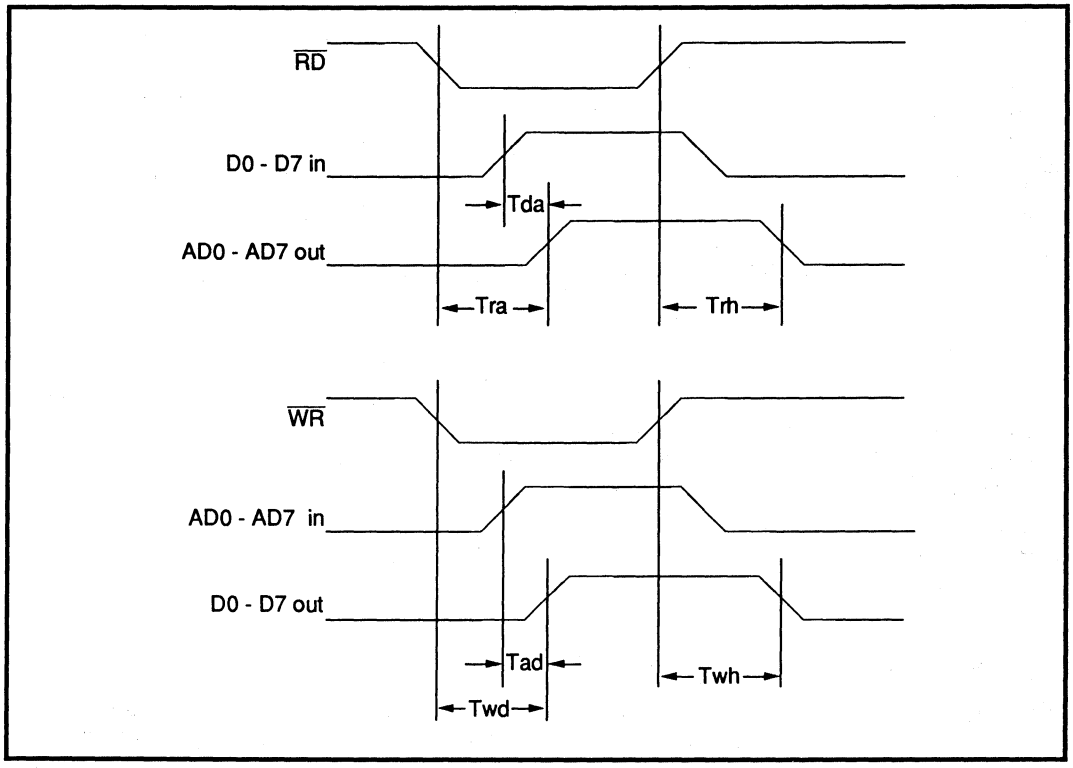


FIGURE 6: External Register Timing

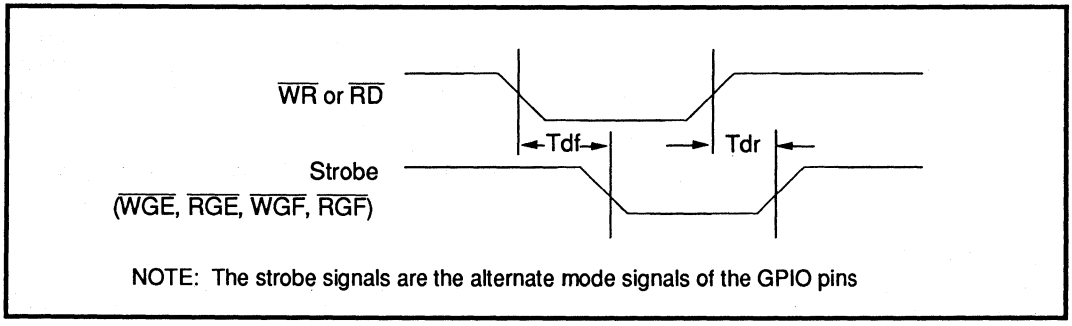


FIGURE 7: Address Decode 6E and 6F Timing

APPLICATIONS INFORMATION

SEQUENCER PROGRAMMING EXAMPLES

This section describes how specific controller functions are implemented with the SSI 32C452. Sequencer programming examples for the specific case of an ST-506 Winchester disk drive are given. For convenience, all the code samples start at sequencer address 00H. In an actual implementation, the sequencer intructions would be distributed throughout the sequencer RAM, with common portions reused, so that the code for all operations would be resident simultaneously. All example values are hex quantities.

SECTOR ID

There are two types of Sector ID operation. In the first, the Sector ID field is read and saved by the controller for examination by the microprocessor. The 8 byte internal stack is used for this type of operation and read data is pushed to the stack under the control of the sequencer. In the second, the sector ID field is compared to a desired value in preparation for some other operation, such as sector read or sector write. In this case, the ID field parameters are compared to the data field of the controller instructions. A sequencer branch instruction is used to test for a positive field ID comparison and no ECC error before the rest of the operation proceeds. The microprocessor must program the SEQBR register with the address of the code for the following operation.

The controller establishes byte synchronism by searching for an address mark after RG is asserted. The data pattern of the address mark is specified in the AMDCON register and the number of bits actually used in the pattern is selected by the bits SYN2/1/0.

ADDR INSTRUCTION (SEQADRF SEQCONF SEQTYPF SEQDATF)

```
                                ; ST-506 Sector Identification example. Assumes AMDCON=A1H, SYN2/1/
                                  0=7
00    60 00 00 00               ; Loop here until Index Pulse (SEQBR=01H)
01    02 40 00 00               ; Turn on RG
02    03 02 80 A1               ; Look for address mark ( A1H in ST-506 format)COMPEN=1DTYP2=1
                                  (Address Mark - Data Separator will detect deliberate coding violations and
                                  assert WAM/AMD pin).
03    04 02 00 FE               ; Look for 2nd byte of address mark (FEH - written as normal data - no coding
                                  violations) COMPEN=1
05    06 12 00 NCYL             ; Compare cylinder number (NCYL) and save too.COMPEN=1, STACKEN=1
06    07 12 00 NHEAD            ; Compare head number (NHEAD) and save too.COMPEN=1, STACKEN=1
07    08 12 00 NSECT            ; Compare sector number (NSECT) and save too.COMPEN=1, STACKEN=1
08    89 10 41 00               ; Check ID field ECC and save ECC bytes.Branch to read or write operation
                                  if positive comparison on field ID and if ECC was good (SECTBR indicates
                                  condition for desired sector operation).DTYP1=1 (ECC byte),
                                  STACKEN=1COUNT=1
0A                              ; Here if sector ID did not match target. Actual ID field and ECC bytes are
                                  available on the stack for microprocessor check.
```

SECTOR READ

Once the sector ID field has been verified, the data field may be read. Detection of the address mark for the data portion of the sector proceeds as for ID field address mark, and causes the serializer/deserializer to be correctly synchronized with the incoming data bytes. At the end of a sector read, the microprocessor may check the ECC result to determine if a reread or error correction computation is required.

ADDR INSTRUCTION (SEQADRF SEQCONF SEQTYPF SEQDATF)

```
                                ; ST-506 Sector Read example assumes that sector ID field verification has
                                  been performed.
00    01 40 00 00               ; Turn on RG
01    02 02 A0 A1               ; Look for data field Address Mark (A1H)COMPEN=1DTYP2=1 (AM byte),
                                  DTYP0=1, enable CLKB when synchronization occurs.
02    E3 02 00 F8               ; Check second byte of AM. Must be F8H for ST-506 data field. Branch if AM
                                  bytes bad.COMPEN=1
03    04 01 FF 00               ; Transfer 256 data bytes DATEN=1COUNT=FFH
04    A5 00 41 00               ; Read ECC bytes, branch on error DTYP1=1 (ECC)COUNT=1
05                              ; Here if read was error free.
```

SECTOR WRITE

Sector writes proceed in a similar fashion to reads. Once the sector ID field has been verified, the sequencer writes a short gap (the 'write splice') and then the sector data, followed by ECC bytes and another gap.

ADDR INSTRUCTION (SEQADRF SEQCONF SEQTYPF SEQDATF)

```
                                ; ST-506 Sector Write exampleAssumes that sector ID field verification has
                                  been performed.
00    01 00 02 00               ; Skip 3 bytes
01    02 80 0C 00               ; Turn on WG and write 13 bytes of 00HCOUNT=0CHSETWG=1
02    03 00 A0 A1               ; Write first data AM byte (A1H)DTYP2=1 (AM), DTYP0=1 (Start CLKB*)
03    04 00 00 F8               ; Write second data AM byte (F8H)DTYP2=0 since this byte is written as
                                  normal data (no coding violations).
04    05 01 FF 00               ; Write 256 data bytes DATEN=1 (transfer enabled, data comes from buffer
                                  memory)COUNT=FFH
05    06 00 41 00               ; Write 2 ECC bytes COUNT=1DTYP1=1 (ECC)
06    07 00 02 00               ; Write three bytes of 00HCOUNT=2
07    08 20 00 00               ; Turn WG off RESWG=1
08                              ; Here when sector write is finished
```

OPERATIONAL INFORMATION

Sector formatting is similar to sector writing, except that the sector ID field is written in addition to the data field. The data field is also written with a fixed value instead of data transferred from buffer memory. Examples of sequencer code to write specific data are given under sector write. When an entire track is to be written, the microprocessor may update ID field information in the sequencer RAM to reflect the next sector while the sequencer is writing the current data field. This allows an entire track to be formatted in one continuous write operation. Formatting begins after the sequencer detects an index pulse.

A **data search** operation can be implemented by a simple modification to the sequencer programming for sector read operations. When the COMPEN bit of the sequencer control field is enabled, incoming data will be compared to buffer data instead of being stored. This allows the sector to be searched for specific data. (The SEARCHOP bit in the OPCON register must also be set for searches).

Data verification can be performed during a sector read if the TRANSINH bit (data transfer inhibit) of OPCON is enabled, because no data will be written to the buffer. However, ECC checking will continue so that at the end of the sector, the ECC result can be verified.

The controller can support **extended sector sizes** of greater than 256 bytes. One simple way to achieve larger sector sizes is to use several sequencer data transfer instructions in a row. The size of the data block that results will be the sum of the counts for each transfer instruction. Large sectors may also be implemented with a single sequencer instruction by using

the CARRYINH bit in OPCON. Sequencer instructions terminate when the carry caused by an underflow of the byte counter is detected. When CARRYINH is set, this carry will not be recognized, so the counter (which is initially loaded with the value specified in each instruction's count field) will wrap around to a full count (FFH). The CARRYINH bit is cleared by an underflow, so that if it is not set again by the microprocessor, the sequencer instruction will terminate after an additional 256 bytes. This permits the sector length to be extended in multiples of 256 bytes.

Multi-sector reads and writes are accomplished in a similar manner to full track formatting. The sequencer is programmed as for a single sector operation. However, when the microprocessor detects that the DATA-TRANS bit in the SEQSTAT register is set (implying that a data transfer is in progress), it alters the ID field information in the sequencer's instruction RAM. When the data transfer for a particular sector is completed, the sequencer is looped back to the same sector ID routine. It will then start a new sector operation using the ID information just loaded by the microprocessor. This type of operation may proceed for an entire track.

ECC IMPLEMENTATION

The ECC hardware may be used for error correction as well as checksum generation. An algorithm for locating and correcting read errors is described below. The algorithm assumes the use of a 32 bit ECC polynomial capable of correcting a single burst of up to 8 bit errors. Longer bursts or multiple bursts may be incorrectable.

1. If an ECC error is detected (ECCERR is set in SEQSTAT) and error correction is needed (ie. multiple reads from the same sector have failed) the error syndrome must be read from the ECC shift register and reloaded in bit-reversed order, as follows:
   - 1.1 Set FEEDINH in ECCCON
   - 1.2 Read and save top 8 bits of shift register from ECC24
   - 1.3 Set ECCSHIFT in ECCCON 8 times
   - 1.4 Repeat 1.2 and 1.3 until all 4 bytes of the syndrome are RAM
   - 1.5 Copy each syndrome bit, starting with the least significant, to ECCIN and set ECCSHIFT after each copy. After 32 such operations the ECC shift register will contain the bit reversed polynomial.
2. The reverse ECC generator polynomial must be written to the ECC generator.
   - 2.1 Configure the bit-reversed polynomial in the 4 feedback registers, POLY0, POLY8, POLY16 and POLY24. This step is not equivalent to bit reversing the feedback register contents, since the coefficients for x^0 and x^{32} are fixed in hardware. The reverse polynomial is generated by subtracting the exponents from 32. The following is a numerical example to illustrate the programming of forward and reverse polynomials for the 32 bit computer-generated code:
     forward:
     $x^0+x^4+x^6+x^{13}+x^{15}+x^{22}+x^{26}+x^{30}+x^{32}$;
     reverse:
     $x^{32}+x^{28}+x^{26}+x^{19}+x^{17}+x^{10}+x^6+x^2+x^0$;

	Forward	Reverse
POLY0	28H	22H
POLY8	50H	02H
POLY16	20H	05H
POLY24	22H	0AH
   - 2.2 Reset FEEDINH and ECCIN in the ECCCON register.
3. The ECC shift register is operated until either the number of shifts exceeds the number of bits in the read block or the 24 least significant bits of the ECC register are zero.
   - 3.1 Compute block length in bits, including ECC and overhead bits.
   - 3.2 Initialize a shift counter to zero.
   - 3.3 Set ECCSHIFT to shift the ECC registers by one, and increment the shift counter.
   - 3.4 If the shift counter exceeds the block length, stop the computation as this means the errors are uncorrectable. Otherwise, if register ECC16 is non-zero, repeat step 3.3.
4. At this point, ECC24 contains the bit-reversed error pattern and the shift counter indicates its displacement from the end of the block. The pattern must be mirrored and aligned to byte boundaries so that the errors in the buffer storage may be corrected.
   - 4.1 Subtract 7 from the shift counter, to compensate for a hardware offset internal to the SSI 32C452.
   - 4.2 Subtract 32 from the shift counter. (This is the number of the ECC bits). If the result is less than zero then no further action is required, since the errors occurred in the ECC portion of the block.
   - 4.3 Read the contents of ECC24 into RAM and bit-reverse this 8 bit quantity.

4.4 Form a 16 bit word with the reversed error pattern as its lower byte and zero as its upper byte.

4.5 If the lowest three bits of the shift counter are non-zero, left shift the 16 bit word and decrement the shift counter.

4.6 Repeat 4.5 until the shift counter's three least significant bits are zero.

4.7 Divide the shift counter by 8, to convert bits into bytes.

5. The position and nature of the errors are now known, so they may be corrected as follows:

5.1 Exclusive OR the lower byte of the error word with the data byte whose offset from the end of the data block is given by the value of the shift counter.

5.2 Exclusive OR the upper byte of the error word with the data byte whose offset from the end of the data block is one more than the value of the shift counter.

The above procedure will correct a single burst of errors, provided that the degree of the error is within the capability of the chosen code. The code whose polynomial is illustrated above is capable of correcting a single burst of up to 8 error bits.

Since the error correction process is time consuming and ties up the ECC hardware, blocks with errors should be re-read to ensure that the errors observed are in fact hard errors.

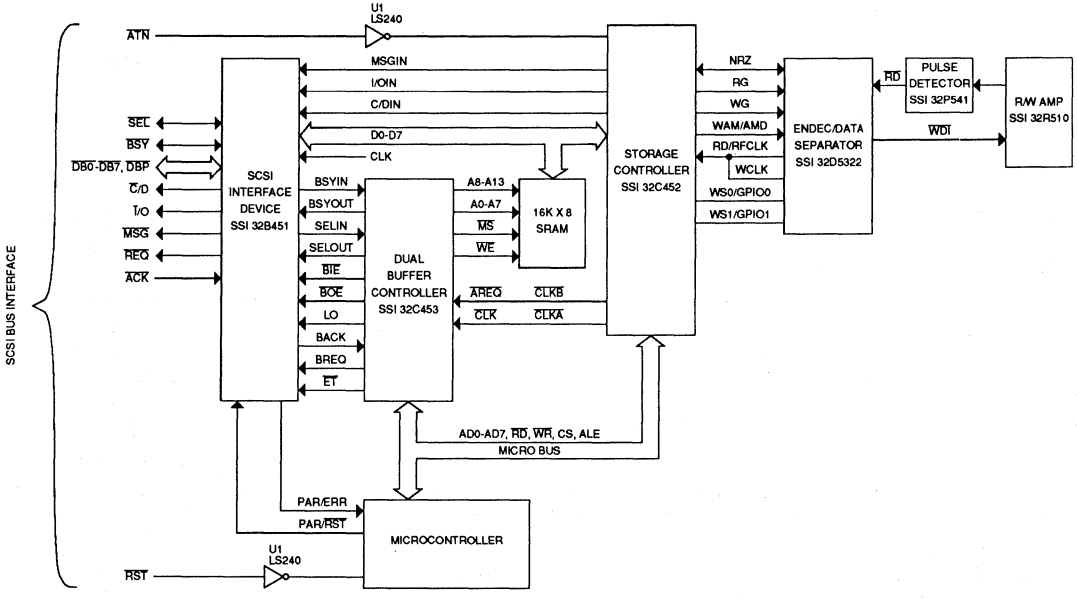
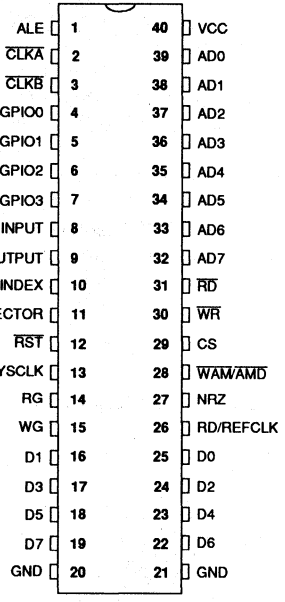


FIGURE 8: Partial Schematic for SCSI Implementation with Arbitration Support using Silicon Systems Microperipheral Devices

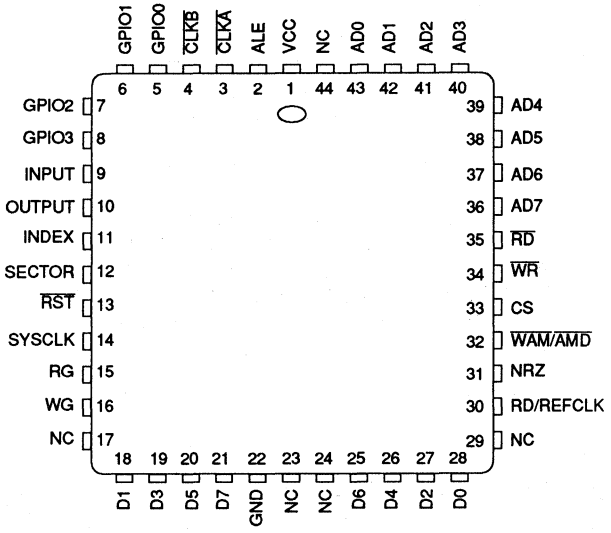
7

SSI 32C452
Storage Controller

PACKAGE PIN DESIGNATIONS
(TOP VIEW)



40-pin DIP



44-pin PLCC

ORDERING INFORMATION

PART DESCRIPTION		ORDER NO.	PKG. MARK
SSI 32C452 Storage Controller	40 Pin DIP	SSI 32C452-CP	32C452-CP
	44 Pin PLCC	SSI 32C452-CH	32C452-CH

Preliminary Data: Indicates a product not completely released to production. The specifications are based on preliminary evaluations and are not guaranteed. Small quantities are available, and Silicon Systems should be consulted for current information.

Silicon Systems, Inc. 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX (714) 731-5457

SSI 32C453
Dual Port Buffer Controller

July, 1990

DESCRIPTION

The SSI 32C453 Dual Port Buffer Controller is a CMOS device that allows low speed RAM to be configured as a dual port circular FIFO buffer. It generates all the buffer memory addressing required and manages two ports: Port A, a synchronous peripheral device interface and Port B, an asynchronous host interface. The SSI 32C453 has arbitration logic to support the SCSI protocol, host DMA transfers and uninterruptible peripheral block transfers.

On-chip counters generate the addresses needed to access the external RAM. In extended addressing mode, 16 bits of address are multiplexed onto 8 lines and the necessary strobes are provided. Direct addressing mode may be used for 10 bit addresses (DIP package) or 14 bit addresses (PLCC package) without multiplexing.

The SSI 32C453 is intended for use in intelligent controllers and includes a set of configuration/status registers which are accessed through the microprocessor interface. It is optimized for 8 bit, multiplexed

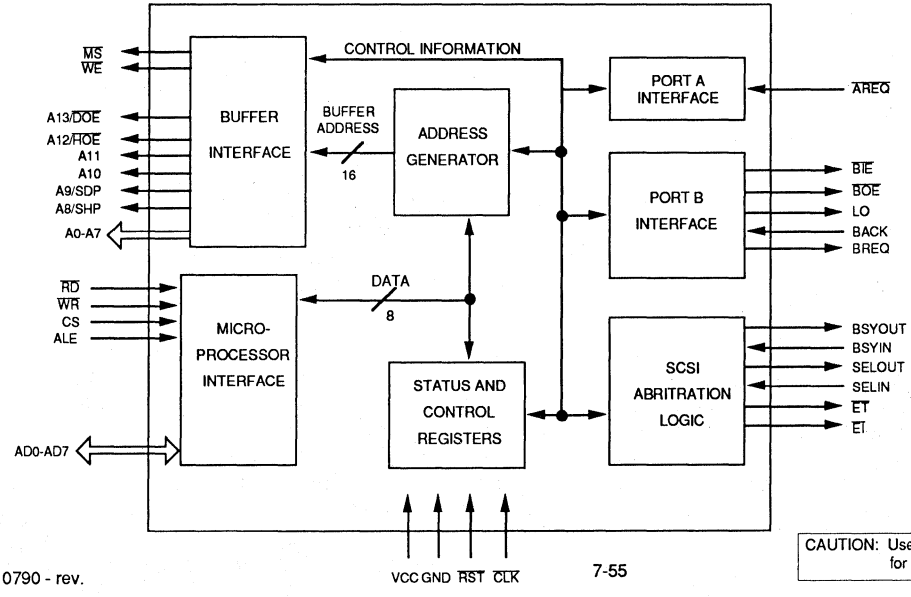
(Continued)

FEATURES

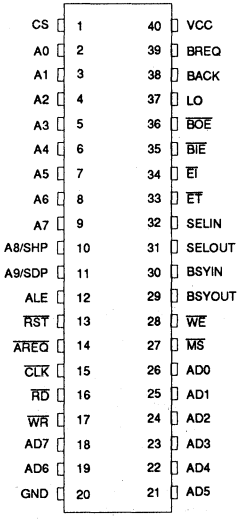
- **Dual port circular FIFO buffer controller**
- **SCSI bus arbitration control**
- **DMA handshake control**
- **Multiplexed mode buffer addressing up to 64 Kbytes**
- **Direct mode buffer addressing up to 1 Kbyte (DIP) or 16 Kbytes (PLCC)**
- **High speed CMOS device has 16 MHz microprocessor interface**
- **Compatible with SSI 32C452 Storage Controller**
- **Plug and software compatible with AIC-300 buffer controller**
- **Single 5V supply**
- **Available in 44-pin PLCC or 40-pin DIP package**

7

BLOCK DIAGRAM



PIN DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

DESCRIPTION (Continued)

address/data bus processors such as the 8085 or 8051, and will also interface easily to most 8 bit microprocessors. The registers allow the designer to select buffer RAM sizes, manipulate the internal address pointers and sense impending overruns of the buffer.

The SSI 32C453 provides a cost-effective buffer memory and SCSI port control solution, and when used in conjunction with an 8 bit microprocessor and a peripheral controller device, such as the SSI 32C452, it forms the basis for an intelligent, high performance Winchester disk drive control system.

FUNCTIONAL DESCRIPTION

The major functional elements and data paths of the SSI 32C453 are shown in the block diagram. Data transfers are requested through two ports, Port A and Port B. The direction of and number of bytes to be transferred are determined by the setting of the status and control register. All buffer memory transfers are synchronous with the $\overline{CLK}$ signal.

The **Port A interface** communicates with the peripheral device controller. The $\overline{AREQ}$ signal is monitored by the SSI 32C453 and when asserted begins the Port A data transfer. The SSI 32C453 then generates the necessary address and control signal to coordinate data transfer between buffer and peripheral device.

The **Port B interface** communicates with the host bus. It supports a two wire request/acknowledge protocol for transferring data asynchronously, and generates the necessary strobes, LO and $\overline{BOE}$, for controlling and external latch and three-state drivers for host bus access.

Since peripheral data transfers occur synchronously and in blocks, Port A requests are alway honored over Port B requests. If the speed of the data transfer from the peripheral device allows, the SSI 32C453 has the capability to alternate Port A and Port B data transfers so that time is not lost waiting on the peripheral device.

The **buffer interface** generates buffer memory read and write cycles during data transfers and presents either the Port A or Port B address to the memory. Its memory address lines can be operated in one of two user selectable modes, supporting buffer sizes from 256 bytes to 64 Kbytes. In direct addressing mode, the buffer address is available on either 10 lines (A0-A9) or 14 lines (A0-A13), depending on the chosen buffer size. If larger buffer sizes are required, extended addressing mode supports up to 16 address lines multiplexed onto pins A0-A7. Two external 8 bit three-state latches must be provided to hold the upper 8 bits of the Port A and Port B addresses. The buffer interface provides the signals SDP and SHP for clocking the latches, and $\overline{DOE}$ and $\overline{HOE}$ for enabling the latch outputs at the appropriate times.

The **address generator** contains two 16 bit pointers, the read address pointer (RAP) and the write address pointer (WAP), which indicate where in the external buffer RAM data is to be read or written. During data transfers, these pointers are automatically incremented as the RAM is accessed. The pointers wrap around to 0 when the programmed buffer size is exceeded. To prevent host overruns of the buffer (caused by one of the pointers overtaking the other), the address generator includes a 16 bit stop pointer (SP). The microprocessor loads SP with the last address in buffer memory to be accessed during a host DMA transfer. When the port B address (RAP during an upload to the host or WAP during a download to the peripheral) reaches the value in SP, the DMA transfer is automatically suspended.

The SSI 32C453 includes the necessary logic to request a **SCSI arbitration** phase. When the microprocessor enables the SCSI logic, it will wait for a 'bus free' condition and then request arbitration. The microprocessor must generate the device address and determine whether the arbitration was favorable or not. Two output pins $\overline{EI}$ and $\overline{ET}$, are provided to allow the SSI 32C453 to be identified as either a target or an initiator.

The **microprocessor interface** decodes microprocessor read and write requests and provides access to the appropriate status or control register location. Since both data and address information are carried on the bus lines AD0-AD7, the microprocessor signal ALE (address latch enable) is used to indicate the presence of a valid address on the bus.

The **status and control registers** contain operational status for, and control information from, the microprocessor. They include data transfer and port status and information such as transfer complete or current address. The control registers configure the SSI 32C453 with parameters such as buffer size, read and write pointers and stop pointer.

PIN DESCRIPTION

GENERAL

NAME	DIP	PLCC	TYPE	DESCRIPTION
VCC	40	1		POWER SUPPLY +5 volts
GND	20-21	22		GROUND
$\overline{RST}$	13	14	I	RESET - Active low signal sets reset bit in RESCON and resets all other registers.
$\overline{CLK}$	15	16	I	MASTER CLOCK - All buffer memory transfers occur on a falling edge of $\overline{CLK}$. There should be at least two $\overline{CLK}$ cycles per byte transferred to allow the host and peripheral to remain in step.

MICROPROCESSOR INTERFACE

CS	1	2	I	CHIP SELECT- Active high signal enables device to respond to microprocessor read or write.
ALE	12	13	I	ADDRESS LATCH ENABLE - Falling edge latches register address from AD0-AD7 pins.
$\overline{RD}$	16	18	I	READ STROBE - Active low signal causes the contents of the addressed register to be placed on the address/databus if CS is also active.
$\overline{WR}$	17	19	I	WRITE STROBE - Active low signal causes the data on the address/ data bus to be written to the addressed register if CS is also active.
AD0-AD7	18-19 21-26	20-21 23-28	I/O	ADDRESS/DATABUS - 8 bit bus which carries register address information and bi-directional data.

BUFFER MEMORY INTERFACE

A0-A7	2-9	3-10	O	BUFFER ADDRESS BITS - In direct addressing mode, these are buffer address bits 0 to 7. In extended addressing mode, these lines are multiplexed between low and high order address bytes.
A8/SHP	10	11	O	A8/PORT B (HOST) ADDRESS STROBE - In direct addressing mode, this pin is buffer address bit 8. In extended addressing mode, this pin is an address strobe whose rising edge is used to clock the contents of pins A0-7 into an external latch, for the upper address byte for Port B transfers.

PIN DESCRIPTION (Continued)

BUFFER MEMORY INTERFACE (Continued)

NAME	DIP	PLCC	TYPE	DESCRIPTION
A9/SDP	11	12	O	A9/PORT A (DEVICE) ADDRESS STROBE - In direct addressing mode, this pin is buffer address bit 9. In extended addressing mode,this pin is an address strobe whose rising edge is used to clock the contents of pins A0-7 into an external latch, containing the upper address byte for Port A transfers.
A10-11		17,29	O	Buffer address bits - They are valid in both addressing modes. (PLCC version only)
A12/$\overline{HOE}$		30	O	A12/PORT B (HOST) ADDRESS ENABLE - In direct addressing mode this pin is buffer address bit 12. In extended addressing mode this pin is an active low signal used to enable an external three-state latch which holds the upper address byte for Port B transfers. (PLCC version only)
A13/$\overline{DOE}$		31	O	A13/PORT A (DEVICE) ADDRESS ENABLE - In direct addressing mode this pin is buffer address bit 13. In extended addressing mode this pin is an active low signal used to enable an external three-state latch which holds the upper address byte for Port A transfers. (PLCC version only)
$\overline{MS}$	27	32	O	MEMORY SELECT - This active low output is used to enable the buffer RAM for read or write access.
$\overline{WE}$	28	33	O	WRITE ENABLE - This active low output enables a write to the buffer RAM, in conjunction with $\overline{MS}$. If $\overline{MS}$ is active while $\overline{WE}$ is inactive, the buffer access will be a read operation.

PORT A INTERFACE

$\overline{AREQ}$	14	15	I	PORT A REQUEST - This active low input is sampled on each falling edge of $\overline{CLK}$. If it is low, a Port A transfer will occur on the next falling edge of $\overline{CLK}$.

PORT B INTERFACE

$\overline{BIE}$	35	40	O	PORT B INPUT ENABLE - Active low signal used to enable output of an external three-state driver which presents host bus data to the buffer RAM. This line is asserted either under microprocessor control or as a result of a Port B DMA transfer request (BREQ). Microprocessor control of this line permits direct host to microprocessor transfers.

PIN DESCRIPTION (Continued)

PORT B INTERFACE (Continued)

NAME	DIP	PLCC	TYPE	DESCRIPTION
$\overline{BOE}$	36	41	O	PORT B OUTPUT ENABLE - Active low signal used to enable output of an external three-state driver which holds buffer RAM output and presents it to the host data bus. This line is asserted either under microprocessor control or as a result of a Port B DMA transfer request (BREQ). Microprocessor control of this line permits direct microprocessor to host transfers.
LO	37	42	O	PORT B OUTPUT LATCH - Active high signal controls an external latch which holds buffer RAM output during Port B read operations.
BACK	38	43	I	PORT B ACKNOWLEDGE - Active high input signal from the host indicates that a Port B transfer request has been accepted and that the host bus is available.
BREQ	39	44	O	PORT B REQUEST - Active high output that requests the host to accept a Port B data transfer.

SCSI BUS ARBITRATION

BSYOUT	29	34	O	BUSY OUT - Active high output that is set either by the microprocessor or the arbitration logic and indicates that the SSI 32C453 is requesting control of the SCSI bus.
BSYIN	30	35	I	BUSY IN - Active high input which indicates that another device has control of the bus.
SELOUT	31	36	O	SELECT OUT - Active high output under microprocessor control which is asserted when bus access is granted to the peripheral controller.
SELIN	32	37	I	SELECT IN - Active high input which indicates that another device has been granted access to the bus.
$\overline{ET}$	33	38	O	ENABLE TARGET MODE - Active low output which allows the microprocessor to identify the peripheral controller as a SCSI Target device.
$\overline{EI}$	34	39	O	ENABLE INITIATOR MODE - Active low output which allows the microprocessor to identify the peripheral controller as a SCSI Initiator device.

REGISTER DESCRIPTION

The microprocessor which controls the system has access to all the SSI 32C453 registers through its external memory address space. The SSI 32C453 and its companion device, the SSI 32C452 storage controller, are designed to occupy a single 256 byte page. The 8 bit page address is latched into the SSI 32C453 from pins AD0-AD7 on a falling edge of ALE and remains valid until the next ALE falling edge.

The external registers are described at the end of this section. They are not implemented in either the SSI 32C453 or SSI 32C452, and are assumed to be implemented in external hardware. They are included as an applications suggestion for a 'standard' peripheral controller design.

SSI 32C453 REGISTER BIT MAP

REGISTER	ADDRESS	D7	D6	D5	D4	D3	D2	D1	D0	ACCESS
IFCON	52H	BSYOUT	SELOUT	BSYIN	SELIN	BOE	BIE	unused	ARB	R/W
DMACON	53H	TARGET	INIT	DMADONE	ROP/$\overline{\text{WOP}}$	RDLATCH	WRLATCH	BACK	unused	R/W
BUFSIZE	54H	BUFFER SIZE								R/W
AMODCON	55H	reserved							AMOD	W
RESCON	59H	unused							RESET	W
RAPL	5AH	READ ADDRESS POINTER (0-7)								R/W
RAPH	5BH	READ ADDRESS POINTER (8-15)								R/W
WAPL	5CH	WRITE ADDRESS POINTER (0-7)								R/W
WAPH	5DH	WRITE ADDRESS POINTER (8-15)								R/W
SPL	5EH	STOP POINTER (0-7)								R/W
SPH	5FH	STOP POINTER (8-15)								R/W

INTERNAL REGISTER DESCRIPTION

IFCON 52H READ/WRITE

INTERFACE CONTROL WORD - Controls and monitors host bus interface and SCSI bus arbitration.		
BIT	**NAME**	**DESCRIPTION**
0	ARB	ARBITRATION - This bit controls the SCSI bus arbitration and returns its status. When it is set, the SSI 32C453 will look for a 'bus free' condition (both SELIN and BSYIN false) and then assert BSYOUT and $\overline{BOE}$, so that the device address may be sent to the host. When ARB is reset, the arbitration activity ceases. When the ARB bit is read it indicates that a SCSI arbitration phase has been recognized if it is set, or not if it is reset.
1		unused
2	$\overline{BIE}$	BUS INPUT ENABLE - While this bit is set, the $\overline{BIE}$ output pin will be asserted if the microprocessor reads locations 50H or 51H (see external registers), enabling an external driver to pass host data to the buffer memory. (Note that the $\overline{BIE}$ pin may also be asserted automatically during DMA operations).
3	$\overline{BOE}$	BUS OUTPUT ENABLE - While this bit is set, the $\overline{BOE}$ output pin will be asserted if the microprocessor writes locations 50H or 51H (see external registers), enabling an external three-state latch to drive buffer data onto the host data bus. (Note that the $\overline{BOE}$ pin may also be asserted automatically during DMA operations).
4	SELIN	SELECT IN - This bit reflects the status of the SELIN pin and is read only.
5	BSYIN	BUSY IN - This bit reflects the status of the BSYIN pin and is read only.
6	SELOUT	SELECT OUT - This bit directly controls the SELOUT pin.
7	BSYOUT	BUSY OUT - This bit directly controls the BSYOUT pin.
Reset State: IFCON= 00H		

7

INTERNAL REGISTER DESCRIPTION (Continued)

DMACON 53H READ/WRITE

DMA CONTROL WORD - Used to initiate and control DMA transfers .

BIT	NAME	DESCRIPTION
0	-	unused
1	BACK	PORT B ACKNOWLEDGE - This read only bit reflects the status of the BACK pin, which is set when the host acknowledges a Port B DMA transfer request from the SSI 32C453.
2	WRLATCH	WRITE LATCH - When this bit is set, a host bus to buffer RAM DMA transfer will be initiated. The transfer continues until the address pointer in WAPL/WAPH is equal to the stop value in SPL/SPH. The ROP/$\overline{WOP}$ bit in this register must be cleared. Until WRLATCH is reset, transfers will resume each time the stop pointer is changed.
3	RDLATCH	READ LATCH - When this bit is set, a buffer RAM to host bus DMA transfer will be initiated. The transfer continues until the address pointer in RAPL/RAPH is equal to the stop value in SPL/SPH. The ROP/$\overline{WOP}$ bit in this register must be set. Until RDLATCH is reset, transfers will resume each time the stop pointer is changed.
4	ROP/$\overline{WOP}$	READ/WRITE OPERATION SELECT - This bit determines the direction of DMA to buffer transfer.
5	DMADONE	DMA DONE - This read only bit is set when a DMA transfer is completed (read or write address pointer reaches stop pointer value) and both BREQ and BACK are inactive. It is cleared when the stop pointer is updated.
6	INIT	ENABLE INITIATOR MODE - The value written to this bit is inverted and presented on the $\overline{EI}$ output pin.
7	TARGET	ENABLE TARGET MODE - The value written to this bit is inverted and presented on the $\overline{ET}$ output pin.

Reset State: DMACON=00H

BUFSIZE 54 READ/WRITE

BUFFER SIZE CONTROL - Used to select buffer size ranging from 256 bytes to 64K bytes. This register contains an 8 bit unsigned value which sets the buffer size as follows:

Buffer Size = 256.(BUFSIZE+1) bytes

In conjunction with the AMODCON register, this allows buffer sizes from 256 bytes to 64K bytes to be selected in 256 byte increments.

Reset State: BUFSIZE=00H

INTERNAL REGISTER DESCRIPTION (Continued)

AMODCON 55H WRITE ONLY

ADDRESS MODE CONTROL - Used in direct addressing mode (non-multiplexed address lines) to select the number of active address lines (10 or 14).

