DATA SHEET

I²C BUS

SAA6750H

Encoder for MPEG2 image recording (EMPIRE)

Product specification

Supersedes data of 2000 May 03

File under Integrated Circuits, IC02

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Philips
Semiconductors

PHILIPS

CONTENTS

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1 FEATURES

- Digital YUV input according to *"ITU-T 601"* and *"ITU-T 656"*

- NTSC and PAL (720 pixels × 480 lines at 60 Hz and 720 pixels × 576 lines at 50 Hz)

- Integrated colour conversion 4 : 2 : 2 to 4 : 2 : 0

- Integrated format conversion to SIF format (optional)

- Real time MPEG2 Simple Profile at Main Level (SP@ML) encoding

- IP frame or I frame only encoding supported

- Programmable Group Of Pictures (GOP) size

- Integrated motion estimation, half pixel accuracy

- Motion compensated noise reduction

- Elementary stream data output compliant to MPEG2 standard (*"ISO 13818-2"*)

- Bitstream output compatible to 16-bit parallel interface with Motorola (68xxx like) protocol style

- No external host processor required

- 4 × 4 Mbit external DRAM required

- I^{2}C-bus controlled

- Single external video clock 27 MHz

- Power supply voltage 3.3 V

- Digital inputs 5 V tolerant

- Boundary Scan Test (BST) supported.

2 GENERAL DESCRIPTION

2.1 General

The SAA6750H is a new approach towards a stand-alone MPEG2 video encoder IC. It combines high quality SP@ML compliant real time encoding with cost-effectiveness, allowing for the first time the use of an MPEG2 encoder IC in applications and markets with a high cost pressure. This has been achieved by means of a number of innovations in architecture and algorithms developed by the Philips Research Laboratories, e.g.:

- The unique motion estimation algorithm supports highly efficient encoding by using only I frame and IP frame mode. B frames need not be used. This leads to a significantly smaller internal circuitry and also reduces DRAM memory requirements from at least 4 to 2 Mbyte. In addition, the absence of B frames simplifies editing of the compressed data stream.

- The patented, motion-compensated temporal noise filtering which was developed by Philips for professional equipment reduces noise in the input video before compression is performed. This technique gives visible improvements in picture quality, especially in the field of home recordings with noisy signal sources where this has proved to be of significant benefit.

Internally the SAA6750H uses a hardware solution for data compression and a specially developed high performance processor for control purposes.

2.2 Function

The SAA6750H is a stand-alone single chip video encoder performing real time MPEG2 compression of digital video data.

The video data input of the SAA6750H accepts a digital YUV video data stream in ITU-T 601 format. PAL standard at 50 Hz and 720 pixels by 576 lines, as well as NTSC at 60 Hz and 720 pixels by 480 lines, are covered. The video synchronization may either follow ITU-T 656 recommendation or can also be supplied by external signals. The external reference clock of 27 MHz to pin VCLK has to be synchronized to the video data. The product family SAA7111 of Philips Semiconductors provides a suitable video data stream and reference clock. Other sources are also supported by the flexible I^{2}C-bus controlled data input interface of the SAA6750H. See Section 7.3 for detailed information.

An internal 4 : 2 : 2 to 4 : 2 : 0 colour format conversion is performed. Optionally, a ITU-T 601 to SIF format conversion may be activated by the I^{2}C-bus control settings.

The real time data encoding part of the SAA6750H combines high-compression rates with high quality picture performance. This is achieved by the integration of Philips unique motion estimation algorithm and a patented motion-compensated noise filtering. The compression algorithm uses I or IP mode encoding. Normally it selects automatically the suitable mode but may also be forced to I mode operating only by the I^{2}C-bus control settings.

In contrast to the encoding part which is designed in dedicated hardware, control functions and data stream handling tasks such as e.g. header generation and bit-rate control are carried out by a dedicated control processor, the so-called Application Specific Instruction-set Processor (ASIP). The ASIP's microcode is contained in an internal RAM and is loaded via the I^{2}C-bus before start of operation.

The ASIP is able to communicate with the outside world via the I^{2}C-bus.

The SAA6750H generates an MPEG2 Elementary Stream (ES) in accordance with the MPEG2 standard (*"ISO 13818-2"*). The 16-bit data output interface supports Motorola (68xxx like) protocol style.

Data processing and control functions are managed by loosely coupled processes. FIFO memories are used to connect these processes. In addition to these internal storages the SAA6750H needs 4×4 Mbit of external DRAM memory ($t_{RAC} = 60$ ns). A block diagram is shown in Fig.1.

Selectable I^{2}C-bus addresses and a special reset mode affecting the output pin behaviour allow the use of two SAA6750H devices in one application.

2.3 Application fields

2.3.1 GENERAL

The SAA6750H can be applied within the following application domains:

- Video editing (PC applications)
- Camera signal transmission
- Digital Versatile Disc (DVD) recording
- Video recording for surveillance
- Digital VCR.

All those systems have to compress video data in order to manage the storage or transmission of digitized video data. The SAA6750H can be handled for most of the applications as a stand-alone device. That means at start-up a microcode and a couple of the I^{2}C-bus settings are loaded and the SAA6750H is started. If needed, settings such as GOP size or bit-rate are changed on-the-fly via the I^{2}C-bus.

2.3.2 VIDEO EDITING (PC APPLICATIONS)

For video editing the SAA6750H can be interfaced gluelessly to a video input processor with ITU-T 656 compliant digital video output. In order to link the SAA6750H to the PC, the use of the PCI bridge SAA7146 is recommended. By this bridge the MPEG2 video ES can be transmitted via the PCI-bus to a HardDisc (HD). Furthermore all the I^{2}C-bus settings can be send from the PC via the bridge to the I^{2}C-bus components on the encoder board. The SAA7146 supports Pulse Code Modulation (PCM) audio capturing. Multiplexing with an audio stream or audio encoding can be done by the CPU of the PC. A block diagram is shown in Fig.18.

2.3.3 CAMERA SIGNAL TRANSMISSION

In this application the SAA6750H will be located inside a camera to compress the received digital video data for transmission.

2.3.4 VIDEO RECORDING FOR SURVEILLANCE

For surveillance systems VCRs with a huge amount of storage capacity are required. A high picture resolution is very important when there is action in the captured picture. The SAA6750H can control the encoded bit-rate by motion detection by its integrated motion estimation algorithm. Doing so the bit-rate can vary from 0.5 to 10 Mbit/s. VCRs with a storage space of 6 month are possible.

2.3.5 DIGITAL VCR

In stand-alone VCRs the SAA6750H works together with an audio encoder and a multiplexer. The SAA6750H is clocked by the video clock of the video input processor (SAA7111 or derivatives). A master clock is derived from the frame pulse. The video clock and master clock domain are de-coupled by a FIFO. The audio clock can be derived from the master clock. The video Packetized Elementary Stream (PES) packetizer has to take care of the fullness of the output buffer of the SAA6750H.

3 QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{DD}	digital supply voltage	3.0	3.3	3.6	V
$I_{DD(tot)}$	total digital supply current	–	0.22	0.56	A
P_{tot}	total power dissipation	–	0.73	2.0	W
f_{VCLK}	video clock frequency	25.6	27.0	28.6	MHz
f_{SCL}	I^{2}C-bus clock frequency	100	–	400	kHz
B	output bit-rate	1.5	–	40	Mbit/s
V_{IH}	HIGH-level input voltage	2.0	–	5.5	V
V_{IL}	LOW-level input voltage	−0.5	–	+0.8	V
V_{OH}	HIGH-level output voltage	2.4	–	V_{DD}	V
V_{OL}	LOW-level output voltage	–	–	0.4	V
T_{amb}	ambient temperature	0	–	70	°C

4 ORDERING INFORMATION

TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
SAA6750H	SQFP208	plastic shrink quad flat package; 208 leads (lead length 1.3 mm); body 28 × 28 × 3.4 mm; high stand-off height	SOT316-1

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5   BLOCK DIAGRAM

Fig.1 Block diagram.

MHB661
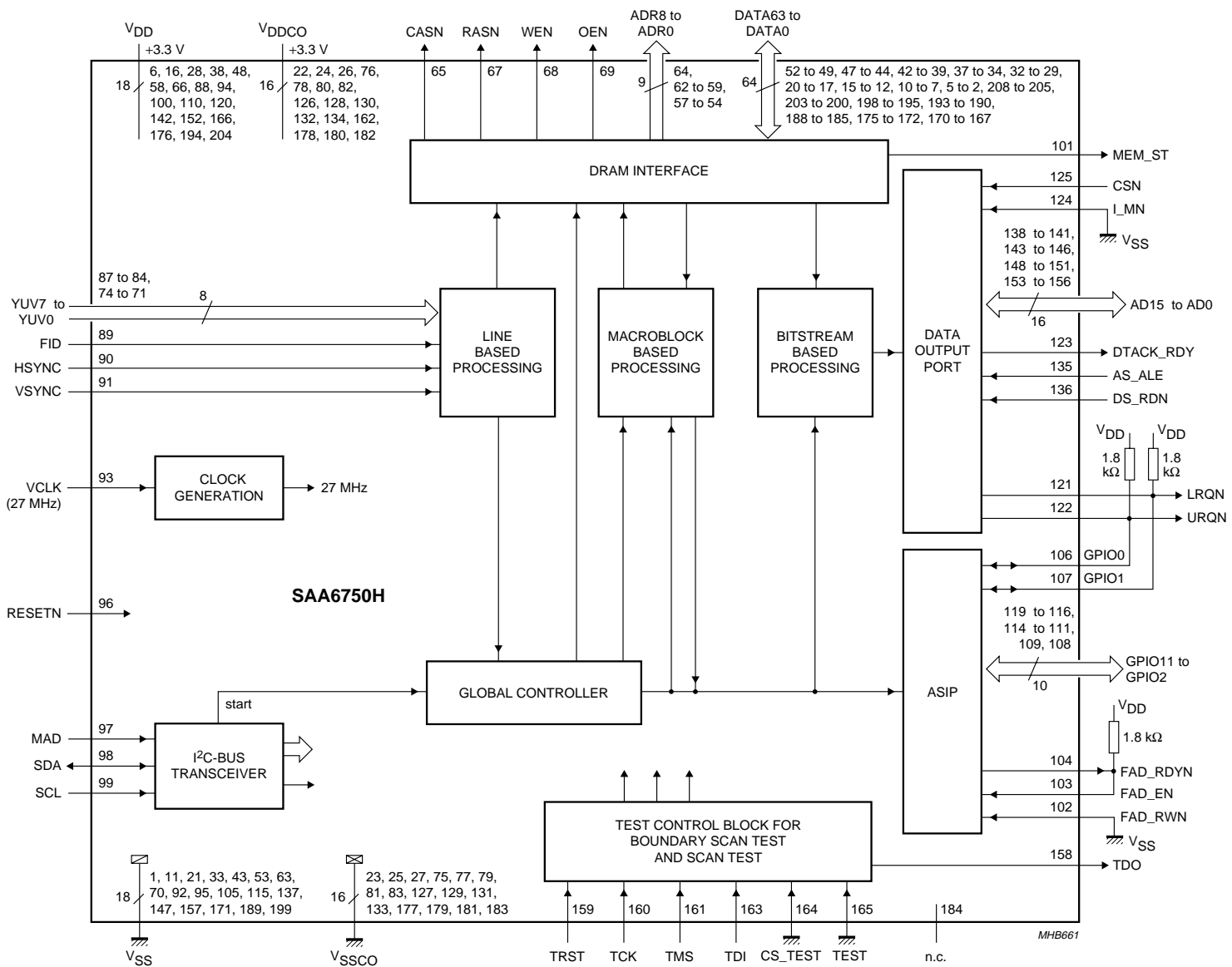
6   PINNING

SYMBOL	PIN	INPUT/OUTPUT[1]	I_{max} (mA)	DESCRIPTION
V_{SS}	1	ground	–	ground for pad ring
DATA28	2	input/output	3	DRAM data interface bit 28
DATA29	3	input/output	3	DRAM data interface bit 29
DATA30	4	input/output	3	DRAM data interface bit 30
DATA31	5	input/output	3	DRAM data interface bit 31
V_{DD}	6	supply	–	supply voltage for pad ring
DATA32	7	input/output	3	DRAM data interface bit 32
DATA33	8	input/output	3	DRAM data interface bit 33
DATA34	9	input/output	3	DRAM data interface bit 34
DATA35	10	input/output	3	DRAM data interface bit 35
V_{SS}	11	ground	–	ground for pad ring
DATA36	12	input/output	3	DRAM data interface bit 36
DATA37	13	input/output	3	DRAM data interface bit 37
DATA38	14	input/output	3	DRAM data interface bit 38
DATA39	15	input/output	3	DRAM data interface bit 39
V_{DD}	16	supply	–	supply voltage for pad ring
DATA40	17	input/output	3	DRAM data interface bit 40
DATA41	18	input/output	3	DRAM data interface bit 41
DATA42	19	input/output	3	DRAM data interface bit 42
DATA43	20	input/output	3	DRAM data interface bit 43
V_{SS}	21	ground	–	ground for pad ring
V_{DDCO}	22	supply	–	supply voltage for core logic
V_{SSCO}	23	ground	–	ground for core logic
V_{DDCO}	24	supply	–	supply voltage for core logic
V_{SSCO}	25	ground	–	ground for core logic
V_{DDCO}	26	supply	–	supply voltage for core logic
V_{SSCO}	27	ground	–	ground for core logic
V_{DD}	28	supply	–	supply voltage for pad ring
DATA44	29	input/output	3	DRAM data interface bit 44
DATA45	30	input/output	3	DRAM data interface bit 45
DATA46	31	input/output	3	DRAM data interface bit 46
DATA47	32	input/output	3	DRAM data interface bit 47
V_{SS}	33	ground	–	ground for pad ring
DATA48	34	input/output	3	DRAM data interface bit 48
DATA49	35	input/output	3	DRAM data interface bit 49
DATA50	36	input/output	3	DRAM data interface bit 50
DATA51	37	input/output	3	DRAM data interface bit 51
V_{DD}	38	supply	–	supply voltage for pad ring
DATA52	39	input/output	3	DRAM data interface bit 52

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SYMBOL	PIN	INPUT/OUTPUT[1]	I$_{max}$ (mA)	DESCRIPTION
DATA53	40	input/output	3	DRAM data interface bit 53
DATA54	41	input/output	3	DRAM data interface bit 54
DATA55	42	input/output	3	DRAM data interface bit 55
V$_{SS}$	43	ground	–	ground for pad ring
DATA56	44	input/output	3	DRAM data interface bit 56
DATA57	45	input/output	3	DRAM data interface bit 57
DATA58	46	input/output	3	DRAM data interface bit 58
DATA59	47	input/output	3	DRAM data interface bit 59
V$_{DD}$	48	supply	–	supply voltage for pad ring
DATA60	49	input/output	3	DRAM data interface bit 60
DATA61	50	input/output	3	DRAM data interface bit 61
DATA62	51	input/output	3	DRAM data interface bit 62
DATA63	52	input/output	3	DRAM data interface bit 63 (MSB)
V$_{SS}$	53	ground	–	ground for pad ring
ADR0	54	output/3-state	3	DRAM address interface bit 0 (LSB)
ADR1	55	output/3-state	3	DRAM address interface bit 1
ADR2	56	output/3-state	3	DRAM address interface bit 2
ADR3	57	output/3-state	3	DRAM address interface bit 3
V$_{DD}$	58	supply	–	supply voltage for pad ring
ADR4	59	output/3-state	3	DRAM address interface bit 4
ADR5	60	output/3-state	3	DRAM address interface bit 5
ADR6	61	output/3-state	3	DRAM address interface bit 6
ADR7	62	output/3-state	3	DRAM address interface bit 7
V$_{SS}$	63	ground	–	ground for pad ring
ADR8	64	output/3-state	3	DRAM address interface bit 8 (MSB)
CASN	65	output/3-state	6	DRAM column address strobe (active LOW)
V$_{DD}$	66	supply	–	supply voltage for pad ring
RASN	67	output/3-state	3	DRAM row address strobe (active LOW)
WEN	68	output/3-state	3	DRAM write enable (active LOW)
OEN	69	output/3-state	3	DRAM chip select (active LOW)
V$_{SS}$	70	ground	–	ground for pad ring
YUV0	71	input	–	video input signal bit 0 (LSB)
YUV1	72	input	–	video input signal bit 1
YUV2	73	input	–	video input signal bit 2
YUV3	74	input	–	video input signal bit 3
V$_{SSCO}$	75	ground	–	ground for core logic
V$_{DDCO}$	76	supply	–	supply voltage for core logic
V$_{SSCO}$	77	ground	–	ground for core logic
V$_{DDCO}$	78	supply	–	supply voltage for core logic
V$_{SSCO}$	79	ground	–	ground for core logic

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SYMBOL	PIN	INPUT/OUTPUT[1]	I_{max} (mA)	DESCRIPTION
V_{DDCO}	80	supply	–	supply voltage for core logic
V_{SSCO}	81	ground	–	ground for core logic
V_{DDCO}	82	supply	–	supply voltage for core logic
V_{SSCO}	83	ground	–	ground for core logic
YUV4	84	input	–	video input signal bit 4
YUV5	85	input	–	video input signal bit 5
YUV6	86	input	–	video input signal bit 6
YUV7	87	input	–	video input signal bit 7 (MSB)
V_{DD}	88	supply	–	supply voltage for pad ring
FID	89	input	–	odd/even field identification
HSYNC	90	input	–	horizontal reference signal
VSYNC	91	input	–	vertical reference signal
V_{SS}	92	ground	–	ground for pad ring
VCLK	93	input	–	video clock input (27 MHz)
V_{DD}	94	supply	–	supply voltage for pad ring
V_{SS}	95	ground	–	ground for pad ring
RESETN	96	input	–	hard reset input (active LOW)
MAD	97	input	–	module address (I²C-bus)
SDA	98	input/open-drain output	6	serial data input/output (I²C-bus)
SCL	99	input/open-drain output	–	serial clock input (I²C-bus)
V_{DD}	100	supply	–	supply voltage for pad ring
MEM_ST	101	output/3-state	3	do not use in the application (reserved)
FAD_RWN	102	input	–	ASIP port data read/write
FAD_EN	103	input	–	ASIP port data enable
FAD_RDYN	104	open-drain output	3	ASIP port data ready (active LOW)
V_{SS}	105	ground	–	ground for pad ring
GPIO0	106	input/output	3	ASIP port data bit 0 (LSB)
GPIO1	107	input/output	3	ASIP port data bit 1
GPIO2	108	input/output	3	ASIP port data bit 2; note 2
GPIO3	109	input/output	3	ASIP port data bit 3; note 2
V_{DD}	110	supply	–	supply voltage for pad ring
GPIO4	111	input/output	3	ASIP port data bit 4; note 2
GPIO5	112	input/output	3	ASIP port data bit 5; note 2
GPIO6	113	input/output	3	ASIP port data bit 6; note 2
GPIO7	114	input/output	3	ASIP port data bit 7; note 2
V_{SS}	115	ground	–	ground for pad ring
GPIO8	116	input/output	3	ASIP port data bit 8; note 2
GPIO9	117	input/output	3	ASIP port data bit 9; note 2
GPIO10	118	input/output	3	ASIP port data bit 10; note 2
GPIO11	119	input/output	3	ASIP port data bit 11 (MSB); note 2