BIT	NAME	DESCRIPTION
0	AMOD	ADDRESSING MODE - In direct addressing mode, this bit determines the number of address lines supported. If AMOD=1, then 14 lines are supported (A0-A13), and if cleared then 10 lines are supported (A0-A9) .
1-7	-	reserved

The AMOD bit and the value chosen for buffer size (BUFSIZE) together determine the addressing mode used, as follows:

AMOD	BUFSIZE	Addressing Mode	Maximum Buffer Size
0	0-3	Direct (10 lines)	1 Kb
0	4-255	Extended (16 lines multiplexed)	64 Kb
1	0-63	Direct (14 lines - PLCC version only)	16 Kb
1	64-255	Extended (16 lines multiplexed)	64 Kb

Reset State: AMODCON=00H

RESCON 59H WRITE ONLY

RESET CONTROL - Used to return all device registers to a known condition.

BIT	NAME	DESCRIPTION
0	RESET	RESET CONTROL - When this bit is set, all the registers are forced to their reset state. It must be cleared by the microprocessor. It is set either by the microprocessor or by hardware, when $\overline{RST}$ is asserted. When not set, a write to it will reset WAP, RAP and SP.
1-7	-	unused

Reset State: RESCON=01H

INTERNAL REGISTER DESCRIPTION (Continued)

RAPL 5AH READ/WRITE

READ ADDRESS POINTER (LOW BYTE) - Lower 8 bits of address where next data byte will be read from buffer memory during DMA operations. When ROP/$\overline{WOP}$ is set, peripheral data will be read from the buffer RAM at this address and transferred to the host data bus, following a Port B DMA request (BREQ). When ROP/$\overline{WOP}$ is reset, host data will be read from the buffer RAM at this address and transferred to the peripheral, following Port A transfer requests ($\overline{AREQ}$).

RAPH 5BH READ/WRITE

READ ADDRESS POINTER (HIGH BYTE) - Upper 8 bits of address where next data byte will be read from buffer memory.

WAPL 5CH READ/WRITE

WRITE ADDRESS POINTER (LOW BYTE) - Lower 8 bits of address where next data byte will be written to buffer memory. When ROP/$\overline{WOP}$ is set, peripheral data will be written to the buffer RAM at this address, following a Port A transfer request ($\overline{AREQ}$). When ROP/$\overline{WOP}$ is reset, host data will be written to the buffer RAM at this address, following a Port B DMA transfer request (BREQ).

WAPH 5DH READ/WRITE

WRITE ADDRESS POINTER (HIGH BYTE) - Upper 8 bits of address where next data byte will be written to buffer memory.

SPL 5EH READ/WRITE

STOP ADDRESS POINTER (LOW BYTE) - During DMA the stop pointer is compared to RAP, for a peripheral to host transfer (ROP/$\overline{WOP}$ is set), or WAP, for a host to peripheral transfer (ROP/$\overline{WOP}$ is reset). Whenever the two pointers are equal, DMA is halted. DMA only resumes when the stop pointer is changed. SPL contains the lower byte of the 16 bit address.

SPH 5FH READ/WRITE

STOP ADDRESS POINTER (HIGH BYTE) - Upper 8 bits of the stop pointer.

EXTERNAL REGISTERS

HOSTL 50H Read/Write

Special decode - Microprocessor reads from this location will cause the $\overline{BIE}$ signal to be asserted if the $\overline{BIE}$ bit in INTCON is set. The $\overline{BIE}$ signal causes an external three-state driver to present host data to the buffer RAM. Microprocessor writes to this location will cause LO and $\overline{BOE}$ to be asserted in succession, if the $\overline{BOE}$ bit in INTCON is set. This allows buffer data to be latched and driven onto the host data bus.

HOSTH 51H Read/Write

Special decode - Same function as for external register HOSTL (50H). In systems with 16 bit hosts, external hardware may be used to distinguish between accesses to locations 50H and 51H, allowing separate access to the lower and upper bytes of the host bus.

BUFACC 70H Read/Write

BUFFER ACCESS - Microprocessor accesses to this location cause $\overline{MS}$ to be asserted. If the access is a write operation, $\overline{WE}$ will be asserted as well. This is intended to allow the microprocessor access to the currently addressed buffer RAM location, without altering the pointer value.

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNIT
Ambient Temperature Under Bias	0 to 70	°C
Storage Temperature	-65 to 150	°C
Voltage on any Pin with respect to Ground	-0.5 to 7	V
Power Dissipation	0.475	W
Maximum Current Injection	±20	mA

Note: Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

PARAMETERS	CONDITIONS	MIN	NOM	MAX	UNIT
VCC, Supply Voltage		4.75		5.25	V
TA, Operating Free Air Temperature		0		70	°C
Input Low Voltage		0		0.4	V
Input High Voltage		2.4		VCC	V

D.C. CHARACTERISTICS (TA = 0°C to 70° C, VCC = recommended range unless otherwise specified.)

PARAMETERS		CONDITIONS	MIN	NOM	MAX	UNIT
VIL	Input Low Voltage		-0.5		0.8	V
VIH	Input High Voltage		2.0		VCC+0.5	V
VOL	Output Low Voltage	IOL = 2 mA			0.4	V
VOH	Output High Voltage	IOH = 400 µA	2.4			V
ICC	Supply Current				85	mA
IL	Input Leakage	0V<VIN<VCC	-10		10	µA
IOL	Output Leakage	0.45V<VOUT<VCC	-10		10	µA
CIN	Input Capacitance				10	pF
COUT	Output Capacitance				10	pF

A. C. TIMING CHARACTERISTICS

TA = 0°C to 70°C, VCC = recommended range unless otherwise specified.
Load condition for all pins - 30 pF. Timing measurements are valid at 50% of rising or falling edge.
NOTE: ↓ indicates falling edge. ↑ indicates rising edge.

PERIPHERAL DEVICE TO BUFFER INTERFACE TIMING (see Figure 1)

PARAMETERS		CONDITIONS	MIN	NOM	MAX	UNIT
T/2	$\overline{CLK}$ half cycle		100			ns
Bs	$\overline{AREQ}$ ↓ to $\overline{CLK}$ ↓ setup time		30			ns
Bh	$\overline{CLK}$ ↓ to $\overline{AREQ}$ ↑ hold time		30			ns
Av	$\overline{CLK}$ ↓ to Address stable and $\overline{HOE}$ / $\overline{DOE}$ ↓				100	ns
Mv	$\overline{CLK}$ ↑ to $\overline{MS}$ ↓				40	ns
Mh	$\overline{CLK}$ ↓ to $\overline{MS}$ ↑		15		90	ns
Wv	$\overline{CLK}$ ↑ to $\overline{WE}$ ↓				40	ns
Wh	$\overline{CLK}$ ↓ to $\overline{WE}$ ↑				36	ns
Ah	$\overline{CLK}$ ↓ to Address stable and $\overline{HOE}$ / $\overline{DOE}$ ↑ hold time	Reading from RAM	15		90	ns
Dwe	$\overline{WE}$ ↑ to Address stable and $\overline{HOE}$ / $\overline{DOE}$ ↑ hold time	Writing to RAM	10		60	ns
Sv	$\overline{CLK}$ ↑ to SHP / SDP ↑				40	ns
Sh	$\overline{CLK}$ ↓ to SHP / SDP ↓				40	ns
Auh	Address, $\overline{HOE}$ / $\overline{DOE}$ stable to SHP/SDP ↑				40	ns

NOTE: In the multiplexed addressing mode, the higher order byte of the address and the control signals are provided for the external latch(es) when RAPH and WAPH are initialized by the microprocessor. When transferring data, the counter will overflow to indicate a need to update the external latch(es). The SSI 32C453 will then provide the correct address and control signals to update the external latches. When this occurs a Port B cycle is stolen to update the latch. The Port A and Port B cycles then occur normally.

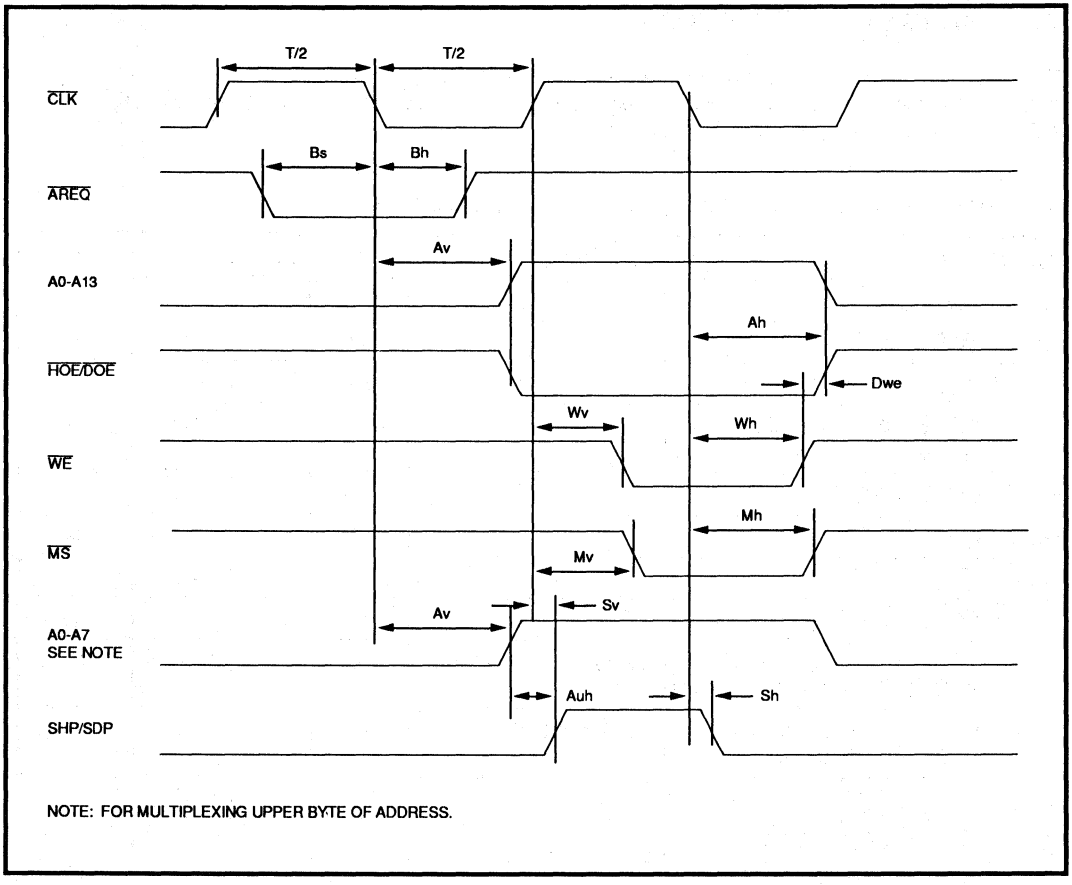


FIGURE 1: Peripheral Device to Buffer Interface Timing

BUFFER TO HOST INTERFACE TIMING (see Figure 2)

PARAMETERS		CONDITIONS	MIN	NOM	MAX	UNIT
Av	$\overline{CLK}$ ↓ to A0-A13 stable				100	ns
Dla	LO ↓ to A0-A13 hold		10		60	ns
Mv	$\overline{CLK}$ ↑ to $\overline{MS}$ ↓				40	ns
Dlm	LO ↓ to $\overline{MS}$ ↑		10		60	ns
Lv	$\overline{CLK}$ ↑ to LO ↑				40	ns
Lh	$\overline{CLK}$ ↓ to LO ↓				36	ns
Bv	$\overline{CLK}$ ↓ to $\overline{BOE}$ ↓				40	ns
Ba	$\overline{CLK}$ ↑ to BREQ ↑				40	ns
Br	$\overline{BOE}$ ↓ to BREQ ↑		70			ns
Ac	BACK ↑ to $\overline{CLK}$ ↑ set up		40			ns
Ar	BACK ↑ to BREQ ↓				40	ns
Acc	BACK ↓ to $\overline{CLK}$ ↓		10			ns

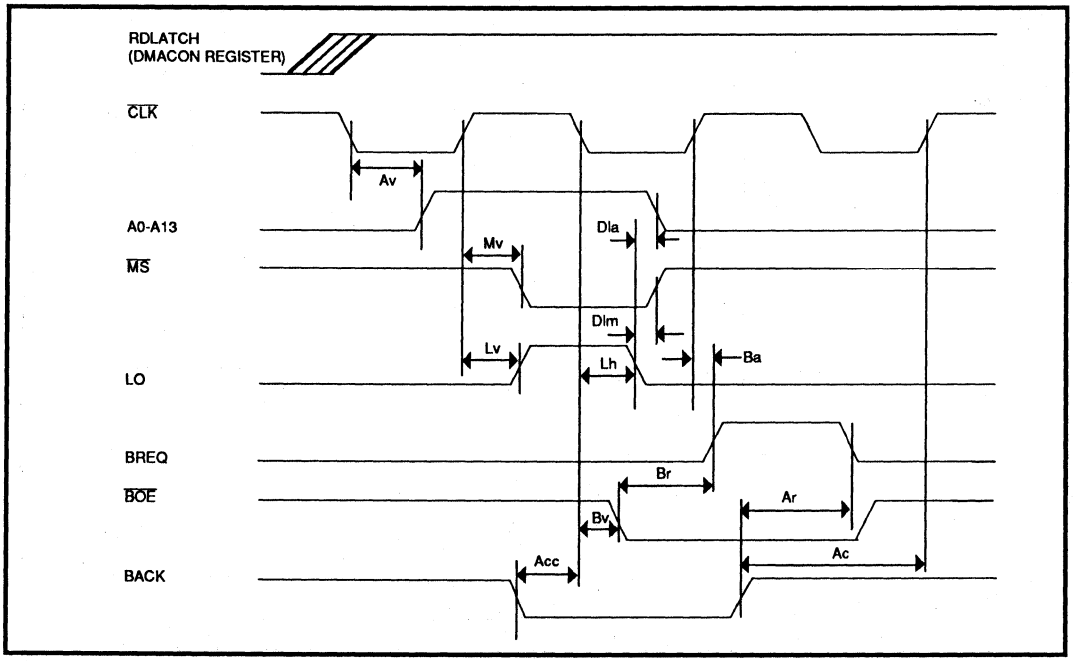


FIGURE 2: Buffer to Host Interface Timing

7

HOST TO BUFFER INTERFACE TIMING (see Figure 3)

PARAMETERS		CONDITIONS	MIN	NOM	MAX	UNIT
Bi	$\overline{CLK}$ ↑ to $\overline{BIE}$ ↓				40	ns
Dwg	$\overline{WE}$ ↑ to BREQ ↓		10		60	ns
Bs	BACK ↑ to $\overline{CLK}$ ↑		40			ns
Av	$\overline{CLK}$ ↓ to A0-A13 stable				100	ns
Dwa	$\overline{WE}$ ↑ to A0-A13 hold time		10		60	ns
Mv	$\overline{CLK}$ ↑ to $\overline{MS}$ ↓				40	ns
Mh	$\overline{CLK}$ ↓ to $\overline{MS}$ ↑				40	ns
Wv	$\overline{CLK}$ ↑ to $\overline{WE}$ ↓				40	ns
Wh	$\overline{CLK}$ ↓ to $\overline{WE}$ ↑				36	ns
Ab	BACK↓ to BREQ ↑				60	ns
Dwi	$\overline{WE}$ ↑ to $\overline{BIE}$ ↑		10		60	ns

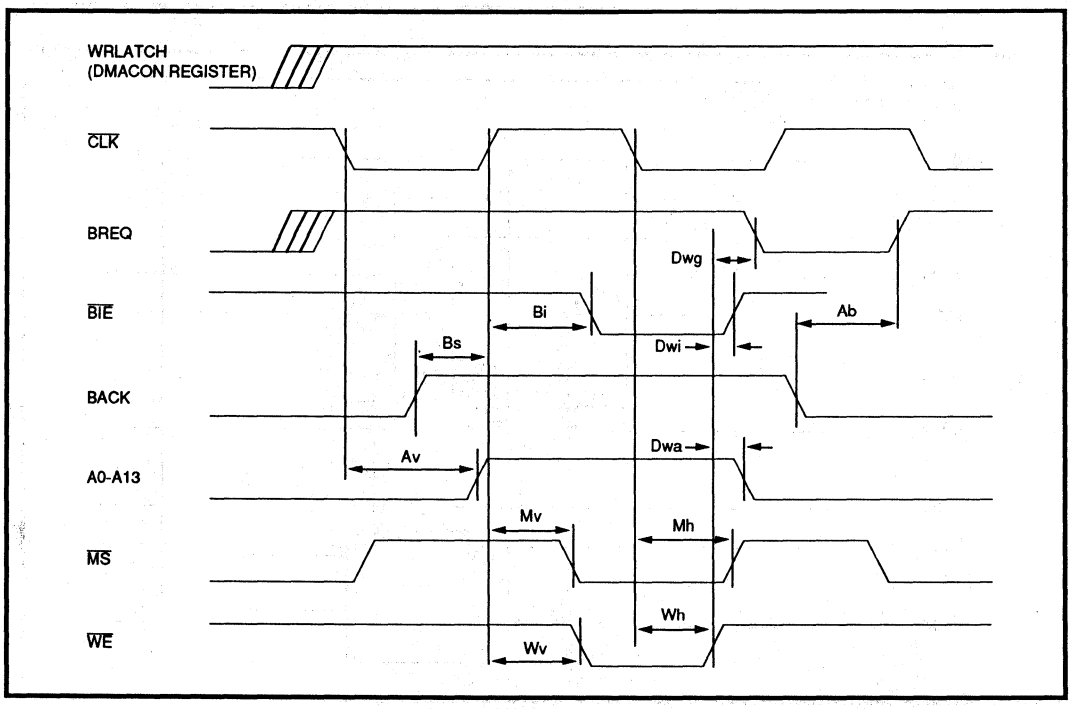


FIGURE 3: Host to Buffer Interface

MICROPROCESSOR INTERFACE TIMING (see Figure 4)

PARAMETERS		CONDITIONS	MIN	NOM	MAX	UNIT
Ta	ALE width		45			ns
Taw	ALE ↓ to $\overline{WR}$ ↓		25			ns
Tar	ALE ↓ to $\overline{RD}$ ↓		25			ns
Tw	$\overline{WR}$ width		200			ns
Tr	$\overline{RD}$ width		200			ns
As	AD0-AD7 set-up time		7.5			ns
Ah	AD0-AD7 hold time		20			ns
Cs	CS set-up time		7.5			ns
Ch	CS hold time		0			ns
Wds	Write data set-up time		70			ns
Wdh	Write data hold time		10			ns
Rts	$\overline{RD}$ ↓ to AD0-AD7 active		0			ns
Rda	$\overline{RD}$ ↓ to AD0-AD7 valid				145	ns
Rdh	AD0-AD7 hold from $\overline{RD}$ ↑				50	ns

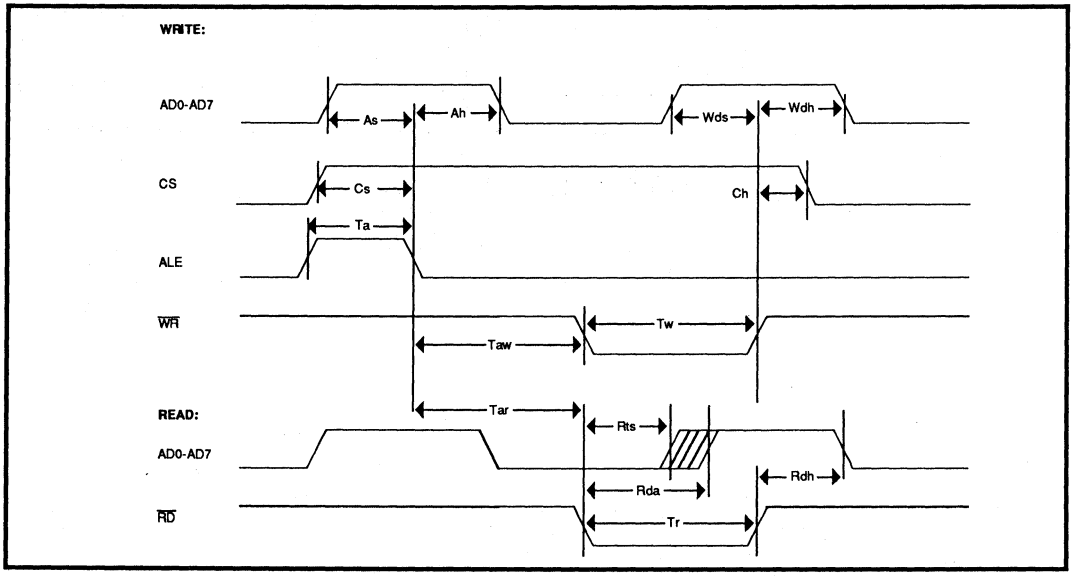


FIGURE 4: Microprocessor Interface

REGISTER 70 TIMING (see Figure 5)

PARAMETERS		CONDITIONS	MIN	NOM	MAX	UNIT
Mcl	$\overline{WR}\downarrow$ or $\overline{RD}\downarrow$ to $\overline{MS}\downarrow$		0		40	ns
Mch	$\overline{WR}\uparrow$ or $\overline{RD}\uparrow$ to $\overline{MS}\uparrow$		0		40	ns
Wwl	$\overline{WR}\downarrow$ to $\overline{WE}\downarrow$		0		40	ns
Wwh	$\overline{WR}\uparrow$ to $\overline{WE}\uparrow$		0		40	ns

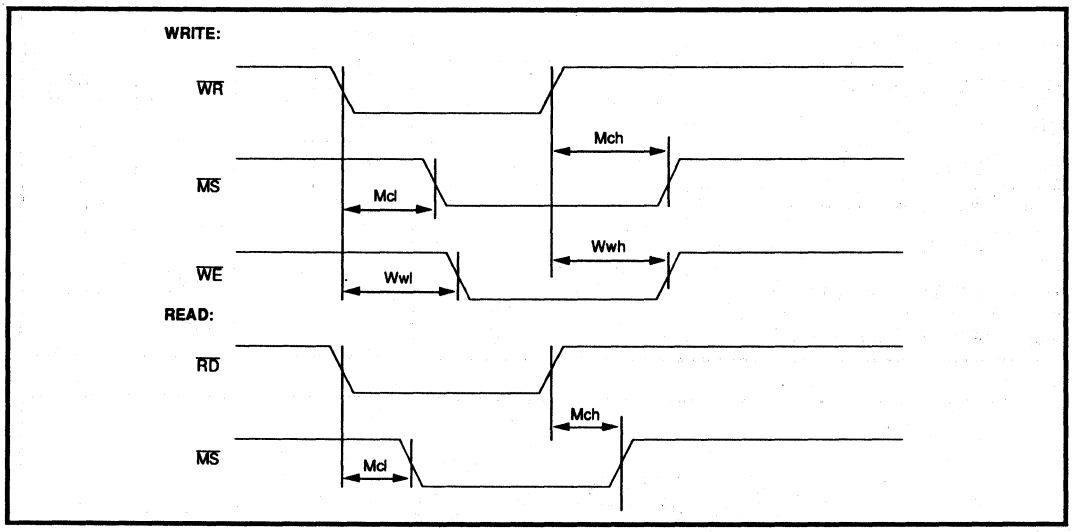


FIGURE 5: Register 70 Timing

SCSI ARBITRATION

The internal SSI 32C453 SCSI arbitration logic is shown in Figure 6. When the ARB bit in register IFCON is set, the SSI 32C453 is enabled to recognize SCSI "bus free" condition. When both the BSYIN and SELIN signals have been inactive for three $\overline{CLK}$ cycles this condition is held in a set/reset latch. After a further four $\overline{CLK}$ cycles, with BSYIN and SELIN remaining inactive ARB will be read as true. This indicates that a SCSI bus arbitration phase is underway. The ARB bit will be cleared if SELIN is active and the microprocessor asserts SELOUT, by setting the SELOUT bit in the IFCON register indicating that the arbitration was successful and the selection phase has begun. Figure 7 shows an overview of the SSI 32C453 SCSI interface timing for system considerations. An example of interfacing these signals to the SCSI bus is shown in Figure 12.

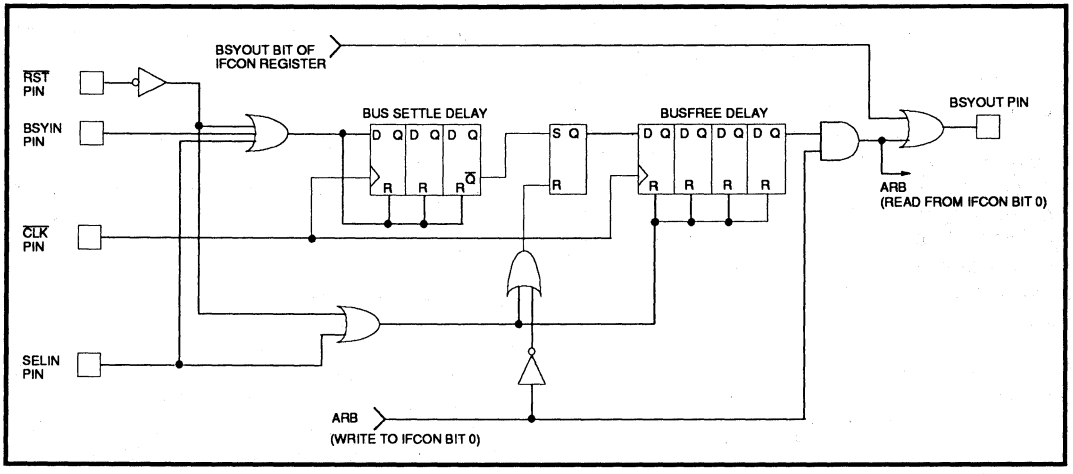


FIGURE 6: SSI 32C453 SCSI Arbitration Logic

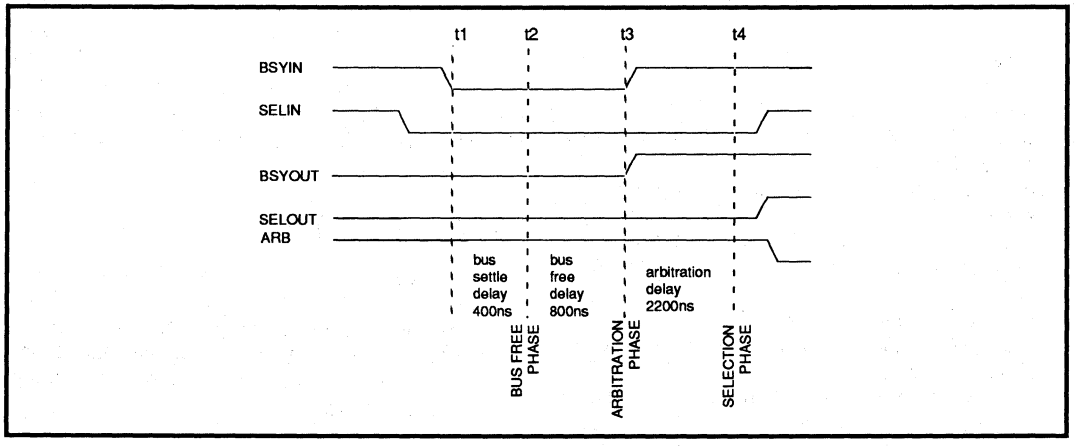


FIGURE 7: SSI 32C453 SCSI Arbitration Logic Timing

APPLICATIONS INFORMATION

EXTERNAL HARDWARE

As described previously, the SSI 32C453 provides a number of strobe outputs to control external interface hardware. Three different addressing configurations are illustrated in figures 8 to 11. Because of pin limitations, the DIP version of the SSI 32C453 does not provide either $\overline{HOE}$ or $\overline{DOE}$. These signals may be recreated with an external D flip-flop as shown in Figure 11. In extended addressing mode, the external Port A and Port B address latches must be initialized with explicit writes to the RAPH and WAPH registers, since only internal registers are initialized upon reset. To avoid interfering with data transfers, these registers should only be accessed when both ports are inactive.The ROP/$\overline{WOP}$ bit must be set correctly before these registers are written to in extended addressing mode, since this control bit can change which pointer is associated with which port. An example of interfacing the SSI 32C453 to the SCSI bus is shown in Figure 12.

A rule of thumb to use when selecting RAM for the buffer is:

$$\text{Buffer cycle time} = \frac{8\ \text{bits/byte}}{3 * \text{bit rate}}$$

SINGLE BLOCK READ

The following steps must be taken to effect the transfer of a single block of data from the peripheral to the host:

1. Initialize SSI 32C453 using RESET bit, and select desired buffer size and addressing mode.
2. Select read operation by setting ROP/$\overline{WOP}$.
3. Clear RAPH, WAPH explicitly when in extended addressing mode.
4. Instruct peripheral controller to commence peripheral read.
5. Wait for end of block. (Will be detected by controller or by observing value of WAP, which increments automatically).
6. Load stop pointer (SP) with the value (WAP-1), since WAP points to the location after the last entry in the FIFO buffer.
7. Set the RDLATCH bit so that the DMA request/ acknowledge cycles commence.
8. Wait for DMADONE to be set. (Occurs when RAP=SP).

SINGLE BLOCK WRITE

The following steps must be taken to effect the transfer of a single block of data from the host to the peripheral:

1. Initialize SSI 32C453 using RESET bit, and select desired buffer size and addressing mode. (This will clear ROP/$\overline{WOP}$.)
2. Clear RAPH, WAPH explicitly when in extended addressing mode.
3. Set SP to be equal to the length of the data block to be transferred.
4. Set the WRLATCH bit so that the DMA request/ acknowledge cycles commence.
5. Wait for DMADONE to be set. (Occurs when WAP=SP).
6. Instruct peripheral controller to commence peripheral read.
7. Wait for end of block. (Will be detected by controller or by observing value of RAP, which increments automatically).

MUTLIPLE BLOCK READ

The initial steps in a multiple block read are similar to those of a single block read. However, once the DMA transfer of the first block to the host is underway, the next peripheral block read can occur, provided that the buffer is sufficiently large to accomodate the next block of data. (The microprocessor can either check the value of RAP, or maintain its own count of the number of blocks currently stored in the buffer, in order to prevent buffer overruns caused by the peripheral.) When the next peripheral block transfer has been initiated, the microprocessor waits for DMADONE to be set. When the host is ready for a new DMA transfer, the value of SP may be changed and a new transfer started (provided there is sufficient data in the buffer to prevent an overrun).

MULTIPLE BLOCK WRITE

As in the case of multiple block reads, the microprocessor starts by causing a single block of host data to be transferred to the buffer memory. Thereafter, host and peripheral transfers may be initiated simultaneously, provided the microprocessor ensures that a buffer overrun does not occur.

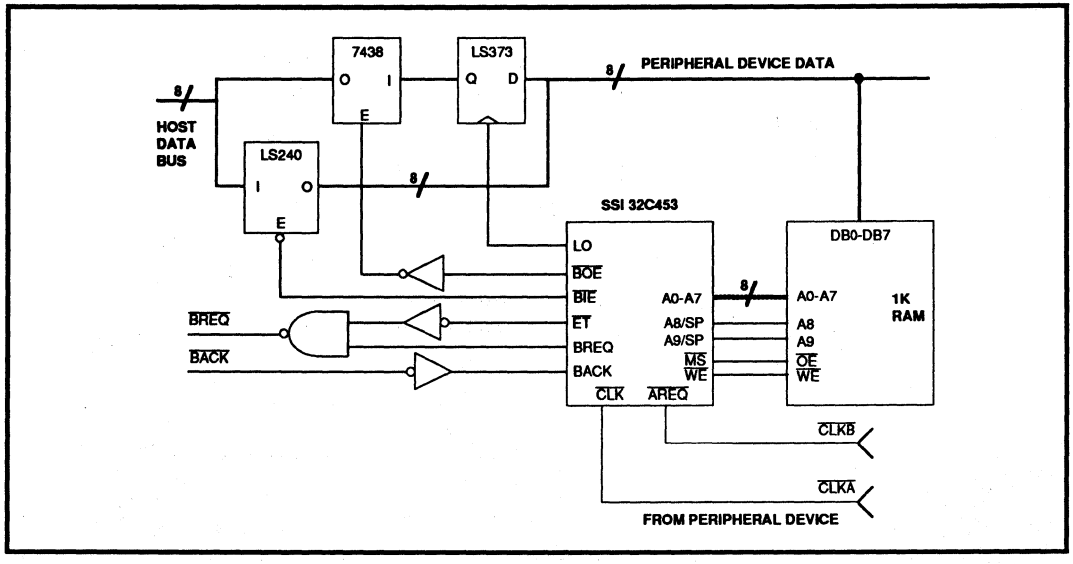


FIGURE 8: Direct Address Mode Example - 10 Address Lines

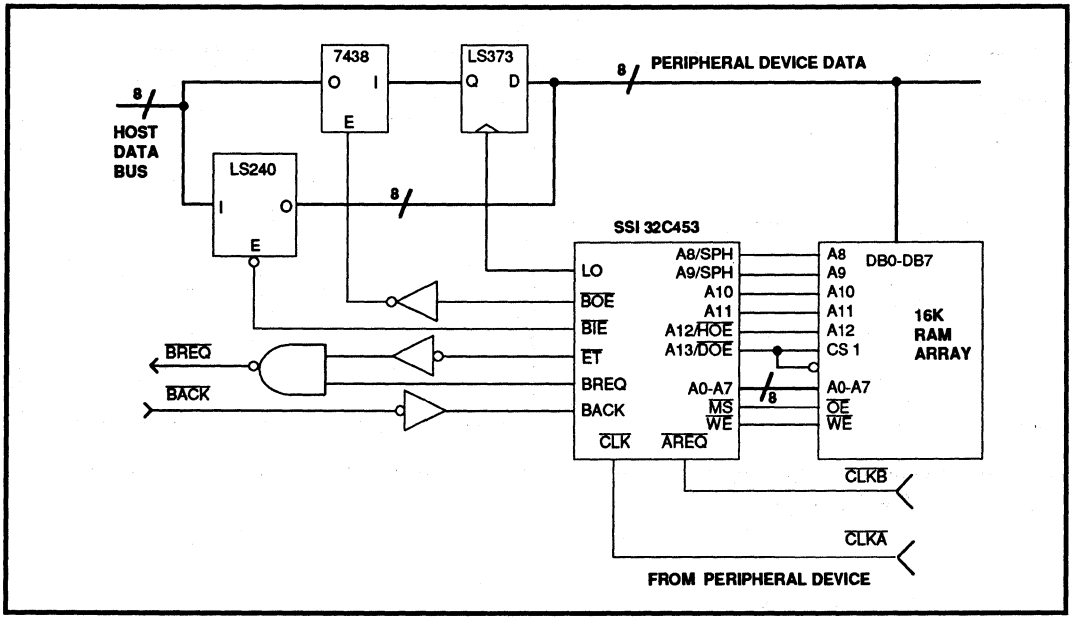


FIGURE 9: Direct Addressing Mode Example - 14 Address Lines (SSI 32C453 PLCC Version Only)

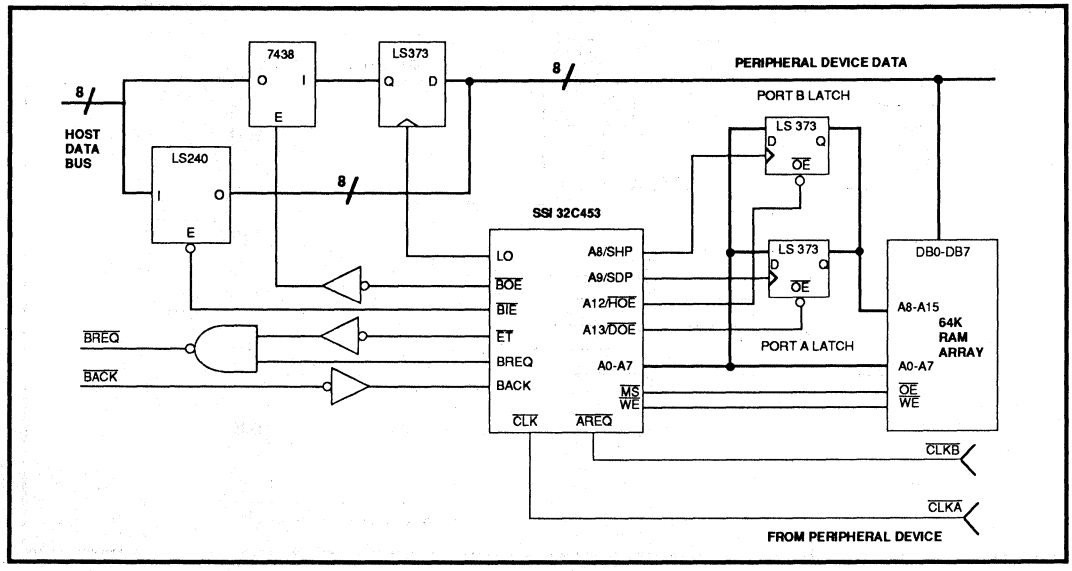


FIGURE 10: Extended Addressing Mode Example

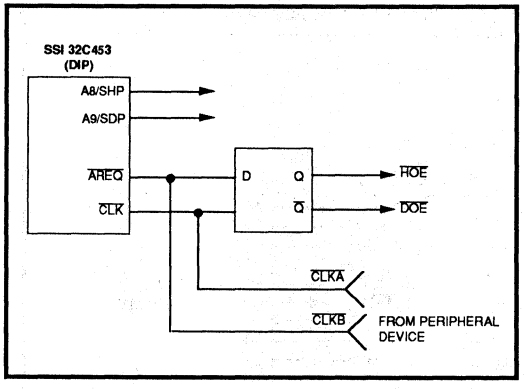


FIGURE 11: Extended Mode Address Strobes for DIP Package

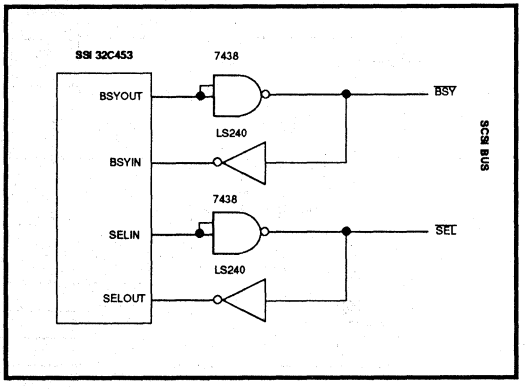


FIGURE 12: SCSI Bus Interface Example

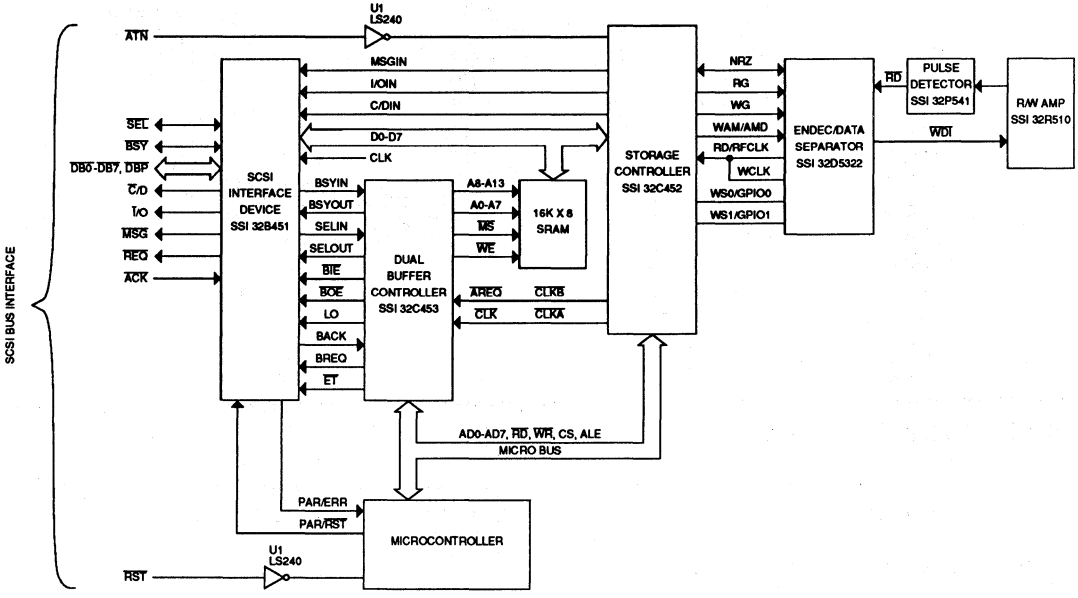


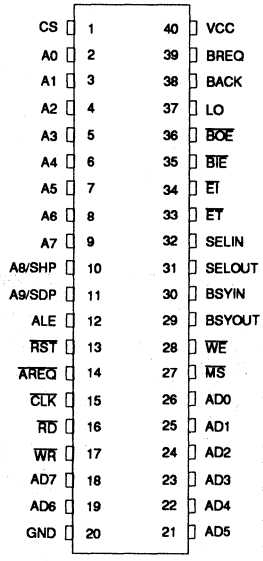
FIGURE 13: Partial Schematic for SCSI Implementation with Arbitration Support using Silicon Systems microperipheral devices

7

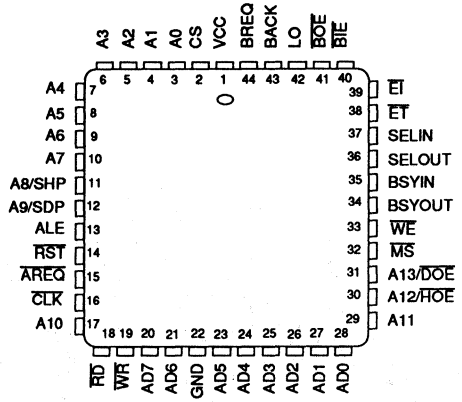
SSI 32C453
Dual Port
Buffer Controller

PACKAGE PIN DESIGNATIONS

(Top View)



40-Pin DIP



44-Lead PLCC

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 32C453 Dual Port Buffer Controller		
40 Pin DIP	SSI 32C453-CP	SSI 32C453-CP
44-Pin PLCC	SSI 32C453-CH	SSI 32C453-CH

Silicon Systems, Inc. 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX (714) 731-5457

SSI 32C4650
PC AT/XT Combo Controller

Advance Information

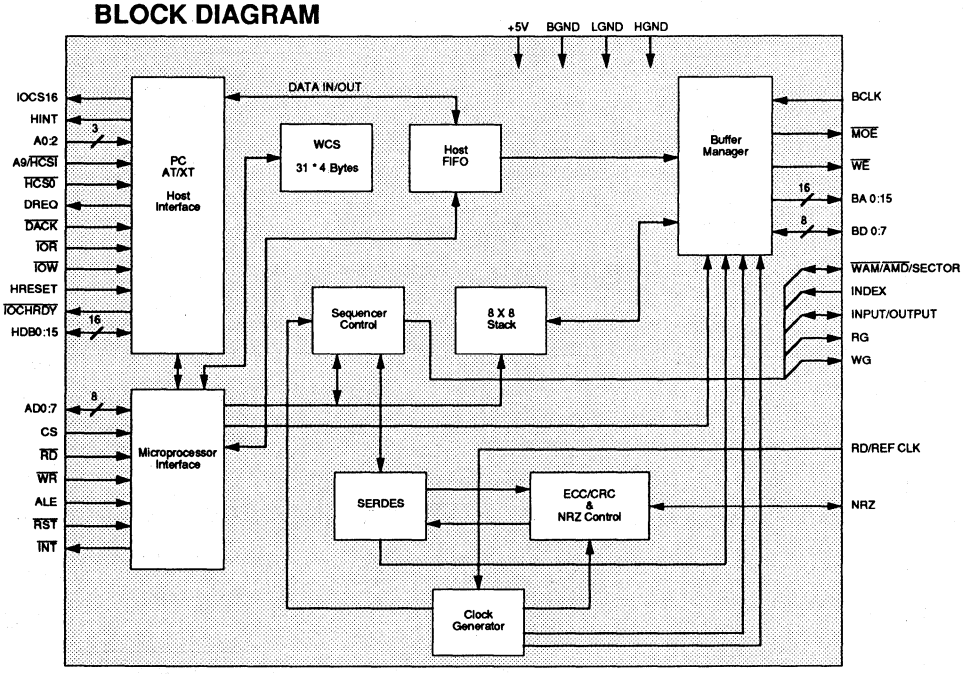
July, 1990

FEATURES

- PC AT/XT Bus Interface
  - Single Chip PC AT/XT Controller
  - Supports ST506/412, ST412HP, ESDI, and SMD disk interfaces
  - Direct bus interface logic with on-chip 24 mA drivers
  - Logic for daisy chaining 2 embedded controller drives on a PC AT
  - Supports 24 Mbit/s concurrent disk transfer on a 12 MHz PC AT without wait states
- Buffer Manager
  - Supports Buffer Memory throughput to 6 MB/s
  - Direct Buffer Memory addressing up to 64 kB static RAM
  - Dual port circular buffer control
- Storage Controller
  - NRZ Data rate up to 24 Mbit/s
  - Selectable 16-bit CRC or 56-bit ECC polynomial with fast hardware correction circuitry
  - Support sector level defect management
  - Support 1:1 interleaved operation
- Microprocessor Interface
  - Supports both Intel 8051, and Motorola 68HC11 family of microprocessors
  - Interrupt or polled microprocessor interface
- Others
  - Low power CMOS technology
  - Plug and Play compatible with Cirrus CL-SH 260 chip
  - Available in 84-pin PLCC or 100-pin QFP

7

BLOCK DIAGRAM



SSI 32C4650
PC AT/XT Combo Controller

DESCRIPTION

The SSI 32C4650 is a CMOS VLSI device which integrates the major portion of the hardware needed to build a PC AT/XT driven hard disk controller. The 32C4650 is capable of supporting interleaved data transfer rate up to 24 Mbit/s. This chip represents a major reduction in part count when used with the SSI 32P4620 Pulse Detector and Data Separator Combo, the SSI 32R4610 Read/Write device, and the SSI 32H4631 Servo and Motor Speed Controller device, implementing a powerful and cost efficient 4-chip set intelligent drive solution. It also has the flexibility to be used as a stand-alone combo controller.

The SSI 32C4650 includes a dual port Buffer Manager, a storage controller and a extensive hardware support, including 24 mA drivers, for the PC AT/XT and other compatible interfaces.

The SSI 32C4650 performs all the controller functions for the peripheral device, such as serialization/ deserialization, ECC generation and checking on the data stream, and CRC generation and checking on the header of the data stream.

PIN DESCRIPTION

NAME	TYPE	DESCRIPTION
GENERAL		
+5V		POWER SUPPLY pin, VCC
BGND		BUFFER BUS GROUND
LGND		LOGIC GROUND
HGND		HOST GROUND
HOST INTERFACE		
A0:2	I	HOST ADDRESS LINES. These pins are used to address the internal registers by the AT bus.
A9/$\overline{HCS1}$	I	HOST ADDRESS LINE 9/ HOST CHIP SELECT 1. A9, this pin is used in conjunction with the A0:2 address lines to address the internal task file registers. HCS1 is an active low pin, used to qualify Host access.
$\overline{HCS0}$	I	HOST CHIP SELECT 0. Active low, this pin selects access to the control, status and data registers.
$\overline{IOCS16}$	O	I/O SELECT 16. An open drain output that indicates that a 16-bit sector buffer transfer is active.
HINT	O	HOST INTERRUPT. Asserted to indicate to the Host that the controller needs attention.
$\overline{IOCHRDY}$	O	I/O CHANNEL READY. Active low, this signal is asserted whenever that internal host FIFO is not ready to transfer data.
DREQ	O	DMA REQUEST. This pin is programmed to function as the PC/AT bus signal in the PC/ AT DMA mode.
$\overline{DACK}$	I	DMA ACKNOWLEDGE. Active low, in the PC/AT DMA mode this pin is programmed to be the PC/AT channel signal - DACK.
$\overline{IOR}$	I	INPUT READ SELECT. Active low, this pin is asserted by the Host during a Host read operation.
$\overline{IOW}$	I	INPUT WRITE SELECT. Active low, asserted by the HOST during a HOST write operation.

NAME	TYPE	DESCRIPTION
HOST INTERFACE (Continued)		
HRESET	I	HOST RESET. This signal resets all commands in progress when active, and initializes the control/status registers.
HDB 15:0	I/O	HOST DATA BUS. Active high bi-directional pins. These bits are used for data transfers between the Host and the Buffer Manager.
DISK INTERFACE		
INDEX	I	INDEX. Input for index pulse received from the drive
INPUT/ OUTPUT	I/O	INPUT/OUTPUT. A general purpose control and status pin. It can be either an input or an output. At power-on, this pin is an input.
$\overline{\text{WAM}}$/ $\overline{\text{AMD}}$/ SECTOR	I/O	WRITE ADDRESS MARK/ADDRESS MARK DETECT/SECTOR. This pin becomes an active low address mark detect if the read gate is on, or write address mark if write gate is on. It operates in hard or soft sector modes. The default is soft sector. In hard sector mode this is the input for the sector pulse.
RG	O	READ GATE. During NRZ data read, this pin is asserted. Active high.
WG	O	WRITE GATE. During NRZ data write, this pin is asserted. Active high.
RD/REF/ CLK	I	READ/REFERENCE CLOCK. This pin is used in conjunction with the NRZ pin to clock data in and out of the SSI 32C4650 device.
NRZ	I/O	NRZ. This pin is used in conjunction with the RG and WG when reading and writing from and to the disk.
MICROPROCESSOR INTERFACE		
$\overline{\text{RST}}$	I	RESET. Active low input, when pulled low, the internal registers of the SSI 32C4650 are held at reset.
ALE	I	ADDRESS LATCH ENABLE. This control signal latches the address on the address/data lines.
CS	I	CHIP SELECT. Active high signal, when asserted, the internal registers of the SSI 32C4650 can be accessed.
$\overline{\text{WR}}$	I	WRITE. Active low input, when active the data is written to the internal registers.
$\overline{\text{RD}}$	I	READ. Active low input, when active the data is read from the internal registers.
$\overline{\text{INT}}$	O	INTERRUPT. An open drain output, when active, the microprocessor is requesting controller service.
AD7:0	I/O	ADDRESS/DATA BUS. 8-bit bus for both microprocessor register address and data.
BUFFER MANAGER INTERFACE		
BA0:15	O	BUFFER MANAGER ADDRESS LINES. Active high, for direct connection to a static RAM.
BD0:7	I/O	BUFFER MANAGER DATA BUS. 7 through 0. Active high, buffer data bus that connects directly to the buffer RAM.
$\overline{\text{MOE}}$	O	MEMORY OUTPUT ENABLE. Active low select for the buffer RAM.
$\overline{\text{WE}}$	O	WRITE ENABLE. Active low, write enable for the buffer RAM.
BCLK	I	SYSTEM CLOCK. This signal is used to synchronize the buffer RAM access, including the generation of memory address bits, write enable $\overline{\text{WE}}$, and memory output enable $\overline{\text{MOE}}$.

7

ABSOLUTE MAXIMUM RATINGS

Maximum limits indicate where a permanent device damage occurs. Continuous operation at these limits is not intended and should be limited to those conditions specified in the DC operating characteristics

PARAMETER	RATING	UNITS
Power Supply Voltage, VCC	7	V
Ambient Temperature	0 to 70	°C
Storage Temperature	-65 to 150	°C
Power Dissipation	750	mW
Input, Output pins	-0.5 to VCC+0.5	V

ELECTRICAL CHARACTERISTICS

PARAMETER	CONDITION	MIN	NOM	MAX	UNITS
VCC Power Supply Voltage		4.75		5.25	V
ICC Supply Current				50	mA
ICCS Supply Current Standby	All Inputs at GND or VCC			250	µA
VIL Input Low Voltage		-0.5		0.8	V
VIH Input High Voltage		2.0		VCC+0.5	V
VOL Output Low Voltage	All pins except PC interface, IOL = 2 mA			0.4	
VOL Output Low Voltage	PC interface pins, IOL = 24 mA			0.5	V
VOH Output High Voltage	IOH = -400 µA			2.4	V
IL Input Leakage Current	0 < VIN < VCC	-10		10	µA
CIN Input Capacitance				10	pF
COUT Output Capacitance				10	pF

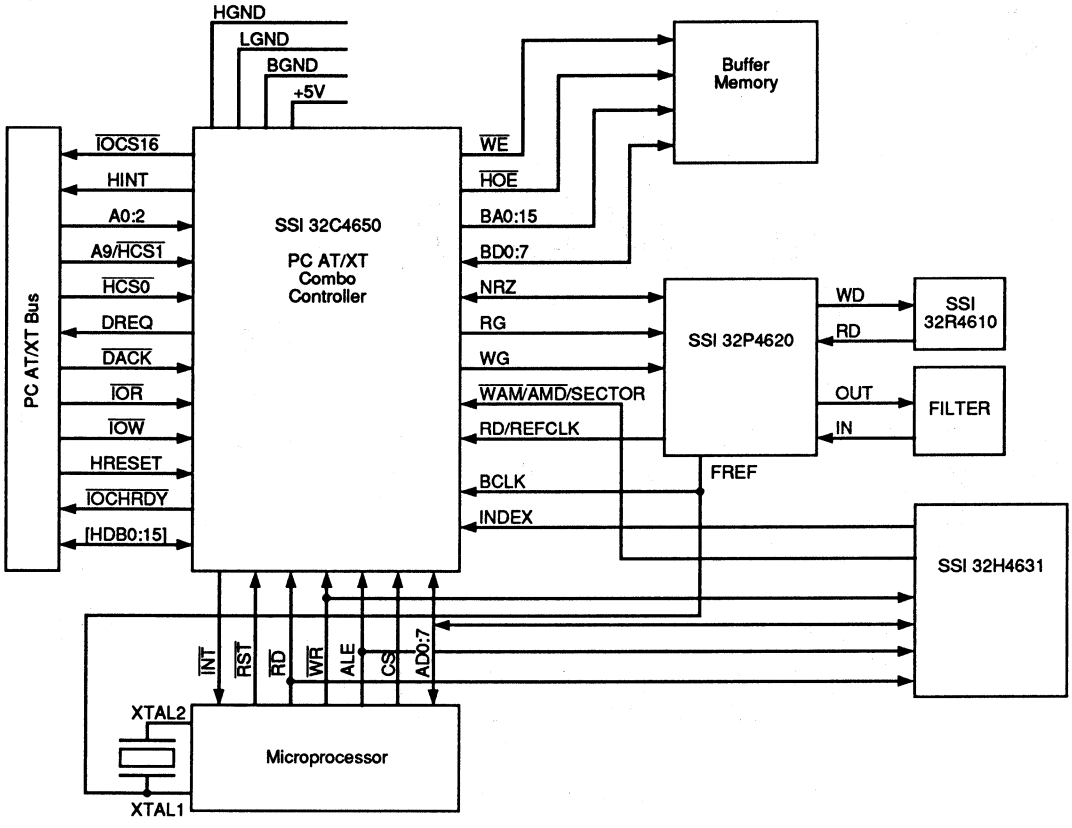


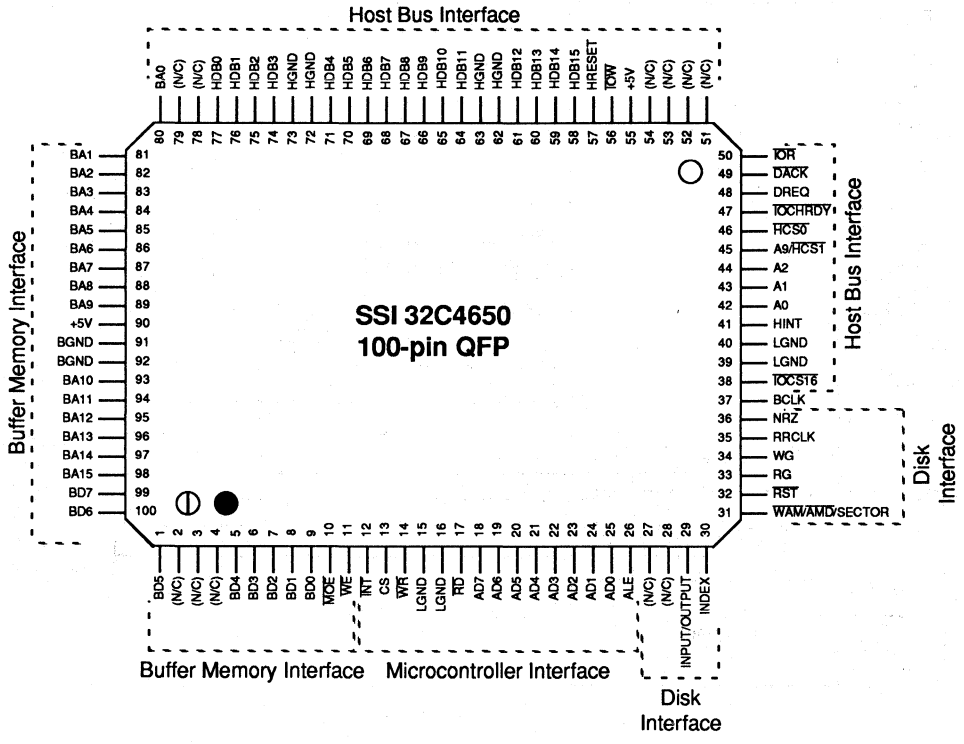
FIGURE 1: System Block Diagram using the SSI 32C4650 PC AT/XT Combo Controller

7

SSI 32C4650
PC AT/XT Combo Controller

PACKAGE PIN DESIGNATIONS
(TOP VIEW)

CAUTION: Use handling procedures necessary for a static sensitive component.



Advance Information: Indicates a product still in the design cycle, and any specifications are based on design goals only. Do not use for final design.

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Section 8

FLOPPY DISK DRIVE CIRCUITS

SSI 34D441
Data Synchronizer & Write Precompensator Device

July, 1990

DESCRIPTION

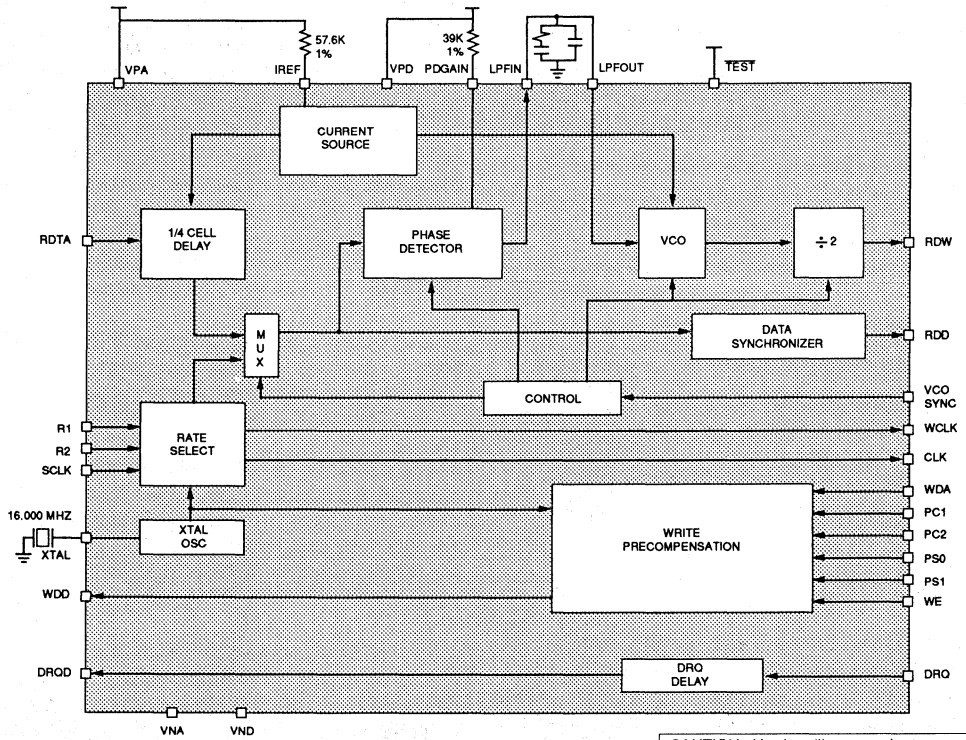
The SSI 34D441 floppy disk data synchronizer/write precompensator performs read-data synchronization and write data precompensation of MFM encoded data for high performance floppy disk drive systems. The SSI 34D441 is optimized for use with the NEC μPD765A/μPD7265 controller family.

The SSI 34D441 contains an analog phase-lock-loop for read data synchronization, a crystal controlled reference oscillator, write precompensation circuitry, and a delay function for the DRQ signal. It employs silicon gate CMOS technology for low power consumption. The SSI 34D441 requires a +5V power supply and is available in 28-pin PDIP and 28-pin PLCC packages.

FEATURES

- **Ideal for operation with NEC μPD765A/μPD7265**
- **Fast acquisition analog PLL for precise read data synchronization**
- **No adjustments or trims needed to external components**
- **Programmable data rate, up to 1 Mbit/s**
- **Internal crystal controlled oscillator**
- **Selectable write precompensation intervals**
- **Programmable write clock**
- **DRQ (Data DMA Request) delay function**
- **Low power CMOS, +5V operation**
- **28-pin PDIP and 28-pin PLCC**

BLOCK DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

8

SSI 34D441
Data Synchronizer & Write Precompensator Device

FUNCTIONAL DESCRIPTION

CRYSTAL OSCILLATOR

The crystal controlled oscillator uses a 16.000 MHz crystal cut for fundamental series mode resonance. Its frequency is divided down and used throughout the 34D441. The device requires only one pin for the crystal input; the other crystal pin is connected to digital ground. An external source (TTL level) can also be used to drive the chip via this pin, if desired.

RATE-SELECT

The rate-select section generates the various write-data frequencies (WCLK), and one of the two alternative clock rates (CLK), as shown in Table 1. In addition, this section provides a time base for the read-data circuitry. The CLK and WCLK signals have their rising edges synchronized. The WCLK signal has a pulse width of 250 ns.

TABLE 1: WRITE-DATA CLOCK FREQUENCIES

R2	R1	WCLK	DATA RATE	SCLK	CLK
1	0	250 kHz	125 kHz	1	8 MHz
0	0	500 kHz	250 kHz	0	4 MHz
0	1	1 MHz	500 kHz		
1	1	2 MHz	1 MHz		

DRQ DELAY

This circuit is used to delay the leading edge of the DRQ signal, which is generated by the NEC 765 before it is sent to the DMA controller. The output pulse appearing at DRQD has its leading edge delayed by six to eight CLK pulses. The DRQ pulse is at least nine CLK pulses wide. The falling edge of the input clears the DRQD pulse.

DATA SEPARATOR

This circuit consists of several blocks, which include the one-shot, VCO, IREF, and the read-path circuitry. Read-data synchronization is accomplished with a fast acquisition phase-lock-loop (PLL). The input data from the disk drive, RDTA, is phase locked with the VCO. The synchronized read data and the VCO (divided by two) are available for external data extraction at the RDD and RDW pins, respectively.

Changing the state of VCOSYNC causes the VCO to be stopped and restarted in phase with the PLL reference, which can be either the internal crystal oscillator or the RDTA input data. Restarting the VCO in phase with the input prevents the PLL from locking to harmonics and insures short lock times. (See Figure 1.)

The one-shot is used to shape the input read data. The IREF block provides reference currents to both the VCO and the One-Shot circuits. Current for the current source block is set by an external resistor connected to the IREF pin. The rate pins R1 and R2 are used to select between various frequencies. The Read-Path circuitry includes the phase detector, charge pump, data synchronizer and control logic circuitry.

The data synchronizer separates the data and clock pulses using windows derived from the VCO output. Using a VCO running at twice the expected input data frequency allows accurate centering of these windows about the expected bit positions. The phase detector controls the charge pump which causes current pulses to flow in or out of the phase-lock-loop filter. The amount of current to be sourced or sunk by the charge pump is controlled by an external resistor connected to the PDGAIN pin. This feature can be used to change the phase detector gain, KPD, which is given by:

$I_{PDGAIN}/2\pi$ [A/rad]

The output read data pulse, RDD, is at least 62.5 ns wide.

WRITE PATH

The WDD output is a re-synchronized version of the input MFM write data (WDA) which has been time shifted, if needed, to reduce interbit interference. The amount of precompensation, as well as the direction of the pulse shifting, is controlled by the external signals PC1, PC2, PS0 and PS1. Table 2 describes the precompensation signals. The output buffer for the precompensated write data (WDD) is capable of sinking 24 mA. The write path circuitry is also used to multiplex the output of the one-shot to the WDD pin for test purposes.

TABLE 2: PRECOMPENSATION DESCRIPTION

PC2	PC1	PRECOMPENSATION INTERNAL	PS0	PS1	SHIFT
0	0	±62.5 ns	0	1	Normal (no shift)
1	0	±125 ns	0	1	Late (delay)
0	1	±187.5 ns	1	0	Early (advance)
1	1	±250 ns	1	1	Invalid (no Shift)

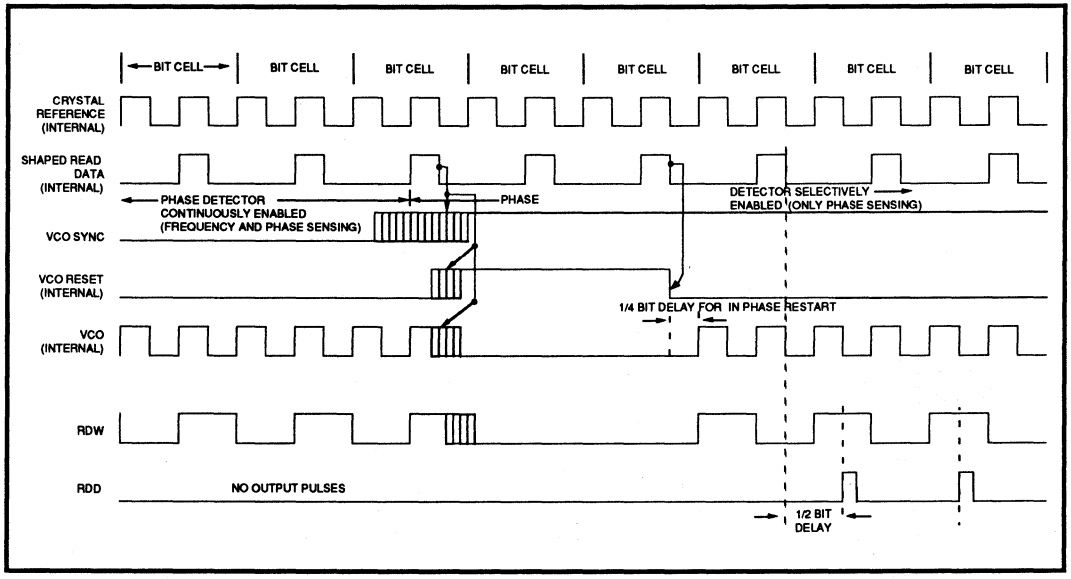


FIGURE 1: PLL Locking Sequence

8

PIN DESCRIPTIONS

<table>
<tr><th>NAME</th><th>PIN NO.</th><th>DESCRIPTION</th></tr>
<tr><td>R1, R2</td><td>3, 4</td><td>Used to set the following conditions: write data clock rate (WCLK), one-shot output pulse width, and the (VCO) voltage - controlled oscillator frequency.
<table>
<tr><th>R2</th><th>R1</th><th>DATA RATE</th><th>NOMINAL WCLK</th><th>VCO FREQ</th></tr>
<tr><td>1</td><td>0</td><td>125 kHz</td><td>250 kHz</td><td>250 kHz</td></tr>
<tr><td>0</td><td>0</td><td>250 kHz</td><td>500 kHz</td><td>500 kHz</td></tr>
<tr><td>0</td><td>1</td><td>500 kHz</td><td>1 MHz</td><td>1 MHz</td></tr>
<tr><td>1</td><td>1</td><td>1 MHz</td><td>2 MHz</td><td>2 MHz</td></tr>
</table></td></tr>
<tr><td>SCLK</td><td>5</td><td>This pin sets the clock frequency CLK
<table>
<tr><th>SCLK</th><th>CLK</th></tr>
<tr><td>0</td><td>4 MHz</td></tr>
<tr><td>1</td><td>8 MHz</td></tr>
</table></td></tr>
<tr><td>PC2, PC1</td><td>6, 7</td><td>Used to set the amount of write-data precompensation.
<table>
<tr><th>PC1</th><th>PC2</th><th>PRECOMPENSATION INTERVAL (ns)</th></tr>
<tr><td>0</td><td>0</td><td>±62.5</td></tr>
<tr><td>0</td><td>1</td><td>±125</td></tr>
<tr><td>1</td><td>0</td><td>±187.5</td></tr>
<tr><td>1</td><td>1</td><td>±250</td></tr>
</table></td></tr>
<tr><td>DRQ</td><td>8</td><td>Accepts DRQ signal from NEC 765 controller to delay it.</td></tr>
<tr><td>$\overline{\text{TEST}}$</td><td>10</td><td>Should be a logic high for normal operation. When $\overline{\text{TEST}}$ is low, the WDD pin outputs the one-shot pulse.</td></tr>
<tr><td>RDTA</td><td>11</td><td>Accepts the MFM encoded read data pulses from the read amplifier circuits.</td></tr>
<tr><td>VCOSYNC</td><td>18</td><td>Selects the reference input to the PLL. Selects a reference frequency equal to WCLK when low, and the incoming read data (RDTA), when high.</td></tr>
<tr><td>WDA</td><td>25</td><td>Accepts write data from the controller. This data is resynchronized and precompensated before being sent to the drive.</td></tr>
</table>

PIN DESCRIPTIONS (Continued)

<table>
<tr><th>NAME</th><th>PIN NO.</th><th>DESCRIPTION</th></tr>
<tr><td>PS0, PS1</td><td>26, 27</td><td>Pins to determine whether to precompensate write data pulses, and to advance or delay the leading edge of pulses.
<table>
<tr><th>PS0</th><th>PS1</th><th>SHIFT</th></tr>
<tr><td>0</td><td>1</td><td>Normal (no shift)</td></tr>
<tr><td>0</td><td>1</td><td>Late (delay)</td></tr>
<tr><td>1</td><td>0</td><td>Early (advance)</td></tr>
<tr><td>1</td><td>1</td><td>Invalid (no shift)</td></tr>
</table></td></tr>
<tr><td>WE</td><td>28</td><td>When high, causes data to be output at the WDD pin. When WE is low, write data (WDD) is low.</td></tr>
<tr><td>VPD</td><td>2</td><td>+5V Digital supply</td></tr>
<tr><td>VND</td><td>24</td><td>Digital ground for chip</td></tr>
<tr><td>VPA</td><td>12</td><td>+5V analog supply (isolated +5V source having very little noise).</td></tr>
<tr><td>VNA</td><td>13</td><td>Analog ground</td></tr>
<tr><td>DRQD</td><td>9</td><td>Output for the delayed DRQ signal from the NEC 765. Only the leading edge of the input signal is delayed.</td></tr>
<tr><td>RDW</td><td>19</td><td>This is a square wave output generated by the VCO which provides a read data window to be used by the NEC 765 controller to separate the read-data and read-clock transitions. RDW has the same frequency as the nominal data rate.</td></tr>
<tr><td>RDD</td><td>20</td><td>This signal consists of pulses that indicate flux reversals present on the floppy disk that could indicate either clock or data information. The leading edge of each RDD pulse will appear in the center of window defined by the RDW signal.</td></tr>
<tr><td>WCLK</td><td>21</td><td>This signal is the write clock for the controller device. All write signals output by the NEC 765 controller, are related to WCLK.</td></tr>
<tr><td>CLK</td><td>22</td><td>This signal is used by the NEC 765 controller and associated devices. The CLK signal has a 50% duty cycle and the rate is set by SCLK.</td></tr>
<tr><td>WDD</td><td>23</td><td>This open-drain output provides re-synchronized and precompensated write data in accordance with settings on PC1,PC2, and PS0, PS1 pins. The leading edge of WDD shall be used to define data. When $\overline{\text{TEST}}$ is low, this pin will output the one-shot pulses.</td></tr>
<tr><td>XTAL</td><td>1</td><td>Single input pin for the 16 MHz crystal oscillator. Other side of crystal to go to digital ground. Option of providing an external 16MHz signal with TTL compatible logic levels and a 40% to 60% duty cycle.</td></tr>
<tr><td>IREF</td><td>14</td><td>Used to set the internal reference current generated for the one-shot and VCO. Desired current shall be derived from a 1% tolerance 57.6 kΩ resistor connected between the analog 5 volt supply and this pin.</td></tr>
</table>

PIN DESCRIPTIONS (Continued)

NAME	PIN NO.	DESCRIPTION
LPFOUT	15	Control voltage input of the VCO, and also for the connection of loop-filter output. Control voltage shall range approximately from 0.7 to 4.5 volts.
LPFIN	16	Output pin for the current pulses from charge pump that the were converted from voltage pulses generated by phase detector. This pin is typically connected to LPFOUT, and an RC low pass loop filter network connected to the analog ground.
PDGAIN	17	Used to set the current level to be sunk or sourced by the charge-pump. A 39K ohm resistor connected between this pin and the digital 5 volt supply VPD, shall provide a 100 µA current to the charge-pump. Some other resistor values and their corresponding currents are given below:

R_{PDGAIN}	I_{PDGAIN}
15K	225 µA
22K	160 µA
30K	120 µA
46K	80 µA

ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNIT
Storage Temperature	-40 to +120	°C
Ambient Operating Temperature, TA	0 to +70	°C
Supply Voltages, VPD, VPA	-0.5 to +7.0	VDC
Voltage Applied to Logic inputs	-0.5 to +7.0	VDC
Voltage Supplied to Logic Outputs	-0.5 to +5.5	VDC
Maximum Power Dissipation	750	mW

RECOMMENDED OPERATING CONDITIONS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Ambient Temperature, TA		0		70	°C
Power Supply Voltage, VPD, VPA		4.75	5	5.25	VDC
High Level Input Voltage, VIH	Power supply = 4.75V	2.0			V
Input Current High, IIH	Power supply =4.75V VIH = 2.4V			20	µA
Low Level Input Voltage, VIL	Power supply = 4.75V			0.8	V
Input Current Low, IIH	Power supply = 5.25V VIL = 0.4V			-20	µA
High Level Output Voltage, VOH	Power supply = 4.75V IOH=4 mA	2.4			V
Low Level Output Voltage All others, VOL	Power supply = 4.75V IOL = 8 mA			0.4	V
Short Circuit Output Current WDD only IOS (to positive supply)	Power supply = 5.25V	20		150	mA

DC CHARACTERISTICS (Unless otherwise specified, power supplies = 4.75V to 5.25V, TA = 0 to 70°C, RIREF = 57.6 kΩ ± 1%, RPDGAIN = 39 kΩ ± 5%, XTAL = 16 MHz crystal in series resonance.)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Supply Current Analog, IVPA	Power supply = 5.25V 51 MHz data rate			10	mA
Supply Current Digital, IVPD	Power supply = 5.25V 1 MHz data rate			6	mA
Short Circuit Output Current (to ground) All others, IOS	Power supply = 5.25V	30		100	mA

8

DYNAMIC CHARACTERISTICS AND TIMING (Load Capacitance = 50 pF)

DATA DETECTION CHARACTERISTICS (See Figure 2)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
TRDDW RDTA pulse width		25			ns
TRDWP RDW period	R1 = 0, R2 = 1		8		µs
	R1 = 0, R2 = 0		4		µs
	R1 = 1, R2 = 0		2		µs
	R1 = 1, R2 = 1		1		µs

DATA DETECTION CHARACTERISTICS (Continued)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TRDWW	RDW pulse width high or low	Same R1, R2 as above		TRDWP / 2		µs
TRDW	RDD pulse width		62.5		187.5	ns
TRDDD	Propagation Delay from RDW transition to RDD positive edge	Same R1, R2 as above	0.025	TRDWP / 4		µs

DRQ CHARACTERISTICS (See Figure 2)

TDLY	Propagation delay from DRQ positive edge to DRQD positive edge	SCLK = 1	0.75		1.0	µs
		SCLK = 0	1.50		2.0	µs
TDRLL	Propagation delay from DRQ negative edge to DRQD negative edge				50	ns