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SYMBOL	PIN	INPUT/OUTPUT[1]	I_{max} (mA)	DESCRIPTION
V_{DD}	120	supply	–	supply voltage for pad ring
LRQN	121	open-drain output	3	output port lower watermark interrupt request (active LOW)
URQN	122	open-drain output	3	output port upper watermark interrupt request (active LOW)
DTACK_RDY	123	open-drain output	3	output port data transfer acknowledge/ready/request
I_MN	124	input	–	output port reserved mode/Motorola bus style selection input (active LOW); with internal pull-up resistor
CSN	125	input	–	output port chip select for external address mode (active LOW); with internal pull-up resistor
V_{DDCO}	126	supply	–	supply voltage for core logic
V_{SSCO}	127	ground	–	ground for core logic
V_{DDCO}	128	supply	–	supply voltage for core logic
V_{SSCO}	129	ground	–	ground for core logic
V_{DDCO}	130	supply	–	supply voltage for core logic
V_{SSCO}	131	ground	–	ground for core logic
V_{DDCO}	132	supply	–	supply voltage for core logic
V_{SSCO}	133	ground	–	ground for core logic
V_{DDCO}	134	supply	–	supply voltage for core logic
AS_ALE	135	input	–	output port address strobe/address latch enable
DS_RDN	136	input	–	output port data strobe/$\overline{read}$
V_{SS}	137	ground	–	ground for pad ring
AD15	138	input/output	3	output port multiplexed address/data line bit 15 (MSB)
AD14	139	input/output	3	output port multiplexed address/data line bit 14
AD13	140	input/output	3	output port multiplexed address/data line bit 13
AD12	141	input/output	3	output port multiplexed address/data line bit 12
V_{DD}	142	supply	–	supply voltage for pad ring
AD11	143	input/output	3	output port multiplexed address/data line bit 11
AD10	144	input/output	3	output port multiplexed address/data line bit 10
AD9	145	input/output	3	output port multiplexed address/data line bit 9
AD8	146	input/output	3	output port multiplexed address/data line bit 8
V_{SS}	147	ground	–	ground for pad ring
AD7	148	input/output	3	output port multiplexed address/data line bit 7/data bus bit 7 (MSB)
AD6	149	input/output	3	output port multiplexed address/data line bit 6/data bus bit 6
AD5	150	input/output	3	output port multiplexed address/data line bit 5/data bus bit 5
AD4	151	input/output	3	output port multiplexed address/data line bit 4/data bus bit 4
V_{DD}	152	supply	–	supply voltage for pad ring
AD3	153	input/output	3	output port multiplexed address/data line bit 3/data bus bit 3
AD2	154	input/output	3	output port multiplexed address/data line bit 2/data bus bit 2
AD1	155	input/output	3	output port multiplexed address/data line bit 1/data bus bit 1
AD0	156	input/output	3	output port multiplexed address/data line bit 0 (LSB)/data bus bit 0 (LSB)

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SYMBOL	PIN	INPUT/OUTPUT[1]	I_{max} (mA)	DESCRIPTION
V_{SS}	157	ground	–	ground for pad ring
TDO	158	output	3	boundary scan test data output; pin not active during normal operating; with 3-state output; note 3
TRST	159	input	–	boundary scan test reset; pin must be set to LOW for normal operating; with internal pull-up resistor; notes 3 and 4
TCK	160	input	–	boundary scan test clock; pin must be set to LOW during normal operating; with internal pull-up resistor; note 3
TMS	161	input	–	boundary scan test mode select; pin must float or set to HIGH during normal operating; with internal pull-up resistor; note 3
V_{DDCO}	162	supply	–	supply voltage for core logic
TDI	163	input	–	boundary scan test data input; pin must float or set to HIGH during normal operating; with internal pull-up resistor; note 3
CS_TEST	164	input	–	test mode for the internal RAMs; pin must be set to LOW during normal operating
TEST	165	input	–	test mode; pin must be set to LOW during normal operating
V_{DD}	166	supply	–	supply voltage for pad ring
DATA0	167	input/output	3	DRAM data interface bit 0 (LSB)
DATA1	168	input/output	3	DRAM data interface bit 1
DATA2	169	input/output	3	DRAM data interface bit 2
DATA3	170	input/output	3	DRAM data interface bit 3
V_{SS}	171	ground	–	ground for pad ring
DATA4	172	input/output	3	DRAM data interface bit 4
DATA5	173	input/output	3	DRAM data interface bit 5
DATA6	174	input/output	3	DRAM data interface bit 6
DATA7	175	input/output	3	DRAM data interface bit 7
V_{DD}	176	supply	–	supply voltage for pad ring
V_{SSCO}	177	ground	–	ground for core logic
V_{DDCO}	178	supply	–	supply voltage for core logic
V_{SSCO}	179	ground	–	ground for core logic
V_{DDCO}	180	supply	–	supply voltage for core logic
V_{SSCO}	181	ground	–	ground for core logic
V_{DDCO}	182	supply	–	supply voltage for core logic
V_{SSCO}	183	ground	–	ground for core logic
n.c.	184	–	–	reserved pin; do not connect
DATA8	185	input/output	3	DRAM data interface bit 8
DATA9	186	input/output	3	DRAM data interface bit 9
DATA10	187	input/output	3	DRAM data interface bit 10
DATA11	188	input/output	3	DRAM data interface bit 11
V_{SS}	189	ground	–	ground for pad ring
DATA12	190	input/output	3	DRAM data interface bit 12
DATA13	191	input/output	3	DRAM data interface bit 13

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SYMBOL	PIN	INPUT/OUTPUT[1]	I_{max} (mA)	DESCRIPTION
DATA14	192	input/output	3	DRAM data interface bit 14
DATA15	193	input/output	3	DRAM data interface bit 15
V_{DD}	194	supply	–	supply voltage for pad ring
DATA16	195	input/output	3	DRAM data interface bit 16
DATA17	196	input/output	3	DRAM data interface bit 17
DATA18	197	input/output	3	DRAM data interface bit 18
DATA19	198	input/output	3	DRAM data interface bit 19
V_{SS}	199	ground	–	ground for pad ring
DATA20	200	input/output	3	DRAM data interface bit 20
DATA21	201	input/output	3	DRAM data interface bit 21
DATA22	202	input/output	3	DRAM data interface bit 22
DATA23	203	input/output	3	DRAM data interface bit 23
V_{DD}	204	supply	–	supply voltage for pad ring
DATA24	205	input/output	3	DRAM data interface bit 24
DATA25	206	input/output	3	DRAM data interface bit 25
DATA26	207	input/output	3	DRAM data interface bit 26
DATA27	208	input/output	3	DRAM data interface bit 27

Notes

1. All input pins, input/output pins (in input mode), output pins (in 3-state mode) and open-drain output pins are 5.0 V tolerant.

2. This pin is recommended to be set to ground or to the supply voltage V_{DD} via a resistor.

3. In accordance with the *"IEEE 1149.1"* standard.

4. Special function of pin TRST:

    a) For board designs without boundary scan implementation, pin TRST must be connected to ground.

    b) Pin TRST provides easy initialization of the internal BST circuit. By applying a LOW it can be used to force the internal Test Access Port (TAP) controller to the Test-Logic-Reset state (normal operating) at once.

The 208 pins are divided in following groups:

Video input port (11 pins):

8 data pins and 3 control pins.

Data output port (23 pins):

16 data pins and 7 control pins.

GPIO port (15 pins):

12 data pins and 3 control pins.

DRAM (77 pins):

  64 data pins

  9 address pins

  4 control pins.

Others (14 pins):

  1 video clock input pin

  3 pins related to the I2C-bus

  1 pin for reset control

  7 pins for test purposes

  1 pin not connected

  1 pin for internal test purposes.

Supply (68 pins):

  16 core supply pins

  18 I/O cell supply pins

  16 core ground pins

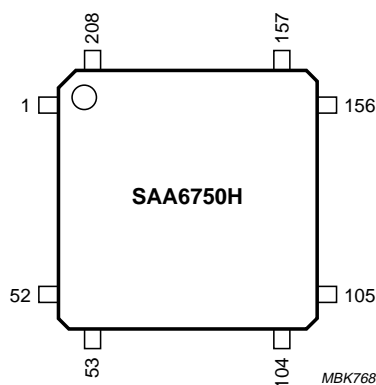 18 I/O cell ground pins.

Fig.2 Pin configuration.

7 FUNCTIONAL DESCRIPTION

7.1 Global architecture description

7.1.1 GENERAL

The SAA6750H has a multi-processor architecture.
The different processing and control modules are not
locked to each other but run independently within the limits
of the global scheduling. The data transfer between the
processing units is carried out via FIFO memories or the
external DRAM (see Fig.1).

The set of functions of the SAA6750H is determined to
a high extent by the microcode of the internal Application
Specific Instruction-set Processor (ASIP). Detailed
information is given in the software specification.

Global settings and selection of the operating modes are
carried out via the I²C-bus (see Sections 7.2 and 7.9).

7.1.2 ARCHITECTURE STRUCTURE

The architecture consist of a data processing, a control
and a memory part.

7.1.2.1 Data processing part

The data processing flow can be split-up as follows:

Line based processing:

Video front-end and formatter (see Section 7.3) including:

1. 4 : 2 : 2 to 4 : 2 : 0 pre-filter

2. Optional SIF subsampling.

The video front-end processes the incoming video data
and writes it to the external DRAM.

Macroblock based processing:

MacroBlock Processor (MBP) (see Section 7.4) including:

1. Discrete Cosine Transformation/Inverse Discrete
    Cosine Transformation (DCT/IDCT)

2. Variable Length Encoding/Run Length Encoding
    (VLE/RLE)

3. Motion Estimation/Motion Compensation (ME/MC)

4. Motion Compensation Noise Reduction (MCNR)

5. Quantization/Inverse Quantization (Q/IQ)

6. Frame/Field (FF) reshuffling and ZigZag (ZZ) scan.

The MBP gets the pre-processed video data from the
external DRAM and performs the data compression.

Bitstream based processing:

Bitstream assembly (see Section 7.5) (Pre-packer, Packer, Stuffing unit and output buffer) and Data output port (see Section 7.6).

The bitstream processing part gets the compressed data from the MBP and the header information from the control part. It provides an MPEG2 compliant Elementary Stream (ES) at the output.

7.1.2.2   Control part

The control part consists of three modules:

1. Application Specific Instruction-set Processor (ASIP) (see Section 7.7): controls the MBP, generates motion vectors, headers and stuffing information

2. The global controller (see Section 7.8): generates the global scheduling information for the MBP, the DRAM interface and the ASIP

3. The I²C-bus interface and controller (see Section 7.9): download of ASIP microcode, tables and constants as well as MBP quantizer table, used for external control settings, allows communication between ASIP and application environment.

7.1.2.3   Memory part

The control and data processing modules exchange data via internal FIFOs and the external DRAM:

1. DRAM interface (see Section 7.10); provides access to the external DRAM memory

2. FIFO memories (see Section 7.11); a number of FIFOs of different size is used to connect internal processing units.

7.2   Start-up and operating modes

7.2.1   START-UP REQUIREMENTS

Simultaneously with power-on, the SAA6750H requires a LOW level at pin RESETN. This external reset has to be kept active until the external video clock signal VCLK has been running stable within the specified limits for at least 10 clock cycles (see Chapter "Quick reference data"). A suitable combination of RESETN and clock signal is e.g. provided by Philips product family SAA7111A. For proper reset behaviour and operation pin TRST has to be LOW.

After power-on and the related internal reset the initialization via the I²C-bus has to be carried out (see Section 7.9.5). It should be noted that a delay of at least 0.5 ms between the end of RESETN LOW state and start of the I²C-bus initialization sequence is required. See Table 1 for information about the operating modes.

7.2.2   RESET PROCESSING

The SAA6750H has internally an asynchronous and a synchronous reset processing.

The asynchronous reset is directly derived from the external reset signal RESETN and gets active as soon as RESETN becomes LOW. It is not depending on the external clock signal. The asynchronous reset forces the SAA6750H into reset mode which does directly affect the behaviour of the output and I/O pins (see Table 2). This does guarantee a defined state of the pins even if no clock signal is available. In addition it initiates the internal synchronous reset which gets active as soon as the VCLK signal is available.

The internal synchronous reset is controlled by RESETN and the settings of control bits E_ST and E_SP. For proper operating the external clock signal VCLK has to be stable within the specified limits.

The internal synchronous reset gets active if RESETN is LOW or by setting the control bits E_ST and E_SP to soft reset mode (see Table 1). It does affect all internal modules except the I²C-bus controller and therefore also the output and I/O pins (see Table 2). In addition, but only if combined with an external reset RESETN, it does reset the I²C-bus control register. It does not affect the contents of the embedded microcode and constant memories (see Section 7.9.4).

See Table 2 for detailed information about the impact of external and internal reset signals as well as control bit settings on the behaviour of internal modules and output pins.

After release of the external reset or setting back bits E_ST and E_SP to operating mode, the internal synchronous reset remains active for 7562 clock cycles (approximately 260 µs). During this time the DRAM initialization sequence is carried out (see Section 7.10.3.2). All other internal modules except the I²C-bus control register stay in reset mode for this time. The external DRAM will not be refreshed during internal synchronous reset.

7.2.3 DESCRIPTION OF OPERATING MODES

Depending on the reset processing and the setting of the I^{2}C-bus control bits E_ST and E_SP (see Tables 22 and 23) the SAA6750H can be set to different operating modes. Purpose and behaviour are described in Table 1.

After an external reset pulse at RESETN, the init mode will be active because control bits E_ST and E_SP are set to LOW.

7.2.4 PIN BEHAVIOUR

The behaviour of I/O and output pins is depending on the operation mode of the SAA6750H. In reset mode the pins are forced to a certain behaviour even if no clock VCLK is available. Reset mode overrules all other internal pin settings. During soft reset mode all output and I/O pins that could create driver conflicts with other devices are forced to 3-state or input mode. The internal reset is active during a period of 7562 clock cycles after reset mode and soft reset mode. The status of pins is determined by the reset behaviour of the internal modules. The internal reset behaviour applies also for the init mode because init mode always follows internal reset.

In operation mode the status of the pins is depending on the function of the SAA6750H.

Table 1 SAA6750H operating modes

MODE	ACTIVATED BY			DESCRIPTION
	RESETN	E_ST	E_SP	
Reset mode	0	X	X	In reset mode all I/O and output pins are forced to a defined state with RESETN = LOW (refer to Table 2). After VCLK is available, also the internal reset becomes active, which puts the internal modules in reset state. The I^{2}C-bus control register is cleared in this mode. After setting RESETN back to HIGH, the internal reset will remain active for 7562 clock cycles. The DRAM initialization sequence will run during this time (see Section 7.10.3.2).
Init mode	1	0	0	In init mode the device initialization via the I^{2}C-bus has to be performed. The external DRAM is not refreshed. See Table 2 for behaviour of pins during init mode. This mode will be active after external reset due to reset of E_ST and E_SP. Remark: Do not switch from operating mode to init mode directly. Always use the soft reset or reset mode as intermediate step.
Soft reset mode	1	0	1	Activates the internal synchronous reset. All internal modules except the I^{2}C-bus control register are in reset mode. This mode allows e.g. operation of a second device SAA6750H. Therefore output and I/O pins are in input or 3-state mode (see Table 2). The external DRAM will not be refreshed. After setting E_SP back to LOW, the internal reset will remain active for 7562 clock cycles. The DRAM initialization sequence will run during this time (see Section 7.10.3.2).
Operating mode	1	1	0	Normal operating.
–	1	1	1	Internal use only.

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Table 2 Behaviour of output and I/O pins

PIN NAME	DESCRIPTION	PIN STATUS		
		RESET MODE	INIT MODE AND INTERNAL RESET	SOFT RESET MODE
DATA0 to DATA63	DRAM data input/output	input	input	input
ADR0 to ADR8	DRAM address output	3-state	output	3-state
CASN	DRAM column address strobe output	3-state	output	3-state
RASN	DRAM row address strobe output	3-state	output	3-state
WEN	DRAM write enable output	3-state	output	3-state
OEN	DRAM chip select output	3-state	output	3-state
SDA	I^2C-bus data input/open-drain output	input	normal operating	normal operating
SCL	I^2C-bus clock input/output	input	normal operating	normal operating
MEM_ST	reserved output	3-state	output	3-state
FAD_RDYN	ASIP data port; data ready output	open-drain; note 1	open-drain	open-drain
GPIO0 to GPIO11	ASIP data port; input/output	input	input	input
LRQN	output port lower watermark interrupt request	open-drain	on	open-drain
URQN	output port upper watermark interrupt request	open-drain	on	open-drain
DTACK_RDY	output port data transfer acknowledge/ready/request	open-drain	on	open-drain
AD0 to AD15	output port address/data input/output	input	input	input

Note

1. Only defined if external clock is available.

7.3 Video front-end and formatter

7.3.1 GENERAL

The video front-end and formatter module consists of an 8-bit data input interface, a formatter sub-module and a luminance and a chrominance address processing unit. The interface is designed for use with Philips SAA7111 video decoder family or similar products. The input interface accepts a digital video input stream according to *"ITU-T 601"*. PAL standard at 50 Hz and 720 pixels by 576 lines as well as NTSC at 60 Hz and 720 pixels by 480 lines are covered. The video synchronization may either follow *"ITU-T 656"* recommendation or can also be supplied by external signals (HSYNC, VSYNC and FID). The formatter module performs a colour conversion from 4 : 2 : 2 to 4 : 2 : 0 format. Optionally, also an SIF down-scaling may be activated for PAL as well as NTSC standard signals. The luminance and chrominance processing units do generate the addresses for storing the front-end output data in the external DRAM memory.

7.3.2 DATA INPUT FORMAT

The 8-bit video input data has to be transferred at a rate of 27 Mwords/s (13.5 MHz for luminance and 6.25 MHz for both chrominance components) i.e. one data word per clock cycle has to be sent. The elements of a data stream have the following order: C_B, Y, C_R, Y, C_B, Y, C_R, Y, etc. The byte combinations 00H and FFH are reserved for synchronization purposes, so that only a subset of 254 of all possible $2^8 = 256$ combinations are used. See Section 7.3.3 for detailed information about the synchronization signals.

The external reference clock VCLK has to be synchronized to the video input data.

7.3.3   FUNCTIONAL DESCRIPTION

7.3.3.1   *General*

The video front-end and formatter module consists of four submodules:

1. The 8-bit data interface and the related control signals connect the SAA6750H to external data sources such as e.g. Philips SAA711x product family

2. The formatter submodule covers two main functions: the processing of the synchronization information (sync processing) and the processing of the picture contents (line based processing)

3. The luminance and chrominance submodules generate the addresses in the external DRAM memory where the output data of the video front-end and formatter module is stored.

The video front-end and formatter module offers various operating modes. The appropriate setting can be selected in the I^{2}C-bus control register (see Tables 3 and 22).

It should be noted that changes of video standard or synchronization settings are only allowed in init mode or soft reset mode. See Section 7.2.3 for information of the operating modes.

Table 3   Video front-end and formatter mode selection

CONTROL BITS[1]			MODE	FUNCTION
STD	SS	SMOD		
0	0	X	NTSC	NTSC input signal processing (60 Hz and 720 pixels by 480 lines)
1	0	X	PAL	PAL input signal processing (50 Hz and 720 pixels by 576 lines)
0	1	X	NTSC-SIF	NTSC input signal processing (60 Hz and 720 pixels by 480 lines); SIF down-scaling active
1	1	X	PAL-SIF	PAL input signal processing (50 Hz and 720 pixels by 576 lines); SIF down-scaling active
X	X	0	ITU-T 656	ITU-T 656 mode sync processing mode; sync information is embedded in the video data input stream
X	X	1	external sync	external sync processing mode; sync information is provided via pins FID, HSYNC and VSYNC

Note

1. X = don't care.

7.3.3.2   Interface definition

The data input interface uses in total 11 pins. Pins YUV0 to YUV7 carry video and synchronization data and 3 pins are reserved for control purposes (see Table 4).