CRYSTAL CHARACTERISTICS

TXTALP	Crystal oscillator frequency period			62.5		ns

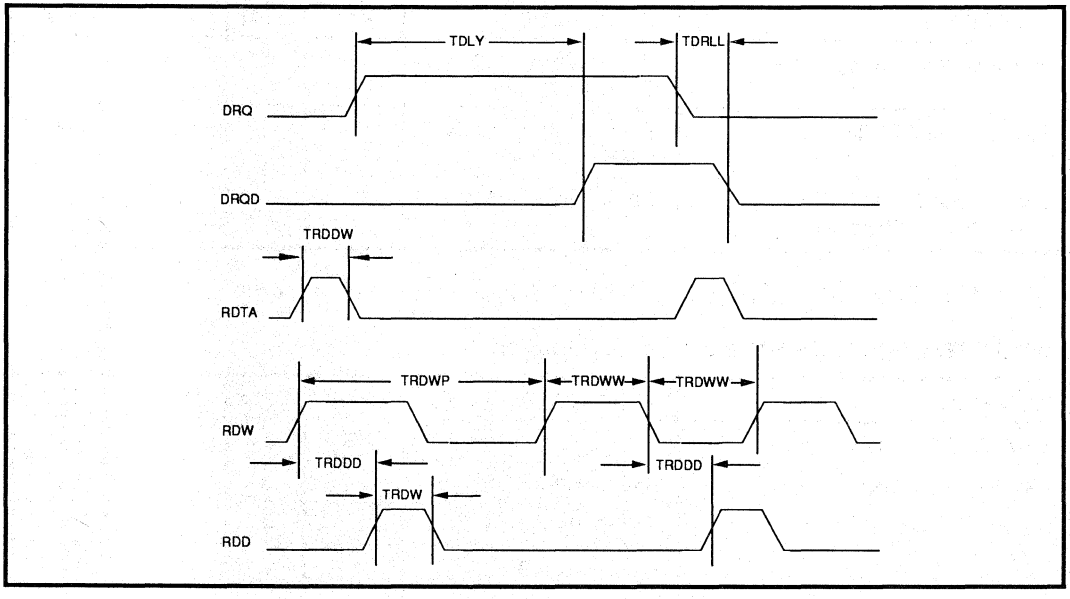


FIGURE 2: Timing Diagram

PHASE-LOCK-LOOP CHARACTERISTICS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VCO frequency range	Nominal frequency set by R1, R2, see Table 1	±20		±40	%
KVCO VCO gain	R2=1, R1=0		$0.5x10^6$		rad/s/V
	R2=0, R1=0		$0.96x10^6$		rad/s/V
	R2=0, R1=1		$1.75x10^6$		rad/s/V
	R2=1, R1=1		$2.98x10^6$		rad/s/V
KPD phase detector gain	RPDGAIN = 39kΩ ± 1%		15.9		µA/rad
VCO phase reset error				±0.2	rad
Number of RDW periods delay from RDTA to RDD			0.5		
Number of RDW periods VCO may be disabled during reference switching				3	

REFERENCE CLOCK (See Figure 3)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TC	CLK period	SCLK = 1		125		ns
		SCLK = 0		250		ns
TCO	CLK pulse width low or high			TC/2		ns
TCR	CLK rise time				15	ns
TCF	CLK fall time				15	ns

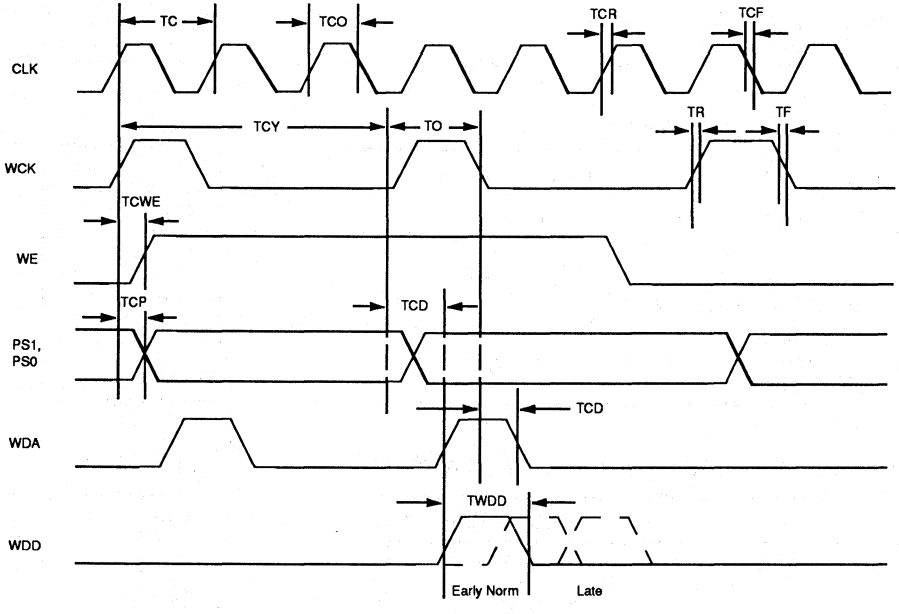
WRITE PRECOMPENSATION SWITCHING CHARACTERISTICS (See Figure 3)

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
TCY	WCLK period	R1 = 0, R2 = 1		4		µs
		R1 = 0, R2 = 0		2		µs
		R1 = 1, R2 = 0		1		µs
		R1 = 1, R2 = 1		0.5		µs
TO	WCLK pulse width	All combinations of R1, R2		250		ns
TR	WCLK rise time				15	ns
TF	WCLK fall time				15	ns

8

WRITE PRECOMPENSATION SWITCHING CHARACTERISTICS (Continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
TCWE Propagation delay from WCLK positive edge to WE positive edge		10		100	ns
TCP Propagation delay from WCLK positive edge to PS0, PS1 transition		10		100	ns
TCD Propagation delay from WCLK positive edge to WDA negative edge		10		100	ns
TWDD WDD pusle width		62.5			ns



Note 1: Not to scale.
Note 2: Read data waveforms do not show delay between RDIA and RDW.
Note 3: Write data waveforms do not show WDD precompensation by exact amounts specified.
Note 4: WCLK and CLK have their rising edges synchronized.

FIGURE 3: Switching Characteristics

APPLICATION

LOOP FILTER

The element in the phase lock loop which controls the loop dynamics is known as the loop filter. Acquisition time, data margin, and data tracking can be optimized by the loop filter selection. One possible loop filter configuration is shown in Figure 4, where the function of C_1 is as an integrating element. The larger the capacitance of C_1, the longer will be the lock time. If the capacitance is too small, the loop will tend to track high frequency jitter. The role of the resistor R is to reduce the phase shift induced by C_1. This is necessary since the loop will oscillate at the frequency where the gain is unity. The capacitor C_2 will suppress high frequency transients when switching occurs. This capacitor will have a minimal effect of the loop response if it is small compared to C_1 (typically, $C_2 = C_1/19$).

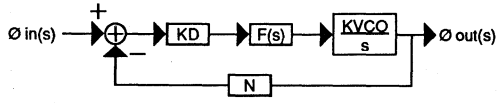
The loop filter transfer function is:

$$F(s) = \frac{Vout}{Iin} = \frac{1 + sRC_1}{sC_1\left(1 + sC_2R + \frac{C_2}{C_1}\right)}$$

if $C_2 < C_1$
then,

$$F(s) = \frac{Vout}{Iin} = \frac{1 + sRC_1}{sC_1}$$

The phase lock loop can be described as:



where,

KD = phase detector gain [A/rad]
F(s) = Filter impedance [V/A]
$\frac{KVCO}{s}$ = oscillator transfer function [rad/s V]
N = ratio of reference input frequency vs. VCO output frequency.

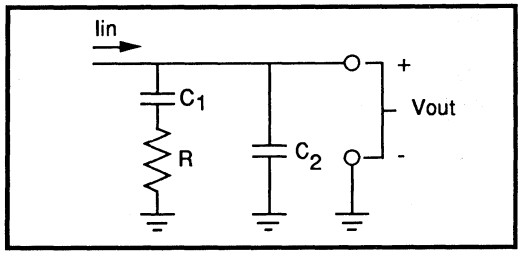


FIGURE 4: Loop Filter

Therefore, the closed loop transfer function is now:

$$T(s) = \frac{Ø\,out(s)}{Ø\,in(s)} = \frac{G(s)}{1 + G(s)H(s)} =$$

$$\frac{KD \times KVCO\left(\frac{1 + sRC_1}{C_1}\right)}{s^2 + s(N \times KD \times KVCO \times R) + \frac{N \times KD \times KVCO}{C_1}}$$

now we can put the characteristic equation (denominator) in the form:

$$s^2 + 2s\zeta\omega_n + \omega_n^2$$

$$\therefore \omega_n^2 = \frac{N \times KD \times KVCO}{C_1} \text{ and } \zeta = \frac{N \times KD \times KVCO \times R}{2\omega_n}$$

which results in:

$$C_1 = \frac{N \times KD \times KVCO}{\omega_n^2}$$

$$R = \frac{2\zeta\omega_n}{N \times KD \times KVCO} \text{ and } C_2 = \frac{C_1}{19}$$

For a $\zeta = 0.8$, the relationship between ω_n and lock time is:

$$\omega_n = \frac{4.5}{\text{lock time}}$$

Therefore, the loop filter components C_1, C_2, and R can be evaluated for a required lock time and coding scheme (N) frequency relationship to the VCO frequency.

8

LOOP FILTER (Continued)

For data rates of 250 Kbits/s, the bit cell is 4 µs long. A lock time of 3 bytes translates into:

lock time = 3 x 8 x 4 = 96 µs

Therefore:

$$\omega_n = \frac{4.5}{96\,\mu s} = 47\ \text{Krad/s}$$

$$C_1 = \frac{15.9 \times 10^{-6} \times 0.96 \times 10^{6}}{2 \times (47 \times 10^{3})^2} = 3500\ \text{pF}$$

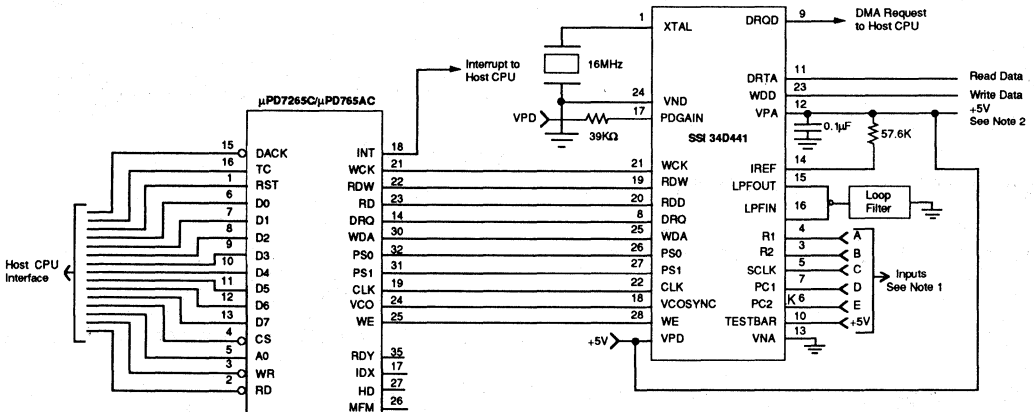
$$R = \frac{2 \times 0.8}{47 \times 10^{3} \times 3.5 \times 10^{-9}} = 9.8\ \text{K}\Omega$$

$$C_2 = \frac{C_1}{19} = 184\ \text{pF}$$

Table 3 lists suggested loop filter component values for various data rates. These values represent only a starting point for the design of the filter and they may be changed to meet the performance requirements of the system.

TABLE 3:

DATA RATE	LOCK TIME	LOOP FILTER
125 kHz	192 µs	R = 10 kΩ, C_1 = 6800 pF C2 = 360 pF
250 kHz	96 µs	R = 10 kΩ, C_1 = 3300 pF C_2 = 180 pF
500 kHz	46 µs	R = 11 kΩ, C_1 = 1500 pF C_2 = 82 pF
1 MHz	24 µs	R = 13 kΩ, C_1 = 680 pF C_2 = 39 pF



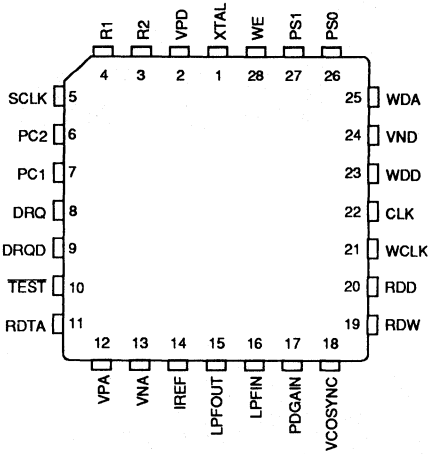
Note 1: Inputs A, B, C, D, and E may either be hardwired to desired control states, or may be programmable if controlled externally.

Note 2: A single voltage regulated +5V power supply should be used for VPA and VPD with appropriate bypassing capacitor.

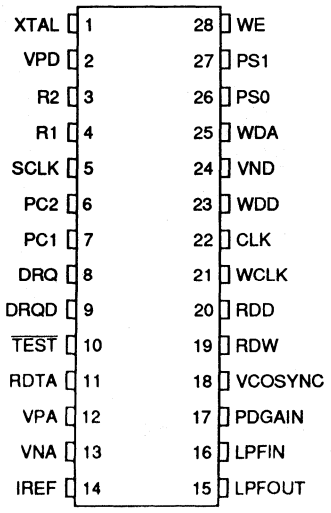
FIGURE 5: Application Diagram

PACKAGE PIN DESIGNATIONS

(Top View)



28-lead PLCC
PLCC pinouts are the same as the 28-pin DIP



600-mil
28-pin DIP

THERMAL CHARACTERISTICS: θja

28-lead PLCC	55°C/W
28-pin PDIP	65°C/W

8

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 34D441 28-pin PDIP	SSI 34D441-CP	34D441-CP
SSI 34D441 28-pin PLCC	SSI 34D441-CH	34D441-CH

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX: (714) 731-5457

Notes:

SSI 34P570
2-Channel Floppy Disk Read/Write Device

July, 1990

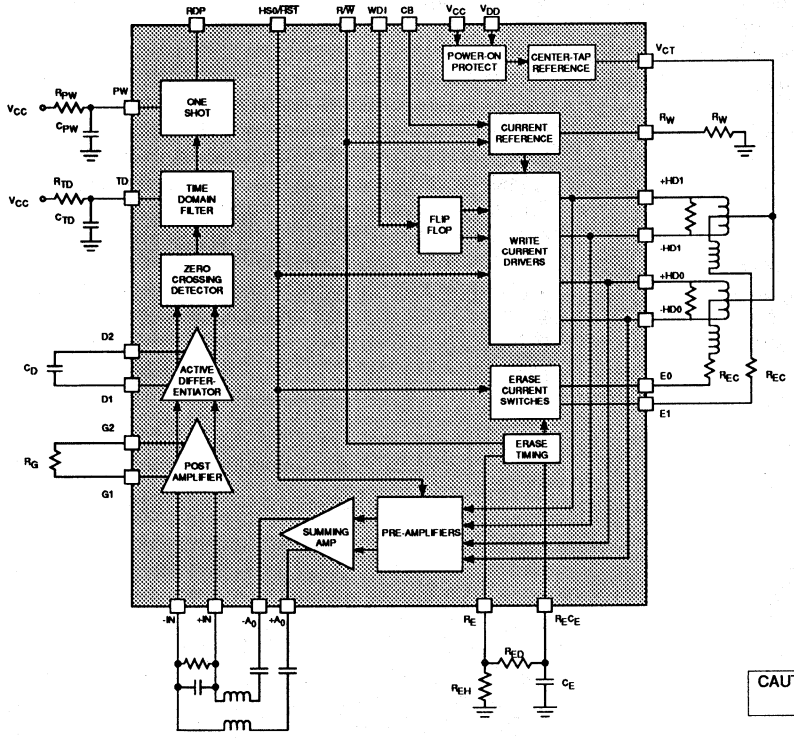
DESCRIPTION

The SSI 34P570 is an integrated circuit which performs the functions of generating write signals, amplifying and processing read signals required for a double-sided floppy disk drive. The write data circuitry includes switching differential current drivers and the erase head drive with programmable delay and hold times. The read data circuitry includes low noise amplifiers for each channel as well as a programmable gain stage and necessary equalization and filtering capability using external passive components. All logic inputs and outputs are TTL compatible and all timing is externally programmable for maximum design flexibility. The circuit operates on +12 volt and +5 volt power supplies and is available in 28-pin plastic DIP and PLCC packages.

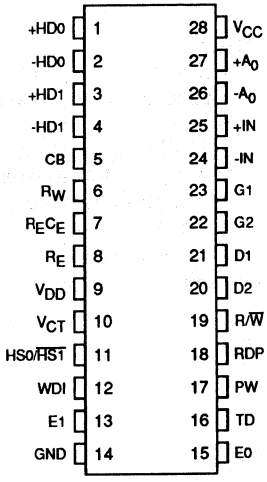
FEATURES

- **Single-chip read/write amplifier and read data processing function**
- **Compatible with 8", 5 1/4" and 3 1/2" drives**
- **Internal write and erase current sources, externally set**
- **Control signals are TTL compatible**
- **Schmitt trigger inputs for higher noise immunity on bussed control signals**
- **TTL selectable write current boost**
- **Operates on +12 volt and +5 volt power supplies**
- **High gain, low noise, low peak shift (0.3% typical) read processing circuits**

BLOCK DIAGRAM



PIN DIAGRAM



8

CAUTION: Use handling procedures necessary for a static sensitive component.

FUNCTIONAL DESCRIPTION

WRITE MODE CIRCUITRY

In Write Mode (R/$\overline{W}$ low), the circuit provides controlled write and erase currents to either of two magnetic heads. The write-erase circuitry consists of two differential write current drivers, a center tap voltage reference, two erase current switches and control circuits for head selection and erase timing.

Write current is toggled between opposing sides of the head on each negative transition of the write data input (WDI) and is set externally by a single resistor, Rw connected between the Rw terminal and ground. Since driver output impedance is large, proper damping resistors must be provided across each head. A signal at the CB terminal provides write current boost.

Erase current is also set externally through resistors REC connected in series with each erase coil. Erase can be activated by, but delayed from, selection of the write mode, and is held active after mode deselection. The turn-on delay is determined by the charging of CE through RED, while the hold time is determined by the discharge of CE through the series combination of RED and REH(see connection diagram). The RECE node may be driven directly by a logic gate, with external resistors per Figure 4, if the erase period is to be controlled separately from the write mode selection. For applications where no delays are required, CE is omitted.

The Center Tap Voltage Reference supplies both write and erase currents. A power turn-on protection circuit prevents undesired writing or erasure by holding the voltage reference off until the supply voltages are within their operating ranges.

READ MODE CIRCUITRY

In the Read Mode (R/$\overline{W}$ high), the circuit performs the functions of amplifying and detecting the selected head output pulses which correspond to magnetic transitions in the media. The read circuitry consists of two differential preamplifiers, a summing amplifier, a postamplifier, an active differentiator, a zero-crossing detector, a time domain filter, and an output one-shot.

The selected preamplifier drives the summing amplifier whose outputs are AC coupled to the postamplifier through an external filter network. The postamplifier adjusts signal amplitudes prior to application of signals to the active differentiator. Postamplifier gain is set as required by connecting a resistor across the gain terminals, G1 and G2. If desired, an additional frequency/phase compensation network may also be connected across these gain terminals.

The differentiator, driven by the postamplifier, provides zero-crossing output voltages in response to input signal peaks. Differentiator response characteristics are set by an external capacitor or more complex series network connected between the D1 and D2 terminals.

The zero-crossing detector provides a unipolar output for each positive or negative zero-crossing of the differentiator output. To enhance signal peak detection the time domain filter inhibits the detection of zero-crossings if they are not sufficiently separated in time. The filter period is set by an external RC network connected to the TD pin.

The time domain filter drives the output one-shot which generates uniform output data pulses. The pulse width is set by an external RC network connected to the PW pin. The output one-shot is inhibited while in the write mode.

ELECTRICAL CHARACTERISTIC Unless otherwise specified, 4.75 V ≤Vcc ≤5.25 V; 11.4 V ≤V_{DD}≤12.6; 0°C≤T_A≤70°C; Rw = 430 Ω; R_{ED} = 62 kΩ; C_E = 0.012 µF; R_{EH} = 62 kΩ; R_{EC} = 220 Ω

ABSOLUTE MAXIMUM RATINGS (Operating above absolute maximum ratings may damage the device.)

PARAMETER	RATING	UNIT
5 V Supply Voltage,Vcc	7	V
12 V Supply Voltage, V_{DD}	14	V
Storage Temperature	65 to +130	°C
Junction Operating Temperature	130	°C
Logic Input Voltage	-0.5 V to 7.0 V	dc
Lead Temperature (Soldering, 10 sec.)	260	°C
Power Dissipation	800	mW

POWER SUPPLY CURRENTS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
I_{CC} - 5 V Supply Current	Read Mode			35	mA
	Write Mode			38	mA
I_{DD} - 12 V Supply Current	Read Mode			26	mA
	Write Mode (excluding Write & Erase currents)			24	mA

LOGIC SIGNALS - READ/$\overline{\text{WRITE}}$ (R/$\overline{\text{W}}$), CURRENT BOOST (CB)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Input Low Voltage (V_{IL})				0.8	V
Input Low Current (I_{IL})	V_{IL} = 0.4 V			-0.4	mA
Input High Voltage (V_{IH})		2.0			V
Input High Current (I_{IH})	V_{IH} = 2.4 V			20	µA

8

LOGIC SIGNALS - WRITE DATA INPUT (WDI), HEAD SELECT (HSO/$\overline{HS1}$)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Threshold Voltage, V_T + Positive - going		1.4		1.9	V
Threshold Voltage, V_T - Negative - going		0.6		1.1	V
Hysteresis, V_T + to V_T-		0.4			V
Input High Current, I_{IH}	V_{IH} = 2.4V			20	µA
Input Low Current, I_{IL}	V_{IL} = 0.4V			-0.4	mA

CENTER TAP VOLTAGE REFERENCE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Output Voltage (V_{CT})	I_{WC} + I_E = 3 mA to 60 mA	V_{DD} -1.5		V_{DD} - .5	V
V_{CC} Turn-Off Threshold	(See Note 1)	4.0			V
V_{DD} Turn-Off Threshold	(See Note 1)	9.6			V
V_{CT} Disabled Voltage				1.0	V

NOTE1: Voltage below which center tap voltage reference is disabled.

ERASE OUTPUTS (E1,E0)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Unselected Head Leakage	V_{E0}, V_{E1} = 12.6 V			100	µA
Output on Voltage (V_{E1}, V_{E0})	I_E = 50 mA			0.5	V

WRITE CURRENT

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Unselected Head Leakage	V_{E1}, V_{E0} = 12.6 V			25	µA
Write Current Range	Rw = 820 Ω to 180 Ω	3		10	mA
Current Reference Accuracy	I_{WC} = 2.3/Rw V_{CB}(current boost) = 0.5 V	-5		+5	%
Write Current Unbalance	I_{WC} = 3 mA to 10 mA			1.0	%
Differential Head Voltage Swing	Δ I_{WC} ≤ 5%	12.8			Vpk
Current Boost	V_{CB} = 2.4 V	1.25 I_{WC}		1.35 I_{WC}	

ERASE TIMING

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Erase Delay Range	R_{ED} = 39 kΩ to 82 kΩ C_E = 0.0015 µF to 0.043 µF	0.1		1.0	msec
Erase Delay Accuracy $\frac{\Delta T_{ED}}{T_{ED}} \times 100\%$	T_{ED} = 0.69 R_{ED} C_E R_{ED} = 39 kΩ to 82 kΩ; C_E = 0.0015 µF to 0.043 µF	-15		+15	%
Erase Hold Range	R_{EH} + R_{ED} =78 kΩ to164 kΩ; C_E = 0.0015 µF to 0.043 µF	0.2		2.0	msec
Erase Hold Accuracy $\frac{\Delta T_{EH}}{T_{EH}} \times 100\%$	T_{EH}= 0.69 (R_{EH} + R_{ED}) C_E R_{EH} + R_{ED} = 78 kΩ to 164 kΩ; C_E= 0.0015 µF to 0.043 µF	-15		+15	%

ELECTRICAL CHARACTERISTICS (Unless otherwise specified: V_{IN} (Preamplifier) = 10 mVpp sine wave, dc coupled to center tap. (See Figure 1.) Summing Amplifier Load = 2 kΩ line-line, ac coupled. V_{IN} (Postamplifier) = 0.2 Vpp sine wave, ac coupled; R_G = open; Data Pulse Load = 1 kΩ to Vcc; C_D = 240 pF; C_{TD} = 100 pF; R_{TD} = 7.5 kΩ ; C_{PW} = 47 pF; R_{PW}= 7.5 kΩ.)

READ MODE

PREAMPLIFIER - SUMMING AMPLIFIER

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Differential Voltage Gain	Freq. = 250 kHz	85		115	V/V
Bandwidth (-3 dB)		3			MHz
Gain Flatness	Freq. = dc to 1.5 MHz			±1.0	dB
Differential Input Impedance	Freq. = 250 kHz	20			kΩ
Max Differential Output Voltage Swing	V_{IN} = 250 kHz sine wave, THD ≤ 5%	2.5			Vpp
Small Signal Differential Output Resistance	Io ≤ 1.0 mApp			75	Ω
Common Mode Rejection Ratio	V_{IN} = 300 mVpp @ 500 kHz Inputs Shorted	50			dB
Power Supply Rejection Ratio	Δ V_{DD} = 300 mVpp @500 kHz Inputs shorted to V_{CT}.	50			dB
Channel Isolation	Unselected Channel V_{IN} 100 mVpp @ 500 kHz Selected channel input connected to V_{CT}	40			dB

8

PREAMPLIFIER - SUMMING AMPLIFIER (cont'd.)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Equivalent Input Noise	Power BW = 10 kHz to 1 MHz Inputs shorted to VCT.			10	µVrms
Center Tap Voltage, V_{CT}			1.5		V

POSTAMPLIFIER - ACTIVE DIFFERENTIATOR

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Ao, Differential Voltage Gain + IN, -IN to D1, D2	Freq. = 250 kHz (See Figure 2)	8.5		11.5	V/V
Bandwidth (-3 dB) + IN< -IN to D1, D2	C_D = 0.1 µF, R_D = 2.5 kΩ	3			MHz
Gain Flatness + IN, -IN to D1, D2	Freq. = dc to 1.5 MHz C_D = 0.1 µF, R_D = 2.5 kΩ			±1.0	dB
Max Differential Output Voltage Swing	V_{IN} = 250 kHz sine wave, ac coupled. ≤ 5% THD in voltage across C_D. (See Figure 2)	5.0			Vpp
Max Differential Input Voltage	V_{IN} = 250 kHz sine wave, ac coupled. ≤ 5% THD in voltage across C_D. R_G = 1.5 kΩ	2.5			2.5 Vpp
Differential Input Impedance		10			kΩ
Gain Control Accuracy $\frac{\Delta A_R}{A_R} \times 100\%$	$A_R = A_O R_G/(8 \times 10^3 + R_G)$ R_G = 2 kΩ	-25		+25	%
Threshold Differential Input Voltage. (See Note 2)	Min differential input voltage at post amp that results in a change of state at RDP V_{IN} = 250 kHz square wave, C_D = 0.1 µF, R_D = 500 Ω, T_R, TF ≤0.2 µsec No overshoot; Data Pulse from each V_{IN} . transition. (See Figure 3)			3.7	mVpp
Peak Differentiator Network Current		1.0			mA

NOTE 2: Threshold Differential Input Voltage can be related to peak shift by the following formula:

$$\text{Peak Shift} = \frac{3.7\,mv}{\pi Vin} \times 100\%$$

where Vin = peak to peak input voltage at post amplifier. Note that this formula demonstrates an inverse relationship between the input amplitude and the Peak Shift.

TIME DOMAIN FILTER

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Delay Accuracy $\frac{\Delta T_{TD}}{T_{TD}} \times 100\%$	$T_{TD} = 0.58\ R_{TD} \times (C_{TD} + 10^{-11}) + 50$ nsec, R_{TD} = 5 kΩ, to 10 kΩ $C_{TD} \geq 56$ pF. V_{IN} = 50 mVpp @ 250 kHz square wave, T_R, $T_F \leq 20$ nsec, ac coupled. Delay measured from 50% input amplitude to1.5 V Data Pulse	-15		+15	%
Delay Range	$T_{TD} = 0.58\ R_{TD} \times (C_{TD} + 10^{-11}) + 50$ nsec, R_{TD} = 5 kΩ to 10 kΩ, C_{TD} = 56 pF to 240 pF	240		2370	ns

DATA PULSE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Width Accuracy $\frac{\Delta T_{PW}}{T_{PW}} \times 100\%$	$T_{PW} = 0.58\ R_{PW} \times (C_{PW} + 8 \times 10^{-12}) + 20$ nsec. R_{PW} = 5 kΩ to 10 kΩ C_{PW} = ≥36 pF width measured at 1.5V amplitudes	-20		+20	%
Active Level Output Voltage	I_{OH} = 400 µA	2.7			V
Inactive Level Output Leakage	I_{OL} =4 mA			0.5	V
Pulse Width	$T_{PW} = 0.58\ R_{PW} \times (C_{PW} + 8$ x10-12) + 20 nsec. R_{PW} = 5 kΩ to 10 kΩ C_{PW} = 36 pF to 200 pF	145		1225	ns

8

TEST SCHEMATICS

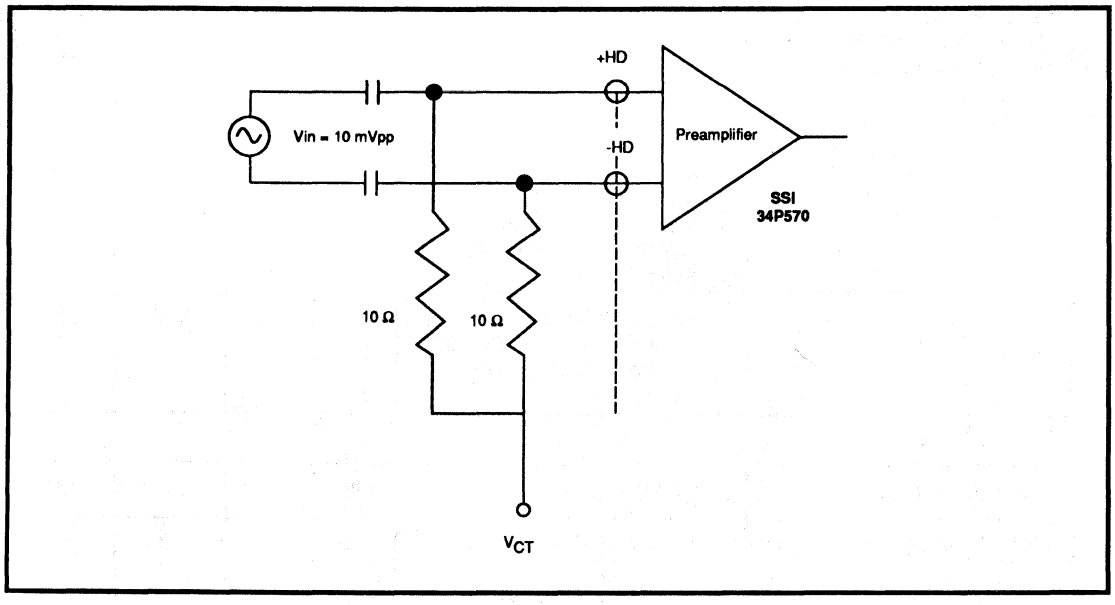


FIGURE 1: Preamplifier Characteristics

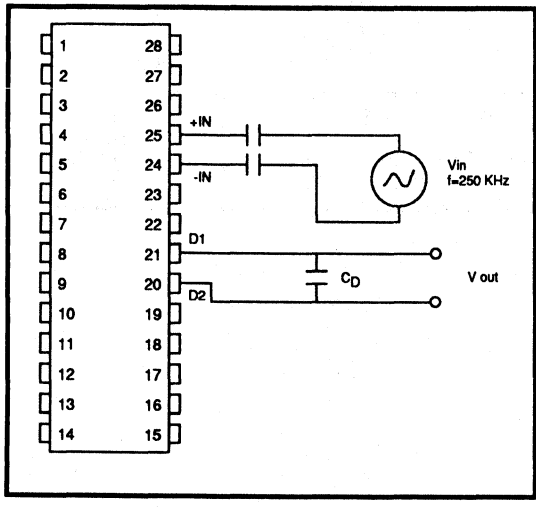


FIGURE 2:
Postamplifier Differential Output Voltage Swing and Voltage Gain

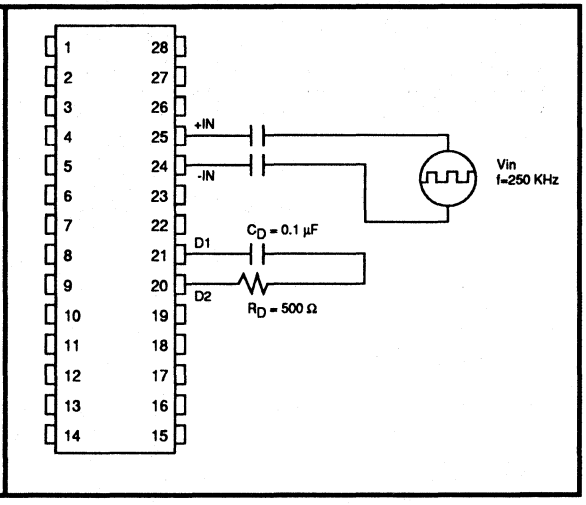


FIGURE 3:
Postamplifier Threshold Differential Input Voltage

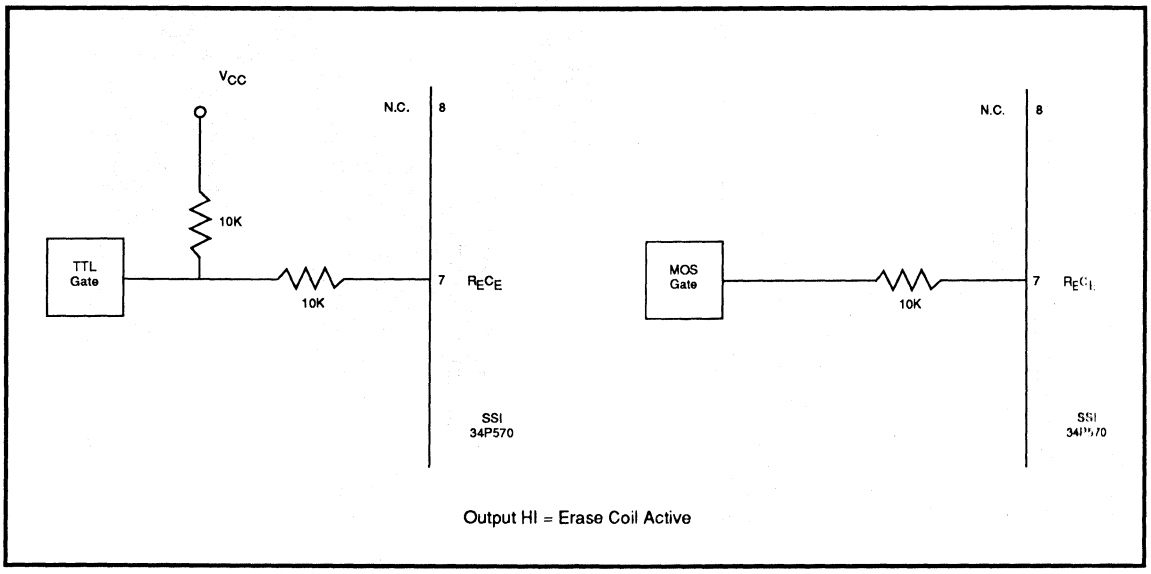


FIGURE 4 : External Erase Control Connections

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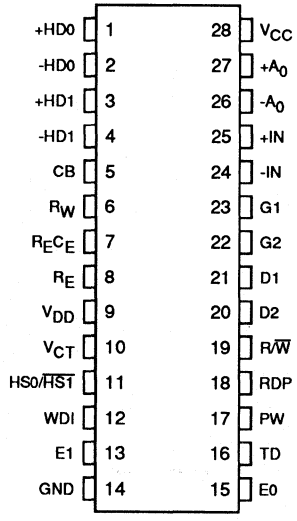
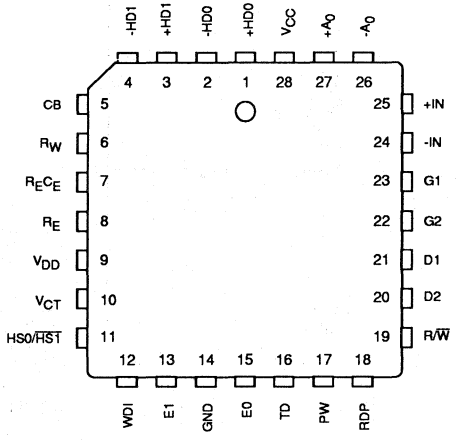
SSI 34P570
2-Channel Floppy Disk Read/Write Device

PACKAGE PIN DESIGNATIONS
(TOP VIEW)



28-Pin DIP



28-Pin PLCC

THERMAL CHARACTERISTICS: Ø ja

28-Pin	DIP	55°C/W
28-Pin	PLCC	65°C/W

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 34P570 28-Pin DIP	SSI 34P570-CP	34P570-CP
SSI 34P570 28-Pin PLCC	SSI 34P570-CH	34P570-CH

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX: (714) 731-5457

SSI 34R575
2 or 4-Channel Floppy Disk Read/Write Device

July, 1990

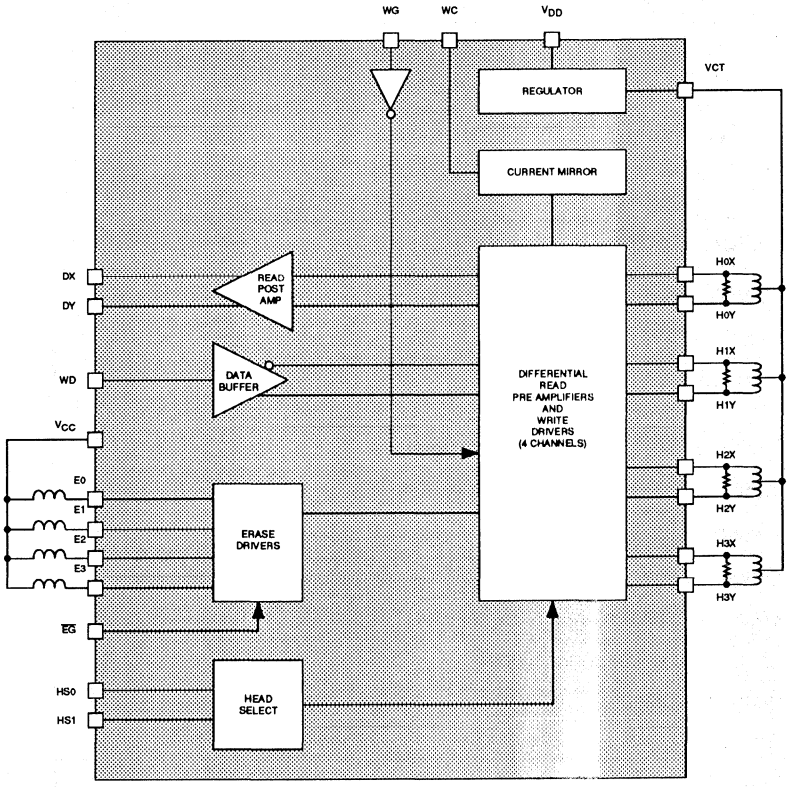
DESCRIPTION

The SSI 34R575 device is a bipolar monolithic integrated circuit used in floppy disk systems for head control and write, erase, and read select functions. The device has either two or four discrete read, write, and erase channels. Channel select inputs are TTL compatible. The SSI 34R575 device requires +5 V and +12 V power supplies and is available in 18-pin (2-channel version) or 24-pin (4-channel version) dual inline packages.

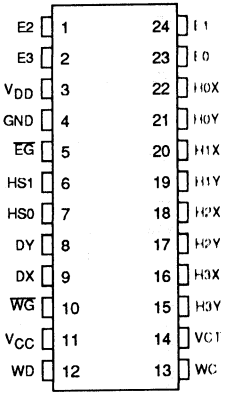
FEATURES

- **Operates on +5 V, +12 V power supplies**
- **Two or four channel capability**
- **TTL compatible control inputs**
- **Read/Write functions on one-chip**
- **Internal center tap voltage source**
- **Supports all disk sizes**
- **Applicable to tape systems**

BLOCK DIAGRAM



PIN DIAGRAM



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CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 34R575
2 or 4-Channel Floppy Disk Read/Write Device

FUNCTIONAL DESCRIPTION

The SSI 34R575 functions as a write and erase driver or as a read amplifier for the selected head. Two TTL compatible inputs are decoded to select the desired read/write and erase heads. Head select logic is indicated in Table 1. Both the erase gate ($\overline{EG}$) and write gate ($\overline{WG}$) lines have internal pull up resistors to prevent an accidental write or erase condition.

MODE SELECTION

The read or write mode is determined by the write gate ($\overline{WG}$) line. The input is open collector TTL compatible. With the input low, the circuit is in the write mode. With the input high (open), the circuit is in the read mode. In the read mode, or with the +5 V supply off, the circuit will not pass write current.

ERASE

The erase operation is controlled by an open collector TTL compatible input. With erase gate ($\overline{EG}$) input high (open) or the +5 V supply off, the circuit will not pass erase current. With $\overline{EG}$ low, the selected open collector erase output will be low and current will be pulled through the erase heads.

READ MODE

With the $\overline{WG}$ line high, the read mode is enabled. In the read mode the circuit functions as a differential amplifier. The state of the head select input determines which amplifier is active. When the mode or head is switched, the read output will have a voltage level shift. External reactive elements must be allowed to recover before proper reading can commence. A current diverting circuit prevents any possible write current from appearing on a head line.

WRITE MODE

With the $\overline{WG}$ line low, externally generated write current is mirrored to the selected head and is switched between head windings by the state of the write data (WD) signal.

PIN DESCRIPTION

NAME	TYPE	DESCRIPTION
V_{CC}		+5 V
V_{DD}		+12 V
H0X-H3X H0Y-H3X		X, Y head connections
DX, DY		X, Y Read Data: Differential read signal out
WG		Write gate: sets write mode of operation
WC		Write current: current mirror used to drive floppy disk heads
WD		Write data line
EG		Erase gate: allows erasure by selected head
E0-E3		Erase head driver connections
HS0-HS1		Head select inputs
GND		Ground
VCT		Center Tap Voltage Source

TABLE 1: HEAD SELECT LOGIC

4 - CHANNELS		
HS1	**HS0**	**HEAD**
0	0	0
0	1	1
1	0	2
1	1	3

2 - CHANNELS	
HS1	**HEAD**
0	0
1	1

ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS

(Operating above absolute maximum ratings may damage the device.)

PARAMETER		RATING	UNIT
DC Supply Voltage:	Vcc	6.0	V
	Vdd	14.0	V
Write Current		10	mA
Head Port Voltage		18.0	V
Digital Input Voltages:	DX, DY, HS0, HS1, WD	-0.3 to + 10	V
	$\overline{EG}$, $\overline{WG}$	-0.3 to V_{cc} + 0.3	V
DX, DY Output Current		-5	mA
VCT Output Current		-10	mA
Storage Temperature Range		-65 to + 150	°C
Junction Temperature		125	°C
Lead Temperature (Soldering, 10 sec.)		260	°C

8

RECOMMENDED OPERATING CONDITIONS (0°C<Ta<50°C, 4.7 V<Vcc<5.3 V, 11 V<V_{DD}<13 V)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Vcc Supply Current					
Read mode	Vcc MAX			15	mA
Write mode	Vcc MAX			35	mA
V_{DD} Supply Current					
Read mode	V_{DD} MAX			25	mA
Write mode	V_{DD} MAX			15	mA
Write Current			5.5		mA

ERASE OUTPUT

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Erase On Voltage	IE = 80 mA	0.7		1.3	VDC
Erase Off Leakage				100	µA

LOGIC SIGNALS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Head Select (HS0, HS1) and Write Data (WD)					
Low Level Voltage		-0.3		0.8	VDC
High Level Voltage		2.0		6.0	VDC
Low Level Current	V_{IN} = 0 volts	-1.6			mA
High Level Current	V_{IN} = 2.7 volts			40	µA
$\overline{\text{WRITE GATE}}$ ($\overline{\text{WG}}$) and $\overline{\text{ERASE GATE}}$ ($\overline{\text{EG}}$)					
Low Level Voltage		-0.3		0.81	VDC
High Level Input Current		-300			µA
Low Level Current	V_{IN} = 0 volts	-2.0			mA

READ MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Differential Gain	f = 100 kHz, Vin = 5 mV Rms R_L = 10 kΩ	80	100	120	V/V
Bandwidth	Vin = 5 m W Rms RL = 10 K CL = 15pF	9			MHz
Input Voltage Range for 95% Linearity	f = 100 kHz, RL = 10 K	25			mVpp
Differential Input Resistance	f = 1 MHz	100			kΩ
Differential Input Capacitance	f = 1 MHz			10	pF
Input Bias Current				25	µA
Input Offset Voltage				12	mV
Output Voltage, Common Mode			8		VDC
Output Resistance				35	Ω
Output Current Sink		2			mA
Output Current Source		3			mA
Common Mode Rejection Ratio	f = 1 MHz (input referred)	50			dB
Power Supply Rejection Ratio	f = 1 MHz (input referred)	50			dB
Channel Separation	f = 1 MHz (input referred)	50			dB
Input Noise	BW = 100 Hz to 1 MHz, Z Source = 0		7		µV RMS

WRITE MODE

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Write Current Gain	IW = 5.5 mA	.97		1.05	A/A
Write Current Voltage Level	IW = 5.5 mA	1.2		2.1	VDC
Differential Head Voltage	IW = 5.5 mA	12.5			VDC
Unselected Head Current	IW = 5.5 mA DC Condition			0.1	mA
Write Current Unbalance	IW = 5.5 mA			1	%
Write Current Time Symmetry	IW = 5.5 mA			±10	ns
Read Amplifier Output Level			10.5		VDC
Center Tap Voltage	(Read and Write Modes)		8.5		VDC

SWITCHING CHARACTERISTICS

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Write and Erase Gate Switching Delay	Delay to 90% of Write Current			1	µsec
Head Select Switching Delay				1	µsec
Head Current Switching Delay	T1 in Fig. 1		10		nsec
Head Current Switching Time	IW = 5.5 mA Shorted Head		10	30	nsec
Write to Read Recovery Time				2	µsec

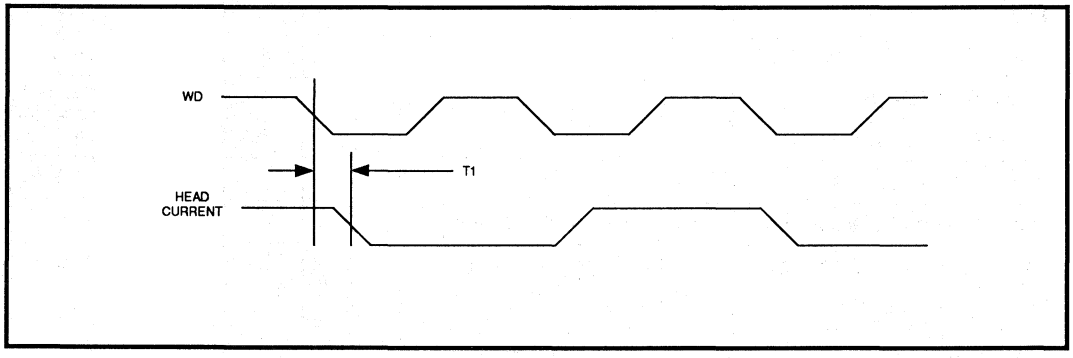
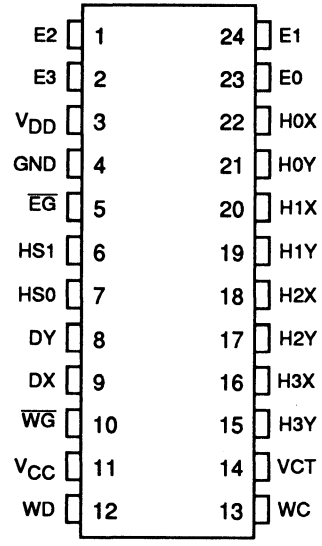


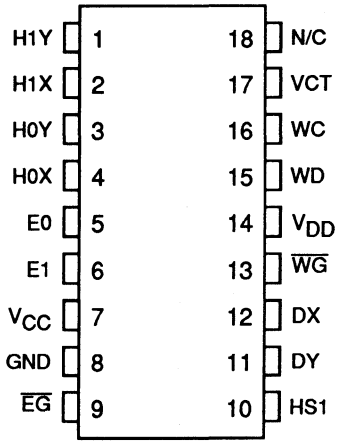
FIGURE 1: Head Current Switching Delay

PACKAGE PIN DESIGNATIONS

(TOP VIEW)



24-Pin DIP



18-Pin DIP

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 34R575 24-Pin DIP	SSI 34R575-4CP	34R575-4CP
SSI 34R575 18-Pin DIP	SSI 34R575-2CP	34R575-2CP

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX: (714) 731-5457

Notes:

SSI 34B580
Port Expander
Floppy Disk Drive

July, 1990

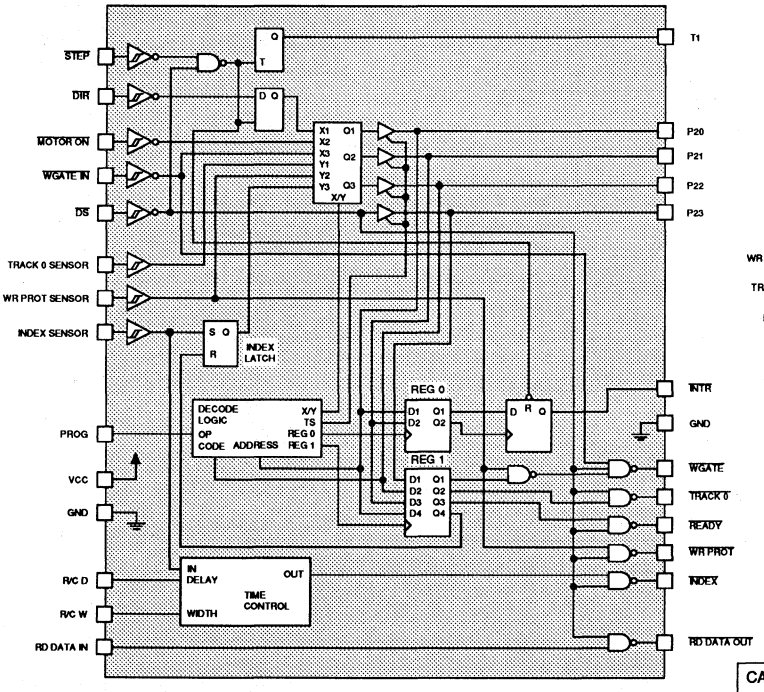
DESCRIPTION

The SSI 34B580 device is a bipolar integrated circuit that serves as an input/output port expander for an 8084 type microprocessor based floppy disk drive system. The device consolidates functions normally performed by a variety of LSTTL, SSI, AND MSI devices. The combination of an SSI 34P570 (read, write, and erase device), an 8048 type microprocessor, and the SSI 34B580 provides the majority of electronics required for a SA400 type floppy disk drive system, including host interface bus driver and receiver. In addition to its port expansion function, the SSI 34B580 processes system data and provides both pulse width and delay control (adjustable by external elements) for the INDEX SENSOR input. The device requires a single +5 V power supply and is available in a 28-pin package.

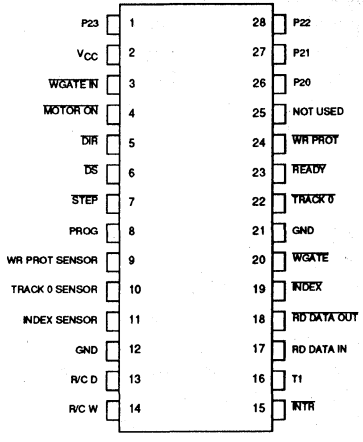
FEATURES

- **Reduces package count in flexible disk drive systems**
- **Replaces bus interface and combinational logic devices between the SSI 34P570, on board microprocessor and mechanical interfaces**
- **Surface mount available for further real estate reduction**
- **Provides drive capability for mechanical and system interfaces**

BLOCK DIAGRAM



PIN DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

8

SSI 34B580
Port Expander
Floppy Disk Drive

FUNCTIONAL DESCRIPTION

PORTS

The SSI 34B580 has two 4-bit input ports, Port A and Port B. Port A receives data from the host interface bus for conveyance to the drive's read/write circuitry and to the microprocessor. Three sensors report the status of the drive to the 34B580 via Port B. Common to both ports is a drive select ($\overline{DS}$) signal from the host interface bus. This allows the host to address separate disk drives. There is also a 4-bit bidirectional port on the SSI 34B580. This is port 2 and it can be used by the microprocessor to write to or read from the SSI 34B580.

READ MODE

Ports A and B can be read by a microprocessor via Port 2. This allows the microprocessor to obtain data from the host interface bus and the status sensors. The PROG signal from the microprocessor provides the timing for the operation. First an OP code and a port address must be placed on Port 2 (see Table 1), then latched in on the falling edge of PROG. When the OP code and addresses have been decoded, the desired input port is selected and output on Port 2. The operation is terminated by the rising edge PROG, which returns Port 2 to the input mode.

WRITE MODE

In the write mode the microprocessor passes system parameters to the SSI 34B580 for logic processing and outputting. Table 2 shows how each bit of Port 2 affects the SSI 34B580. A logic one on the zero bit of Port 2 will reset the index latch. P21, qualified by the $\overline{DS}$ signal, sends a "this drive ready" signal from the microprocessor the the host interface bus. Similarly P22 is $\overline{DS}$ qualified and sent to the host as a signal that the head is positioned over track 0. P23 is used in the logic that sends a R/$\overline{W}$ signal to the drive's read/write circuitry. The write mode occurs when the proper OP code and address is placed on Port 2 and latched in on the falling edge of PROG (see Table 2). The microprocessor writes in the data on PROG's rising edge.

INDEX PULSE

An optical sensor connected to the INDEX SENSOR pin detects the diskette's index marker. The state of the index sensor is latched into the SSI 34B580 and is available to be read by the microprocessor on P22. The latch may be reset by writing a one to P20 from the microprocessor. The pulse received from the sensor also drives the host interface signal $\overline{INDEX}$, the width and delay of which can be controlled by external R/C circuits. The time constant attached to the R/C D pin determines the delay from the INDEX SENSOR input to the $\overline{INDEX}$ signal on the host interface bus. The equation for the delay is Td = 0.59Rd x Cd (seconds). The width of the $\overline{INDEX}$ signal is determined by the circuit attached to the R/C W pin and the equation Tw = 0.59Rw x Cw (seconds).

INTERRUPT

The $\overline{INTR}$ signal is asserted every time a step command is issued to the drive on the host interface bus. Thus when $\overline{INTR}$ is tied to the interrupt pin of 8048 type microprocessor, an interrupt service routine will be executed on each step command. This routine typically obtains information on the direction the heads should move and the status of the track 0 sensor to use for generating the stepper motor control signals. The interrupt signal is cleared (set high) by first placing the the proper OP code and address on Port 2 (seeTable 2). This is latched in on the falling edge of PROG, then on its rising edge logic ones on P20 and P21 will be latched in to set $\overline{INTR}$ back to a high state. Note that an indeterminate operation will result from holding the INDEX SENSOR latch reset (holding P20 high).

T1 PIN

This signal changes state with the $\overline{STEP}$ command of the host interface bus when the drive is selected. It drives the T1 pin on an 8048 type microprocessor which is an input to a counter. The 8048 can use this count and the DIR signal read from Port 2 of the SSI 34B580 to monitor the head position and issue a CB (current boost) command to the SSI 34P570 when a specific track is reached.

INPUT TO PORT2		READ FROM PORT 2				4-BIT
OP Code P22	Addr. P20	P23	P22	P21	P20	Input Port
0	0	$\overline{DS}$	Index Sensor Latch	WR Sensor	Track 0 Sensor	B
0	1	$\overline{DS}$	$\overline{WGATEIN}$	$\overline{MOTORON}$	$\overline{DIR}$	A

TABLE 1: Read Mode

INPUT TO PORT2		DATA PROCESSED FROM PORT 2				
OP Code P22	Addr. P20	$\overline{WGATE}$	$\overline{TRACK0}$	$\overline{READY}$	$\overline{INTR}$	Index Latch Reset
1	0	Z	$\overline{(P22 \cdot DS)}$	$\overline{(P21 \cdot DS)}$		P20
1	1				See Text	
Where Z = (P23 • WR PROT SENSOR) + $\overline{(DS \cdot WGATEIN)}$						

TABLE 2: Write Mode

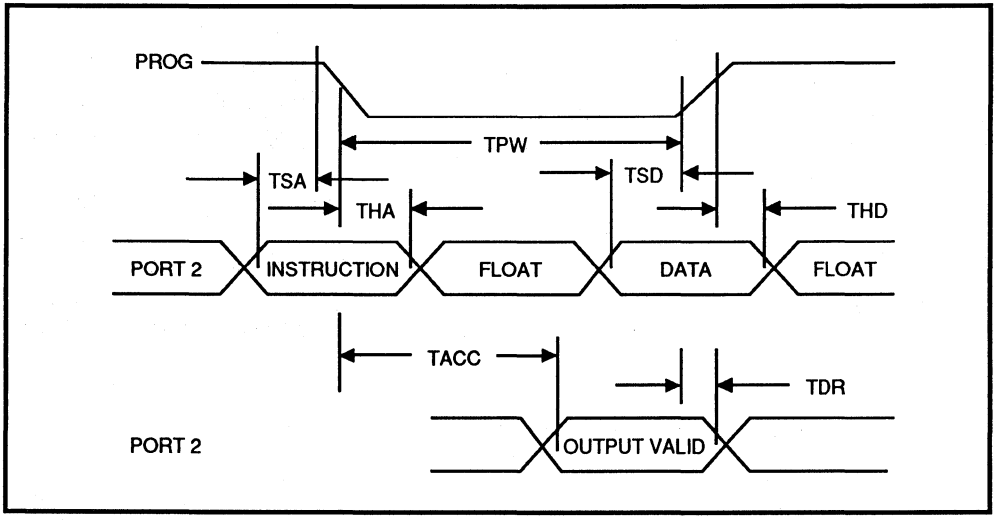


FIGURE 1: Timing Diagram

PIN DESCRIPTIONS

NAME	TYPE	DESCRIPTION
P20 - P23	I/O	4-bit bidirectional port, referred to as Port 2.
$\overline{\text{WGATE IN}}$	I	This input command to write is asserted by the host interface bus.
$\overline{\text{MOTOR ON}}$	I	This input command to turn on the spindle motor comes from the host interface bus.
$\overline{\text{DIR}}$	I	Input from the host interface bus selecting the direction in which the stepper motor should move the head.
$\overline{\text{DS}}$	I	Drive Select
INDEX SENSOR	I	Input from the photodiode that indicates the index marker in the diskette.
WR PROT SENSOR	I	Input from the photodiode that indicates if the diskette is write protected.
TRACK 0 SENSOR	I	Input from the photodiode that detects when the head is positioned over track 0.
$\overline{\text{STEP}}$	I	Input from the host interface bus indicating that the head should be moved.
T1	O	This pin changes state when a $\overline{\text{STEP}}$ command is received from the host interface bus.
RD DATA IN and $\overline{\text{RD DATA OUT}}$	I/O	Read data path
$\overline{\text{WGATE}}$	O	Output to the disk drive's read/write circuitry.
$\overline{\text{INDEX}}$	O	Output to the host interface bus indicating index sensor status.
$\overline{\text{TRACK 0}}$	O	Output to the host interface bus indicating track 0 sensor status.
$\overline{\text{READY}}$	O	Output to the host interface bus indicating track 0 sensor status.
$\overline{\text{WR PROT}}$	O	Output to the host interface bus indicating write protect sensor status.
PROG	I	Input from the 8048 microprocessor for I/O control of the SSI 34B580.
$\overline{\text{INTR}}$	O	Output to the interrupt pin of the 8048 microprocessor.
R/C D and R/C W		The external resistor and capacitor networks tied to these pins determine the delay and width of the output pulse to the $\overline{\text{INDEX}}$ pin.
Vcc		+5 V supply
GND		Ground

ABSOLUTE MAXIMUM RATINGS (All voltages referred to GND)

Operation above absolute maximum ratings may permanently damage the device.

PARAMETER	RATING	UNIT
DC Supply	+ 7	VDC
Voltage Range (any pin to GND)	-0.4 to + 7	VDC
Power Dissipation	700	mW
Storage Temperature	-40 to + 125	°C
Lead Temperature (10 sec soldering)	260	°C

ELECTRICAL CHARACTERISTICS

(Unless otherwise specified, 4.75 ≤ Vcc ≤ 5.25 VDC; 0°C < Ta < 70°C)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Totem pole outputs (P20 - P23, $\overline{INTR}$, T1)					
Output High Voltage	IOH = -400 A	2.5			V
Output Low Voltage	IOL = 2 mA			0.5	V
Open collector outputs ($\overline{RD\ DATA\ OUT}$, $\overline{INDEX}$, $\overline{WGATE}$, $\overline{TRACK0}$,$\overline{READY}$, $\overline{WR\ PROT}$)					
Output High Current	VOH = 5.25 V			250	µA
Output Low Voltage	IOL = 48 mA			0.5 V	V
Inputs (P20 - P23, PROG, RD DATA IN)					
Input High Voltage		2.0			V
Input Low Voltage				0.8	V
Input Low Current	VIL = 0.5 V			-0.8	mA
Input High Current	VIH = 2.4 V			40	µA
Input Current	Vin = 7.0 V			0.1	mA
Schmitt - Trigger Inputs ($\overline{WGATE\ IN}$, $\overline{MOTOR\ ON}$, $\overline{DIR}$, $\overline{DS}$, $\overline{STEP}$)					
Threshold Voltage	Positive Going, Vcc = 5.0 V	1.3		2.0	V
	Negative Going, Vcc = 5.0 V	0.6		1.1	V
Hysteresis	Vcc = 5.0 V	0.4			V
Input High Current	VIH = 2.4 V			40	µA
Input Low Current	VIL = 0.5 V			-0.4	mA
Input Current	VIN = 7.0 V			0.1	mA

High Impedance Inputs with Hysteresis (WR PROT SENSOR, TRACK 0 SENSOR, INDEX SENSOR)

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
Input High Voltage				2.0	V
Input Low Voltage		0.8			V
Hysteresis		0.2			V
Input Current	Vin = 0 to Vcc			-0.25	mA

TIMING CHARACTERISTICS (Unless otherwise specified; Ta = 25°C; 4.75V ≤ Vcc≤ 5.25V; CL = 15 pf.)

PARAMETER	CONDITION	MIN	NOM	MAX	UNIT
Propagation Delay Time	RD DATA IN to $\overline{\text{RD DATA OUT}}$			35	ns
	$\overline{\text{DS}}$ to $\overline{\text{WGATE}}$, $\overline{\text{TRACK 0}}$ $\overline{\text{READY}}$ $\overline{\text{WR PROT}}$,$\overline{\text{RD DATA}}$, $\overline{\text{INDEX}}$			80	ns
	PROG to $\overline{\text{INTR}}$, $\overline{\text{WGATE}}$, $\overline{\text{TRACK 0}}$ (Rising edge) $\overline{\text{READY}}$, $\overline{\text{WR PROT}}$			100	ns
	WR PROT to $\overline{\text{WGATE}}$, $\overline{\text{WR PROT SENSOR}}$			250	ns
	$\overline{\text{WGATE IN}}$ to $\overline{\text{WGATE}}$			80	ns
	$\overline{\text{STEP}}$ to T1, P20			80	ns
	TRACK 0 SENSOR WR PROT SENSOR to Port 2 INDEX SENSOR			250	ns
	$\overline{\text{MOTOR ON}}$ $\overline{\text{WGATE IN}}$ to Port 2 $\overline{\text{DS}}$			80	ns
Data Setup Time	$\overline{\text{DIR}}$ to $\overline{\text{STEP}}$	50			ns
Data Hold Time	$\overline{\text{DIR}}$ to $\overline{\text{STEP}}$	0			ns
Delay Accuracy (Pin 13)	Td = 0.59 Rd x Cd R_D = 3.9 K to 10 K C_D = 75 pF to 300 pF	0.8TD		1.2TD	sec
Pulse Width Accuracy (Pin 14)	Tw = 0.59 Rw x Cw Rw = 3.9 K to 10 K Cw = 75 pF to 300 pF	0.8Tw		1.2Tw	sec

PORT 2 (P20 - P23) TIMING (Timing Referenced to PROG signal, Figure 1.)

SYMBOL	DESCRIPTION	MIN	NOM	MAX	UNIT
TSA	Addr. setup time	100			ns
THA	Addr. hold time	80			ns
TSD	Data-in setup time	100			ns
THD	Data-in hold time	80			ns
TACC	Data-out access time			700	ns
TDR	Data-out release time			200	ns
TPW	PROG pulse width	1500			ns

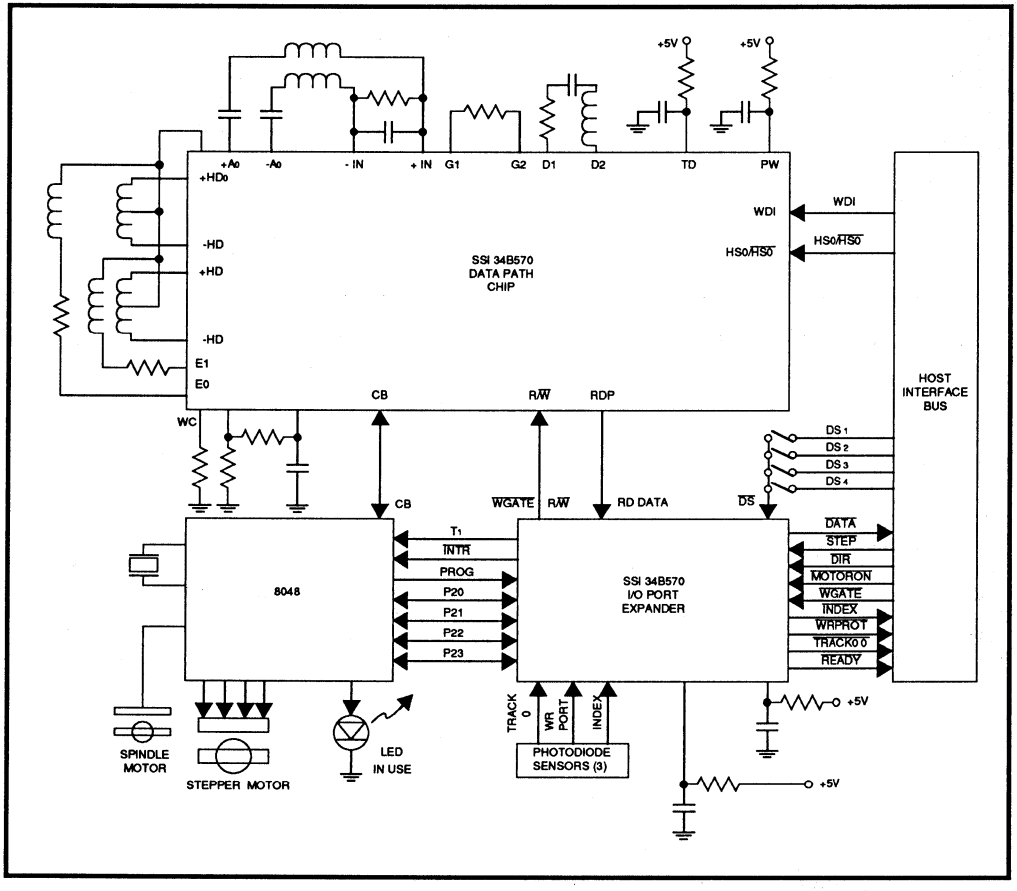
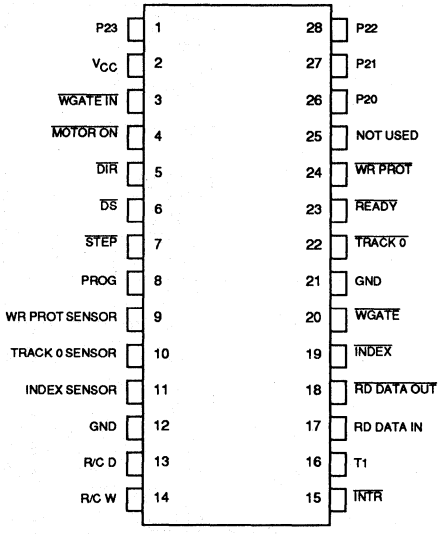


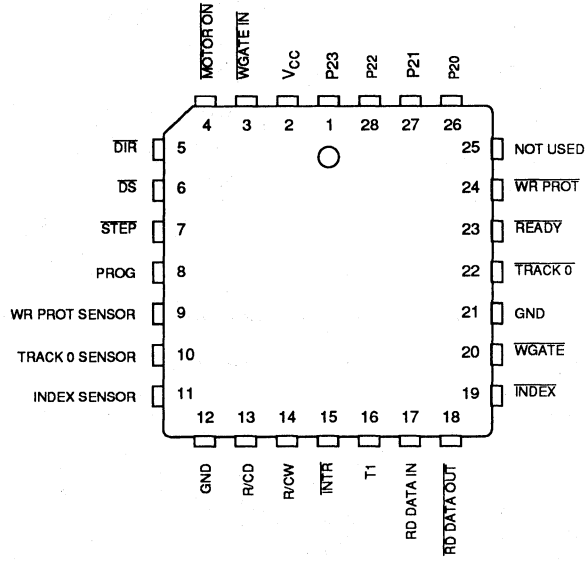
FIGURE 2: Typical Application

SSI 34B580
Port Expander
Floppy Disk Drive

PACKAGE PIN DESIGNATIONS
(TOP VIEW)



28-Pin DIP



28-Pin PLCC

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 34B580 28-Pin DIP	SSI 34B580-CP	34B580-CP
SSI 34B580 28-Pin PLCC	SSI 34B580-CH	34B580-CH

Silicon Systems, Inc., 14351 Myford Road, Tustin, CA 92680, (714) 731-7110, FAX: (714) 731-5457

Section 9

TAPE DRIVE CIRCUITS

SSI 35P550
4-Channel Magnetic Tape Read Device

July, 1990

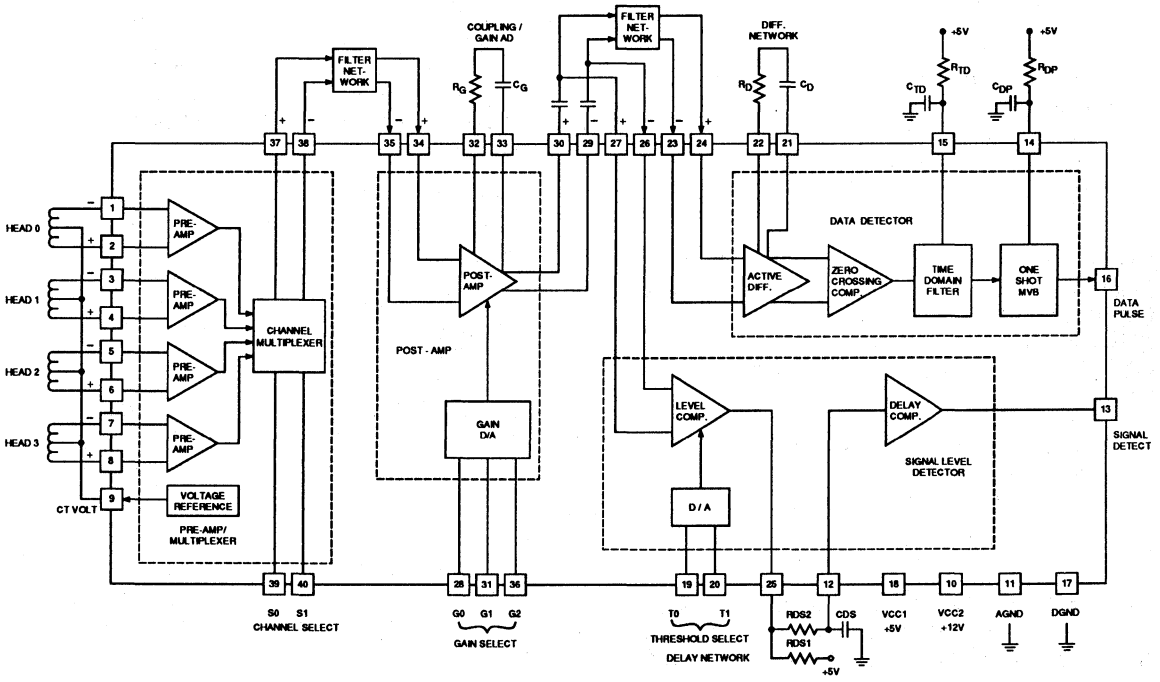
DESCRIPTION

Silicon Systems' SSI 35P550 combines magnetic tape head read signal amplification and processing onto a single integrated circuit. The device accepts up to 4 center-tapped magnetic read heads connected directly to the head inputs; head center tap voltage is provided by an on-chip reference. The device architecture permits system design flexibility by providing the external connections between the Preamplifier/Multiplexer, Postamplifier, Signal Level Detector, and Data Detector; this allows the implementation of many suitable filtering combinations. Low noise amplifiers are used throughout the device. The SSI 35P550 operates on +5 and +12 Volt supplies and has TTL compatible control signals.

FEATURES

- **4-Channel Multiplexer with differential-input Preamplifiers**
- **Postamplifier has component-adjustable and programmable gain**
- **On-chip Signal Level Detector with programmable threshold and adjustable delay**
- **Data Detection Circuit includes spurious signal rejection (adjustable time domain filter) and provides an adjustable uniform Data Pulse output**
- **Available in 40-pin DIP or 44-pin PLCC plastic packages**

BLOCK DIAGRAM



Note: Shown with typical external circuitry.
Pin #s refer to PLCC pinout.

CAUTION: Use handling procedures necessary for a static sensitive component.

SSI 35P550
4-Channel Magnetic Tape Read Device

FUNCTIONAL DESCRIPTION

4-CHANNEL PREAMPLIFIER AND MULTIPLEXER

The device contains four low level differential-input Preamplifiers. The differential output of a single Preamplifier is selectively connected to the Preamplifier output terminals by means of two logical CHANNEL SELECT signals, S0 and S1. The selected Preamplifier number is the binary value of the logical SELECT signals for active high voltage levels.

The Preamplifier inputs are intended for connection to center-tapped magnetic read heads. An appropriate Preamplifier input bias voltage level is obtained by connecting the head center taps to the circuit C.T. VOLT terminal.

The C.T. VOLT terminal is the output of a voltage reference which has a value to center the Preamplifier inputs within their operating range.

POSTAMPLIFIER

The Postamplifier is a differential-input, differential-output circuit which has two means of gain adjustment. A continuously-variable gain adjustment is obtained by use of an external resistor or potentiometer. Discrete values of gain setting are additionally obtained by applying combinations of logical signal levels to the three GAIN SELECT terminals, G0, G1, and G2.

The Postamplifier receives the output signals of the Preamplifier after frequency selection by an external filter network. The input characteristics of the Postamplifier are such that the inputs may have DC coupling to the Preamplifier output, or may be AC coupled with proper bias of 3V nom.

A suitable coupling capacitor must be connected between the GAIN1, GAIN2 terminals independent of the use of a gain setting resistor.

SIGNAL LEVEL DETECT CIRCUITS

The Signal Level Detect circuits consist of detector circuits which compare the amplitude of the signal envelope of the Postamplifier output with a selectable threshold and provide a logical output level which indicates the presence of Postamplifier signal greater than the threshold. AC coupling is required between the Postamplifier output and the Signal Level Detect circuits input. The Signal Level Detect input has internal bias connections so that no external bias network is required.