Table 4   List of pins data input port

PIN NAME	PIN TYPE	DESCRIPTION
YUV0 to YUV7	input	video input signal (synchronous to VCLK)
FID	input	odd/even field identification signal; note 1
HSYNC	input	horizontal synchronization signal; note 1
VSYNC	input	vertical synchronization signal; note 1

Note

1.   In ITU-T 656 mode sync signals are embedded in the video data input stream. The external sync signals are not used.

7.3.3.3   Line based processing

The line based processing works the same way for PAL and NTSC signals.

Each of the three components of the video signals Y, U and V are filtered horizontally. The filter is symmetrical and has seven taps. The seven taps are weighted with three programmable parameters a1, a2 and a3 as shown in Table 5.

Table 5   Horizontal filtering

TAP	−3	−2	−1	0	+1	+2	+3
Horizontal filtering f(a1, a2 and a3)	a3	a2	a1	$1 - 2(a1 + a2 + a3)$	a1	a2	a3

The three parameters must be loaded by setting the I^{2}C-bus control register words A1, A2 and A3. The valid range is 0 to 255. Reset state is 0.

To convert the video signal from 4 : 2 : 2 to 4 : 2 : 0 format, vertical filtering and subsampling of the chrominance components has to be performed. The vertical filter has six taps. The filter coefficients are given in Table 6.

Table 6   Vertical filtering

TAP	1	2	3	4	5	6
Vertical filtering top fields	−3	+13	+30	+24	+4	−4
Vertical filtering bottom fields	−4	+4	+24	+30	+13	−3

As mentioned, optionally an SIF mode conversion of PAL or NTSC standard input signals may be activated by setting the I^{2}C-bus control bit SS (see Tables 3 and 22). To convert the video signal to SIF resolution the bottom fields are discarded. Furthermore, all components of the video signal are horizontally subsampled by factor two.

7.3.3.4   Sync processing

Because the synchronization information may be delivered by a video data source in two different ways, the internal sync processing of the SAA6750H is carried out in two related modes:

1. The ITU-T 656 mode:

    The ITU-T 656 recommendation describes the unidirectional interconnection between a video data source and a video data sink. Luminance and chrominance data as well as the complete set of control data (V-sync, H-sync, field indication or byte information such as SAV, EAV, etc.) are transferred interleaved on one 8-bit bus. Both, sync and data signal, are in the form of binary coded 8-bit words. The external sync signals HSYNC, VSYNC and FID are not used.

2. The external sync mode:

    The synchronization may also be provided via pins HSYNC, VSYNC and FID. In this case, the 8-bit bus carries only the video data information.

The internal sync processing mode may be selected by the I^2C-bus control bit SMOD (see Tables 3 and 22).

Sync signals must be active at regular time intervals. If a time interval is too short, a sync is skipped. Top and bottom fields must follow each other. If two top fields or two bottom fields follow each other immediately, than the second field is skipped.

The number of clock cycles and H-sync signals that have to occur before processing starts (horizontal and vertical shift) can be set via the I^2C-bus. In this way the active part of the video can be determined. The vertical shift can be specified independently for top and bottom fields by using the control words 'Vertical shift top field' and 'Vertical shift bottom field' (see Table 22). The horizontal shift is controlled by control word 'Horizontal shift'. The shift can be programmed in a range of 127 clock cycles in horizontal direction respectively 127 lines in vertical direction. Horizontal shift should be carried out in steps of a multiple of 4 because a minimum data sequence (C_B, Y, C_R and Y) needs 4 clock cycles. It should be noted that the horizontal blanking in PAL mode takes 280 clock cycles and in NTSC mode 268 cycles.

Due to the fact that the horizontal offset value can not compensate the whole blanking interval, the polarity of the three external sync lines (H-SYNC, V-SYNC and FID) can also be adapted via the I^2C-bus. Control bits HREFP, VREFP and FIDP are used for this purpose (see Table 22).

Internally, the edge-detection circuitries for these signals change polarity with these settings. By this way different synchronization schemes are supported. The horizontal respectively vertical processing starts with the selected edge.

Due to requirements from the internal vertical filtering the line based processing needs 3 horizontal sync pulses during vertical blanking which have to follow directly the active part of the frame (e.g. 288 active lines in PAL mode). The related line data is not processed. This restriction does not allow edge selection at the end of the previous field [e.g. vertical sync of line 623 or line 1 (see Fig.3)]. In this case the polarity bit VREFP has to be set to select the falling edge of the sync lines.

The following sections contain descriptions of different styles of synchronization signals and how they are handled in the SAA6750H.
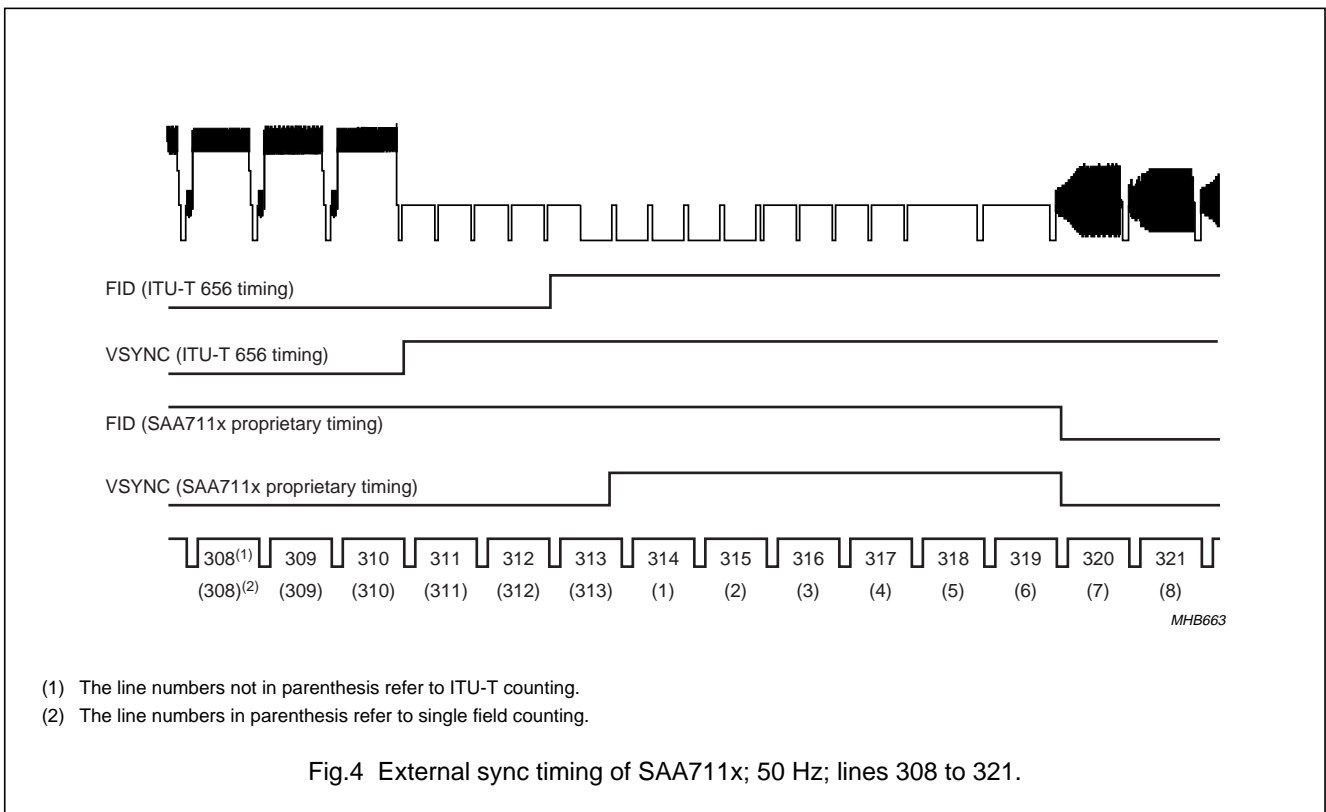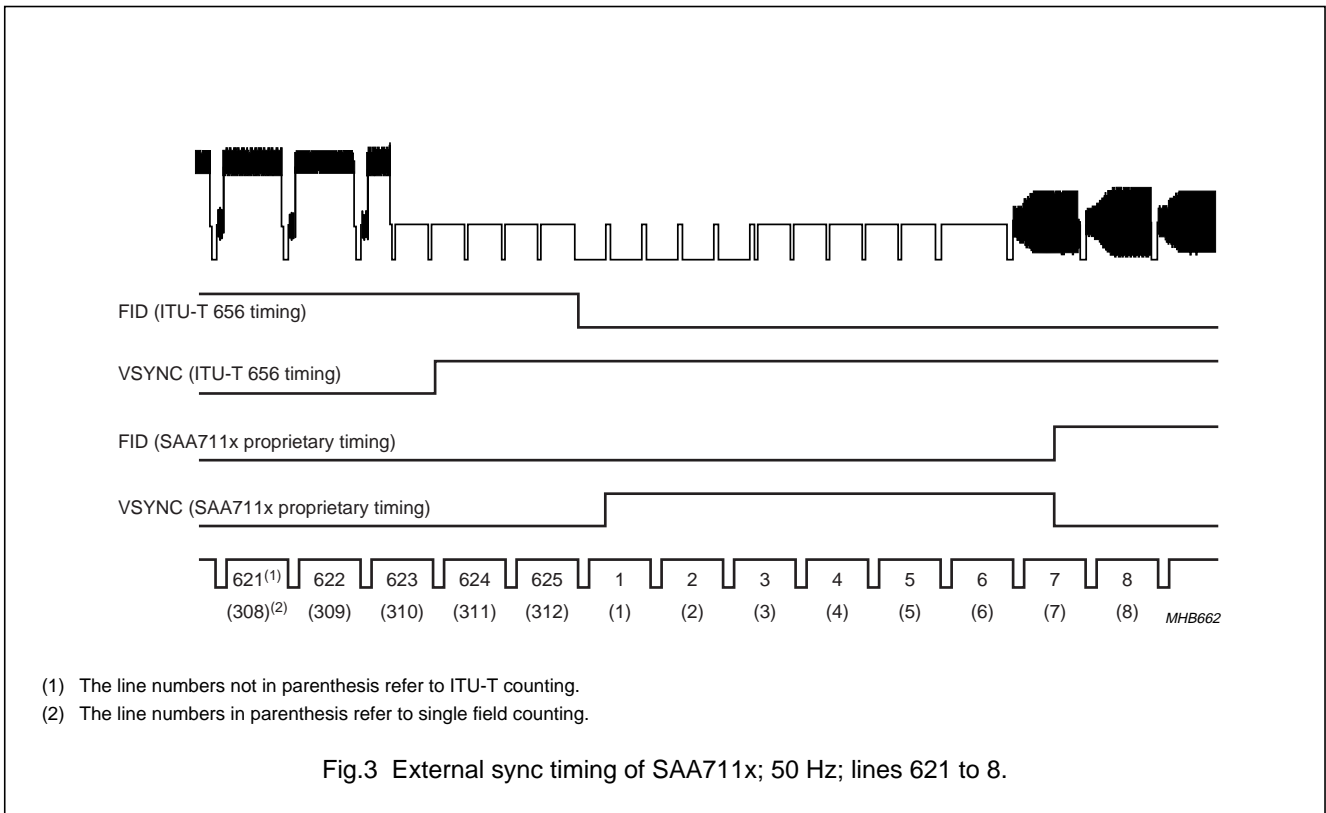
7.3.3.5   Sync processing PAL (50 Hz)

The PAL (50 Hz) input signal has 625 lines per frame and typically takes 1728 clock cycles per line. The minimum number of clock cycles per line is 1706. The active part of a field consists of 288 lines of 720 pixels (see Fig.7).

Figures 3 and 4 and the related Table 7 give an example illustrating how different sources providing different external sync signals can be adapted to the SAA6750H. In the given example, the SAA711x is connected to pins HSYNC, VSYNC and FID and provides external sync signals in two different modes: according to the timing convention of the ITU-T 656 mode and in a SAA711x proprietary format. In addition another mode HREF/VREF is mentioned in Table 7. From a timing point of view the HREF/VREF mode behaves like ITU-T 656, but horizontal sync and vertical sync signals (VSYNC) are inverted. See data sheet SAA7111A for detailed information.

As mentioned, in addition to the external sync mode, the ITU-T 656 mode is supported. Sections 7.3.3.7, 7.3.3.8 and Figs 7 and 8 contain detailed information on this sync mode.

(1) The line numbers not in parenthesis refer to ITU-T counting.

(2) The line numbers in parenthesis refer to single field counting.

Fig.3 External sync timing of SAA711x; 50 Hz; lines 621 to 8.

(1) The line numbers not in parenthesis refer to ITU-T counting.

(2) The line numbers in parenthesis refer to single field counting.

Fig.4 External sync timing of SAA711x; 50 Hz; lines 308 to 321.

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Table 7 PAL mode programming example for different sync modes and timing schemes

PAL SYNC MODE AND TIMING	CONTROL BIT AND CONTROL WORD SETTINGS[1]						
	SMOD	FIDP	VREFP	HREFP	VERTICAL SHIFT TOP FIELD	VERTICAL SHIFT BOTTOM FIELD	HORIZONTAL SHIFT
ITU-T 656 mode	0	0	0	0	0	0	0
External sync mode; VREF/HREF mode input signals; ITU-T 656 timing; note 2	1	0	0	0	0	0	0
External sync mode; ITU-T 656 timing; note 3	1	0	1	1	0	0	0
External sync mode; SAA711x proprietary timing; note 3	1	0	1	1	15	16	0

Notes

1. Changes of video standard or synchronization set-up settings are only allowed in init mode or soft reset mode. See Section 7.2.3 for information of the SAA6750H operating modes.

2. See the SAA711x documentation.

3. As illustrated in Figs 3 and 4.

7.3.3.6   Sync processing NTSC (60 Hz ≈ 59.94 Hz)

This NTSC (60 Hz) input signal has 525 lines per frame and typically takes 1716 clock cycles per line.
The minimum number of clock cycles per line is 1706.
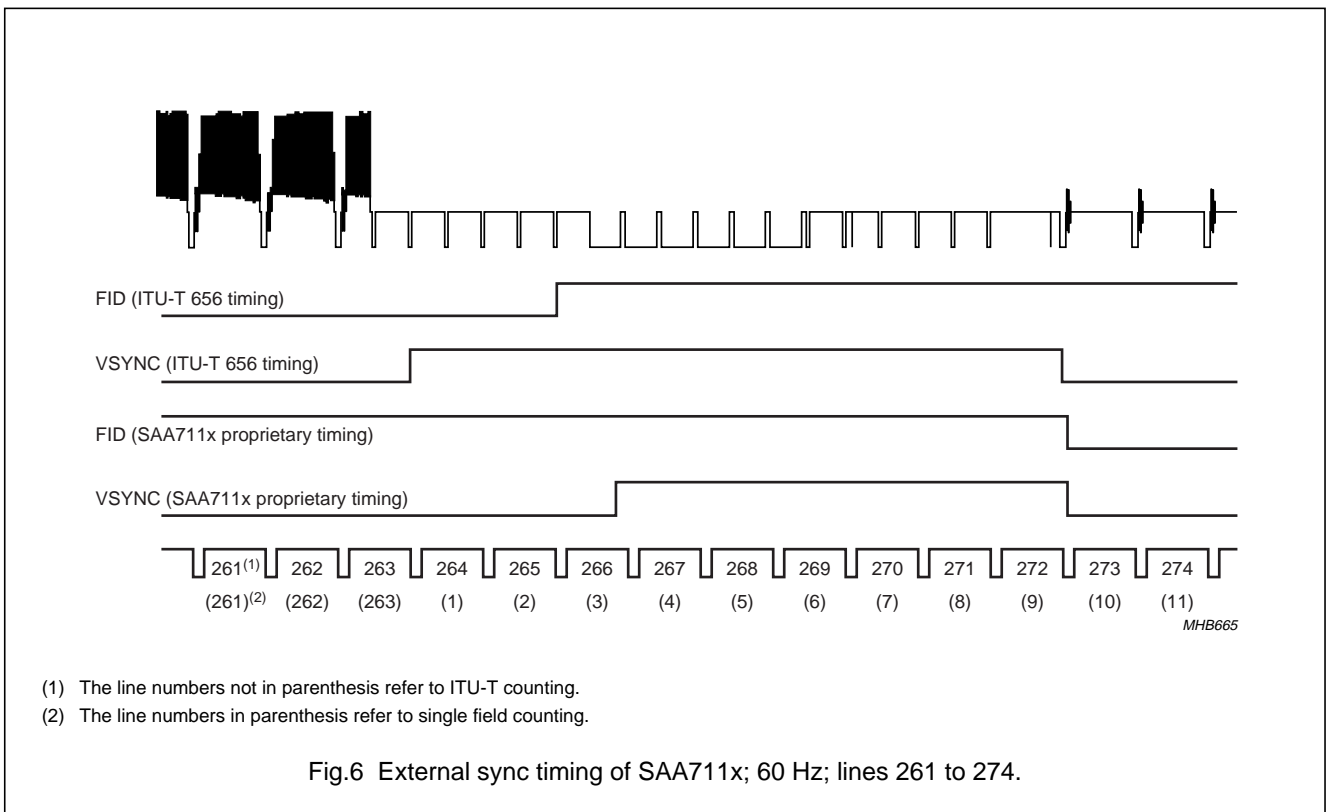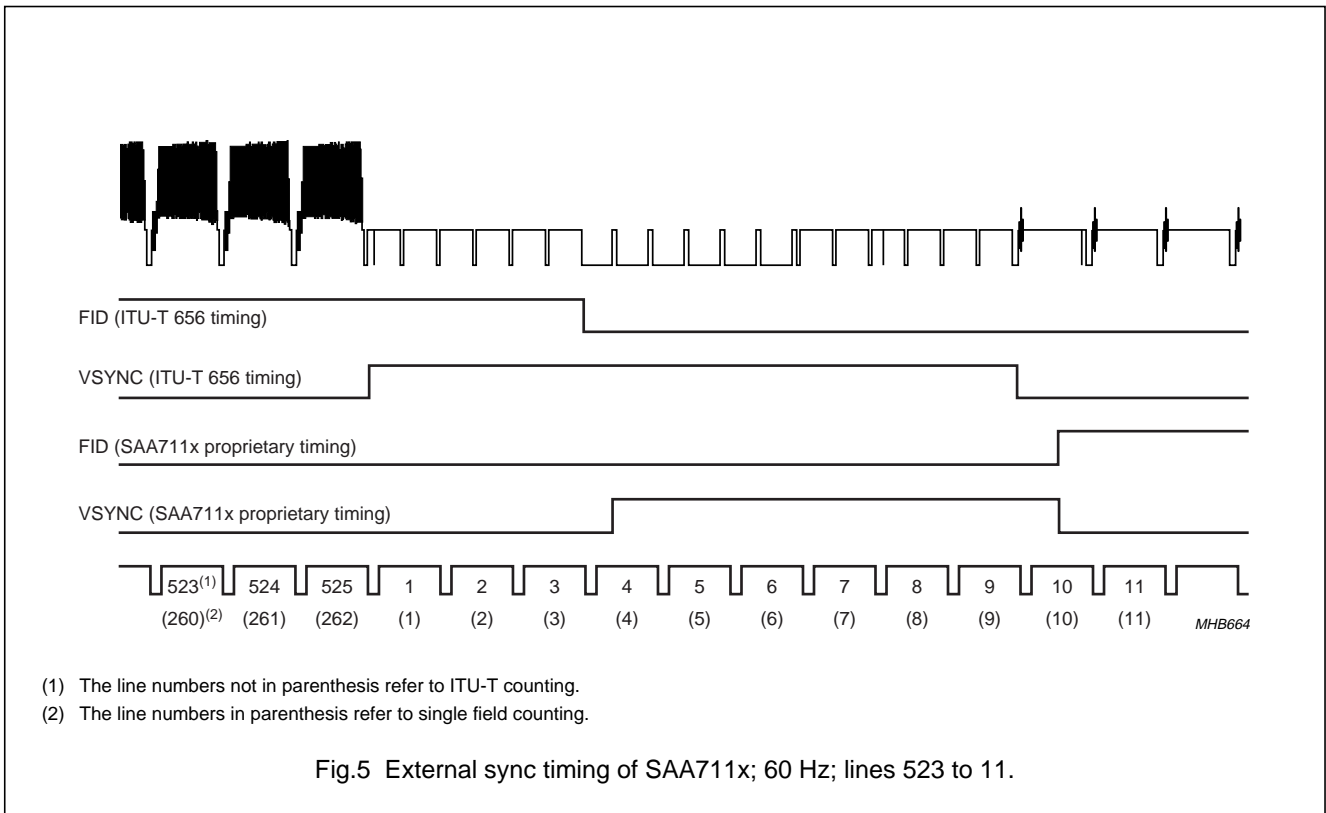The active part of a field consists of 240 lines of 720 pixels (see Fig.9).

Figures 5 and 6 and the related Table 8 give an example illustrating how different sources providing different external sync signals can be adapted to the SAA6750H. In the given example, the SAA711x is connected to pins HSYNC, VSYNC and FID of the SAA6750H and provides external sync signals in two different modes: according to the timing convention of the ITU-T 656 mode and in an SAA711x proprietary format.

In addition, another mode, HREF/VREF, is mentioned in Table 7. From timing point of view the HREF/VREF mode behaves like ITU-T 656, but signals horizontal sync and vertical sync (VSYNC) are inverted. See data sheet SAA7111A for detailed information.

As mentioned, in addition to the external sync mode, the ITU-T 656 mode is supported. Sections 7.3.3.7, 7.3.3.8 and Figs 9 and 10 contain detailed information on this sync mode.

(1) The line numbers not in parenthesis refer to ITU-T counting.

(2) The line numbers in parenthesis refer to single field counting.

Fig.5 External sync timing of SAA711x; 60 Hz; lines 523 to 11.

(1) The line numbers not in parenthesis refer to ITU-T counting.

(2) The line numbers in parenthesis refer to single field counting.

Fig.6 External sync timing of SAA711x; 60 Hz; lines 261 to 274.

Table 8 NTSC mode programming example for different sync modes and timing schemes

NTSC SYNC MODE AND TIMING	CONTROL BIT AND CONTROL WORD SETTINGS[1]						
	SMOD	FIDP	VREFP	HREFP	VERTICAL SHIFT TOP FIELD	VERTICAL SHIFT BOTTOM FIELD	HORIZONTAL SHIFT
ITU-T 656 mode	0	0	0	0	0	0	0
External sync mode; VREF/HREF mode input signals; ITU-T 656 timing; note 2	1	0	0	0	0	0	0
External sync mode; ITU-T 656 timing; note 3	1	0	1	1	0	0	0
External sync mode; SAA711x proprietary timing; note 3	1	0	1	1	9	10	0

Notes

1. Changes of video standard or synchronization set-up settings are only allowed in init mode or soft reset mode. See Section 7.2.3 for information of the SAA6750H operating modes.

2. See data sheet SAA711x documentation.

3. As illustrated in Figs 5 and 6.

7.3.3.7   Sync processing coding characteristics according to "ITU-T 656"

The video data and the control data H_sync, V_sync and field identification are interleaved as follows.
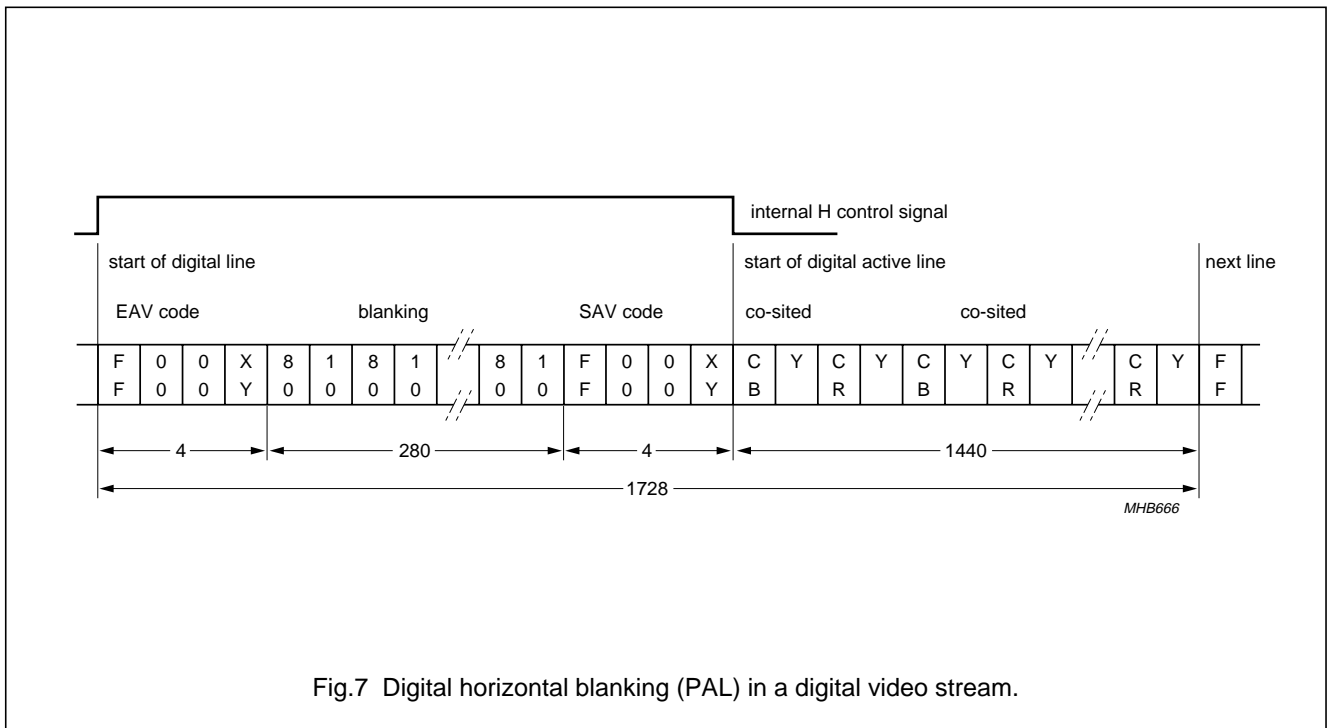

Fig.7 Digital horizontal blanking (PAL) in a digital video stream.

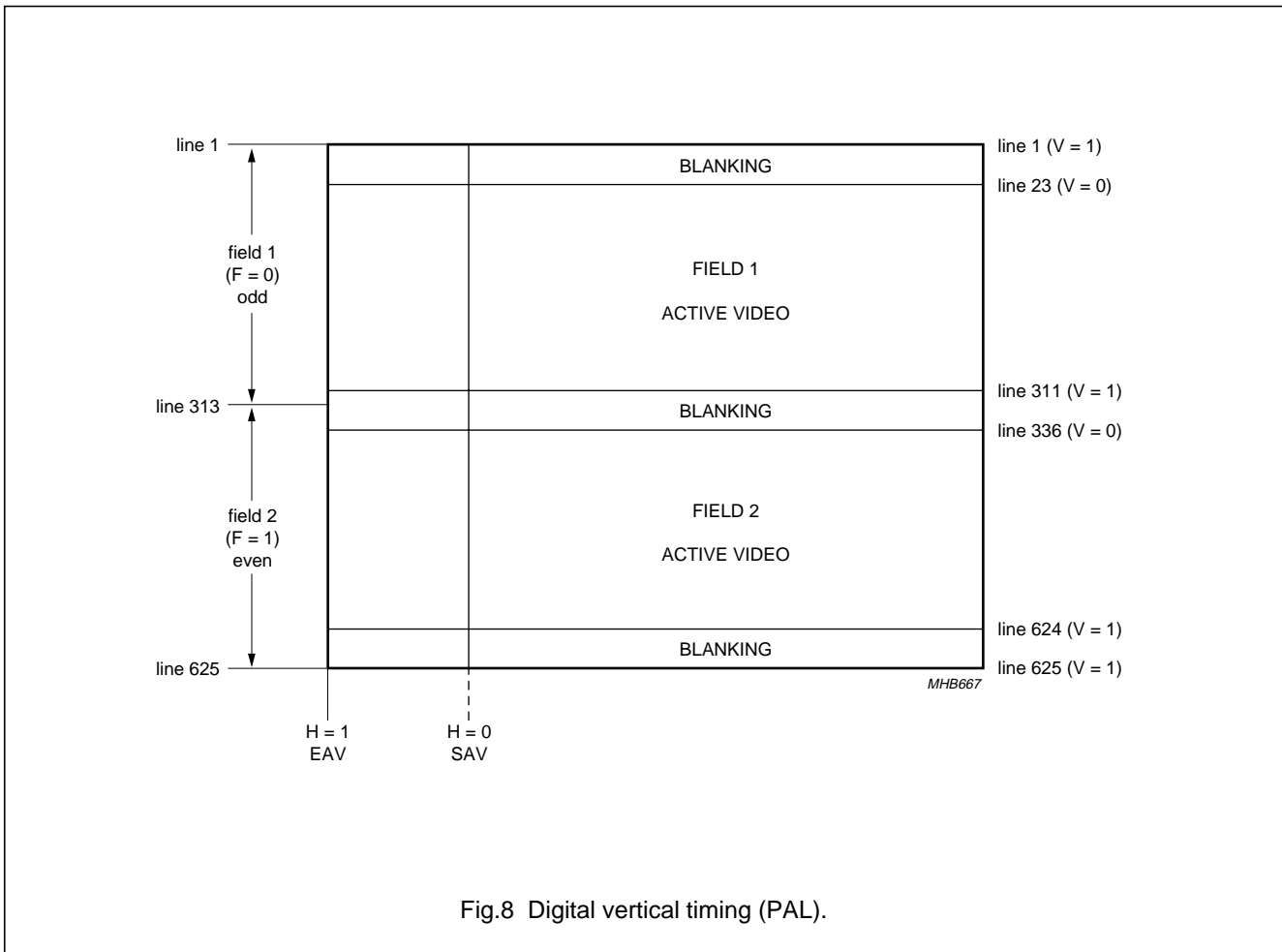## Encoder for MPEG2 image recording (EMPIRE)

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Fig.8 Digital vertical timing (PAL).

Table 9 Digital vertical timing (PAL)

LINE NUMBER	F	V	H (EAV)	H (SAV)
1 to 22	0	1	1	0
23 to 310	0	0	1	0
311 and 312	0	1	1	0
313 to 335	1	1	1	0
336 to 623	1	0	1	0
624 and 625	1	1	1	0

Encoder for MPEG2 image recording (EMPIRE)
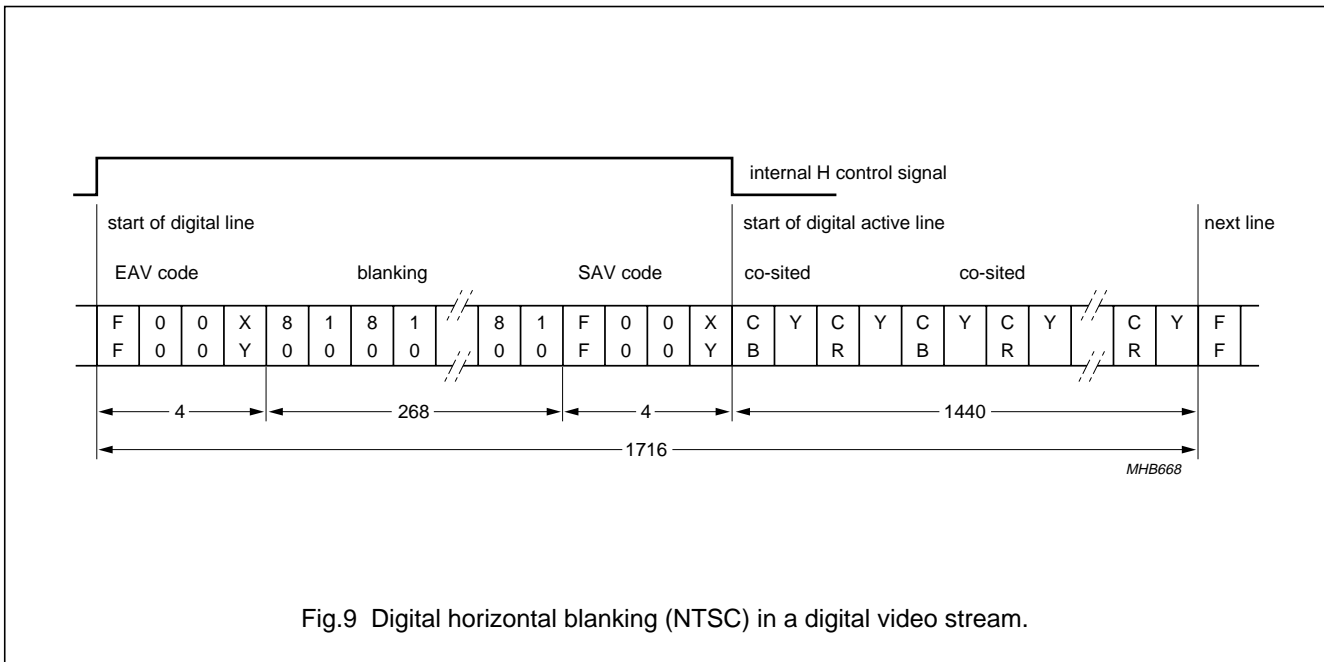
SAA6750H

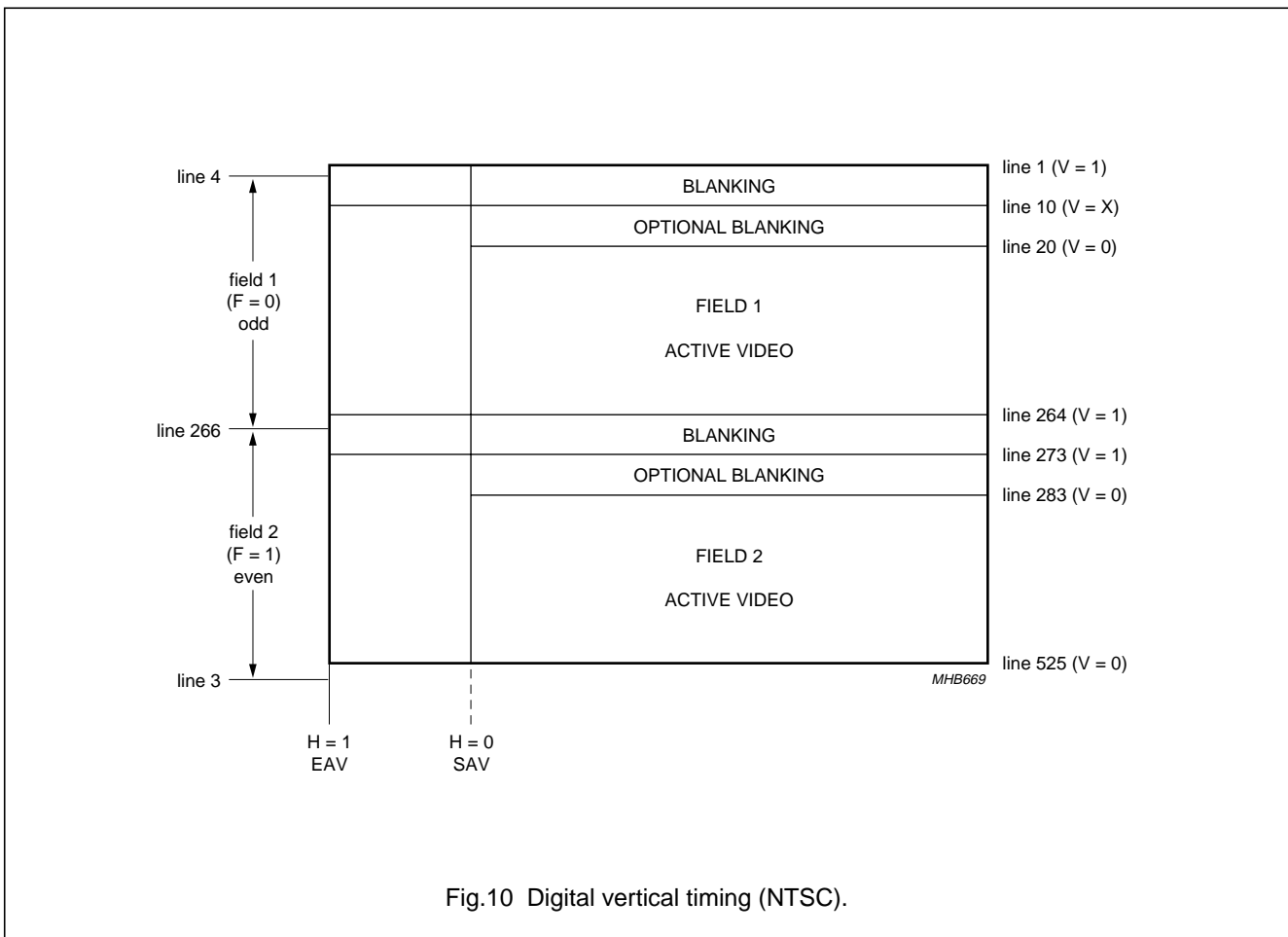Fig.9 Digital horizontal blanking (NTSC) in a digital video stream.

Fig.10 Digital vertical timing (NTSC).

Table 10 Digital vertical timing (NTSC)

LINE NUMBER	F	V	H (EAV)	H (SAV)
1 to 3	1	1	1	0
4 to 19	0	1	1	0
20 to 263	0	0	1	0
264 and 265	0	1	1	0
266 to 282	1	1	1	0
283 to 525	1	0	1	0

7.3.3.8   Video timing reference codes (ITU-T 656)

There are two timing reference signals, one at the beginning of each video data block (start of active video, SAV) and one at the end of each video data block (end of active video, EAV).

Each timing reference signal consists of a four word sequence in the following format: FF 00 00 XY (values are expressed in hexadecimal notation). The first three words are a fixed preamble. The forth word XY contains information defining field 2 identification, the state of field blanking, and the state of line blanking. The assignment of bits within the timing reference signal is shown in Table 11.