The threshold to which the Postamplifier signals are compared is selected by means of two THRESHOLD SELECT logical inputs T0 and T1. The result of the comparison is delayed from appearing at the circuit SIGNAL DETECT output terminal by means of a delay circuit which is adjustable by means of external components. The delay associated with signal detection is set by combinations of capacitor CDS and resistor RDS1. The delay associated with signal loss is set by combinations of CDS and resistors RDS1 plus RDS2.

DATA DETECTION CIRCUITS

The Data Detection circuits are AC coupled to the Postamplifier outputs through an (optional) external filter network and provide logical output pulse signals in response to positive and negative input signal amplitude peaks. This function is performed by differentiating input signals to obtain zero-crossing voltages at points of inflection and detecting these crossings to provide output signals.

To enhance the signal peak detection, spurious inflection points which occur in pairs between true signal peaks are suppressed by means of the Time Domain Filter. The filter inhibits the propagation of detected zero-crossings if they are not sufficiently separated in time. This time period is set by external capacitor CTD and resistor RTD.

Uniform DATA PULSE output signals are provided by the One-Shot Multivibrator which is triggered by outputs of the Time Domain Filter. The time duration of the DATA PULSE signals is set by external capacitor CDP and RDP.

DC paths through the external filter network to the Signal Level Detect circuits inputs are required to properly bias the Data Detection circuits. The resistance of each path is not critical and may be as large as 10 kΩ.

PIN DESCRIPTION

NAME	40-PIN	44-PIN	DESCRIPTION
IN0 -	1	1	Channel 0 (-) input
IN0 +	2	2	Channel 0 (+) input
IN1 -	3	3	Channel 1 (-) input
IN1 +	4	4	Channel 1 (+) input
IN2 -	5	5	Channel 2 (-) input
N/C		6	No internal connection
IN2 +	6	7	Channel 2 (+) input
IN3 -	7	8	Channel 3 (-) input
IN3 +	8	9	(+) input
CT VOLT	9	10	Center tap voltage
VCC2	10	11	+ 12 Volt supply connection
AGND	11	12	Analog signal ground
DEL IN	12	13	Input to delay comparator
SIGNAL DETECT	13	14	Output of delay comparator
DPN	14	15	External RC for output pulse width
TDF	15	16	External RC for time-domain delay
N/C		17	No internal connection
DATA PULSE	16	18	Output of time-domain filter
DGND	17	19	Ground
VCC1	18	20	+5 Volt supply
T0	19	21	Threshold select signal (1 of 2)
T1	20	22	Threshold select signal (1 of 2)
CAP1	21	23	External differentiating capacitor connection
CAP2	22	24	
DIF -	23	25	Inputs to active differentiator
DIF +	24	26	
LEV OUT	25	27	Output to level detector
N/C		28	No internal connection
LEV -	26	29	Inputs to level detector
LEV +	27	30	
G0	28	31	Postamp gain select (1 of 3)

PIN DESCRIPTION (Continued)

NAME	40-PIN	44-PIN	DESCRIPTION
PSTOUT -	29	32	Outputs of Postamplifier
PSTOUT +	30	33	
G1	31	34	Postamp gain select (1 of 3)
GAIN 1	32	35	External Postamplifier gain adjusting RC terminals
GAIN 2	33	36	
PSTIN +	34	37	Inputs to Postamplifier
PSTIN -	35	38	
N/C		39	No internal connection
G2	36	40	Postamp gain select (1 of 3)
PREOUT +	37	41	(+) Output of Preamplifier
PREOUT -	38	42	(-) Output of Preamplifier
S0	39	43	Input channel select (1 of 2)
S1	40	44	Input channel select (1 of 2)

ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS

Operation above absolute maximum ratings may permanently damage the device.

PARAMETER	RATING	UNIT
Storage Temperature	-65 to +150	°C
Junction Operating Temperature	0 to 130	°C
Supply Voltage, VCC1	-0.5 to +6.0	VDC
Supply Voltage, VCC2	-0.5 to +14.0	VDC
Voltage Applied to Logic Inputs	-0.5 to VCC1 +0.5	VDC
Voltage Applied to OFF Logic Outputs	-0.5 to VCC1 +0.5	VDC
Current Into ON Logic Outputs	5.0	mA
Lead Temperature (soldering, 10 sec)	+260	°C

DC CHARACTERISTICS
(Unless otherwise specified, VCC1 = 4.75V to 5.25V, VCC2 = 11.4V to 12.6V, Ta = 0 to 70 °C.)

CHARACTERISTICS	CONDITIONS	MIN	NOM	MAX	UNITS
Input Current Logical Inputs HIGH	Vih = VCC1			100	µA
Input Current Logical Inputs LOW	Vil = 0V			-400	µA
Output Voltage Delay Comparator OFF	Ioh = -400 µA	2.4			V
Output Voltage Delay Comparator ON	Iol = 2.0 mA			0.5	V
Data Pulse Inactive Level Output Voltage	Ioh = -400 µA	2.4			V
Data Pulse Active Level Output Voltage	Iol = 2.0 mA			0.5	V
VCC1 Power Supply Current	No Head Inputs			30	mA
VCC2 Power Supply Current	No Head Inputs			62	mA
NOTE: Characteristic applies to Inputs S0, S1, G0, G1, G2, T0, T1					

PREAMPLIFIER AND MULTIPLEXER CHARACTERISTICS
Output Load = 2 kΩ line-line, Channel Select Signals (S0,S1): VON = 2V Min., VOFF = 0.8V Max.

CHARACTERISTICS	CONDITIONS	MIN	NOM	MAX	UNITS
Differential Voltage Gain	Vin = 4 mVpp @ 100 kHz ref. to CT VOLT	80		120	V/V
Gain Flatness	Vin = 4 mVpp DC to 0.5 MHz ref. to CT VOLT	±0.5			dB
Bandwidth, -1 dB	Vin = 4 mVpp	1.5			MHz
Bandwidth, -3 dB	Vin = 4 mVpp	3.0			MHz
Differential Input Impedance	Vin = 4 mVpp @ 100 kHz ref to CT VOLT	10			kΩ
Common-Mode Rejection Ratio	Vin = 300 mVpp @ 500 kHz Inputs shorted to CT VOLT	50			dB
Power Supply Rejection Ratio	Δ VCC = 300 mVpp @ 500 kHz Inputs shorted to CT VOLT	50			dB
Channel Isolation	Unselected Vin = 100 mVpp @ 2 MHz. Selected Channel inputs connected to CT VOLT	60			dB

PREAMPLIFIER AND MULTIPLEXER CHARACTERISTICS (Continued)

CHARACTERISTICS	CONDITIONS	MIN	NOM	MAX	UNITS
Total Harmonic Distortion	Vin = 0.5 to 6.0 mV pp @ 500 kHz			2	%
Equivalent Input Noise	Power BW = 10 kHz to 1MHz Inputs shorted to CT VOLT			10	μVrms
Small Signal Single-Ended Output Res.	Io = 1 mApp @ 100 kHz			35	Ω
Maximum Diff. Output Voltage	Freq = 100 kHz THD < 5%	3			Vpp
Output Offset Voltage	Inputs shorted to CT VOLT Volt Load = Open Circuit			±1.0	V
Common-Mode Output Voltage	Inputs shorted to CT VOLT Volt Load = Open Circuit	2.68		3.5	V
Center Tap Voltage, CT VOLT			3.0		V

DATA DETECTION CIRCUIT CHARACTERISTICS
Vin = 1.0Vpp diff. square wave, Tr, Tf < 20 ns, dc-coupled (for biasing).
RD = 2.5 kΩ; CD = 0.1 μF; RTD = 7.8 kΩ; CTD = 200 pF; RDP = 3.9 kΩ;
CDP = 100 pF. Data Pulse load = 2.5 kΩ to VCC1 plus 20 pF or less to PWR GND.

CHARACTERISTICS	CONDITIONS	MIN	NOM	MAX	UNITS
Differentiator Maximum Differential Input Voltage	Vin = 100 kHz sine wave, dc-coupled. < 5% THD in voltage across CD. CD = 620 pF RD = 0	5.0			Vpp
Differentiator Input Impedance	Vin = 4Vpp diff., 100 kHz sine wave. CD = 620 pF RD = 0	10			kΩ
Differentiator Threshold Differential Input Voltage	Vin = 100 kHz square wave, Tr, Tf , 0.4 μs, no overshoot. Data Pulse from each Vin transition.			300	mVpp
Data Pulse Width Accuracy	TDP = .59 RDP X CDP, RDP = .85 TDP 3.9 kΩ to10 kΩ, CDP = 75 pF to 300 pF. Width measured at 1.5V amplitude	.85TDP		1.15TDP	sec

DATA DETECTION CIRCUIT CHARACTERISTICS

CHARACTERISTICS	CONDITIONS	MIN	NOM	MAX	UNITS
Time Domain Filter Delay Accuracy	TTD = 0.59 RTD X CTD + 50 ns, RTD = 3.9 kΩ to 10 kΩ, CTD =100 pF to 750 pF Delay measured from 50% input amplitude to 1.5V Data Pulse amplitude	.85TTD		1.15TTD	sec
Data Pulse Width Drift from + 25 °C value	Width measure from 1.5V amplitude			±5.0	%
Time Domain Filter Delay Drift from +25 °C value	Delay measured from 50% Input amplitude to 1.5V Data Pulse amplitude			±5.0	%
Note: Differentiating network impedance should be chosen such that 1 mA peak current flows at maximum signal level and frequency.					

SIGNAL LEVEL DETECT CIRCUITS CHARACTERISTICS

Level Comparator Inputs connected in parallel with Differentiator Inputs. Vin (Level Comp) = 100 kHz sine wave, ac-coupled. RDS1 = 5 kΩ; RDS2, CDS = open

CHARACTERISTICS	CONDITIONS	MIN	NOM	MAX	UNITS
Level Comparator Input Thresholds, Single-Ended, Each Input	T0 VT0 = 0.8V VT1 = 0.8V Vo pulse value < 0.5V at MAX LIMIT, >VCC1 - 0.5V at MIN LIMIT	30		70	mV pk
	T1 VT0 = 2.0V VT1 = 0.8V Vo pulse Value <0.5V at MAX LIMIT, >VCC1 - 0.5V at MIN LIMIT	97		153	mV pk
	T2 VT0 = 0.8V VT1 = 2.0V Vo pulse value <0.5V at MAX LIMIT, >VCC1 - 0.5V at MIN LIMIT	138		202	mV pk
	T3 VT0 = 2.0V VT1 = 2.0V Vo pulse value <0.5V at MAX LIMIT, >VCC1 - 0.5V at MIN LIMIT	210		290	mV pk
Level Comparator Diff. Input Resistance	Vin = 5 Vpp @ 100 kHz	5			kΩ
Level Comparator Off Output Leakage	Vo = VCC1			25	µA

SIGNAL LEVEL DETECT CIRCUITS CHARACTERISTICS (Continued)

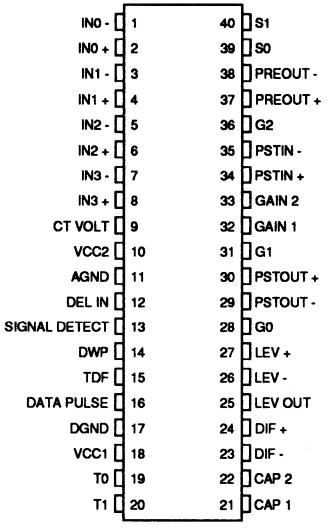
CHARACTERISTICS	CONDITIONS	MIN	NOM	MAX	UNITS
Level Comparator ON Output Voltage	VT0 = 0.8V VT1 = 0.8V Vin = ±140 mV diff. dc Io = 2.0 mA			0.25	V
Delay Comparator Upper Threshold Voltage	Vo > 2.4V	.65VCC1		.75VCC1	V
Delay Comparator Lower Threshold Voltage	Vo < 0.5V	.25VCC1		.35VCC1	V
Delay Comparator Input Current	0V < Vin < VCC1			25	µA

POSTAMPLIFIER CHARACTERISTICS

Output Load = 2.5 kΩ + 0.1 µF line-line, Vin = 100 mVpp, 100 kHz sine wave, dc-coupled (to provide proper biasing). CG = 0.1 µF, RG = 0.

CHARACTERISTICS	CONDITIONS	MIN	MAX	UNITS
Differential Voltage Gain	A0 VG0 = 0.8V VG1 = 0.8V VG2 = 0.8V A1 VG0 = 2.0V VG1 = 0.8V VG2 = 0.8V A2 VG0 = 0.8V VG1 = 2.0V VG2 = 0.8V A3 VG0 = 2.0V VG1 = 2.0V VG2 = 0.8V A4 VG0 = 0.8V VG1 = 0.8V VG2 = 2.0V A5 VG0 = 2.0V VG1 = 0.8V VG2 = 2.0V A6 VG0 = 0.8V VG1 = 2.0V VG2 = 2.0V A7 VG0 = 2.0V VG1 = 2.0V VG2 = 2.0V ARG VG0 = 2.0V VG1 = 2.0V VG2 = 2.0V when RG = 2.5 kΩ	A7 - 14.75 A7 - 12.75 A7 - 10.75 A7 - 8.75 A7 - 6.75 A7 - 4.75 A7 - 2.75 32 A7 - 7.5	A7 - 13.25 A7 - 11.25 A7 - 9.25 A7 - 7.25 A7 - 5.25 A7 - 3.25 A7 - 1.25 36 A7 - 4.5	dB dB dB dB dB dB dB dB dB
Differential Input Impedance	VG0 = 2.0V VG1 = 2.0V VG2 = 2.0V	10		kΩ
Bandwidth, 1dB	VG0 = 2.0V VG1 = 2.0V VG2 = 2.0V	1.5		MHz
Bandwidth, 3dB	VG0 = 2.0V VG1 = 2.0V VG2 = 2.0V	3.0		MHz
Maximum Diff. Output Voltage	VG0 = 0.8V VG1 - 0.8V VG2 = 0.8V VIN = 100 kHz sine wave THD < 5%	5		Vpp
Small Signal Single-Ended Output Res	VG0 = 2.0V VG1 = 2.0V VG2 = 2.0V VIN = 0V Io = 1 mApp, 100 kHz		35	Ω
Input Bias Offset Voltage Range	VG0 = 0.8V VG1 = 0.8V VG2 = 0.8V THD < 2.0%		±1.0	V
Input Bias Common-Mode Voltage Range	VG0 = 0.8V VG1 = 0.8V VG2 = 0.8V THD < 2.0%	2.68	3.5	V

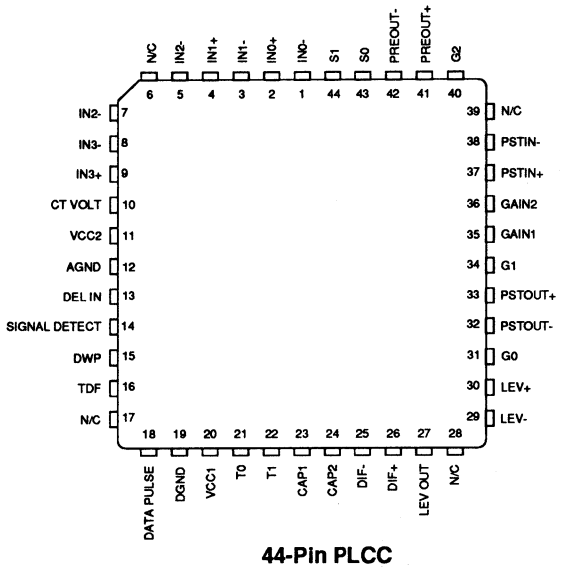
PACKAGE PIN DESIGNATIONS
(TOP VIEW)



40-Pin DIP

THERMAL CHARACTERISTICS: θja

40-pin PDIP	45°C/W
44-pin PLCC	60°C/W



44-Pin PLCC

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 35P550		
44-Pin PLCC	SSI 35P550-CH	35P550-CH
40-Pin DIP	SSI 35P550-CP	35P550-CP

9

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Notes:

Section 10

CUSTOM/SEMICUSTOM CAPABILITIES

silicon systems®

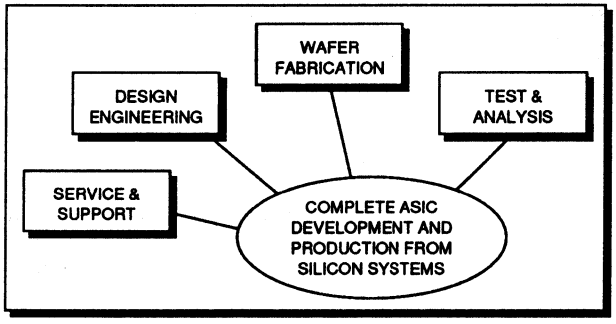
Custom/Semicustom Capabilities

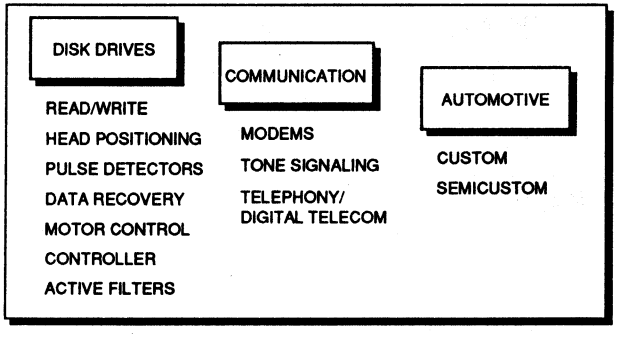
SILICON SYSTEMS LEADS THE WAY DEVELOPING MIXED-SIGNAL CUSTOM/SEMICUSTOM PRODUCTS

Silicon Systems is committed to leadership in the development of high-performance, application-specific, custom/semicustom Mixed-Signal Integrated Circuits (MSICs™).

Silicon Systems offers innovative designs for digital, analog, and mixed analog/digital ICs; a versatile range of CMOS and bipolar processes; quick-turn design methodologies supported by advanced and integrated design automation tools; specialized manufacturing facilities; comprehensive test, quality assurance, and prototype assembly programs; and nearly 20 years of IC design experience. Silicon Systems' efforts pay off by dramatically reducing the time (and cost) it takes to deliver the most optimized custom/semicustom ICs available.

Whether a customer's application falls in Silicon Systems' specialty areas of communications, storage products, automotive, or other areas, Silicon Systems' technical capabilities turn designs around faster and minimize a product's time to market for the competitive advantage.





10

Custom/Semicustom Capabilities

BROAD RANGE OF ANALOG AND DIGITAL DESIGN EXPERIENCE

With a broad base of experience, systems knowledge, and applications expertise, Silicon Systems' designers provide creative IC solutions in both CMOS and bipolar process technologies for analog, digital, and mixed-signal applications.

In CMOS, Silicon Systems has designed digital products ranging from FIFOs to complex hard-disk drive controllers. Combined analog/digital products range from cross-point switches to complete, one-chip 2400 bit/s modems.

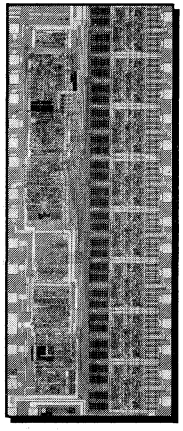
In bipolar, Silicon Systems' design expertise focuses on applications requiring high-speed ECL logic combined with high-performance analog circuitry. Bipolar products range from low-noise amps to very sophisticated data separators that employ patented phase locked loops.

Technique	Application	Silicon Systems Designed Examples
CMOS Signal Processing	For analog continuous time and sampled data (switched-capacitor implementation) and Digital Signal Processing (DSP) applications. Low-power capability also allows inclusion of ROMs, RAMs, and other analog/digital subsystems.	• 73K224 complete single-chip 2400 bit/s modem • C301 single-chip telephone headset amplifier • 14.4 kbit modem • Direct-broadcast satellite descrambler • Motor controllers • Hi-resolution analog data acquisition
Bipolar Signal Processing	For high-performance, low noise, wideband signal acquisition and processing applications. Offers TTL and/or ECL logic interfaces with high current drive.	• Sub 1 nV/sHz HDD R/W amplifiers • AGC, pulse detection amplifiers • High-speed data separators • Wideband transceivers • PLLs (Phase Locked Loops) • Optical signal processing
Digital CMOS	ForASIC controllers, sequencers and data path applications with on-board ROM, RAM, and PLA sub-systems. Offers standard TTL and/or CMOS logic interfaces.	• Hard disk drive controllers • SCSI interface controllers • UARTs • Protocol controllers • Digital signal processors
Digital Bipolar	High-speed logic and interface circuitry. Offers standard logic or custom interfaces.	• Encoders and decoders • High-speed digital transceivers

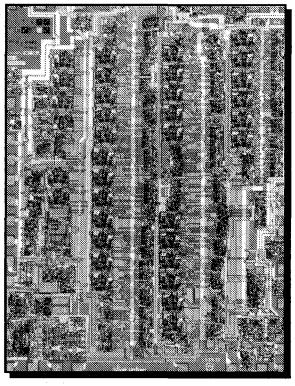
FULL ANALOG AND DIGITAL INTEGRATION ON THE SAME CHIP

Silicon Systems leads its competition in the design of complete systems on a chip which combine complex analog and digital functions. The total system solution approach allows designers to satisfy their application, cost, and performance objectives.

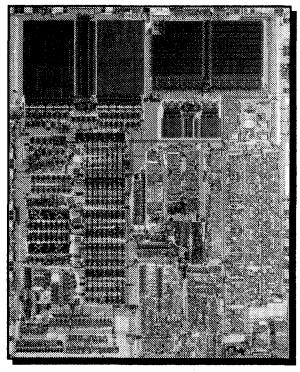
Custom mixed-signal Bipolar low-noise read/write IC



Standard Bipolar mixed-signal, high-performance data separator



Standard product single-chip 2400 bit/s modem with switched capacitor filters and RISC DSP



"DESIGN-FOR-TESTABILITY" AND TEST SUPPORT

Silicon Systems employs design-for-testability methodologies, such as built-in test modes that allow direct testing of internal subsystems. Silicon Systems uses highly specialized equipment, test programs and test procedures for combined analog/digital designs to ensure delivery of high-quality product. To determine product reliability under extreme conditions, products are tested in-house by a wide variety of advanced analog or digital testers including:

- LTX (TS88/DX90) testers
- Trillium Micromaster Plus
- Teradyne A520

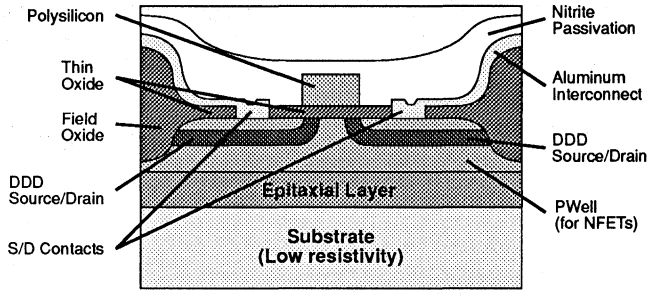
These testers are supported by:

- Automatic handlers (Trigon PLCC, Symtek & Tesec SOIC, and MCT DIP and Delta QFP)
- Burn-in sockets, temperature chambers, Aehr burn-in ovens, and Highly Accelerated Stress Test (HAST)

CMOS PROCESS TECHNOLOGIES

Silicon Systems' mixed signal CMOS processes are used to implement low-power, highly integrated systems solutions.

The two main processes used for new designs are CH (for 12V applications) and CG (for 5V applications). These processes are summarized in the table below. Other production process technologies (such as metal gate) are not utilized for new designs.



CH CMOS PROCESS TRANSISTOR

Process	Type	Application Voltage	BVDSS	Drawn Gate Length	Interconnect Pitches Poly 1	Metal 1	Metal 2	Features
CH	Si-Gate, single metal, dual poly, P Well	12V	18 V	3.6μ	5.8μ	6.4μ	n/a	• DDD S/D structure • Poly-poly capacitors • Low-voltage coefficient • High Ω /□poly resistors • Epi substrate option • Buried Well-ring
CG	Si-Gate, dual metal, dual poly, P Well	5V	7V	1.5μ	3.0μ	4.5μ	6.0μ	• DDD S/D structure • Poly-poly capacitors • Shrinkable to 1.2μ

CMOS PROCESS CHART

The CH process is used for applications requiring a higher (12V) voltage operation. This higher voltage operation is achieved through the use of a DDD (double diffused drain) source/drain structure. This increases the S/D junction grading and thus increases the breakdown voltage and lowers the associated junction capacitance. The CH process also provides low-voltage coefficient, precision poly-poly capacitors. These high quality capacitors support high performance switched-capacitor filtering and data conversion (A/D and D/A) circuits. "Digital" CMOS processes which have been modified to provide poly-diffusion capacitors do not support high performance analog applications such as those possible with poly-poly capacitors. Poly-poly capacitors have much lower voltage coefficients and do not have a large parasitic bottom place capacitor.

Another important feature for analog applications is found on the Silicon Systems CH process, high Ω/□ poly resistors. These resistors have a low voltage coefficient which is very important for low distortion, continuous time filters such as in anti-aliasing applications. Typical CMOS processes provide only high value well resistors, which are unacceptable in these applications.

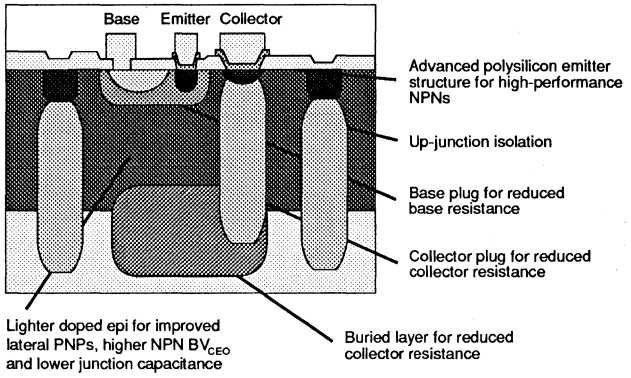
To improve the reliability of your system, Silicon Systems has incorporated a well ring into the CH process. This improves the well tie-down and increases the latchup immunity. In applications with harsh 'environments' (inductive motor drivers, automotive applications...) an epi substrate option is utilized for CH to increase latchup immunity to well over 200 mA.

The CG process is designed to support 5V mixed-signal systems. As the feature size (1.5μ) is significantly reduced over the CH process, much higher levels of system integration are possible. In addition to the much higher level of digital complexity possible, high performance analog circuitry is supported. Just as with the CH process, excellent poly-poly capacitors are available. The CG process is shrinkable to 1.2μ. Both the CH and CG process are proven production processes, thus minimizing your unknowns and risks.

BIPOLAR PROCESS TECHNOLOGIES

Silicon Systems uses its bipolar processes to implement high performance mixed-signal integrated circuits.

The two bipolar processes utilized for new designs are BK (12V) and BN (5V). These processes are summarized in the table below. Other production bipolar processes are not used for new designs.



BK BIPOLAR PROCESS NPN TRANSISTOR

Process	Type	BV_{CEO}	NPN Ft	Emitter Size	M1 Pitch	M2 Pitch	Features
BK	Junction-isolated	12V	2 GHz	2.5μ	9.0μ	14.0μ	• Polysilicon emitters • A1 Schottky diodes • Nitride capacitors • Ion implanted resistors • Up/down junction isolation • Collector/base plugs
BN	Oxide-isolated	6V	8 GHz	2.0μ	4.5μ	8.0μ	• High performance NPNs • PtSi Schotty diodes • Nitride capacitors • Ion implanted resistors • Sidewall oxide isolation • Collector/base plugs

BIPOLAR PROCESS CHART

The BK process is an analog/digital process technology used for applications requiring a higher voltage (12V) operation. Higher voltage operation is achieved through the use of lighter-doped epi, which also improves the performance (current gain and speed) of the lateral PNP transistors. Deep N+ and P+ enhancement layers are provided to reduce the collector series resistance and base resistance, respectively. Up-junction isolation is used to allow a significant reduction in device area as compared to conventional junction isolation methods. Metal-Poly capacitors with a nitride dielectric are provided in BK.

The BN process is a sidewall oxide-isolated bipolar process targeted at applications using 5V power supply. The use of oxide isolation greatly reduces the sidewall parasitic capacitances and allows the fabrication of very small transistors. A minimum size BN transistor consumes 1/5th the area of a minimum size BK transistor. The NPN transistors are available in walled and non-walled configurations with the additional option of recessed collectors to further reduce the base-collector capacitance. Excellent PtSi Schottky diodes are provided as well as nitride/oxide capacitors, dual layer metal, and 100-200 MHz lateral and substrate PNP transistors. The high performance NPN transistors can be used to make sub-nanosecond ECL and CML logic gates as well as high-precision, high-speed analog circuitry. The fine metal pitches and small device sizes produce very dense circuit designs. The intrinsic speed and packing density of this process allow the designer to implement high performance analog/digital systems.

MIXED-SIGNAL ARRAYS

The Mixed-Signal Array (MSA) series has been designed for those applications requiring both analog and digital circuits on a single chip.

Silicon Systems' Mixed-Signal Array program is a hardware and software system for automating integrated circuit design. The arrays are developed with Silicon Systems' Integrated Design Methodology (IDM™), a semicustom design technique for designing high density, high performance mixed-signal (analog and digital) arrays in both Bipolar and CMOS devices.

General Description

The MSA Series is a family of semiconductor arrays designed for efficient implementation of mixed analog/digital circuits. The series consists of seven base arrays ranging in complexity from 24 to 1608 digital gates, 8 to 40 analog cells, and 28 to 66 I/O pads.

Silicon Systems' Mixed-Signal Arrays are prefabricated integrated circuits consisting of tiles surrounded by a periphery of input/output tiles capable of a wide range of system interfaces. The Mixed-Signal Arrays employ a tile architecture which provides a systems designer with an open array of tiles containing unconnected active and passive semiconductor components. The components and tiles are interconnected to build specific electronic functions in combined analog and digital technology through the use of single tiles or tile/component combinations.

In Silicon Systems' integrated CAD/CAE environment, the designer has the option of using the predefined macros provided in the library, or he can use these macros as models for creating macros specific to his own needs. The designer also has the option of storing newly generated or modified macros in a library and reusing them in other designs at a later time.

ADVANTAGES OF MIXED-SIGNAL ARRAYS

The benefits of using arrays are:

- An array can be designed from concept to prototypes in ten to fifteen weeks.
- Manufacturing time is greatly reduced due to the prefabrication of base arrays.
- Arrays are economic. System size and cost are reduced. Power consumption is reduced but performance is generally enhanced.
- Arrays can be reconfigured to fit your unique design requirements.

FEATURES

- CMOS and Bipolar families
- Combines high performance analog and digital circuits on a single chip
- System speeds up to 2 GHz (bipolar)
- Twelve versatile arrays for a variety of applications
- High voltage capability
- ESD protection at each I/O pad
- Full CAE support on Mentor Graphics workstations
- Analog and digital macro library

MIXED-SIGNAL ARRAY	TECHNOLOGY	EQUIVALENT GATES	EQUIVALENT OP AMPS	BONDING PADS
6701	CMOS	1608	40	66
6702	CMOS	280	12	36
6703	CMOS	604	12	42
6704	CMOS	604	12	44
6901	Bipolar	96	24	48
6902	Bipolar	0	8	28
6903	Bipolar	24	26	52
6951	High Performance Bipolar	144	52	64
6952		24	16	40
6953		72	34	56
6954		144	16	56
6955		288	22	72

Silicon Systems Mixed-Signal Array Series

INTEGRATED DESIGN METHODOLOGY—THE IDM™ ADVANTAGE

Silicon Systems has spent almost 10 years developing its Integrated Design Methodology (IDM™). IDM™ consists of an interlocking set of design methods supported by a single Computer-Aided Engineering (CAE) and Computer-Aided Design (CAD) system. As IDM™ supports analog and digital designs in any of Silicon Systems' CMOS and bipolar technologies, it offers the tremendous advantage of flexibility.

COMPARE FULL-CUSTOM TO SEMICUSTOM DESIGN

IDM™ is based on two major design approaches: full-custom and semicustom.

Full-custom design is a "handcrafted" approach used to produce the most compact, high-performance design possible. Two approaches for full-custom physical design are possible: either composite or symbolic. In composite design, every process mask layer is drawn down to the process minimums. This yields the densest, highest-performance designs but is the most time-consuming approach. Symbolic design utilizes correct-by-construction, stick-like, process symbols, such as resistors, capacitors, and wires. Symbolic design is significantly more productive than composite and supports a higher level of circuit verification for greater design accuracy.

Semicustom design is an "automated" approach used to produce the most timely and cost-efficient designs possible. Two approaches are possible: either automatically placed-and-routed library components, including standard cells, or prefabricated array components.

Silicon Systems' analog and digital standard cells are pre-characterized, library-maintained circuits that are automatically placed and routed to generate a layout. The automatic place-and-route software also utilizes macro cell assemblers to route full-custom circuitry. The standard cell approach requires minimal layout effort, leading to lower development cost and a higher first article success rate.

Silicon Systems' mixed-signal arrays are bipolar and CMOS families of integrated circuits which are ninety percent prefabricated. The base arrays utilize a three-tile type core structure each of which is targeted for a specific design application, i.e., analog, digital, and reference. The three tile types forming the array core are separated by interconnect "highways" capable of handling both analog and digital signal busses. The core, in turn, is enclosed by a periphery of predefined I/O functions.

Array customization is achieved by the definition and interconnection of metal and poly-Si or double metal layers. Silicon Systems mixed-signal arrays provide a systems designer with fast prototype cycle times, lower integration costs, and the ability to migrate to either standard cell or custom integration with a minimum perturbation in design production.

CHOOSE THE OPTIMUM DESIGN APPROACH BASED ON TRADE-OFFS

Each IDM™ design approach offers unique cost, time, and performance trade-offs.

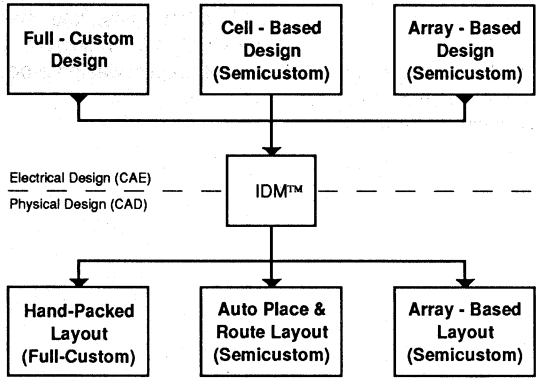
CUSTOM / SEMICUSTOM TRADE-OFFS

	Full - Custom		Semicustom	
	Composite Design	Symbolic Design	Cell-Based Design	Array-based Design
Design Parameters				
Cost (non-recurring expense)	1.0	0.5 - 0.8	0.4 - 0.7	0.2 - 0.4
Time (schedule)	1.0	0.5 - 0.7	0.4 - 0.6	0.2 - 0.4
Production Parameters				
Piece Price (production cost)	1.0	1.2 - 1.4	1.5 - 2.0	2.0 - 2.5
Die Size (silicon area)	1.0	1.1 - 1.2	1.3 - 1.6	1.6 - 2.0

Note: All comparisons are normalized to a composite-level design.

MIX FULL-CUSTOM AND SEMICUSTOM DESIGN ON A SINGLE CHIP

Due to the interlocking nature of Silicon Systems' design approaches, full-custom and semicustom design can be mixed on the electrical and/or physical design of any given IC.

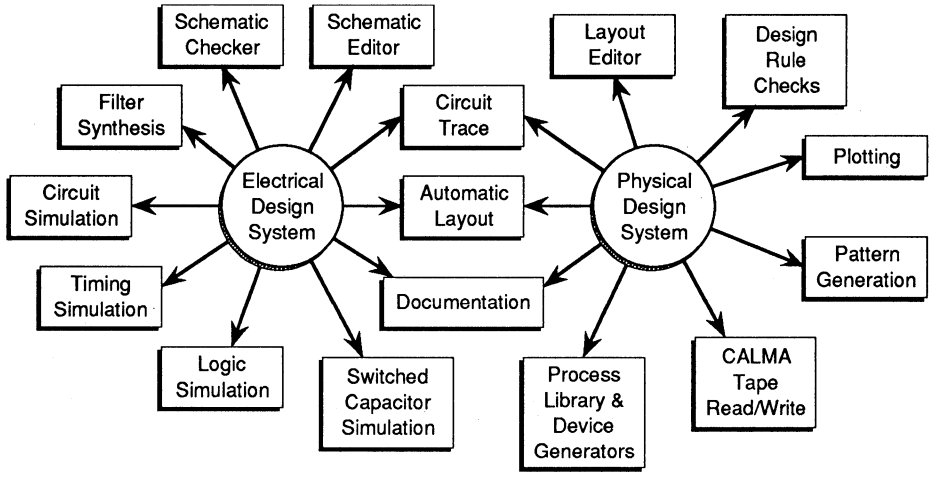


CONVERT SEMICUSTOM DESIGN INTO FULL-CUSTOM DESIGN

With its unique integrated design automation system, Silicon Systems can easily convert a semicustom design into full-custom circuitry. This capability allows Silicon Systems' customers to reduce production costs by converting an area-inefficient semicustom design into a high-performance full-custom design.

SOPHISTICATED DESIGN AUTOMATION TOOLS

The Pegasys™ design automation system, with proprietary and Silicon Systems-enhanced vendor software, addresses both the electrical and physical phases of design.



ELECTRICAL DESIGN

Electrical design is done on Mentor Graphics/Apollo engineering workstations with Silicon Systems-enhanced software that provides schematic capture, simulation, synthesis, and documentation tools. This software is supported by libraries of pre-designed cells and components. Due to our integrated CAE environment, there is no distinction between any schematic capture, simulation, or synthesis capabilities for full- or semicustom design approaches.

ANALOG & DIGITAL SIMULATION

Simulation ensures that we meet the customer's performance specification before converting the design into silicon. Circuit simulation, an important key to Silicon Systems' design methodology, allows us to accurately simulate the performance numbers of our technologies. For circuit simulation, we use Meta-Software's HSPICE™ with a proprietary analog CMOS model that accurately predicts output impedance and other analog parameters over a wide range of operating conditions and device sizes. The HSPICE environment includes a fully hierarchical netlister, a preprocessor called PHSPICE, and a Meta-Software graphic plotter called HSPLOT™. For the analog simulation of switched capacitors, we use Columbia University's SWITCAP™.