Table 11 Video timing reference codes

1	$F^{(1)}$	$V^{(2)}$	$H^{(3)}$	$P_3^{(4)}$	$P_2^{(4)}$	$P_1^{(4)}$	$P_0^{(4)}$

Notes

1. F = 0 during field 1; F = 1 during field 2.

2. V = 1 during field blanking; V = 0 elsewhere.

3. H = 0 in SAV; H = 1 in EAV.

4. Protection bits are ignored by SAA6750H data processing.

7.4   Macroblock processor

7.4.1   GENERAL

The MacroBlock Processor (MBP) performs the compression of macroblocks. It fetches its input data from the external DRAM memory where this was stored by the video front-end and formatter. The data processing is macroblock related. The processing start information and the global scheduling is provided by the global controller module.

The functionality of the MBP is controlled by the Application Specific Instruction-set Processor (ASIP). The ASIP does also perform some computing of data needed by the MBP. The compressed data is fed to the packer module.

7.4.2   FUNCTIONAL DESCRIPTION

7.4.2.1   General

The MBP performs source coding on macroblock level. It contains several items: motion estimation; motion compensation, noise reduction and frame field conversion; Discrete and Inverse Discrete Cosine Transformations (DCT and IDCT), quantization and inverse quantization; motion decompensation and frame-field conversion; zigzag scanning; DC trend removal (residue); Run-Length Encoding (RLE) and Variable-Length Encoding (VLE).

7.4.2.2   Motion estimation

The motion estimator considers frame based motion. Furthermore, the frame distance is one frame and, consequently, can only be used for P frames.

The motion estimation is based on the recursive block matching algorithm. Per macroblock the ASIP must feed the motion estimator with five candidate vectors. Depending on a control word, the last two vectors can be relative to the computed vector of the previous macroblock or can be absolute. The vectors are compared by the Minimum Absolute Difference (MAD) of the estimated macroblock in the previous frame and the current macroblock. The vector that leads to the smallest MAD is selected. The fifth vector gets a penalty and can be used as random vector candidate. The two coordinates of the selected vector and the corresponding MAD value are returned to the ASIP.

7.4.2.3   Noise filtering

The availability of the motion estimator makes motion compensated adaptive temporal filtering possible. The functioning of this filter can be programmed by two parameters. These parameters are provided by the ASIP.

The noise reduction may only be activated if control bit INTRA is set to logic 0 (see Table 22).

7.4.2.4 Intra/inter coded macroblock selection in P frames

The selection of intra or inter coded macroblock compression mode depends on a control byte from the ASIP or on the MAD value. A macroblock is coded intra, if the ASIP demands so or when the MAD resulting from the motion estimation is above a threshold value. This threshold value is provided by the ASIP. The resulting encoding mode is returned to the ASIP.

7.4.2.5 Field/frame DCT coded macroblock selection for luminance blocks

Depending on motion between the two fields comprising a frame, the four 8×8 pixel DCT luminance blocks of a macroblock are differently derived from the 16×16 pixels. The luminance pixels of a macroblock are vertically Walsh-Hadamard transformed in order to detect the field motion. If the first coefficient is higher than a threshold value, then the DCT is performed field-wise. The ASIP can force frame DCT coding. The result, i.e. frame or field DCT coding, is returned to the ASIP. The output of the DCT are four luminance and two chrominance blocks consisting of 8×8 pixels each.

7.4.2.6 Quantization

The quantization performs the redundancy removal, depending on settings provided by the ASIP.

The quantization may be customized by using a dedicated quantization table which can be loaded via the I²C-bus (see Section 7.9.4). The quantization table data is part of the software packages and will be described in the software specification.

7.4.2.7 Trend removal

DC coefficients are coded differentially. However, at the start of every slice and for every intra coded macroblock, the absolute values are coded. Therefore, the ASIP sends a control word to the MBP indicating the start of a slice.

7.4.2.8 Run-length coding and variable-length coding

The MBP compresses the quantized DCT coefficients by (zero) Run-Length Coding (RLC) and Variable-Length Coding (VLC). To inform the ASIP about the achieved compression, it sends the number of bits used in the bitstream to the ASIP. The maximum number of bits used for each of the six blocks (see Section 7.4.2.5) must be set by the ASIP. Furthermore, the coded block pattern is sent to the ASIP.

7.4.2.9 Addressing

The MBP only relies on the format used to store macroblocks in the external DRAM. It works independently from the memory map where to find which macroblock. The ASIP has to keep track of the macroblocks base addresses and has to inform the MBP where to find the data. The MBP only increments the addresses to fetch next data or to write results back.

7.4.2.10 Communication with the ASIP

The communication with the ASIP is the same for every macroblock. That means that although many settings remain unchanged they have to be repeatedly sent from the ASIP to the MBP. The communication is handled by FIFOs.

7.5 Bitstream assembly

7.5.1 GENERAL

While MBP only processes the incoming video data and the ASIP generates the corresponding MPEG2 compliant header and stuffing information, these information must be gathered to form a complete output stream.

Parts involved are:

- Packing unit (packer and pre-packer)
- Stuffing unit (Buffer_out_address and Buffer_out_data)
- Various FIFOs connecting all parts together.

The packing unit does the bit-wise processing of the ASIP and MBP generated streams while the stuffing unit is byte oriented. Handshaking of all blocks is done via FIFOs.

7.5.2 PRE-PACKER AND PACKER

The packing unit (consisting of packer and pre-packer) is responsible to compose a fluent bitstream. Each clock cycle the packer gets a certain amount of valid bits (0 to 24) as input data either from the ASIP (e.g. header information) or from the MBP (compressed macroblock coefficients via pre-packer) and generates 64-bit words with valid bits only. These words are stored into the 4 Mbit output buffer located in the external DRAM.

To reduce the memory needs of the compressed macroblock data, a pre-packing to get words of 24 valid bits is performed before storing data for packing.

7.6 Data output port

7.6.1 GENERAL

The data output port connects the data output stream of
the SAA6750H to the outside world. The data output port
interface implements a Motorola-style bus protocol with
different addressing modes. The status of the internal data
buffer is reported by dedicated output signals.

The data output interface of the SAA6750H will always
behave as a slave on the bus.

7.6.2 DATA OUTPUT FORMAT

The output data is provided in 16-bit words. The most
significant bit of the data word represents the first bit in the
serial MPEG2 elementary stream. Depending on the
addressing mode the external host uses the bus transfers
plain data (non-multiplex mode) or a multiplex of
addresses and data (multiplex mode) for selection of the
data output port, See Section 7.6.3 for information about
the interface protocol.

7.6.3 FUNCTIONAL DESCRIPTION

7.6.3.1 General

The data output port supports Motorola-style bus protocol.

The addressing can be carried out by the external host in
two different modes:

1. **Internal address decoding**

   The data output port provides a programmable internal
   address decoding. This does support e.g. the use of
   several slaves on the bus. The data output port's
   16-bit address is determined by the setting of bytes
   Bus address (MSB) and Bus address (LSB) in the
   I^2C-bus control register (see Table 21). During reset
   mode the contents of Bus address will be set to
   0000H.

   The external host may select the data output port by
   sending the address value that was programmed in
   the I^2C-bus control register. In internal address
   decoding mode, the output data bus carries
   multiplexed address and data information.

   Pin CSN is not used in this mode and must be set to
   HIGH.

2. **External address decoding**

   External address decoding mode may be appropriate
   if e.g. an external address decoding hardware is
   available or if the SAA6750H is the only slave on the
   bus. The data output port is selected by setting
   pin CSN to LOW. In this mode, the internal address
   decoder is disabled and consequently the setting of
   bytes Bus address is ignored. In external address
   decoding mode, the output data bus carries plain data
   information.

The bus protocol mode and address decoding mode are
depending on the setting of the I^2C-bus control register
bit BUS. See Tables 12 and 22 and Section 7.6.3.4 for
detailed information.

Table 12 Data output port mode selection

BIT BUS	PIN I_MN	FUNCTION
0	LOW	Motorola-style protocol mode with external address decoding (non-multiplexed bus); note 1
1	LOW	Motorola-style protocol mode with internal 16-bit address decoding (multiplexed bus); notes 1 and 2
X[3]	HIGH	reserved

Notes

1. Bit BUS is set to logic 0 during reset mode.

2. The 16-bit data output port address (see Table 21) must be loaded via the I^2C-bus with the application specific value.
   The default address is set to 0000H during reset mode.

3. X = don't care.

7.6.3.2 Interface definition

The data output interface uses in total 23 pins. Pins AD0 to AD15 carry data and address information. 7 pins are reserved for control purposes. Partly, the functionality of these pins changes with the selected address or protocol mode (see Tables 13 and 14).

Table 13 List of pins data output port

PIN NAME	PIN TYPE	DESCRIPTION
AD0 to AD15	input/output	internal address decoding: multiplexed address/data bus; external address decoding: non-multiplexed data bus
AS_ALE	input	protocol mode depending functionality; see Table 14
CSN	input	internal address decoding: not used; connect to HIGH; external address decoding: data output port select input
DS_RDN	input	protocol mode depending functionality; see Table 14
DTACK_RDY	output	protocol mode depending functionality; see Table 14
I_MN	input	select protocol mode: LOW is Motorola-style protocol mode (must be set to logic 0); HIGH is reserved mode
LRQN	output	LOW indicates that the fullness of the output buffer is below the programmable lower watermark value; see Table 22
URQN	output	LOW indicates that the fullness of the output buffer is higher than the programmable higher watermark value; see Table 22

Table 14 Protocol mode depending pins

PIN NAME	MOTOROLA-STYLE PROTOCOL MODE		RESERVED MODE	
AS_ALE	AS	address strobe	ALE	reserved
DS_RDN	DS	data strobe	RDN	reserved
DTACK_RDY	DTACK	data transfer acknowledge	RDY	reserved

7.6.3.3 Status reporting data output buffer

The data output port of the SAA6750H provides information about the status of the internal 4 Mbit output buffer. Two signals that are available via pins LRQN and URQN are related to internal buffer watermarks. The external host may use this information to control the data stream in a way that highest rates are possible without out-of-data or buffer-overflow situations. The watermark levels are programmable via the I^{2}C-bus (see Table 22).

The lower watermark reporting may be used by the host to prevent out-of-data situations. The fullness of the data output buffer is monitored. If the current value is below the threshold programmed in control word 'BS_BUFFER lower level' in the I^{2}C-bus control register, the signal LRQN goes to LOW. The host may use this information to stop requesting data. Value 'BS_BUFFER lower level' has a range of 0 to 63. If the value is set to 0, LRQN will not be activated. The threshold can be selected in 64-bit steps.

The upper watermark reporting may be used by the host to prevent data overflow of the output buffer of the SAA6750H. The fullness of the data output buffer located in the external DRAM is monitored. If the current value is two times or more than two times the value programmed in bytes 'BS_BUFFER upper level' in the I^{2}C-bus control register, the signal URQN goes to LOW. The host may use this information to start requesting data. If it does not, an internal buffer overflow may result in loss of data. Value 'BS_BUFFER upper level' has a valid range of 1 to 32752. The threshold can be selected in 128-bit steps. The maximum watermark value equals 4 Mbit.

During reset mode, 'BS_BUFFER lower level' and 'BS_BUFFER upper level' are set to logic 0. The I^{2}C-bus control register values BS_BUFFER should be initialized with the desired values before starting operating mode. If 'BS_ BUFFER lower level' has a value greater than 0, LRQN will be LOW as long as no valid data is available.

7.6.3.4   Motorola-style protocol mode

1. **Internal address decoding**

   The host starts a data transfer cycle by applying the
   data output port address onto the multiplexed
   address/data lines (see Fig.16). By setting AS_ALE to
   LOW the host indicates that the address is valid and by
   setting DS_RDN to LOW that it gives up driving the
   address data and allows the data output interface of
   the SAA6750H to send data via the bus. The
   SAA6750H will drive DTACK_RDY to LOW, when it
   has placed valid data onto AD15 to AD0.
   A DS_RDN = HIGH by the host will force the
   SAA6750H to set DTACK_RDY back to HIGH, to stop
   driving the data bus and to interrupt the transfer of the
   current word, however, this may lead to a loss of data.
   The data read sequence may be repeated by setting
   DS_RDN to LOW and so forth.

   The transfer cycle is ended as soon as the host sets
   DS_RDN and AS_ALE back to HIGH. After this, the
   SAA6750H will also set DTACK_RDY to HIGH and
   stops driving data after a delay t_{dz}
   (see Chapter "Characteristics"). A new transfer cycle
   may not be started as long as DTACK_RDY is LOW or
   the SAA6750H is driving the data bus. CSN has to be
   HIGH all the time. See Fig.16 and
   Chapter "Characteristics" for timing information.

2. **External address decoding**

   The host starts a data transfer cycle by setting the
   CSN signal to LOW (see Fig.17). By setting DS_RDN
   to LOW the host indicates that it wants to read a data
   word and allows the data output interface of the
   SAA6750H to send data via the bus. The SAA6750H
   will drive DTACK_RDY to LOW, when it has placed
   valid data onto AD15 to AD0. A DS_RDN = HIGH by
   the host will force the SAA6750H to set DTACK_RDY
   back to HIGH, to stop driving the data bus and to
   interrupt the transfer of the current word however this
   may lead to a loss of data. The data read sequence
   may be repeated by setting DS_RDN to LOW and so
   forth.

   The transfer cycle is ended as soon as the host sets
   DS_RDN and CSN back to HIGH. After this, the
   SAA6750H will also set DTACK_RDY to HIGH and
   stop driving data after a delay t_{dz}
   (see Chapter "Characteristics"). A new transfer cycle
   may not be started as long as DTACK_RDY is LOW or
   the SAA6750H is driving the data bus. AS_ALE has to
   be HIGH all the time. See Fig.17 and
   Chapter "Characteristics" for timing information.

7.7   Application Specific Instruction-set Processor (ASIP)

7.7.1   GENERAL

The ASIP is a programmable controller specially designed
for the architecture and system requirements of the
SAA6750H. Generally it has to cover internal control
functions. The following tasks are handled:

- Controlling of the MBP
- Macroblock base address generation for the MBP
- Motion vector generation
- Bitstream header generation
- Management of bitstream assembly
- Bit-rate control.

The microcode of the ASIP has to be downloaded by the
I²C-bus into internal RAMs during initialization of the
SAA6750H.

The ASIP is able to communicate with the outside world
via an I²C-bus interface (see Section 7.9.4).

7.8   Global controller

7.8.1   GENERAL

The global controller generates a global scheduling for the
loosely coupled processes of the SAA6750H. It is
controlled by the bits E_ST, E_SP, SS and STD which are
located in the I²C-bus control register (see Table 22). The
global controller is automatically synchronized with the
front-end block.

7.9   I²C-bus interface and controller

7.9.1   GENERAL

The I²C-bus interface within the SAA6750H is a slave
transceiver. It is used to download the microcode of the
ASIP, constants and tables as well as the quantization
matrix table to the MBP. In addition, all control settings are
carried out via the I²C-bus. The read mode may be used to
read back data from registers connected internally to the
ASIP. In total 8 subaddresses are used to store or read
data.

The I²C-bus interface is compliant to the I²C-bus standard
at 100 and 400 kHz clock frequency and suitable for
bus-line voltage levels from 3.3 to 5 V.

The I²C-bus slave address (SAD) is 40H respectively 42H
depending on the state of pin MAD. This allows the use of
two devices SAA6750H in one application. See the
general I²C-bus specification for detailed information on
the bus protocol.

7.9.2 SPECIAL CONSIDERATIONS

Eight subaddresses are used to read or write data from or to the internal SRAM memories and registers of the SAA6750H. An explanation of purpose, function and data transfer will be given in the following chapters. It should be noted that all subaddresses can only be used as data sink or as data source. It is not possible to write data into a register and read it back later on.

Due to the internal memory architecture data may only be transmitted to the subaddresses 00H to 03H when the SAA6750H is in init mode. After the control bit E_ST is set to logic 1, sending data via the I²C-bus to the SRAMs 00H to 03H is forbidden.

The I²C-bus interface will not respond to the general call address 00H and it will not use clock stretch to slow down a data transmission.

The acknowledgement of a data byte by the I²C-bus interface only indicates that the transmission was received and that the correct slave address was used. It does not necessarily say that the data reached its destination. E.g. also if a subaddress outside the valid range from 00H to 007H was sent to the SAA6750H or a transmission to subaddress 01H took place while bit E_ST was logic 1, the I²C-bus interface will return an acknowledge.

A special sequence of commands is used to read data from the subaddress 04H. See Section 7.9.3.4 for detailed information.

7.9.3 I²C-BUS DATA TRANSFER MODES

7.9.3.1 General

Data transfer follows the I²C-bus specification for fast (400 kHz) or normal (100 kHz) mode. The SAA6750H slave address in write mode is:

- 40H if pin MAD is LOW
- 42H if pin MAD is HIGH.

For read operations the following slave addresses have to be used:

- 41H if pin MAD is LOW
- 43H if pin MAD is HIGH.

The I²C-bus will transfer data always as a whole byte consisting of 8 bits. If the address or data word consists of several bytes, the Most Significant Byte (MSB) has to be sent first and the Least Significant Byte (LSB) last. This rule does also apply for read operations. In this case the MSB will be received first.

If the memory's address or data word does not have a width of a multiple of 8 bits, dummy bits have to be added on the left side (most significant bit side) of the MSB. E.g. the ASIP microcode has 177 bits wide data words. 177 divided by 8 gives 22 and a remainder of 1. Therefore the I²C-bus master has to send 23 data bytes of which the higher 7 bits of the MSB are dummy bits. Also the same rule applies for read operations.

Depending on the type of storage the data transfer to or from the memories and registers has to be carried out in different modes which will be described in the following chapters.

Table 15 Abbreviations used in data transfer diagrams

ABBREVIATION	FUNCTION
S	I²C-bus START condition, generated by master
RS	I²C-bus REPEATED START condition, generated by master
SAD	Higher 7 bits of slave address byte: 7-bit slave address: 0100000 (pin MAD = LOW), 40H/41H; 7-bit slave address: 0100001 (pin MAD = HIGH), 42H/43H
W	write mode: LSB of slave address byte = 0
R	read mode: LSB of slave address byte = 1
MA	master acknowledge (acknowledge generated by master)
MN	master acknowledge not (no acknowledge by master)
SA	slave acknowledge (acknowledge generated by SAA6750H)
SD	8-bit subaddress
ADR	address byte
DATA	data byte to be written/read
P	I²C-bus STOP condition, generated by master

7.9.3.2   Random access memory write mode

This mode provides random access to specific memory addresses.

The data has to be written according to following scheme:

Table 16 Data transfer using random access write mode

S	SAD	W	SA	SD	SA	ADR1 (MSB)	SA	ADR2 (LSB)	SA	DATA$_1$ (MSB)	SA	...	DATA$_{n-1}$	SA	DATA$_n$ (LSB)	SA	P

In this example the address word consists of 2 bytes and the data word out of n bytes. This sequence has to be repeated for every data word that has to be sent to the memory.

7.9.3.3   Write mode

The write mode is used if a number of data bytes has to be written to a subaddress if there is no specific memory address. I.e. this mode is used to write data to registers. The data has to be sent according to following scheme:

Table 17 Data transfer using write mode

S	SAD	W	SA	SD	SA	DATA$_1$ (MSB)	SA	DATA$_2$ (MSB − 1)	SA	DATA$_3$ (MSB − 2)	SA	...	DATA$_{n-1}$	SA	DATA$_n$ (LSB)	SA	P

In this example the data word consists of n bytes.

7.9.3.4   Read mode

This mode is used to read data bytes from memories or registers. It is not possible to access a specific memory address. The first byte to be received will be the MSB. If a certain information is needed, the read transfer has to be carried out until the specific byte is available. The data transfer has to be closed by the I^{2}C-bus master by sending an MN (not acknowledge) after the last data byte. This tells the SAA6750H to stop sending further data.

The transfer has to follow this scheme:

Table 18 Data transfer using read mode

S	SAD	W	SA	SD	SA	RS	SAD	R	DATA$_1$ (MSB)	MA	DATA$_2$ (MSB − 1)	MA	...	DATA$_{n-1}$	MA	DATA$_n$ (LSB)	MN	P

In this example the read operation gets n data bytes out of the SAA6750H.

7.9.4   I^{2}C-BUS MEMORIES AND REGISTERS

Eight different SRAM memories and registers may be written or read via the I^{2}C-bus. Each has a specific subaddress. This chapter will explain the purpose of these storages and how they have to be used.

7.9.4.1   Allocation of subaddresses

Following table shows which memories or registers are allocated to the subaddresses 00H to 07H:

Table 19 Subaddresses and related memories

SUBADDRESS (HEX)	STORAGE NAME	DESIGN BLOCK	DEPTH (WORDS)	WIDTH(BITS)	DESCRIPTION
00	quantization matrix SRAM	MBP	128	8	SRAM memory containing a constant table for the macroblock processor quantization function
01	microcode SRAM	ASIP	1024	177	SRAM memory containing the microcode of the ASIP
02	microcode ROM table	ASIP	512	24	SRAM memory containing the microcode ROM table of the ASIP
03	microcode constants	ASIP	256	24	SRAM memory containing the microcode constants of the ASIP
04	serial output register	ASIP	7	24	register bank that can be written by the ASIP; contents depending on the ASIP software
05	serial input register	ASIP	14	24	register bank that can be read by the ASIP; used to control the ASIP externally; the function of the register settings is depending on the ASIP software
06	control register	I^{2}C-bus	1	160	register containing the hardware control bits of the SAA6750H
07	internal use	none	–	–	–

7.9.4.2 I^2C-bus data transfer to subaddresses

The following tables describe the data transfer to or from the subaddresses 0 to 7. See Sections 7.9.3.2, 7.9.3.3 and 7.9.3.4 for information of the data transfer modes.

Table 20 Data transfer to subaddresses

SUBADDRESS (HEX)	STORAGE NAME	DATA TRANSFER MODE	ADDRESS BYTES PER TRANSMISSION	DATA BYTES PER TRANSMISSION	I^2C-BUS BYTE TRANSFERS PER TRANSMISSION
00	quantization matrix SRAM	random access write mode	1	1	4 = 2 + 1 + 1
01	microcode SRAM	random access write mode	2	23	27 = 2 + 2 + 23
02	microcode ROM table	random access write mode	2	3	7 = 2 + 2 + 3
03	microcode constants	random access write mode	1	3	6 = 2 + 1 + 3
04	serial output register	read mode	0	21	24 = 2 + 1 + 21
05	serial input register	random access write mode	1	24	6 = 2 + 1 + 3
06	control bits register	write mode	0	20	22 = 2 + 20
07	internal use	none	–	–	–

7.9.4.3   Quantization matrix SRAM

SUBADDRESS (HEX)	STORAGE NAME	DESIGN BLOCK	DEPTH (WORDS)	WIDTH (BITS)	DATA TRANSFER MODE
00	quantization matrix SRAM	MBP	128	8	random access write mode

SRAM memory containing a constant table for the macroblock processor quantization function.

The data to be loaded into this memory will be part of the application software and described in the software specification.

Remark: Data may only be sent to this subaddress if the SAA6750H is in the init mode (see Table 23).

7.9.4.4   Microcode SRAM

SUBADDRESS (HEX)	STORAGE NAME	DESIGN BLOCK	DEPTH (WORDS)	WIDTH (BITS)	DATA TRANSFER MODE
01	microcode SRAM	ASIP	1024	177	random access write mode

SRAM memory containing the ASIP's microcode.

The microcode to be loaded into this memory will be part of the application software and described in the software specification.

Remark: Data may only be sent to this subaddress if the SAA6750H is in the init mode (see Table 23).

7.9.4.5   Microcode ROM table SRAM

SUBADDRESS (HEX)	STORAGE NAME	DESIGN BLOCK	DEPTH (WORDS)	WIDTH (BITS)	DATA TRANSFER MODE
02	microcode ROM table SRAM	ASIP	512	24	random access write mode

SRAM memory containing special tables that are needed by the ASIP software. The quantization matrix data loaded into subaddress 0 is also part of this set of data.

The data to be loaded into this memory will be included in the application software and described in the software specification.

Remark: Data may only be sent to this subaddress if the SAA6750H is in the init mode (see Table 23).

7.9.4.6   Microcode constant SRAM

SUBADDRESS (HEX)	STORAGE NAME	DESIGN BLOCK	DEPTH (WORDS)	WIDTH (BITS)	DATA TRANSFER MODE
03	microcode constants SRAM	ASIP	256	24	random access write mode

SRAM memory containing constants that are needed by the ASIP software.

The data to be loaded into this memory will be included in the application software and described in the software specification.

Remark: Data may only be sent to this subaddress if the SAA6750H is in the init mode (see Table 23).

7.9.4.7   Serial output register

SUBADDRESS (HEX)	STORAGE NAME	DESIGN BLOCK	DEPTH (WORDS)	WIDTH (BITS)	DATA TRANSFER MODE
04	serial output register	ASIP	7	24	read mode

Register bank that can be written by the ASIP and read by the I^{2}C-bus.

The ASIP is able to access a specific register by writing the address and the related data word. On the contrary it is not possible to access a specific register by the I^{2}C-bus. Starting an I^{2}C-bus read operation will return the data of register 0 first, starting with the most significant byte. After the LSB of register 0 was received, the register address will be incremented automatically and the MSB of register 1 will be received next. Consequently, 21 data words have to be read if the data of register 6 is needed.

The register data depends on the ASIP's software and the state of the SAA6750H. A description will be part of the software specification.

7.9.4.8   Serial input register

SUBADDRESS (HEX)	STORAGE NAME	DESIGN BLOCK	DEPTH (WORDS)	WIDTH (BITS)	DATA TRANSFER MODE
05	serial input register	ASIP	14	24	random access write mode

Register bank that can be read by the ASIP. Used to control the ASIP externally. The function of register settings is depending on the ASIP software. A description will be part of the software specification.

The valid address range reaches from 01H to 0EH. Any data sent by the I^{2}C-bus to address 00H will always be overwritten by an internal signal.

7.9.4.9   Control register

SUBADDRESS (HEX)	STORAGE NAME	DESIGN BLOCK	DEPTH (WORDS)	WIDTH (BITS)	DATA TRANSFER MODE
06	control register	I^{2}C	1	160	write mode

Register bank used to control internal signals. The allocation of control bits in the register is shown in Table 21. The function of the specific bits is described in Table 22.

During external reset, all register bits will be set to logic 0.

During initialization all 20 bytes starting with the MSB and ending with the LSB (control) have to be sent by the I^{2}C-bus in one go.

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Table 21 Description of the I²C-bus control register; note 1

REGISTER BYTE	BIT ADDRESS (HEX)	MSB							LSB
		D7	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**
Control	00 to 07	STD	SS	INTRA	BUS	E_ST	E_SP	SMOD	BYP
FIFO PMI(S) time slot setting	08 to 0F	PMI7	PMI6	PMI5	PMI4	PMI3	PMI2	PMI1	PMI0
FIFO WR_AD(MC) time slot setting	10 to 17	WR7	WR6	WR5	WR4	WR3	WR2	WR1	WR0
FIFO RD_ADR(MA) time slot setting	18 to 1F	RD7	RD6	RD5	RD4	RD3	RD2	RD1	RD0
FIFO BUF_ADR(H) time slot setting	20 to 27	BUF7	BUF6	BUF5	BUF4	BUF3	BUF2	BUF1	BUF0
FIFO REFR(G) time slot setting	28 to 2F	RFR7	RFR6	RFR5	RFR4	RFR3	RFR2	RFR1	RFR0
FIFO MC(E) time slot setting	30 to 37	MC7	MC6	MC5	MC4	MC3	MC2	MC1	MC0
FIFO ML(B) time slot setting	38 to 3F	ML7	ML6	ML5	ML4	ML3	ML2	ML1	ML0
FIDP and vertical shift bottom field	40 to 47	FIDP	VSB6	VSB5	VSB4	VSB3	VSB2	VSB1	VSB0
VREFP and vertical shift top field	48 to 4F	VREFP	VST6	VST5	VST4	VST3	VST2	VST1	VST0
HREFP and horizontal shift	50 to 57	HREFP	HOR6	HOR5	HOR4	HOR3	HOR2	HOR1	HOR0
Filter coefficient a3	58 to 5F	FA37	FA36	FA35	FA34	FA33	FA32	FA31	FA30
Filter coefficient a2	60 to 67	FA27	FA26	FA25	FA24	FA23	FA22	FA21	FA20
Filter coefficient a1	68 to 6F	FA17	FA16	FA15	FA14	FA13	FA12	FA11	FA10
Shift start	70 to 77	SH7	SH6	SH5	SH4	SH3	SH2	SH1	SH0
BS_BUFFER lower level	78 to 7F	X	X	BL5	BL4	BL3	BL2	BL1	BL0
BS_BUFFER upper level (LSB)	80 to 87	BU7	BU6	BU5	BU4	BU3	BU2	BU1	BU0
BS_BUFFER upper level (MSB)	88 to 8F	X	BU14	BU13	BU12	BU11	BU10	BU9	BU8
Bus address (LSB)	90 to 97	DADR7	DADR6	DADR5	DADR4	DADR3	DADR2	DADR1	DADR0
Bus address (MSB)	98 to 9F	DADR15	DADR14	DADR13	DADR12	DADR11	DADR10	DADR9	DADR8

Note

1. X = don't care; should be set to logic 0 during initialization.

Table 22 Description of the I²C-bus control bits and words

BIT ADDRESS (HEX)	BIT NAME	CONTROL WORD NAME	DATA BYTE	DESCRIPTION
00	BYP		19	internal use; it must be set to LOW during initialization
01	SMOD[1]			external/internal sync signal selection; LOW: sync is derived from the SAV and EAV information decoded from the data stream at port YUV; HIGH: sync is derived from the external sync signals at pins FID, HSYNC and VSYNC
02	E_SP			engine stop; see Table 23
03	E_ST			engine start; see Table 23
04	BUS			data output port address mode selection; LOW: external address decoding (CSN pin); HIGH: internal address decoding (AD pin)
05	INTRA			maximum output bit-rate selection; use default setting given in the software specification
06	SS[1]			non SIF mode/SIF mode selection; LOW: subsampling off; HIGH: subsampling on (SIF mode conversion active)
07	STD[1]			NTSC/PAL selection; LOW: NTSC mode input signal expected; HIGH: PAL mode input signal expected
08 to 0F	PMI0 to PMI7		18	use default setting given in the software specification
10 to 17	WR0 to WR7		17	use default setting given in the software specification
18 to 1F	RD0 to RD7		16	use default setting given in the software specification
20 to 27	BUF0 to BUF7		15	use default setting given in the software specification
28 to 2F	RFR0 to RFR7		14	use default setting given in the software specification
30 to 37	MC0 to MC7		13	use default setting given in the software specification
38 to 3F	ML0 to ML7		12	use default setting given in the software specification
40 to 46	VSB0 to VSB6	vertical shift bottom field	11	value determines number of H-syncs occurring after V-sync before the bottom field line based processing starts; note 2
47	FIDP[1]			FID signal polarity selection; LOW: FID signal not inverted (FID = LOW indicates odd field); HIGH: FID signal inverted (FID = HIGH indicates odd field); this setting takes affect for external as well as for SAV and EAV sync

BIT ADDRESS (HEX)	BIT NAME	CONTROL WORD NAME	DATA BYTE	DESCRIPTION
48 to 4E	VST0 to VST6[1]	vertical shift top field	10	value determines number of H-syncs occurring after V-sync before the top field line based processing starts; note 2
4F	VREFP[1]			VSYNC signal polarity selection; LOW: VSYNC signal not inverted, VREF signal expected at pin VSYNC; HIGH: VSYNC signal inverted, vertical blanking qualifier expected at VSYNC pin; this setting does not affect the sync derived from SAV and EAV codes
55 to 56	HOR0 to HOR6[1]	horizontal shift	9	setting determines the number of clock cycles occurring after the H-sync before the line based processing starts; value should have a multiple of 4 because a minimum data sequence (C_B, Y, C_R and Y) needs 4 clock cycles
57	HREFP[1]			HSYNC signal polarity selection; LOW: HSYNC signal not inverted, HREF signal expected at pin HSYNC; HIGH: HSYNC signal inverted, horizontal blanking qualifier expected at pin HSYNC; this setting does not affect the sync derived from SAV and EAV codes
58 to 5F	FA30 to FA37	Filter coefficient a3	8	filter coefficient a3 for the horizontal filtering of video input signal
60 to 67	FA20 to FA27	Filter coefficient a2	7	filter coefficient a2 for the horizontal filtering of video input signal
68 to 6F	FA10 to FA17	Filter coefficient a1	6	filter coefficient a1 for the horizontal filtering of video input signal
70 to 77	SH0 to SH7	Shift start (time slot)	5	use default setting given in the software specification
78 to 7D	BL0 to BL5	BS_BUFFER lower level	4	lower watermark value for data output buffer monitoring in 64-bit steps
7E to 7F	–			not used; it must be set to LOW during initialization
80 to 87	BU0 to BU7	BS_BUFFER upper level (LSB)	3	upper watermark value for data output buffer monitoring (LSB); the valid range for BS_BUFFER upper level is 1 to 32752 in 128-bit steps
88 to 8E	BU8 to BU14	BS_BUFFER upper level (MSB)	2	upper watermark value for data output buffer monitoring (MSB); the valid range for BS_BUFFER upper level is 1 to 32752 in 128-bit steps
8F	–			not used; it must be set to LOW during initialization
90 to 97	DADR0 to DADR7	Bus address (LSB)	1	address value for internal address decoding mode of data output port (LSB)
98 to 9F	DADR8 to DADR15	Bus address (MSB)	0	address value for internal address decoding mode of data output port (MSB)

Notes

1. Changes of this setting are only allowed in init mode or soft reset mode. See Section 7.2.3 for information of the SAA6750H operating modes.

2. The range of sensible values is 00H to 10H for PAL and 00H to 07H for NTSC.

Table 23 Description of engine bits

E_ST	E_SP	SELECTED OPERATING MODE
0	0	init mode
0	1	soft reset mode
1	0	operating mode
1	1	internal use only

The engine control bits are used to set the SAA6750H in a specific operating mode. After reset mode the init mode will be activated automatically. For information about the operating modes of the SAA6750H refer to Table 1.

7.9.5 I^2C-BUS INITIALIZATION

After power-on and the related RESETN pulse the SAA6750H has to be initialized via the I^2C-bus. The internal RAMs must be loaded and the control bits must be set.

The internal memories reachable via subaddresses 00H, 01H, 02H and 03H should be loaded first. Use the data files that belong to a specific ASIP software version. The control register should be written at last. Activate bit E_ST only if all other settings have the desired state.

There has to be a 0.5 ms delay between the end of the external reset RESETN and the start of the I^2C-bus initialization.

The registers and memories of the SAA6750H should be initialized in following order:

1.   Subaddress 00H: MBP quantization matrix

2.   Subaddress 01H: ASIP microcode

3.   Subaddress 02H: ASIP microcode ROM table

4.   Subaddress 03H: ASIP microcode constant

5.   Subaddress 05H: ASIP serial input

6.   Subaddress 06H: Control register (see Table 24).

The following example shows a control register setting for PAL input signal, SAV/EAV sync and external output port address decoding for inter and intra mode. It should be noted that the settings for the INTRA bit and the FIFO time slot values are depending on a specific ASIP software version. Use in any case those settings given in the ASIP software specification.

Table 24 Example for control register settings

REGISTER BYTE	DATA BYTE	INTER/INTRA MODE		INTRA FORCE MODE	
		BINARY	HEX	BINARY	HEX
Control	19	1000 1000	88	1010 1000	A8
PMI	18	0010 0011	23	0010 0011	23
WR	17	1000 0100	84	1000 0100	84
RD	16	0110 1011	6B	1000 0001	81
BUF	15	0000 0111	07	0000 0111	07
RFR	14	0000 0001	01	0000 0001	01
MC	13	1010 0001	A1	1010 0001	A1
ML	12	1001 0111	97	1001 0111	97
FIDP and vertical shift bottom	11	0000 0000	00	0000 0000	00
VREFP and vertical shift top	10	0000 0000	00	0000 0000	00
HREFP and horizontal shift	9	0000 0000	00	0000 0000	00
Filter coefficient a3	8	0000 0000	00	0000 0000	00
Filter coefficient a2	7	0000 0000	00	0000 0000	00
Filter coefficient a1	6	0000 0000	00	0000 0000	00
Shift start	5	0000 1000	08	0000 0100	04
BS_BUFFER lower level	4	0000 0000	00	0000 0000	00
BS_BUFFER upper level (LSB)	3	1111 1111	FF	1111 1111	FF
BS_BUFFER upper level (MSB)	2	0100 1111	4F	0100 1111	4F
Bus address (LSB)	1	1111 1111	FF	1111 1111	FF
Bus address (MSB)	0	1111 1111	FF	1111 1111	FF

7.10 DRAM interface

7.10.1 GENERAL

The DRAM interface of the SAA6750H schedules and handles all accesses of internal read and write clients to the external 4×4 Mbit DRAM memory. It also takes care of the DRAM refresh after Power-on reset and performs the initialization of the external DRAM.

Four fast page mode or Extended Data Out (EDO) DRAM devices (t_{RAC} = 60 ns) with 16-bit data and 9-bit row and column address have to be applied in parallel. Therefore the accessible DRAM format is $262\,144 \times 64$ bits.

7.10.2 APPLICATION HINTS

It should be noted that the DRAM interface is timing sensitive. Make sure that wires between the SAA6750H and the external DRAM memories are as short as possible. In addition the CASN, RASN, address and data lines should have approximately the same parasitic load.

7.10.3 FUNCTIONAL DESCRIPTION

7.10.3.1 Interface definition

The connection between the DRAM interface and the memory consists of 77 signals. ADR0 to ADR8 are used to transfer the row or the column address. The signals CASN and RASN indicate, that a column/row address is present on ADR0 to ADR8. WEN enables a write access and OEN selects/deselects the associated memory chip. The signals CASN, RASN, WEN and OEN are active LOW.

7.10.3.2 DRAM initialization

After the external reset signal RESETN becomes inactive, the DRAM interface immediately starts generating a DRAM initialization sequence. First, the Row Address Strobe (RASN) and Column Address Strobe (CASN) are kept stable in HIGH state for a minimum of 200 µs. After this the DRAM interface generates a sequence of initialization pulses. This sequence consists of 9 CASN cycles before RASN refresh (CBR) events (see Fig.15).

7.10.3.3 *DRAM refresh*

The DRAM interface takes care of periodically refresh of
the external DRAM. Refresh is carried out by addressing
the specific DRAM page. It should be noted that refresh
only works if the SAA6750H is in operating mode
(see Table 1).

7.10.3.4 *Memory sharing*

The SAA6750H can be part of a system in which it shares
the memory with other devices. To this end the DRAM
interface output ports of the SAA6750H can be put to
3-state respectively input state by an appropriate setting of
the I^{2}C-bus control register (see Table 1). Another IC
cannot use the memory concurrently with the SAA6750H.