For digital simulation, we use a proprietary version of SimuCad's SILOS™ that performs gate and switch-level, zero-delay, functional logic and fault simulation. To analyze delays with a timing-based logic simulation, we use a combination of TSIM™ (developed on Meta-Software's Circuit Path Finder™) and SILOS.

DEVICE MODELING AND CHARACTERIZATION LABORATORY

Highly-accurate circuit simulation models and parameters are developed in Silicon Systems' state-of-the-art Device Modeling and Characterization (DMC) laboratory. With capabilities including precision AC measurement, RS1 statistical analysis, and worst-case modeling, the DMC lab provides complete device model data for our processes.

PHYSICAL DESIGN

Silicon Systems is in the process of converting its physical design system from a proprietary VAX-based system (ALICE) to an enhanced Mentor Graphics/Apollo-based system (ICgraph™). Both systems support a full range of capabilities, including graphical editing, design rule checking (DRC), circuit trace, and pattern generation (PG) in an integrated environment.

With the ALICE system, Silicon Systems pioneered a correct-by-construction device-level design methodology which has proven highly effective in the production of mixed analog/digital chips. Silicon Systems will embody this methodology within the Mentor Graphics-based system.

AUTOMATIC PLACE AND ROUTE SOFTWARE

Silicon Systems' cell-based automatic place-and-route capability, which is based on Cadence's TANCELL™ software, performs physical design far more rapidly than can be done by hand. Extensive proprietary software, developed to complement TANCELL, supports hierarchical routing, parameter passing, library creation and maintenance, and CMOS switched-capacitor analog macro generation directly from full-custom design. A random-logic digital macro assembler is in development. This flexible place-and-route environment supports floor planning, automatic chip construction, and the mix and match of custom cells, standard cells, and compiled cells—all of which are used to reduce design development time.

AUTOMATIC CIRCUIT TRACE AND VERIFICATION SOFTWARE

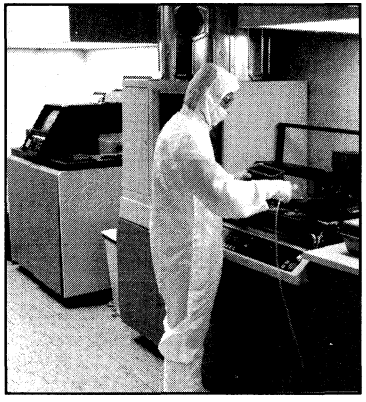
Using a proprietary circuit-trace program called ANITA™, we compare the completed IC layout database automatically to the Mentor schematic database to ensure that the layout implementation matches the schematic design exactly. When this trace program is applied to CMOS and bipolar mixed analog/digital designs, it performs a more detailed trace than is available through commercial layout-versus-schematic (LVS) packages. ANITA allows Silicon Systems to dramatically reduce design errors and minimize the time to product introduction.

DESIGN AUTOMATION BENEFITS

The proprietary Pegasys™ Design Automation system gives Silicon Systems the flexibility to create increasingly complex ASIC designs for our customers while dramatically reducing design schedules, costs, and errors.

MANUFACTURING SUPPORTS CMOS AND BIPOLAR TECHNOLOGIES

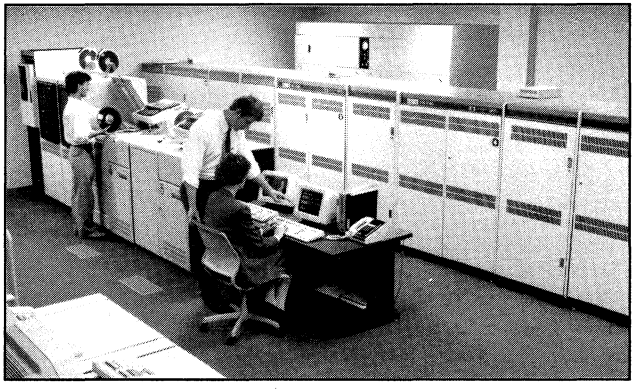
Silicon Systems continually invests in quality and capacity improvements to ensure that the company's wafer fabrication, test, and assembly capabilities meet the latest manufacturing requirements.



Two manufacturing facilities offer specialized capabilities depending on fabrication needs. Both facilities offer high resolution stepper photolithography technology, positive resist, dry plasma etch systems, high current implantation and automatic sputtering.

Fab 1 in Tustin employs bipolar processes including the high-speed BN process. Four-inch wafers are produced, targeted primarily toward the storage products marketplace. Fab 2 in Santa Cruz runs both bipolar and CMOS processes on both four- and six-inch wafers targeted primarily toward the communications and automotive products sector. The newest of the two manufacturing facilities, Fab 2, offers 5x stepper technology, robotics, and a migration towards sub-micron capability.

COMPUTER-AIDED MANUFACTURING WITH PROMIS™ FOR RAPID DELIVERY OF RELIABLE ICs



Committed to Computer-Aided Manufacturing (CAM), Silicon Systems has invested in extensive computer resources. To handle the vast amounts of data required for manufacturing, monitoring, and statistical process control, Silicon Systems uses the Process and Management Information System (PROMIS™). The PROMIS system:

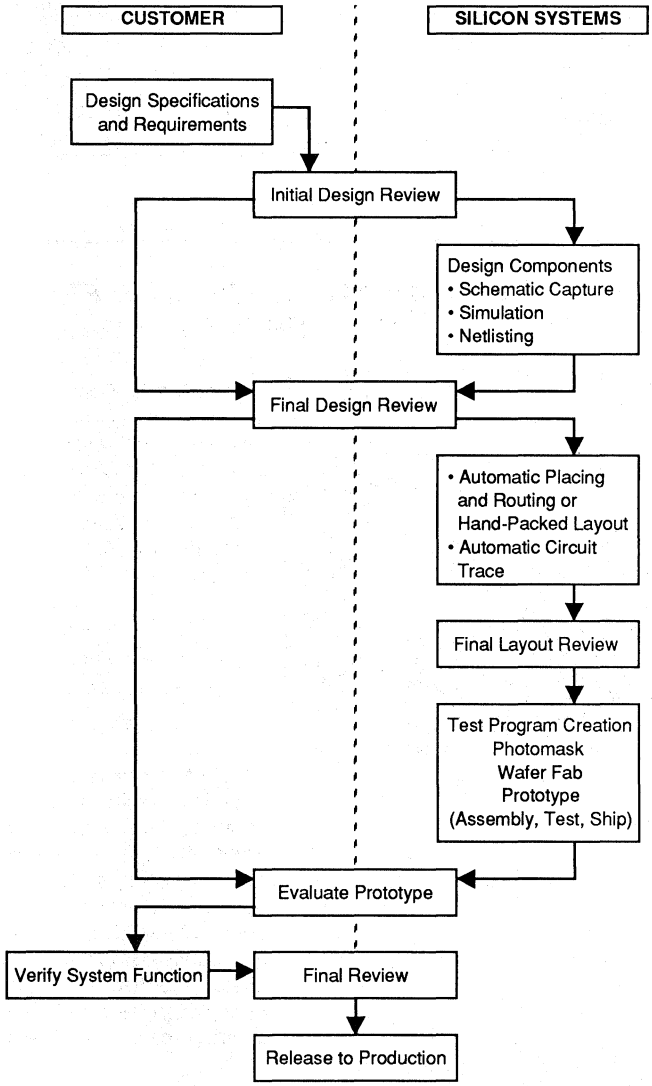
- manages inventory information,
- tracks wafers in process,
- monitors the clean room environment
- performs statistical process control.

PROMIS™ provides computer-controlled (i.e., paperless) facilities, which reduces sources of contamination in the wafer fab clean rooms. Silicon Systems' wafer fab is a class "50" environment with class "10" work surfaces. Cleanliness is maintained through the service chase approach, which channels a minimum of 5 air exchanges per minute. PROMIS allows Silicon Systems to deliver reliable ICs rapidly, thus allowing customers to introduce products to the marketplace on schedule and within budget.

SILICON SYSTEMS WORKS WITH CUSTOMERS TO CREATE THE BEST IC SOLUTION

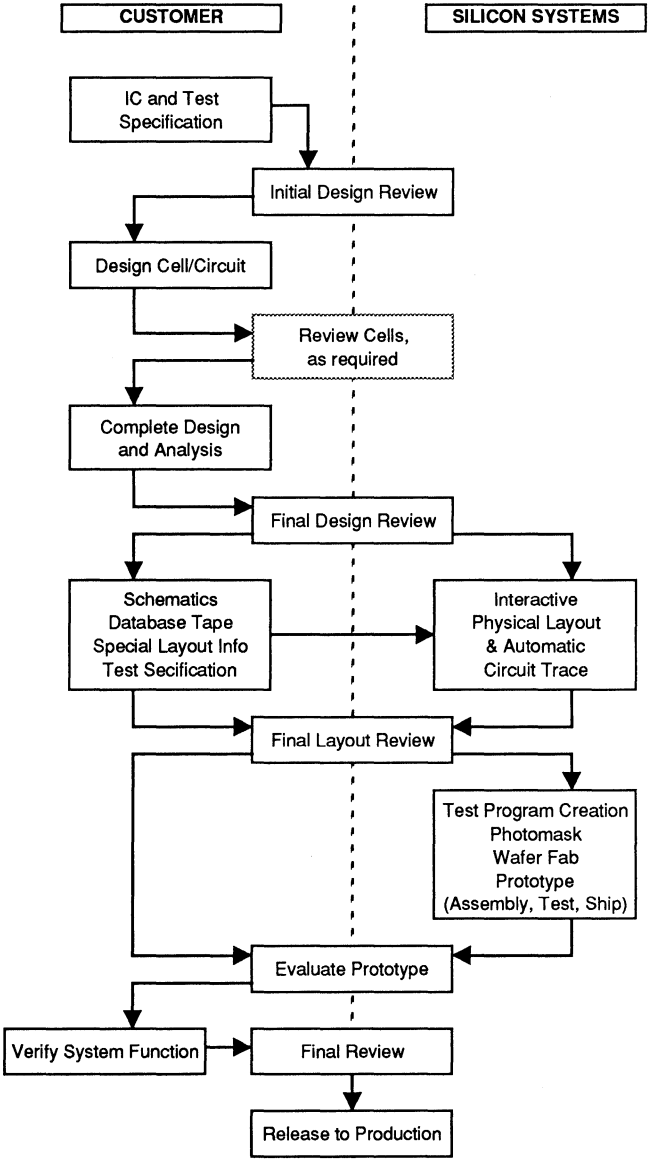
Silicon Systems has five IC design centers located in Tustin, Grass Valley, and Santa Clara, California as well as Tokyo and Singapore. Any of these design centers can accept a functional specification and complete the entire design task using either a full-custom or a cell-based approach.

CUSTOMER INTERFACE FOR FULL-CUSTOM AND CELL-BASED DESIGNS



Or, a customer can complete most of the design, using array technology, and take advantage of Silicon Systems' expertise for physical layout.

CUSTOMER INTERFACE FOR ARRAY-BASED DESIGNS



Notes:

Section 11

QUALITY ASSURANCE AND RELIABILITY

SECTION 1

1.1 INTRODUCTION

Silicon Systems is committed to the goal of customer satisfaction through the on-time delivery of defect free products that meet the customer's expectations and requirements. This statement serves as the corporate quality policy and reflects key elements that are instrumental in attaining true customer satisfaction. This section outlines Silicon Systems' ongoing activities for the control and continual improvement of quality in every aspect of our organization.

Silicon Systems is diligently working to maintain and improve its position as a world-class provider of mixed-signal integrated circuits (MSICs™). Our Corporate Quality Mission describes that commitment: "Achieve Total Customer Satisfaction Through Quality Excellence and Exceed the Goal of 1 ppm by Continuous Improvement."

We realize and practice the concept that quality must be designed and built into our products. In addition, Silicon Systems utilizes rigid inspections and data analysis to evaluate the acceptability and variation existing in incoming materials and performs stringent outgoing quality verification. The manufacturing process flow is encompassed by an effective system of test/inspection checks and in-line monitors which focus on the control and reduction of process variation. These gates and monitors ensure precise adherence to prescribed standards and procedures.

Silicon Systems also incorporates the use of statistical process control techniques into company operations. The control and reduction of the process variation by the use of statistical problem solving techniques, analytical controls and other quantitative methods ensures that Silicon Systems' products maintain the highest levels of quality and reliability. Our Reliability and Quality Assurance organization is committed to working closely with the customer to provide assistance and a continually improving level of product quality.

1.2 RELIABILITY AND QUALITY ASSURANCE

It is the objective of the Reliability and Quality Assurance organization to ensure that proactive quality systems are in place to ensure that Silicon Systems' products will meet or exceed customer requirements and expectations. In addition, the Reliability and Quality Assurance organization works to facilitate the timely implementation of solutions and monitors the effectiveness of corrective actions. These organizational strategies support the continuing enhancement of quality consciousness throughout Silicon Systems, a necessary element in supporting our objective of world-class quality.

To facilitate the close coordination required of the Reliability and Quality function, a combined Reliability and Quality Assurance organization has been established. The R&QA organization structure is pictured in Figure 1. For maximum effectiveness, this organization is headed by a Senior Vice President reporting directly to the President/CEO.

SECTION 2: QUALITY ASSURANCE

2.1 QUALITY OBJECTIVES

While all Silicon Systems employees have direct responsibility for quality in their functions, Quality Assurance has the ultimate responsibility for the reliable performance of our products. This is accomplished through the administration of formal systems which assure Silicon Systems' management, as well as our customers, that products will meet the requirements of customer purchase orders and all other specifications related to design, raw material and thorough completion of the finished product.

Quality Assurance supports and directs the formal qualification of suppliers, material, processes, and products, and the administration of quality systems and production monitors to assure that our products meet Silicon Systems quality standards. Quality Assurance also provides the liaison between

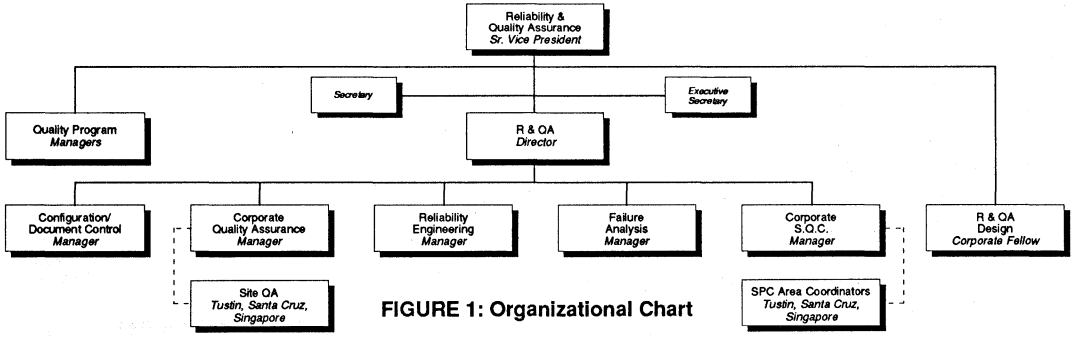


FIGURE 1: Organizational Chart

Silicon Systems and the customer for all product quality related concerns.

It is the practice of Silicon Systems to have the corporate quality and reliability objectives encompass all of its activities. This starts with a strong commitment of support from the corporate level and continues with exceptional customer support long after the product has been shipped.

Silicon Systems emphasizes the belief that quality must be built into all of its products by ensuring that all employees are educated in the quality philosophy of the company. Some of the features built into Silicon Systems Quality Culture include:

1. Structured training programs directed at Wafer Fabrication, Test, and Process Control personnel.
2. Stringent in-process inspection, gates, and monitors.
3. Rigorous evaluation of designs, materials, and processing procedures.
4. Stringent electrical testing (100% and QA AQL/Sample testing).
5. Ongoing reliability monitors and process verifications.
6. Real-time use of statistical process control methodology.
7. Corporate level audits of manufacturing, subcontractors, and suppliers.
8. Timely corrective action system.
9. Control of non-conforming material.

These focused quality methods result in products which deliver superior performance and reliability in the field.

2.2.1 INCOMING INSPECTIONS

Incoming inspection plays a key role in Silicon Systems' quality efforts. Small variations in incoming material can traverse the entire production cycle before being detected much later in the process. By paying strict attention to the monitoring of materials at the earliest possible stage, variation can be reduced, resulting in a stable uniform process.

2.2.2 IN-PROCESS INSPECTIONS

Silicon Systems has established key inspection monitors in such strategic areas as Wafer Fabrication, Wafer Probe, Assembly, and Final Test. These quality monitoring tests are performed in addition to the intermediate and final inspections found in the manufacturing process.

Quality control monitors have been integrated throughout the manufacturing flow, so that data may be collected and analyzed to verify the results of intermediary manufacturing steps. This data is used to document quality trends or long term improvements in the quality of specific operations. A generic description of the product flow and QC inspection points is shown in Figure 2.

2.3 DESIGN FOR QUALITY

Since the foundation of a reliable product is in the design process, the Reliability and Quality Assurance organization utilizes comprehensive reviews of design stages prior to the product's transition to production status. These review stages assure a predictable and effective development cycle. Other important design-related functions include ensuring that process specification revisions are translated into updated design parameters and the translation of manufacturing process capability into design guidelines. This is accomplished through the identification and monitoring of critical process and device parameters. These elements, included in Silicon Systems design for quality effort, support the development of robust design rules which are as insensitive as possible to manufacturing variation. The result is a product that delivers predictable and reliable long term performance.

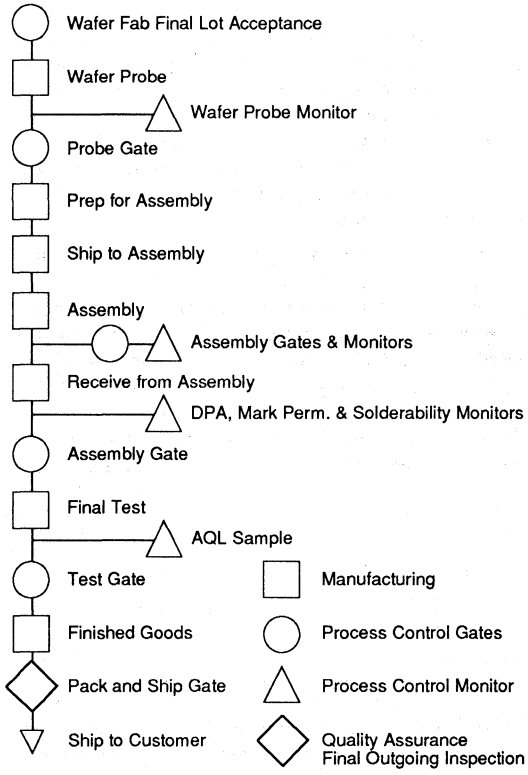


FIGURE 2
Process Control Gates and Monitors

2.4 PPM REDUCTION PROGRAM

The primary purpose of a PPM reduction program is to provide a formalized feedback system in which data from nonconforming products can be used to improve product consistency and reliability. The action portion of this program is accomplished in three stages:

1. Identification of defects by failure mode.
2. Identification of defect causes and initiation of corrective action.
3. Measurement of results and setting of improved goals.

The data summarized from the established PPM program is compiled as a ratio of units rejected/tested. This ratio is then expressed in terms of defective parts per million (PPM). Founded on a statistically valid database of PPM data and an established five-year strategic plan identifying PPM improvement goals, Silicon Systems has progressively achieved excellent quality standards and will continue to improve on PPM standards as set by the industry.

2.5. COMPUTER AIDED MANUFACTURING CONTROL

Computer Aided Manufacturing (CAM) is used throughout Silicon Systems for the identification, control, collection and dissemination of timely data for logistics control. Silicon Systems also uses this type of computerized system for statistical process control and manufacturing monitoring. PROMIS, the Process Management and Information System, displays approved/controlled recipes, processes, and procedures; tracks work-in-process; reports accurate inventory information; allows continuous recording of facilities data; contains statistical analysis capabilities; and much more. PROMIS allows for a paperless facility, which assists in minimizing contamination of clean room areas.

The PROMIS system has been configured to meet the specific requirements of Silicon Systems.

SECTION 3: RELIABILITY

3.1 RELIABILITY PROGRAM

Silicon Systems has defined various programs that will characterize product reliability levels on a continuous basis. These programs can be categorically described by:

1. Qualifications
2. Production Monitors
3. Evaluations
4. Failure Analysis
5. Data collection and presentation for improvement projects

3.2 QUALIFICATIONS

The application of this program ensures that all new product designs, processes, and packaging configurations meet the absolute maximum ratings of design and the worst case criteria for end use. A large database generated by means of accelerated stress testing results in a high degree of confidence in determining final use performance.

3.3 PRODUCTION MONITORS

This program has been established to randomly select a statistically significant sample of production products for subjection to maximum stress test levels in order to evaluate the useful life of the product in a field use environment.

Table 1 lists reliability methods that are in use at Silicon Systems. This analysis of production monitor at Silicon Systems provides valuable information on possible design/process changes which assure continued improved reliability.

3.4 EVALUATIONS

The evaluation program at Silicon Systems is an ongoing effort that will continue defining standards which address the reliability assessment of the circuit design, process parameters, and package of a new product. This program continuously analyzes updated performance characteristics of product as they undergo improvement projects at Silicon Systems.

3.5 FAILURE ANALYSIS

The failure analysis function is an integral part of the Reliability department at Silicon Systems. Silicon Systems has assembled a high technical and sophisticated failure analysis laboratory and staff. This laboratory provides visual analysis, electrical reject mode analysis, and both destructive and nondestructive data to aid the engineers in developing corrective action for improvement. These test analyses may include metallurgic, optical, chemical, electrical, and SEM with X-ray dispersive analysis as needed.

These conclusive in-house testing and analysis techniques allow Silicon Systems to monitor all aspects of product manufacturing to ensure that the product of highest quality is shipped to our customers.

3.6 DATA COLLECTION AND PRESENTATION FOR IMPROVEMENT PROJECTS

Data collected from each element of the Reliability program is summarized for scope and impact and distributed among all engineering disciplines in the company. This data facilitates improvement and provides our customers an opportunity to review the performance of our product.

TEST	CONDITIONS	PURPOSE OF EVALUATION
Biased temperature/humidity	85°C/85° %RH	Resistance to high humidity with bias
High temperature operating life (HTOL)	Mil 883C, Method 1005	Resistance to electrical and thermal stress
Highly accelerated stress test (HAST)	SSi Method	Evaluates package integrity
Steam pressure	121°C/15PSI	Resistance to high humidity
Temperature cycling	Mil 883C, Method 1010	Resistance to thermal excursion (air)
Thermal shock	Mil 883C, Method 1011	Resistance to thermal excursion (liquid)
Salt atmosphere	Mil 883C, Method 1009	Resistance to corrosive environment
Constant acceleration	Mil 883C, Method 2001	Resistance to constant acceleration
Mechanical shock	Mil 883C, Method 2002	Resistance to mechanical shocks
Solderability	Mil 883C, Method 2003	Evaluates solderability of leads
Lead integrity	Mil 883C, Method 2004	Evaluates lead integrity before board assembly
Vibration, variable frequency	Mil 883C, Method 2007	Resistance to vibration
Thermal resistance	SSi Method	Evaluates thermal dissipation
Electrostatic damage	Method 3015	Evaluates ESD susceptability
Latch-up	SSi Method	Evaluates latch-up susceptibility
Seal fine and gross leak	Mil Std 883C, Method 1014	Evaluates hermeticity of sealed packages

TABLE 1: Reliability Stress Tests

3.7 RELIABILITY METHODS

The Reliability Program utilizes a number of stress tests that are presently being used to define performance levels of our products. Many of these stress tests are per MIL-STD-883C as shown in Table 3.

3.8 RELIABILITY PREDICTION METHODOLOGY

At Silicon Systems, the Arrhenius model is used to relate a failure rate at an accelerated temperature test condition to a normal use temperature condition.

The model basically states $FR = A \exp(-Ea/KT)$

Where:

FR = Failure rate

A = Constant

Ea= Activation Energy (eV)

K = Boltzmann's constant 8.62×10^{-5} eV/ degree K

T = Absolute temperature (degree K)

SECTION 4: ELECTROSTATIC DISCHARGE PROGRAM

4.1 ESD PREVENTION

Silicon Systems recognizes that procedures for the protection of Electrostatic Discharge (ESD) sensitive devices from damage by electrical transients and static electricity are vital. ESD safe procedures are incorporated throughout all operations which come in contact with these devices. Continuous improvement in the ESD protection levels is being accomplished through the incorporation of increasingly robust protection devices during the circuit design process.

Silicon Systems' quality activity incorporates several protection measures for the control of ESD. Some of the preventive measures include handling of parts at static safe-guarded workstations, the wearing of wrist straps during all handling operation, the use of conductive lab coats in all test areas and areas which handle parts and the packaging of components in conductive or anti-static containers.

Section 12

PACKAGING/ORDERING INFORMATION

Silicon Systems
Packaging Index
Ordering Information

*SON is a 150 mil width package.

**SOL is a 300 mil width package.

***SOW is a 400 mil width package.

****SOM is a 300 mil width package, fine pitch.

Package Type	8	10	14	16	18	20	22	24	28	32	34	36	40	44	52	68	100
Plastic DIP																	
300 mil	X		X	X	X	X		S									
400 mil							X										
600 mil								X	X	X			X				
Cerdip																	
300 mil	X		X	X	X	X											
400 mil							X										
600 mil								X	X				X				
Side Braze																	
300 mil	X		X	X	X	X		S									
400 mil							X										
600 mil								X	X				X				
Small Outline																	
150 mil	X		X	X													
300 mil				X		X		X	X		X	X		X			
400 mil										X							
Flatpack		X	X					X	X	X							
Chip Carrier				X		X			X								
Plastic Quad									X	X				X	X	X	
Ceramic Quad									X					X		X	
QFP															X		X

12

Silicon Systems
Storage Products
Package Types

DEVICE TYPE	PACKAGE TYPE				
	P S* Plastic	D Cerdip	H PLCC	N L W M Small Outline	QFP Quad Fine Pitch
SSI 32B451			44		
SSI 32C260			84		100
SSI 32C452	40		44		
SSI 32C453	40		44		
SSI 32C4650			84		100
SSI 32D5321	28		28		
SSI 32D5322	28		28		
SSI 32D534A	28		28		
SSI 32D535	32			32W, 28L	
SSI 32D5351	32			32W, 28L	
SSI 32D5362	28		28	32W	
SSI 32D5371/5372	28		28	32W	
SSI 32D5381	28		28		
SSI 32D539			44		
SSI 32D4660/4661	24			24	
SSI 33F8011	16			16N, 16L	
SSI 32F8020	16			16N, 16L	
SSI 32H101/1012	8			8N	
SSI 32H116A/1162A	8	10		8N	
SSI 32H523R				14N	
SSI 32H566R				14N	
SSI 32H567	28		28		
SSI 32H568	32		44		
SSI 32H569	20			20L	
SSI 32H4631					100
SSI 32H6110	8	10		8N	
SSI 32H6210	28		28	28L	
SSI 32H6220			44		
SSI 32H6230	20			20L	
SSI 6240			28		
*Narrow					

DEVICE TYPE	PACKAGE TYPE				
	P S* Plastic	D Cerdip	H PLCC	N L W M Small Outline	QFP Quad Fine Pitch
SSI 32M5901	8				
SSI 32M5902	14			16L	
SSI 32M591	16			16L	
SSI 32M593A	20			20L	
SSI 32M594	20			20L	
SSI 32M595			28	28L	
SSI 32P4620/4621	68				100
SSI 32P540	28		28		
SSI 32P541	24		28	24L	
SSI 32P541A	24		28	24L	
SSI 32P541B	24		28	24L	
SSI 32P549	24		28	24L	
SSI 32P544			44		
SSI 32P546				32W	
SSI 32P547			52		
SSI 32P548			68		52
SSI 32P3000				36M	
SSI 32P4620			68		100
SSI 32R117/117R-2	18				
SSI 32R117/117R-4	22	24		24L	
SSI 32R117/117R-6	28	28	28	28L	
SSI 32R117A/117AR-2	18				
SSI 32R117A/117AR-4	22	24		24L	
SSI 32R117A/117AR-6	28	28	28	28L	
SSI 32R501/501R-4				24L	
SSI 32R501/501R-6	28	28	28	28L	
SSI 32R501/501R-8	40	32	44	32W	
SSI 32R502R-6			28	28L	
SSI 32R502R-7			28		
SSI 32R502R-8				32W	
*Narrow					

Silicon Systems
Storage Products
Package Types

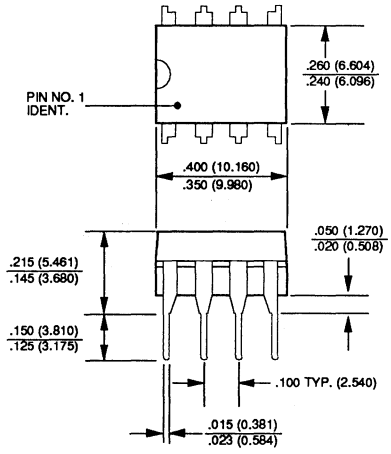
DEVICE TYPE	PACKAGE TYPE				
	P S* Plastic	D Cerdip	H PLCC	N L W M Small Outline	QFP Quad Fine Pitch
SSI 32R510A/510AR-2	18			20L	
SSI 32R510A/510AR-4	22	24		24L	
SSI 32R510A/510AR-6	28	28	28	28L	
SSI 32R511/511R-4				24L	
SSI 32R511/511R-6			28	28L	
SSI 32R511/511R-8	40	32	44	32W	
SSI 32R511M/511RM-6				28L	
SSI 32R511M/511RM-8				32W	
SSI 32R5111/5111R-4				24L	
SSI 32R5111/5111R-6			28	28L	
SSI 32R5111/5111R-8		32	44	32W, 34L	
SSI 32R5111M/5111RM-6				28L	
SSI 32R5111M/5111RM-8				32W, 34L	
SSI 32R512/512R-8				32W	
SSI 32R512/512R-9				34L	
SSI 32R512M/512RM-8				32W	
SSI 32R512M/512RM-9				34L	
SSI 32R5121/5121R			44	44L	
SSI 32R514/514R-2				18L	
SSI 32R514/514R-4				24L	
SSI 32R514/514R-6			28	28L	
SSI 32R515R-9				34L	
SSI 32R515R-10			44	36L	
SSI 32R515RM-9				34L	
SSI 32R515RM-10				36M	
SSI 32R516/516R-4				24L	
SSI 32R516/516R-6			28	28L	
SSI 32R516/516R-8				28L, 32W, 34L	
SSI 32R516M/516RM-6				28L	
SSI 32R516M/516RM-8			44	32W, 34L	
*Narrow					

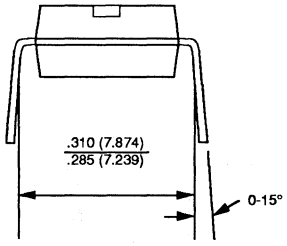
DEVICE TYPE	PACKAGE TYPE				
	P S* Plastic	D Cerdip	H PLCC	N L W M Small Outline	QFP Quad Fine Pitch
SSI 32R5161				36M	
SSI 32R521/521R		28	28	28L	
SSI 32R5211			28	28L	
SSI 32R522/522R-4		24			
SSI 32R522/522R-6			28	28L	
SSI 32R524R/524RM				32W, 34L	
SSI 32R525R		24		24L	
SSI 32R526R		24		24L	
SSI 32R527R-8				32W	
SSI 32R527RM-9				34L	
SSI 32R528/528R-8				32W	
SSI 32R528/528R-9				34L	
SSI 32R529-8				32W	
SSI 32R529-9				34L	
SSI 32R1200-2				16L	
SSI 32R1200-4				20L	
SSI 32R2010R-8				36M	
SSI 32R2010R-10				44M	
SSI 32R4610/4611-2				16L	
SSI 32R4610/4611-4				20L, 24L	
SSI 34B580	28		28		
SSI 32D441	28		28		
SSI 34P570	28		28		
SSI 34R575-2	18				
SSI 34R575-4	24				
SSI 35P550	40		44		

*Narrow

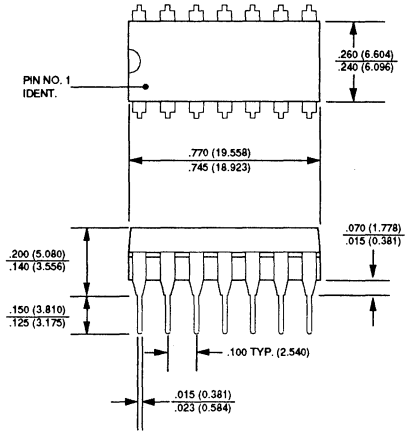
SSI NNA NNNN A AA - N A A
Optional
PRODUCT CATEGORY
32B HDD Interface
32C HDD Controller
32D HDD Data Recovery
32H HDD Head Positioning
32M HDD Motor Speed Controller
32P HDD Pulse Detection
32R HDD Read/Write Amp
34B FDD Interface
34D FDD Data Recovery
34P FDD Pulse Detection
34R FDD Read/Write Amp
35P Tape Drive Pulse Detection
73D Modem Device Set
73K K-Series Modem
73M Modem/Modem Support
75T Tone Signaling
78A Analog Telecom
78P Digital Telecom
DEVICE TYPE
3 or 4 Digits
RELEASE LEVEL (Revision)
A through E
NUMBER OF CHANNELS
MODIFIERS
J Burn-In (168 Hours)
K Burn-In (48 Hours)
LJ Low Noise Burn-In (168 Hours)
L Low Power
LN Low Noise
LQ Low Noise, Resistor, Mirror Image
LR Low Noise, Resistor
M Mirror Image
S Serial Version
SL Low Power Serial
R Damping Resistor
RM Resistor, Mirror Image
U On-Chip UART
Cannot use A-E in left position
PACKAGE TYPE
C Side-Brazed Ceramic
D Ceramic Dip
F Flat Pack
G QFP (25 mil. pitch)
H PLCC
P Plastic Dip
T Metal Can
S Plastic, Skinny Dip
N Small Outline, Narrow (150 mil.)
L Small Outline, Large (300 mil.)
W Small Outline, Wide (400 mil.)
M Small Outline, Large (31.6 mil. pitch)
TEMPERATURE RANGE
C Commercial (0 °C to +70 °C)
I Industrial (-40 °C to +85 °C)
M Military (-55 °C to +125 °C)

Package Information

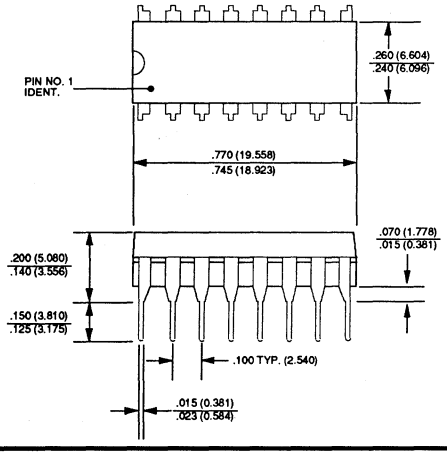


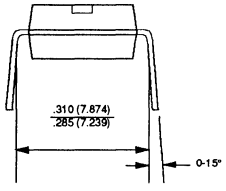


8-Pin Plastic

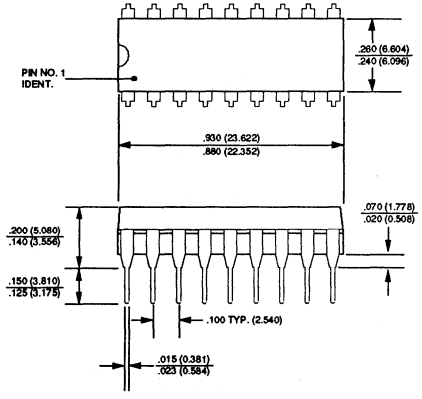


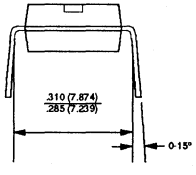
14-Pin Plastic





16-Pin Plastic

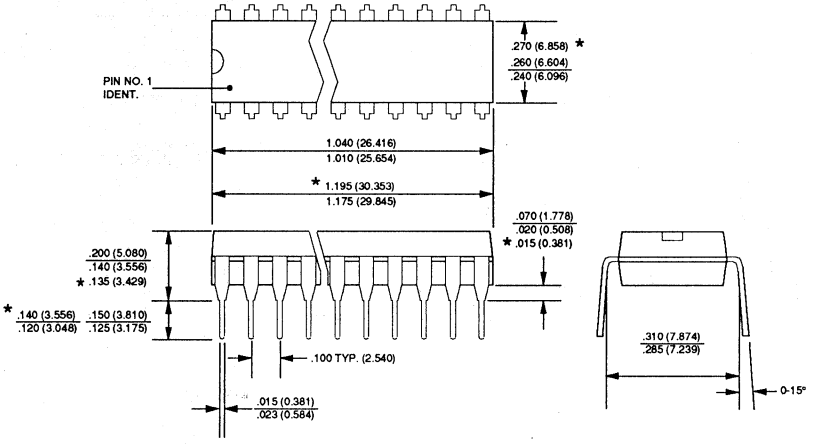




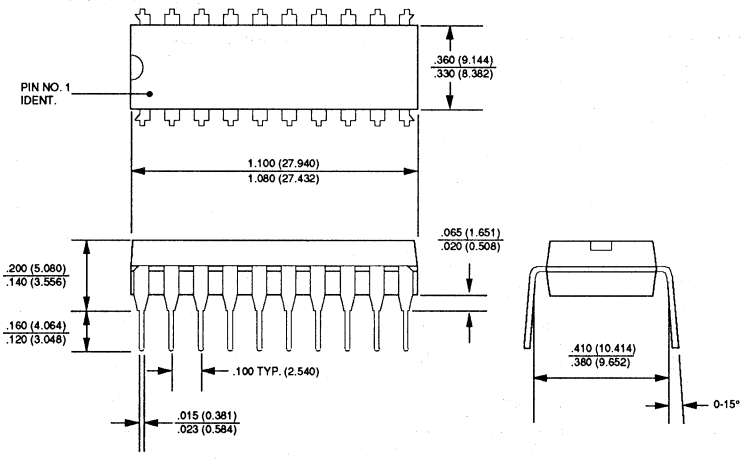
18-Pin Plastic

12

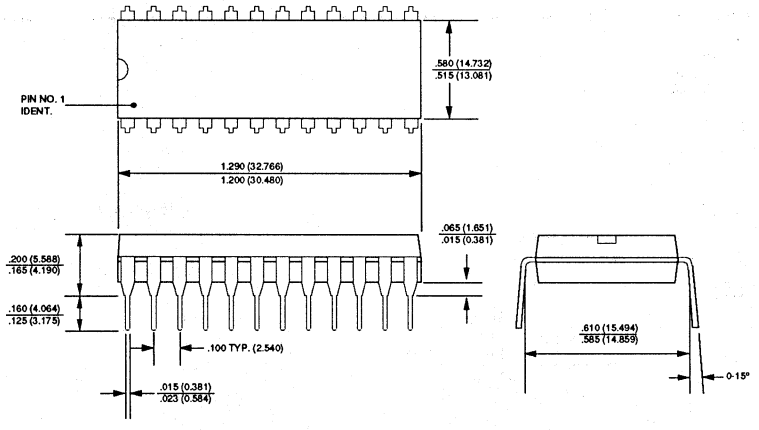
Package Information
(Plastic DIP)