7.10.3.5 *Scheduling*

The DRAM interface allows access to the external DRAM
once every two clock cycles. Therefore the nominal 'Fast
Page Mode Cycle Time' is t_{PC} = 74 ns for a 27 MHz clock.
If the DRAM address changes from one page to another
page, which means a change in the most significant 9 bits
of the address, a page transition occurs. A page transition
also happens, if the data direction changes from read to
write or vice versa (a change of the WEN signal).
A detailed description of the timing can be found in
Figs 13 and 14 and Chapter "Characteristics".

All internal clients of the DRAM interface are served using
a round robin scheme where the access time of each client
can be programmed via the I^{2}C-bus within some limits.
These settings are depending on the embedded
microcode and will be provided in the software package.
Within one macroblock-period, which is defined as
650 clock cycles of the 27 MHz system clock, all clients
have to be served at least with two accesses but the sum
of all client accesses is not allowed to exceed the time of
one macroblock period.

7.11 FIFO memories

The FIFOs are data buffers which connect the internal
processes. This kind of coupling is necessary because
due to the multi-processor architecture e.g. one process
may give bursts of data, while the next process consumes
the data at constant rate. The state of the FIFOs therefore
also has an impact on the process behaviour. As long as
the FIFO buffers are not full or empty, the depending
processes work at their normal speed. If a data read or
write request from or to a FIFO cannot be served, the
depending process is interrupted.

7.12 Clock distribution

The SAA6750H needs a video clock signal VCLK as
specified in Chapter "Quick reference data". The external
clock signal has to be synchronous to the video input data
stream. In the standard application e.g. the clock signal is
provided by a SAA7111A colour decoder.

The internal clock generation unit creates all internal
processing clocks.

7.13 Input/output levels

All input and I/O pad cells are 5 V tolerant. The output and
I/O pad cells provide 3.3 V output levels.
See Chapters "Quick reference data" and "Limiting
values" for detailed information.

7.14 Boundary scan test

7.14.1 GENERAL

The SAA6750H has built-in logic and 5 dedicated pins to
support boundary scan testing, which allows board testing
without special hardware (nails). The SAA6750H follows
the *"IEEE Std. 1149.1 - Standard Test Access Port and
Boundary Scan Architecture"* set by the Joint Test Action
Group (JTAG) chaired by Philips.

The 5 special pins are Test Mode Select (TMS), Test
Clock (TCK), Test Reset (TRST), Test Data Input (TDI)
and Test Data Output (TDO).

The Boundary Scan Test (BST) functions BYPASS,
EXTEST, SAMPLE, CLAMP and IDCODE are all
supported (see Table 25). Details about the
JTAG BST-TEST can be found in the specification
"IEEE Std. 1149.1". A file containing the detailed Boundary
Scan Description Language (BSDL) description of the
SAA6750H is available on request.

Table 25 Boundary Scan Test (BST) instructions supported by the SAA6750H

INSTRUCTION	DESCRIPTION
BYPASS	This mandatory instruction provides a minimum length serial path (1 bit) between TDI and TDO, when no test operation of the component is required.
EXTEST	This mandatory instruction allows testing of off-chip circuitry and board level interconnections.
SAMPLE	This mandatory instruction can be used to take a sample of the inputs during normal operating of the component. It can also be used to preload data values into the latched outputs of the boundary scan register.
CLAMP	This optional instruction is useful for testing, when not all ICs have BST. This instruction addresses the bypass register, while the boundary scan register is in external test mode.
IDCODE	This optional instruction will provide information on the components manufacturer, part number and version number.

7.14.2 INITIALIZATION OF BOUNDARY SCAN CIRCUIT

The Test Access Port (TAP) controller of an IC should be in the reset state (TEST_LOGIC_RESET), when the IC is in functional mode. This reset state also forces the instruction register into a functional instruction such as IDCODE or BYPASS.

To solve the power-up reset, the standard specifies that the TAP controller will be forced asynchronously to the TEST_LOGIC_RESET state by setting pin TRST to LOW.

7.14.3 DEVICE IDENTIFICATION CODES

A device identification register is specified in *"IEEE Std. 1149.1-1990 -IEEE Standard Test Access Port and Boundary Scan Architecture"*. It is a 32-bit register which contains fields for the specification of the IC manufacturer, the IC part number and the IC version number.

Its biggest advantage is the possibility to check for the correct ICs mounted after production and determination of the version number of ICs during field service.

When the IDCODE instruction is loaded into the BST instruction register, the identification register will be connected between TDI and TDO of the IC.
The identification register will load a component specific code during the CAPTURE_DATA_REGISTER state of the TAP controller and this code can subsequently be shifted out. At board level this code can be used to verify component manufacturer, type and version number.
The device identification register contains 32 bits, numbered 31 to 0, where bit 31 is the most significant bit (nearest to TDI) and bit 0 is the least significant bit (nearest to TDO); see Fig.11.
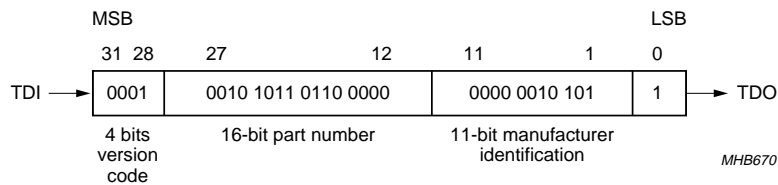

Fig.11 32 bits of identification code.

8   LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{DD}	digital supply voltage		−0.5	+4.0	V
V_I	digital input voltage	note 1	−0.5	+5.5	V
V_O	digital output voltage		−0.5	V_{DD} + 0.5	V
$I_{lu(prot)}$	latch-up protection current		−	100	mA
P_{tot}	total power dissipation		−	2.0	W
T_{stg}	storage temperature		−25	+150	°C
T_{amb}	ambient temperature		0	70	°C
V_{es}	electrostatic handling voltage	note 2	−2000	+2000	V
		note 3	−200	+200	V

Notes

1.   All input pads, input/output pads in input mode and output pads in 3-state mode are 5 V tolerant.

2.   Human body model: C = 100 pF; R = 1.5 kΩ.

3.   Machine model: C = 200 pF; L = 0.75 μH; R = 0 Ω.

9   THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air; soldered to a PCB with supply and ground plane	28	K/W

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10 CHARACTERISTICS

V_{DDCO} = 3.3 V; V_{DD} = 3.3 V; supply voltages V_{DD} and V_{DDCO} are connected externally together; grounds V_{SS} and V_{SSCO} are connected externally together; T_{amb} = 25 °C; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Supplies: V$_{DD}$ and V$_{DDCO}$						
V_{DD}	digital supply voltage (I/O cells)		3.0	3.3	3.6	V
V_{DDCO}	digital supply voltage (core)		3.0	3.3	3.6	V
I_{DD}	digital supply current (I/O cells)		–	40	–	mA
I_{DDCO}	digital supply current (core)		–	180	–	mA
$I_{DD(tot)}$	total digital supply current		–	0.22	0.56	A
P_{tot}	total power dissipation		–	0.73	2.0	W
Inputs: YUV7 to YUV0, FID, HSYNC, VSYNC, VCLK, RESETN, MAD, FAD_RWN, FAD_EN, AS_ALE, DS_RDN, CS_TEST and TEST; note 1						
V_{IL}	LOW-level input voltage		−0.5	–	+0.8	V
V_{IH}	HIGH-level input voltage	V_{DD} = 3.6 V	2.0	–	5.5	V
I_{IL}	LOW-level input current	$V_{IL} = V_{SS}$	–	–	1	µA
I_{IH}	HIGH-level input current	$V_{IH} = V_{DD}$	−1	–	–	µA
C_I	input capacitance		–	–	10	pF
Inputs: TRST, TCK, TMS, TDI, I_MN and CSN; notes 1 and 2						
V_{IL}	LOW-level input voltage		−0.5	–	+0.8	V
V_{IH}	HIGH-level input voltage	V_{DD} = 3.6 V	2.0	–	5.5	V
I_{pu}	pull-up input current	$V_{IL} = V_{SS}$	–	–	125	µA
I_{IH}	HIGH-level input current	$V_{IH} = V_{DD}$	−10	–	–	µA
C_I	input capacitance		–	–	10	pF
Inputs/outputs (3-state): DATA63 to DATA0, AD15 to AD0, GPIO11 to GPIO0; note 1						
V_{IL}	LOW-level input voltage		−0.5	–	+0.8	V
V_{IH}	HIGH-level input voltage	V_{DD} = 3.6 V	2.0	–	5.5	V
V_{OL}	LOW-level output voltage	3 mA sink current	–	–	0.4	V
V_{OH}	HIGH-level output voltage	3 mA load current	2.4	–	V_{DD}	V
I_{TL}	3-state leakage current	$V_{IH} = V_{DD}$; $V_{IL} = V_{SS}$	−5	–	+5	µA
C_I	input capacitance		–	–	10	pF
C_L	load capacitance		–	–	40	pF
Output (3-state): TDO; note 3						
V_{OL}	LOW-level output voltage	3 mA sink current	–	–	0.4	V
V_{OH}	HIGH-level output voltage	3 mA load current	2.4	–	V_{DD}	V
I_{TL}	3-state leakage current	$V_{IH} = V_{DD}$; $V_{IL} = V_{SS}$	−5	–	+5	µA
C_L	load capacitance		–	–	40	pF

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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Outputs (3-state): ADR8 to ADR0, CASN, RASN, WEN and OEN; note 3						
V_{OL}	LOW-level output voltage	3 mA sink current; CASN: 6 mA sink current	–	–	0.4	V
V_{OH}	HIGH-level output voltage	3 mA load current; CASN: 6 mA load current	2.4	–	V_{DD}	V
I_{TL}	3-state leakage current	$V_{IH} = V_{DD}$; $V_{IL} = V_{SS}$	–5	–	+5	µA
C_L	load capacitance	any pin except CASN	–	–	40	pF
		only CASN pin	–	–	60	pF
Outputs (open-drain): LRQN, URQN, DTACK_RDY and FAD_RDYN; note 4						
V_{OL}	LOW-level output voltage	3 mA sink current	–	–	0.4	V
V_{OH}	HIGH-level output voltage		2.4	–	V_{DD}	V
I_{SL}	switch-off leakage current	$V_{OH} = V_{DD}$	–5	–	–	µA
C_L	load capacitance		–	–	40	pF
Video clock input timing: VCLK; see Fig.12						
T_{cy}	cycle time		35	37	39	ns
δ	duty factor	t_{HIGH}/T_{cy}	40	50	60	%
$t_{r(VCLK)}$	rise time	V_{DD} = 0.8 to 2.0 V	–	–	5	ns
$t_{f(VCLK)}$	fall time	V_{DD} = 2.0 to 0.8 V	–	–	6	ns
Video input data and control input timing: YUV7 to YUV0, FID, HSYNC and VSYNC; see Fig.12						
$t_{SU; DAT}$	data set-up time		6	–	–	ns
$t_{HD; DAT}$	data hold time		3	–	–	ns

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
DRAM interface data, address and control timing: DATA63 to DATA0, ADR8 to ADR0, CASN, RASN, WEN and OEN; see Figs 13 to 15						
t_{PC}	fast page mode cycle time		60	$2T_{cy}$	–	ns
t_{RP}	RASN precharge time		60	$2T_{cy}$	–	ns
t_{RHCP}	RASN hold time from CASN precharge		60	$2T_{cy}$	–	ns
t_{RDH}	read data hold time		0	–	–	ns
t_{CAS}	CASN pulse width		30	T_{cy}	45	ns
t_{CP}	precharge time (page mode)		30	T_{cy}	–	ns
t_{RCS}	read command set-up time		60	$2T_{cy}$	–	ns
t_{RCH}	read command hold time referenced to CASN		30	T_{cy}	–	ns
t_{WCS}	WEN set-up time		60	$2T_{cy}$	–	ns
t_{WCH}	WEN hold time referenced to CASN		30	$2T_{cy}$	–	ns
t_{RRH}	read command hold time referenced to RASN		30	T_{cy}	–	ns
t_{CSS}	chip select OEN set-up time		60	$2T_{cy}$	–	ns
t_{CSH}	chip select OEN hold time referenced to CASN		0	–	–	ns
t_{ASR}	row address set-up time		20	T_{cy}	–	ns
t_{RAH}	row address hold time		12	$\frac{1}{2}T_{cy}$	–	ns
t_{ASC}	column address set-up time		10	note 5	–	ns
t_{CAH}	column address hold time		20	T_{cy}	–	ns
t_{DS}	data write set-up time		20	T_{cy}	–	ns
t_{DH}	data write hold time		20	T_{cy}	–	ns
t_{RAC}	access time from RASN		–	–	60	ns
t_{CAC}	access time from CASN		–	–	20	ns
t_{RCI}	read/write cycle time in initialization mode		160	$5T_{cy}$	–	ns
t_{RASI}	RASN pulse width in initialization mode		100	$3T_{cy}$	–	ns
t_{CSR}	CASN set-up time		30	T_{cy}	–	ns
t_{CHR}	CASN hold time		30	T_{cy}	–	ns

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Data output interface timing: DTACK_RDY, I_MN, CSN, AS_ALE, DS_RDN and AD15 to AD0; see Figs 16 and 17 and Table 13						
t_{as}	address set-up time		15	–	–	ns
t_{ah}	address hold time		20	–	–	ns
t_{az}	address 3-state time		20	–	–	ns
t_{cs}	CSN set-up time		0	–	–	ns
t_{dhr}	data hold time read		0	–	–	ns
t_{dsr}	data set-up time read		0	–	–	ns
t_{idl}	AS pulse width		60	–	–	ns
t_{drtL}	DTACK reaction time LOW	note 6	–	$2T_{cy}$	–	ns
t_{drtH}	DTACK reaction time HIGH		–	T_{cy}	–	ns
t_{rwi}	read/write or data strobe pulse width		60	–	–	ns
t_{dz}	data 3-state		0	–	60	ns
I^{2}C-bus interface: SCL and SDA; note 7						
f_{SCL}	SCL clock frequency		100	–	400	kHz
V_{IL}	LOW-level input voltage		–	–	$0.3V_{DD}$	V
V_{IH}	HIGH-level input voltage		$0.7V_{DD}$	–	5.5	V
I_I	input current		–10	–	+10	µA
V_{OL}	LOW-level output voltage	3 mA sink current	0	–	0.4	V
		6 mA sink current	0	–	0.6	V
t_{LOW}	SCL LOW time		1.3	–	–	µs
t_{HIGH}	SCL HIGH time		0.6	–	–	µs
t_r	rise time SDA and SCL		–	–	0.3	µs
t_f	fall time SDA and SCL		–	–	0.3	µs
$t_{SU;DAT}$	data set-up time		100	–	–	ns
$t_{HD;STA}$	hold time START condition		0.6	–	–	µs
$t_{SU;STO}$	set-up time STOP condition		0.6	–	–	µs

Notes

1. All input pins are 5 V tolerant.

2. In accordance with the *"IEEE1149.1"* standard the input pins TCK, TDI, TMS and TRST must have an internal pull-up resistor.

3. The outputs, which can be switched in the 3-state mode, are 5 V tolerant due to the bus application of 5 V.

4. The open-drain outputs, which can be switched off, are 5 V tolerant due to the 5 V application.

5. $\frac{1}{2}T_{cy}$ applies for first column address after a row address, T_{cy} for all other modes.

6. Typical values are maximum when data is available.

7. I/O pins of the I^{2}C-bus interface must not obstruct the SDA and SCL lines if the supply voltage V_{DD} is switched off.
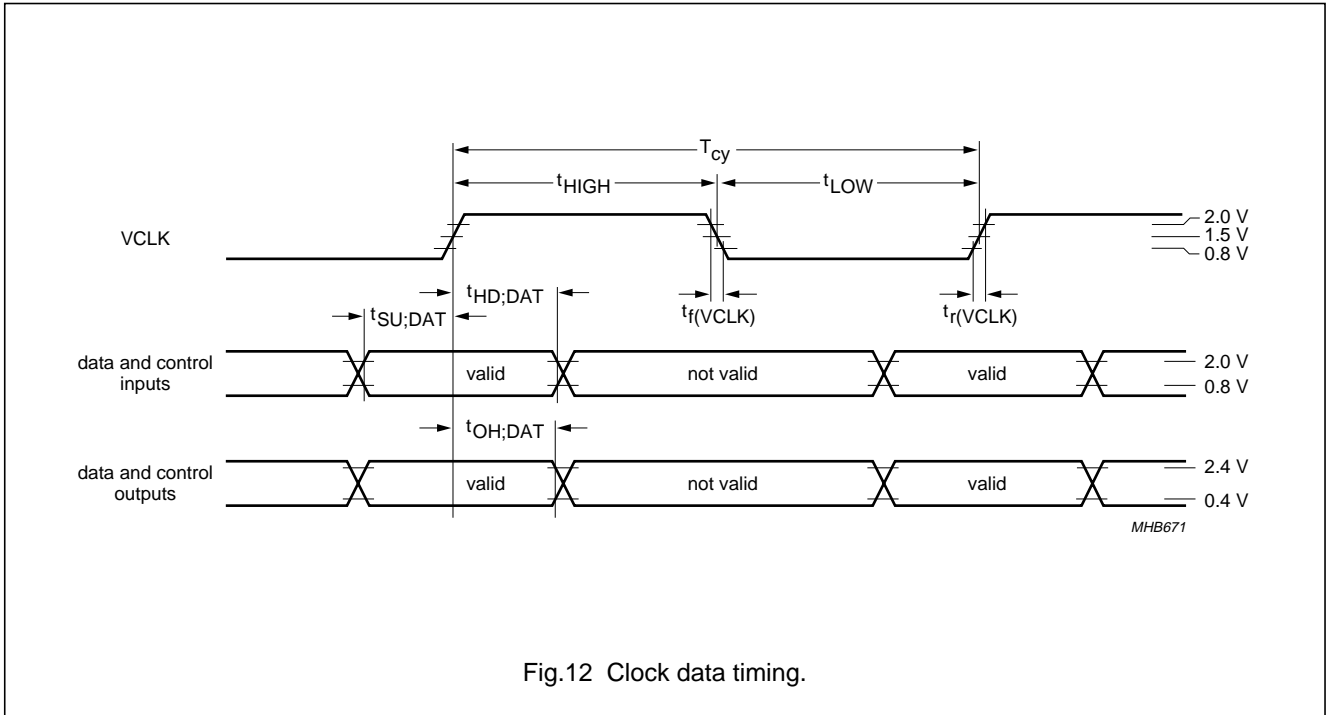
Fig.12 Clock data timing.
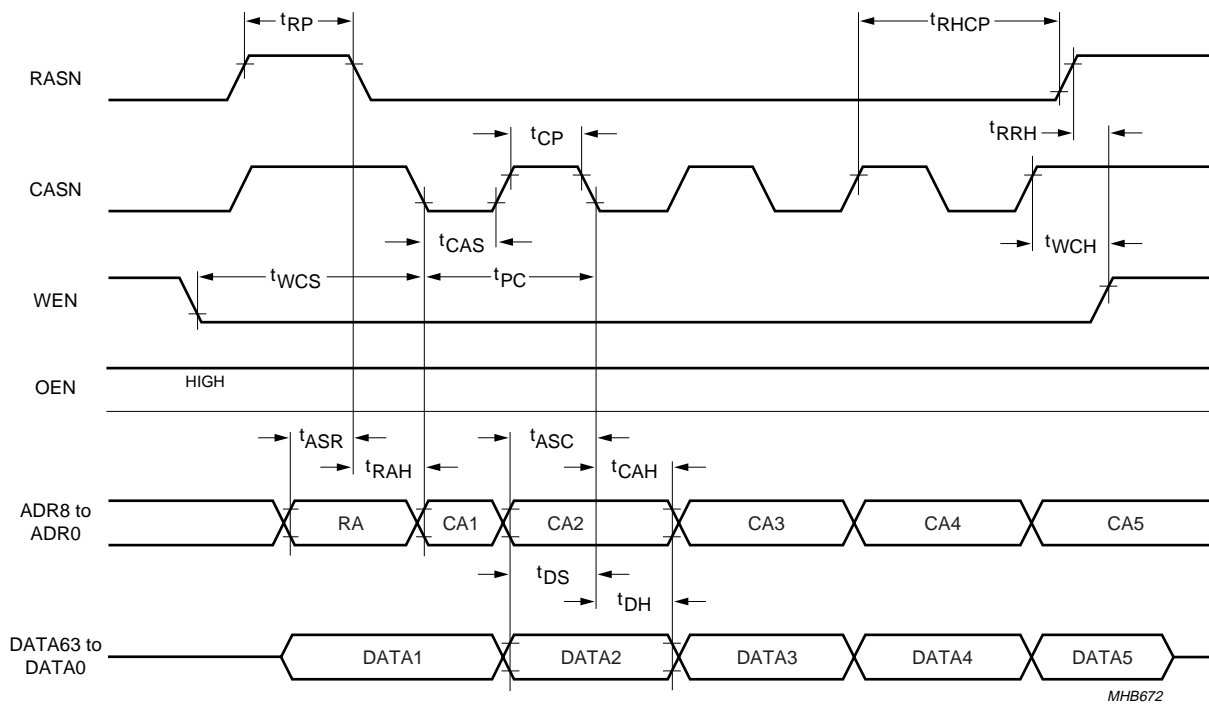
RA = row address.
CA = column address.