20 Pin Plastic
***24S Pin Plastic**

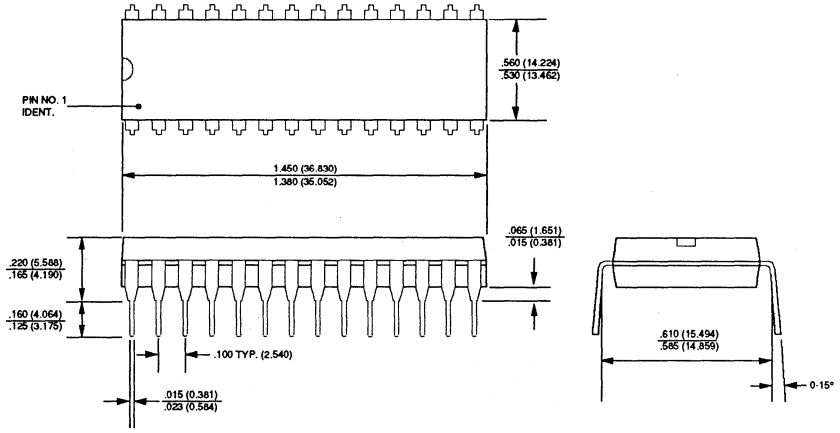


22-Pin Plastic

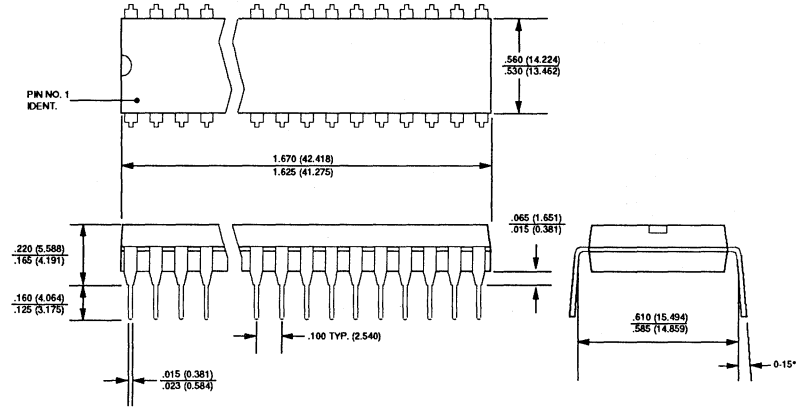


24-Pin Plastic

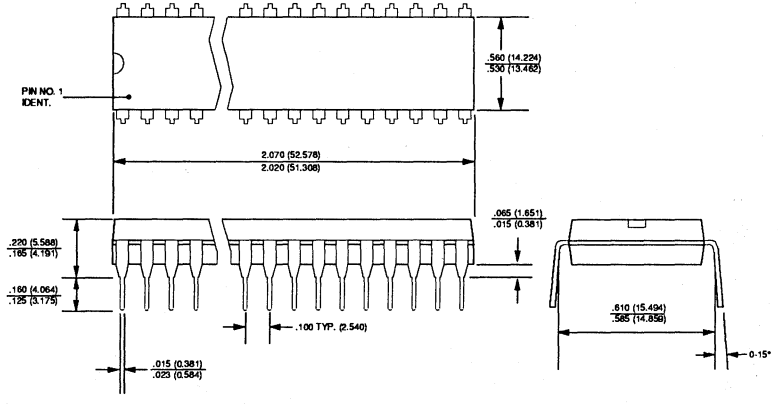
Package Information



28-Pin Plastic

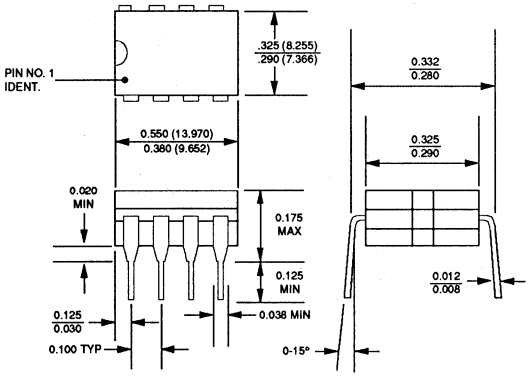


32-Pin Plastic

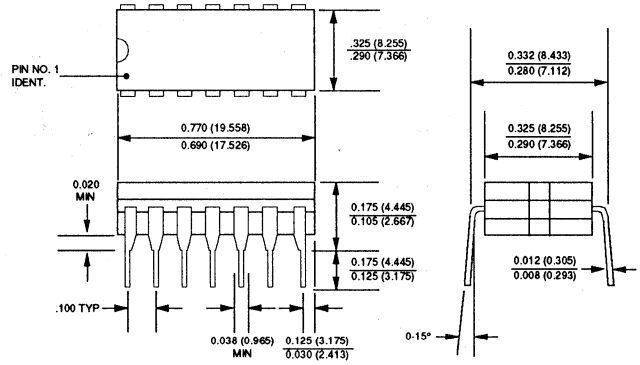


40-Pin Plastic

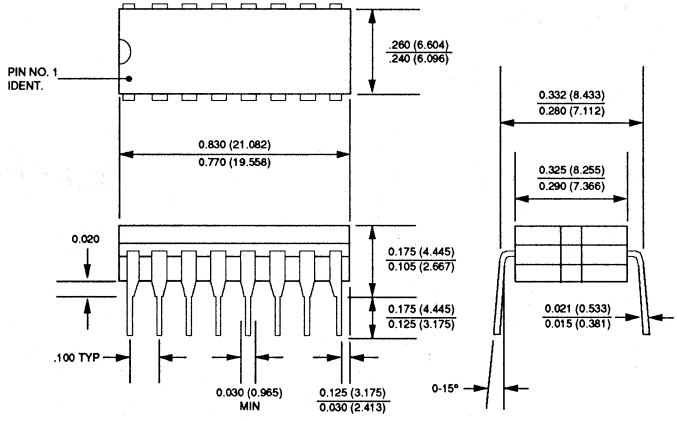
Package Information
(Cerdip)



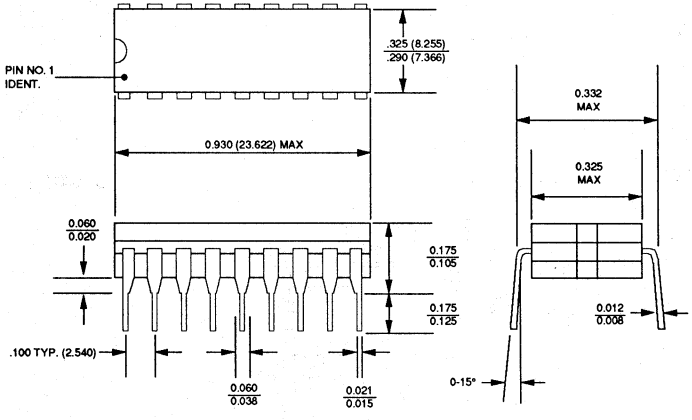
8-Pin Cerdip



14-Pin Cerdip

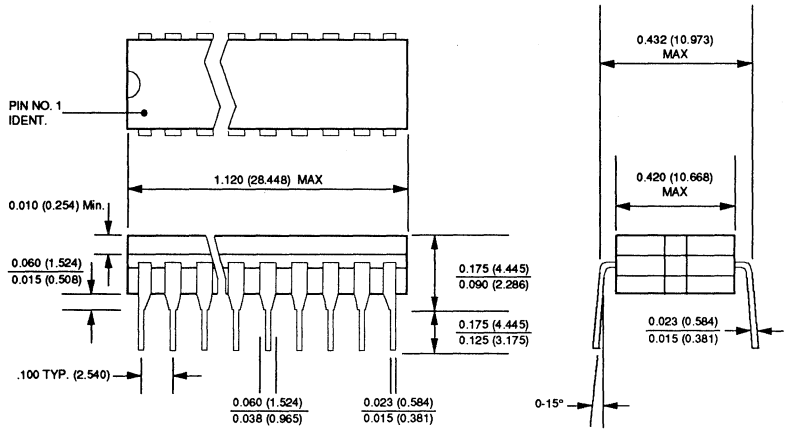


16-Pin Cerdip

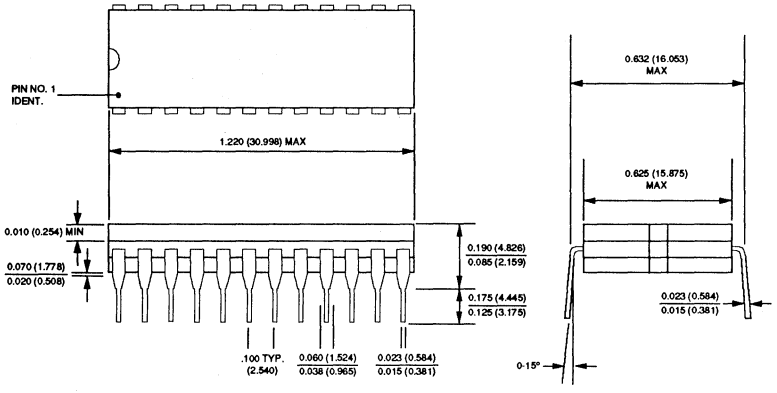


18-Pin Cerdip

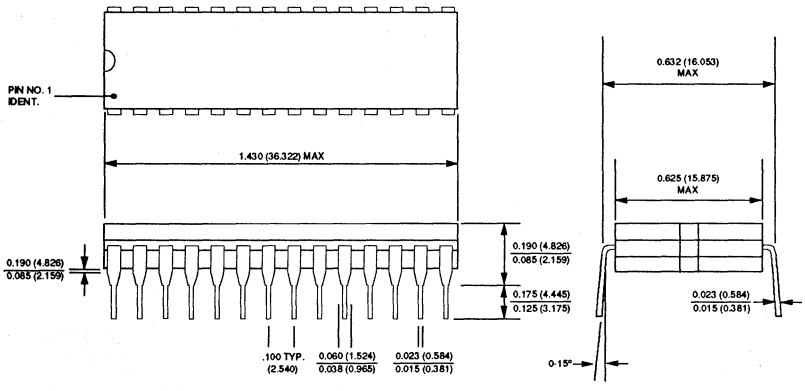
Package Information



22-Pin Cerdip



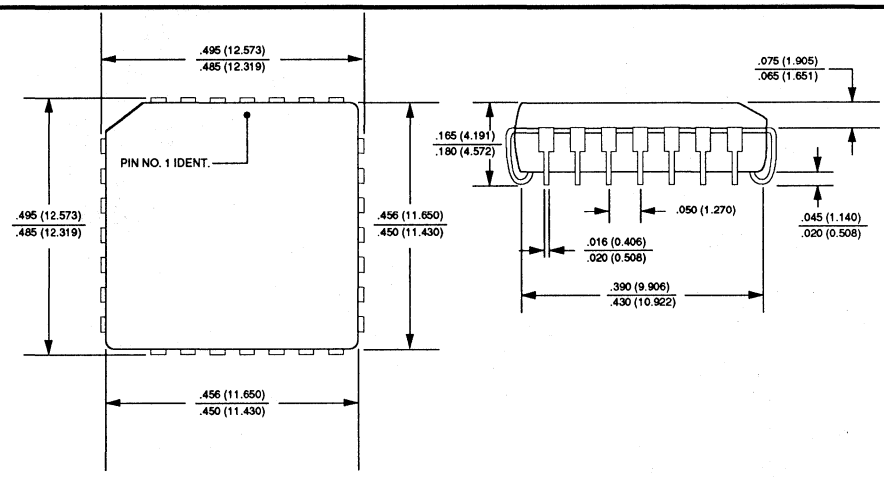
24-Pin Cerdip



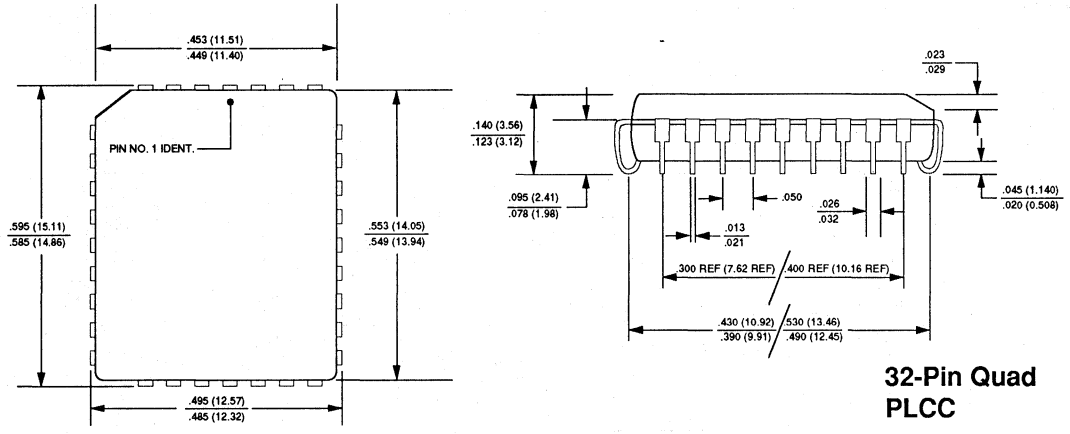
28-Pin Cerdip

12

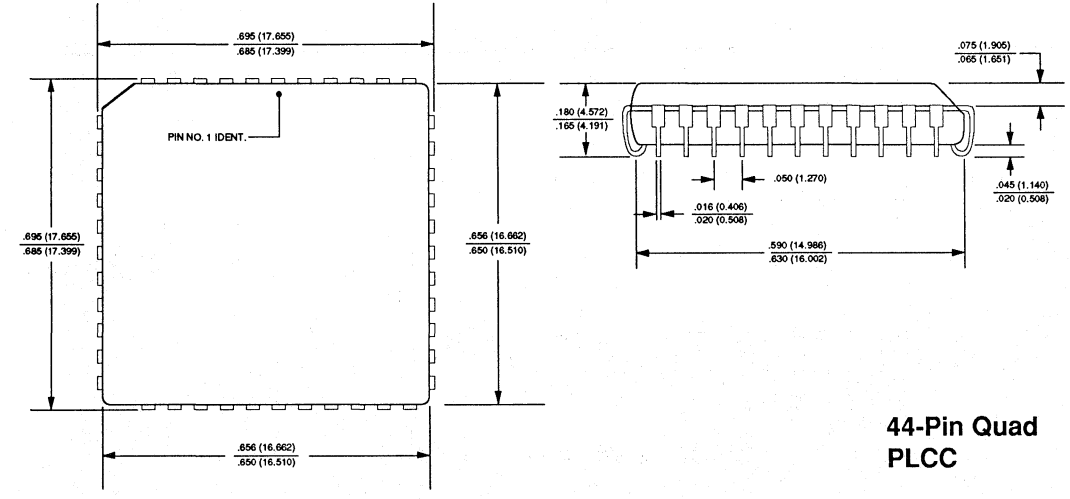
Package Information
PLCC (Quad)



28-Pin Quad PLCC

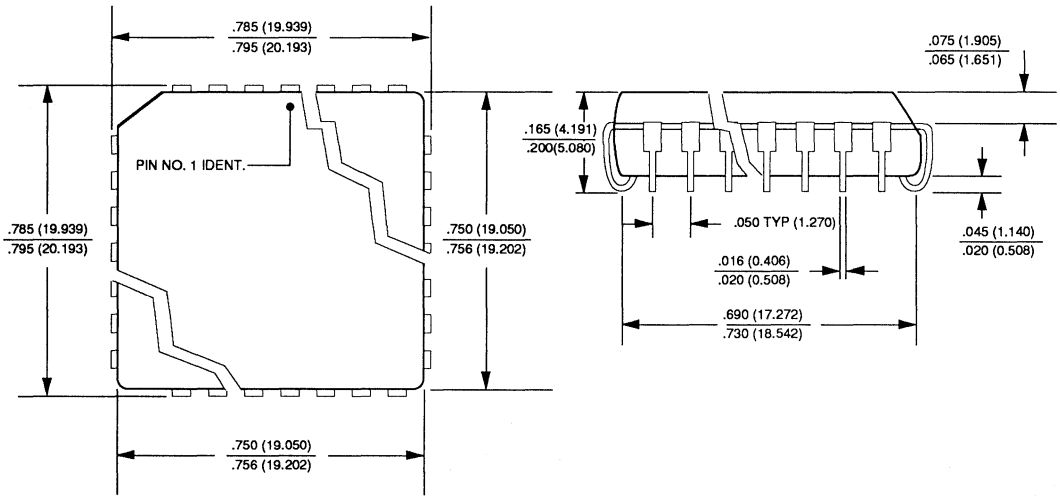


32-Pin Quad PLCC

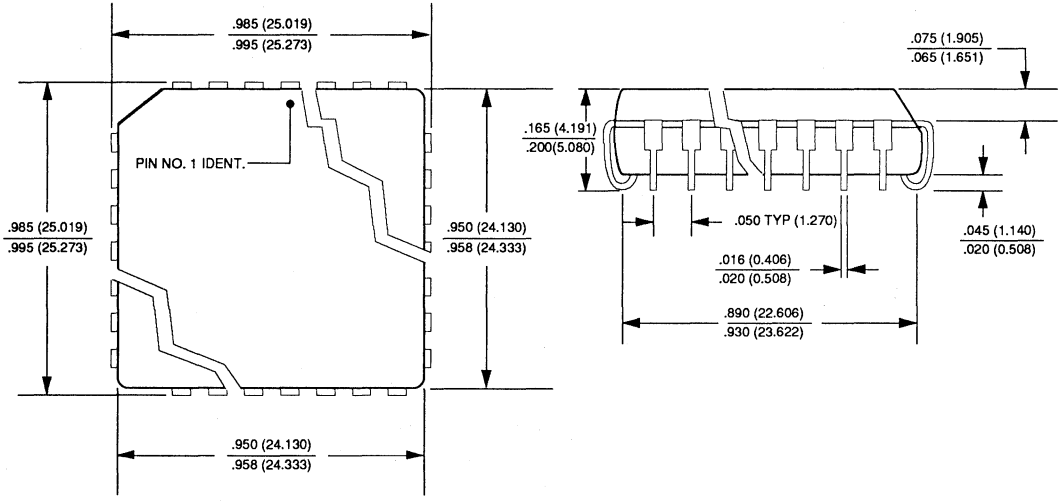


44-Pin Quad PLCC

Package Information



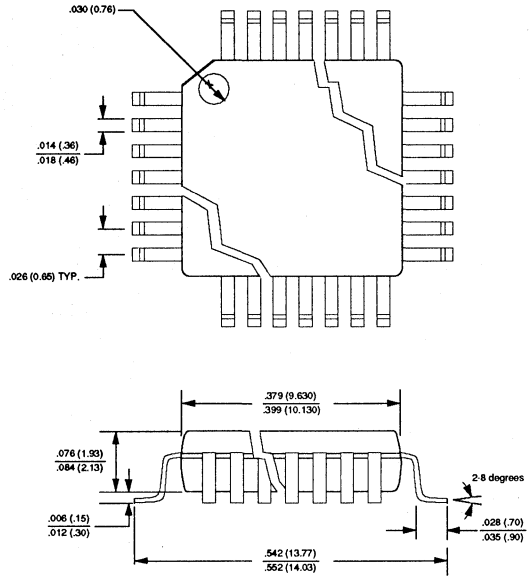
52-Pin Quad PLCC



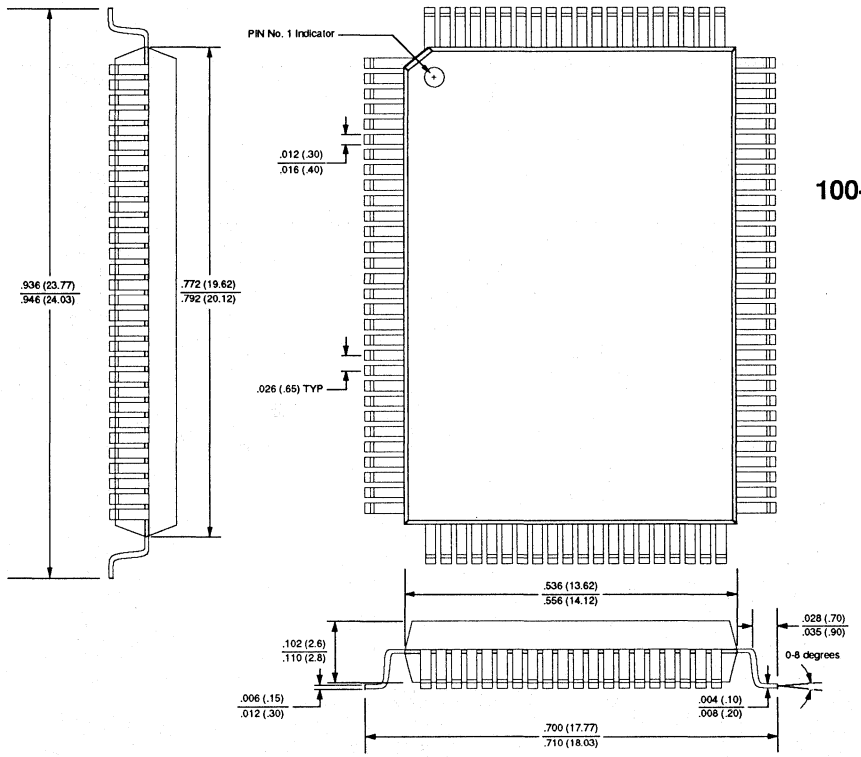
68-Pin Quad PLCC

12

Package Information
Quad (Fine Pitch)

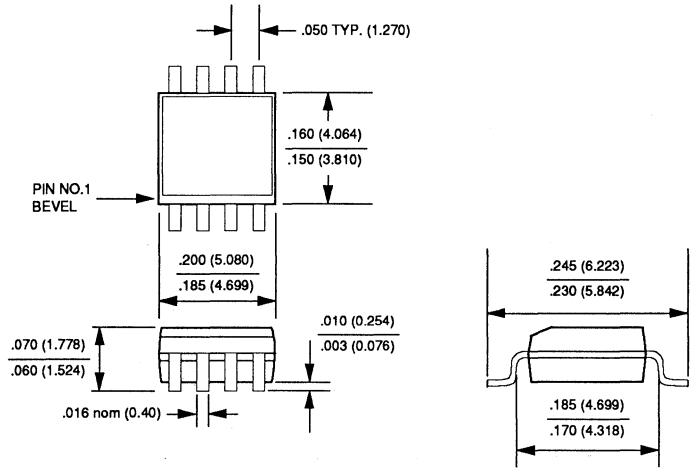


52-Lead Quad Fine Pitch

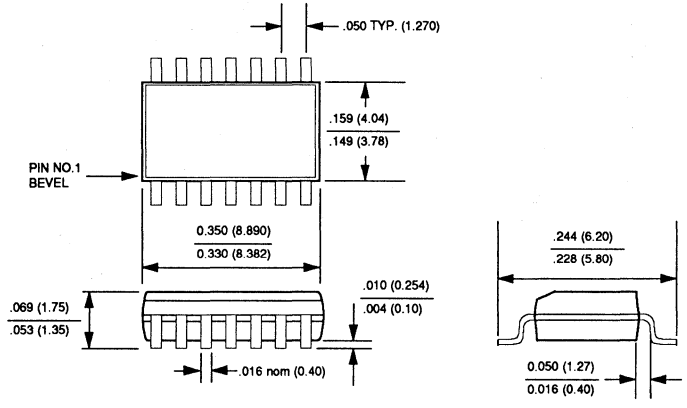


100-Lead Quad Fine Pitch

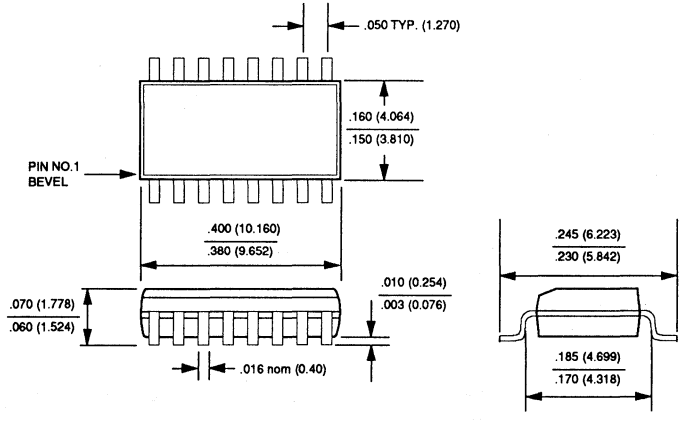
Package Information
(SON)



8-Pin SON

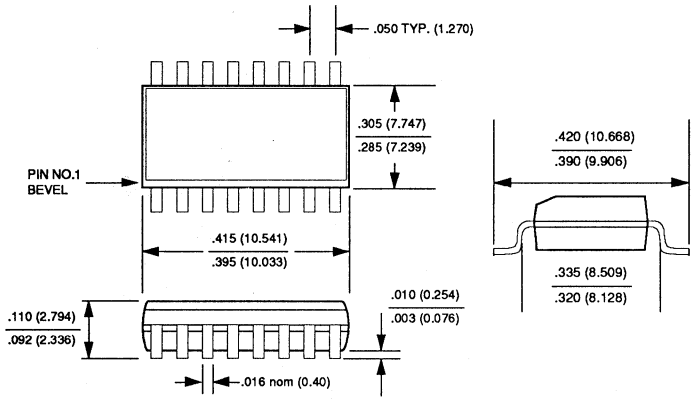


14-Pin SON

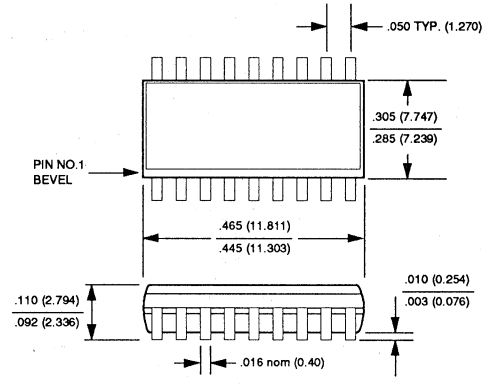


16-Pin SON

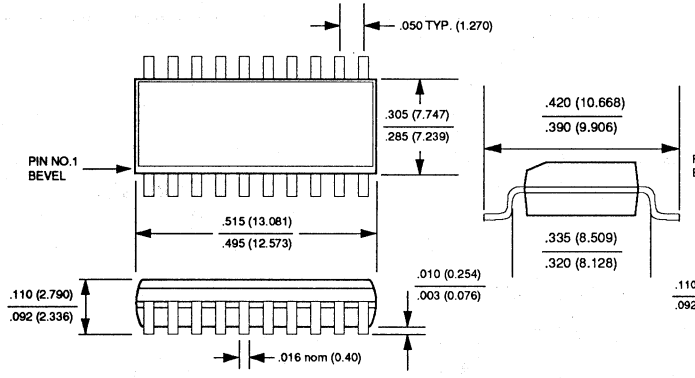
Package Information
(SOL)



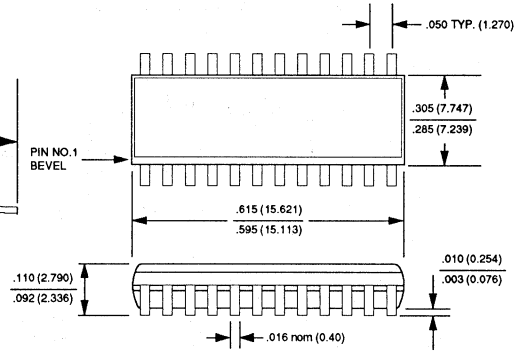
16-Pin SOL



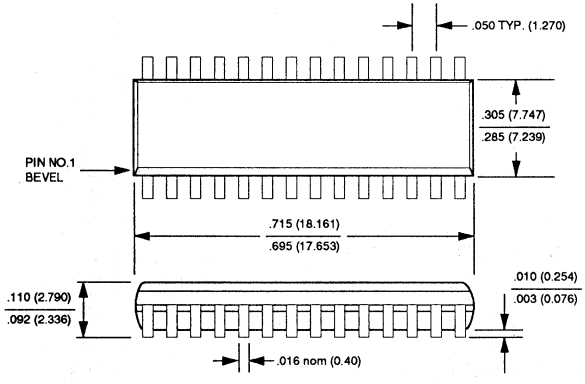
18-Pin SOL



20-Pin SOL

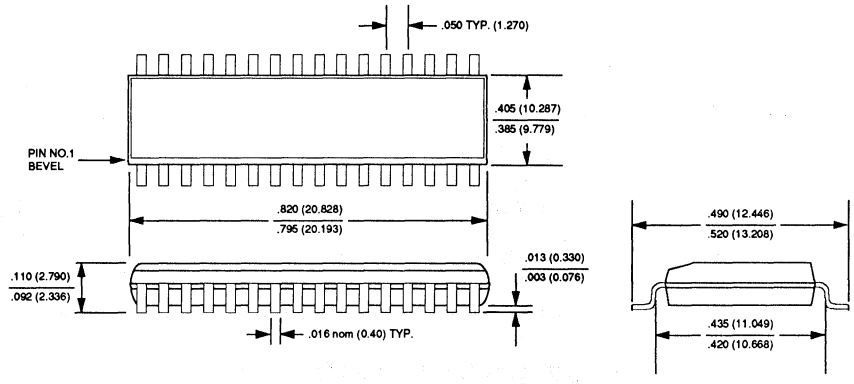


24-Pin SOL

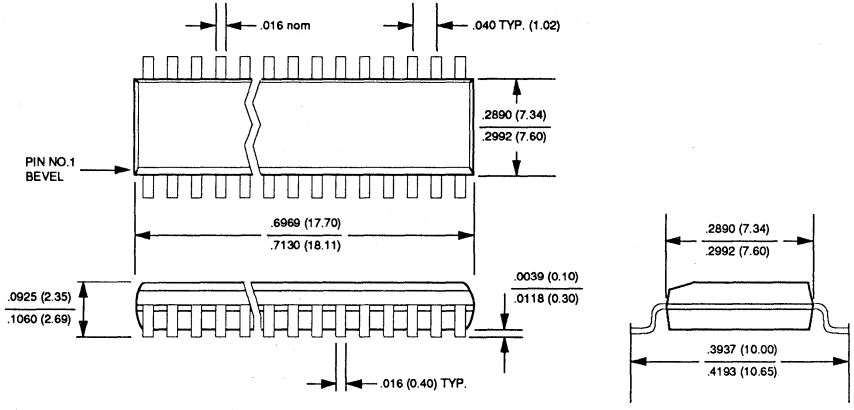


28-Pin SOL

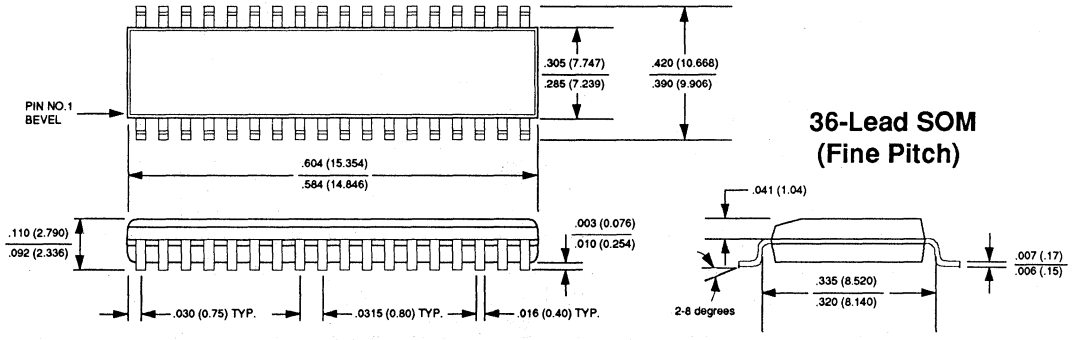
Package Information (SOL/SOM/SOW)



32-Pin SOW

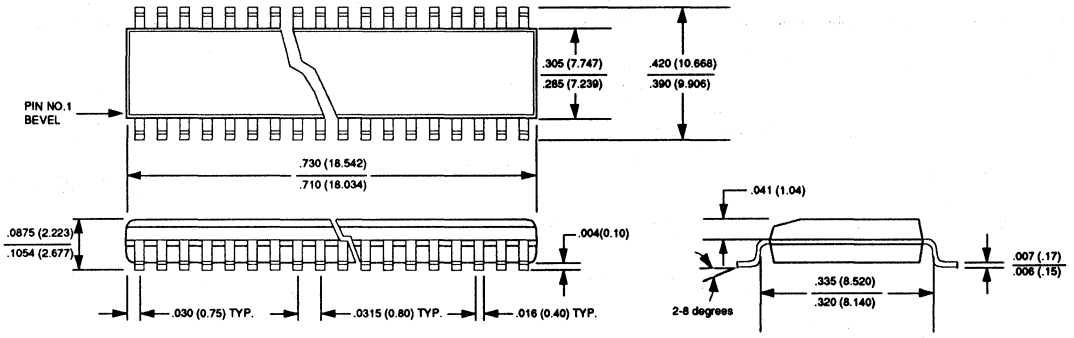


34-Pin SOL

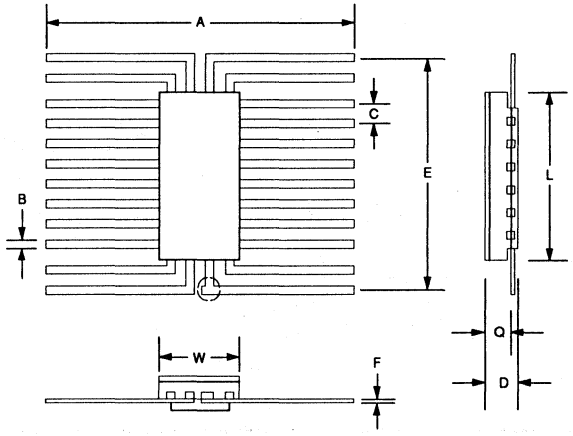


36-Lead SOM (Fine Pitch)

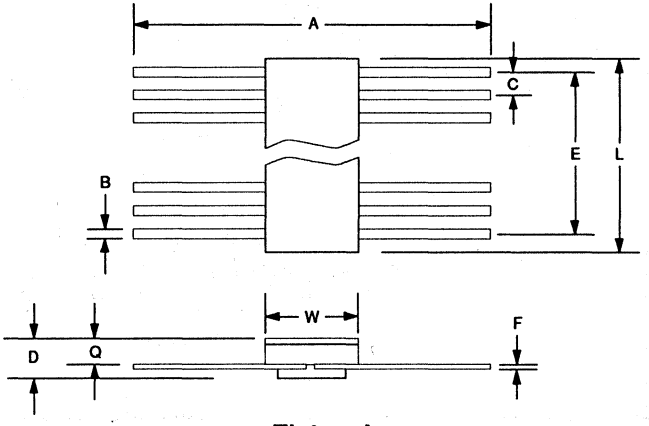
44-Lead SOM
(Fine Pitch)



Package Information
(Flatpack)



Flatpack
24-Leads



Flatpack
10, 28, 32-Leads

Pkg. Type	Lead Cnt.	A	B	C	D	E	F	L	Q	W
F	10	.900	.015 / .019	.045 / .055	.090 max	.200 typ	.004 / .007	.250 / .260	.074 typ	.250 / .260
F	24	.900	.015 / .019	.050 typ	.087 max	.567 typ	.004 / .007	.391 / .405	.075 typ	.264 / .276
F	28	1.150	.015 / .019	.045 / .055	.092 max	.645 / .655	.004 / .007	.712 / .728	.085 / .078	.492 / .508
F	32	1.150	.015 / .019	.045 / .055	.092 max	.745 / .755	.004 / .007	.812 / .828	.085 / .078	.492 / .508

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FAX: (603) 898-9538

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FAX: (804) 239-1333

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Mike Traviolia, Manager
Silicon Systems, Inc.
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Elmhurst, IL 60126
Ph: (708) 832-3111
FAX: (708) 832-3172

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Mel Marchbanks, Manager
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454 Carson Plaza Drive, Suite 209
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Jon Tammel, Manager
Silicon Systems, Inc.
2840 San Thomas Exp., Suite 140A
Santa Clara, CA 95051
Ph: (408) 980-9771
FAX: (408) 748-9488
TLX: 171-200

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Silicon Systems, Int'l
Woodpeckers, The Common
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TWX: 822-542 ELYP CH

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Ellyptic AG
Maribor
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HEADQUARTERS
K. S. Ong, District Sales Mgr.
Silicon Systems, Singapore
3015A UBI Road 1 #03-01
Singapore 1440
Ph: (65) 380-9157
FAX: (65) 281-3423

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Guadalajara, Jalisco
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FAX: (52) 36-30-3115

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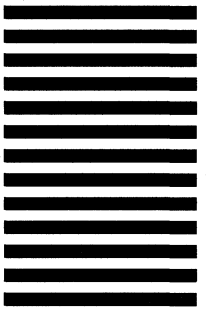

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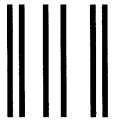

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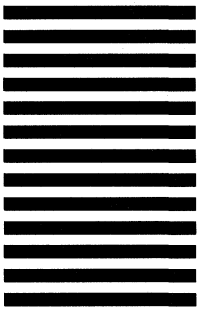

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