Fig.13 DRAM fast page mode write cycles to external DRAM.

RA = row address.
CA = column address.

Fig.14 DRAM fast page mode read cycles from external DRAM.

Fig.15 DRAM initialization sequence.
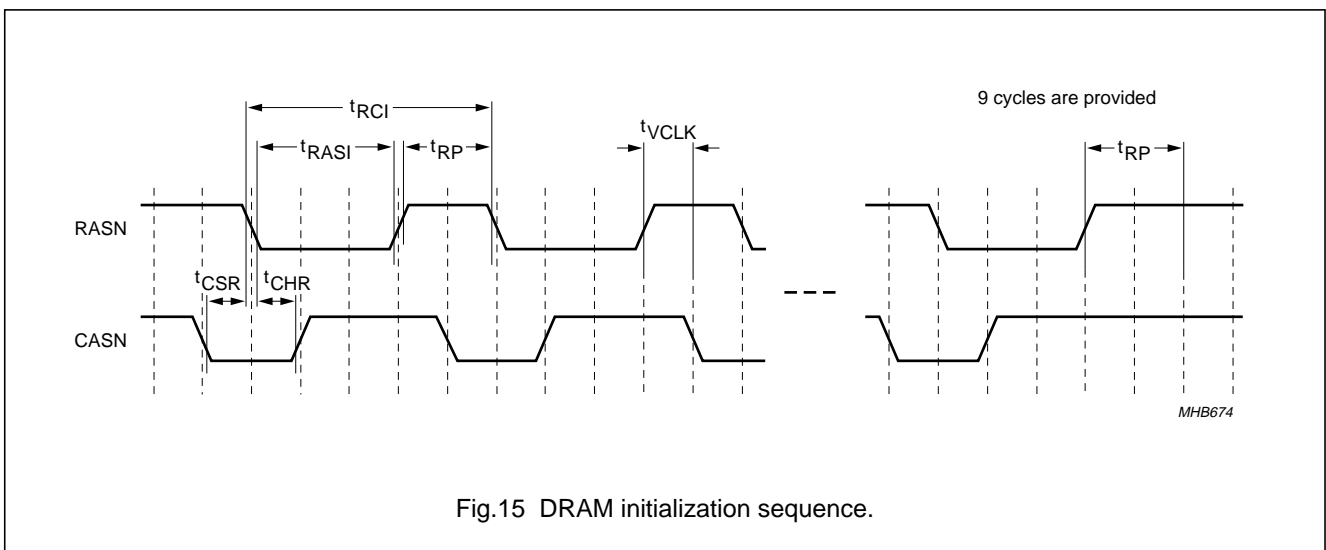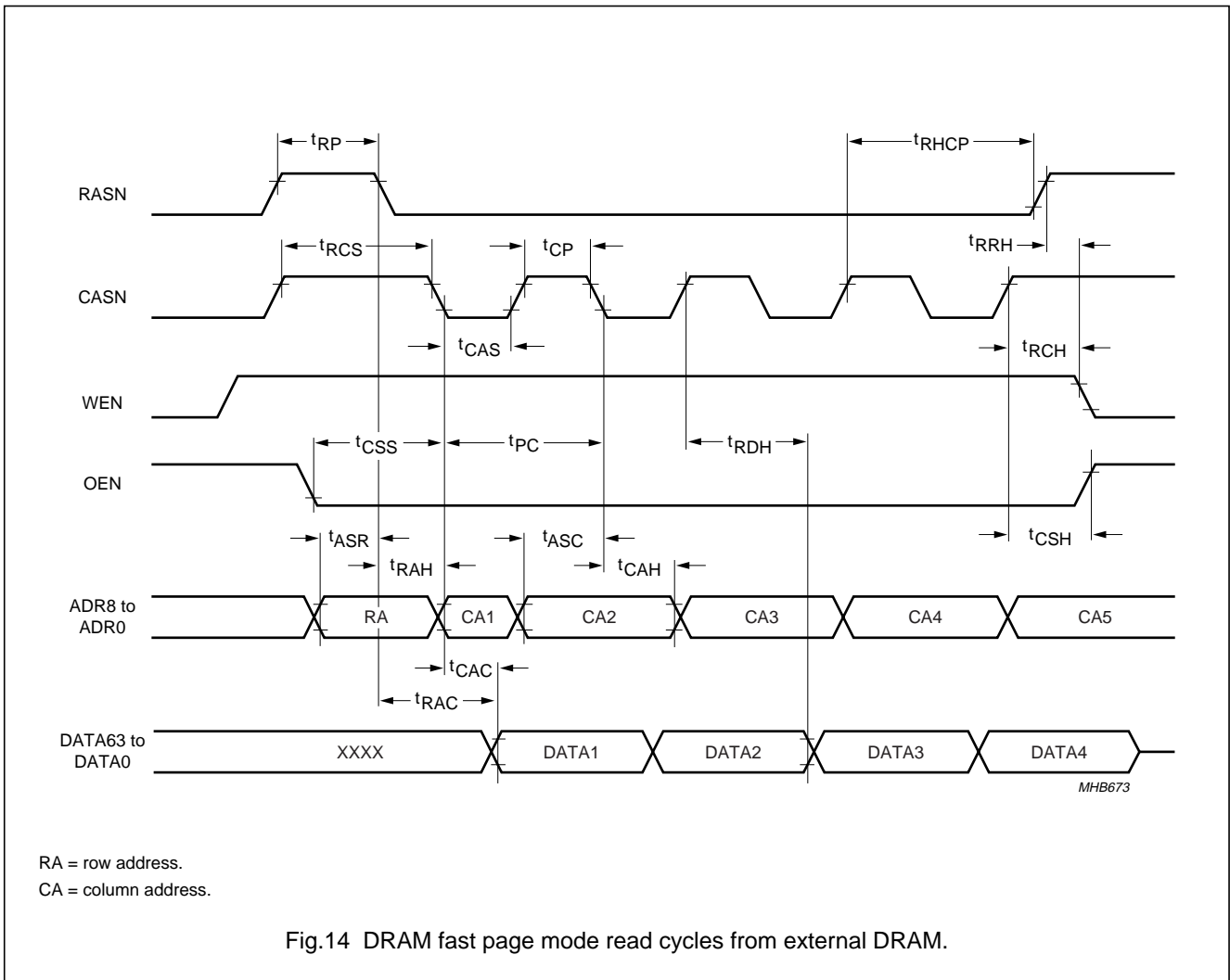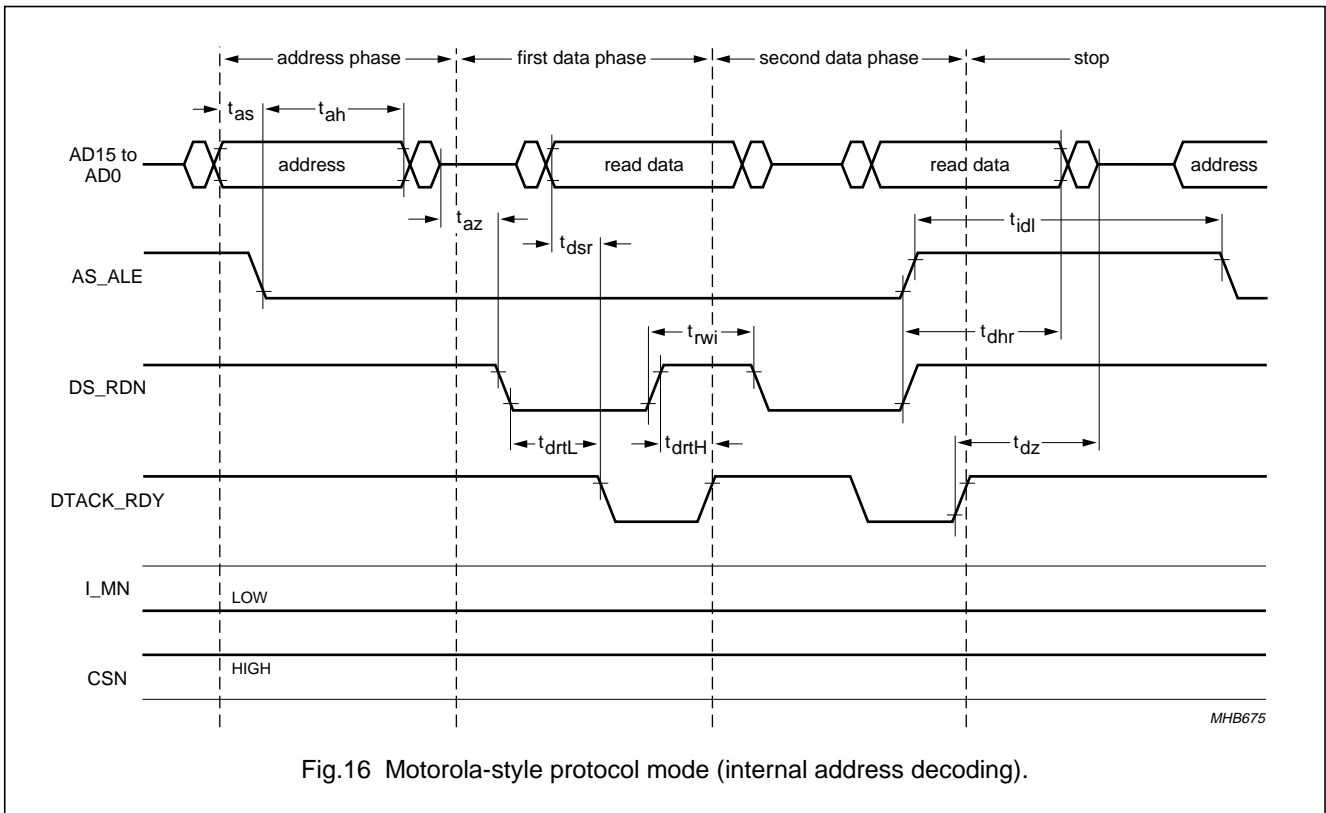
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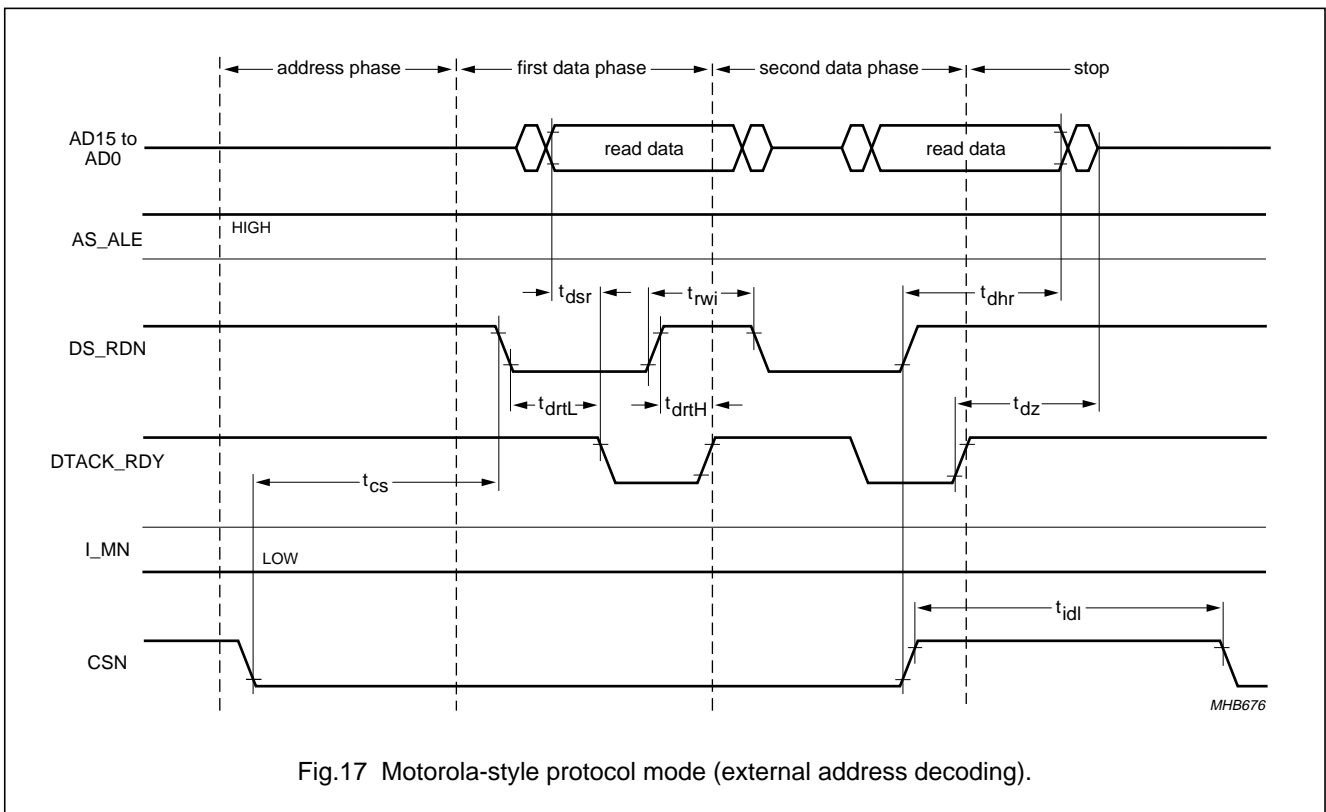Fig.16 Motorola-style protocol mode (internal address decoding).

Fig.17 Motorola-style protocol mode (external address decoding).

11 APPLICATION INFORMATION
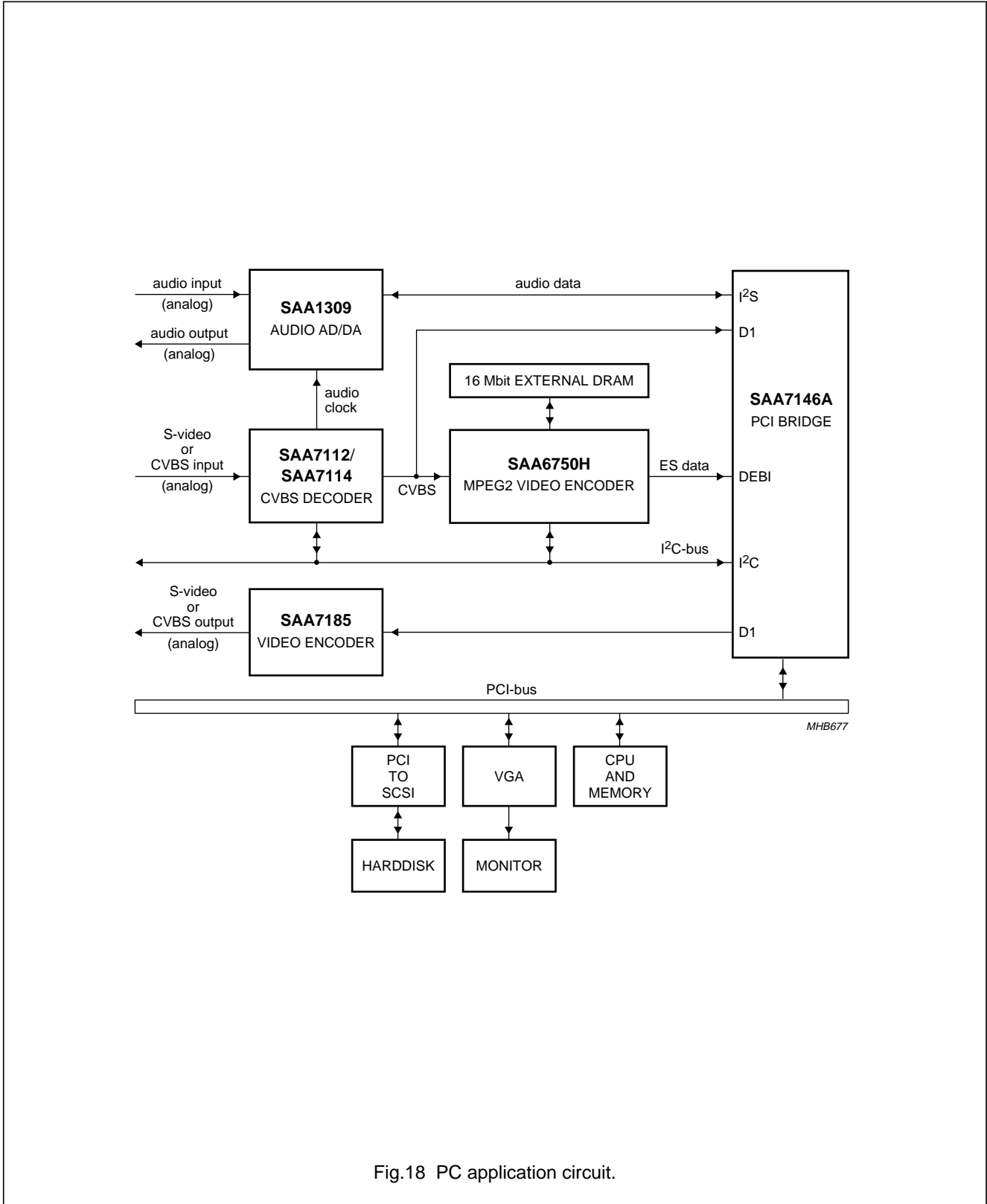
Fig.18 PC application circuit.

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12 PACKAGE OUTLINE

SQFP208: plastic shrink quad flat package;
208 leads (lead length 1.3 mm); body 28 x 28 x 3.4 mm; high stand-off height

SOT316-1

scale

0   5   10 mm
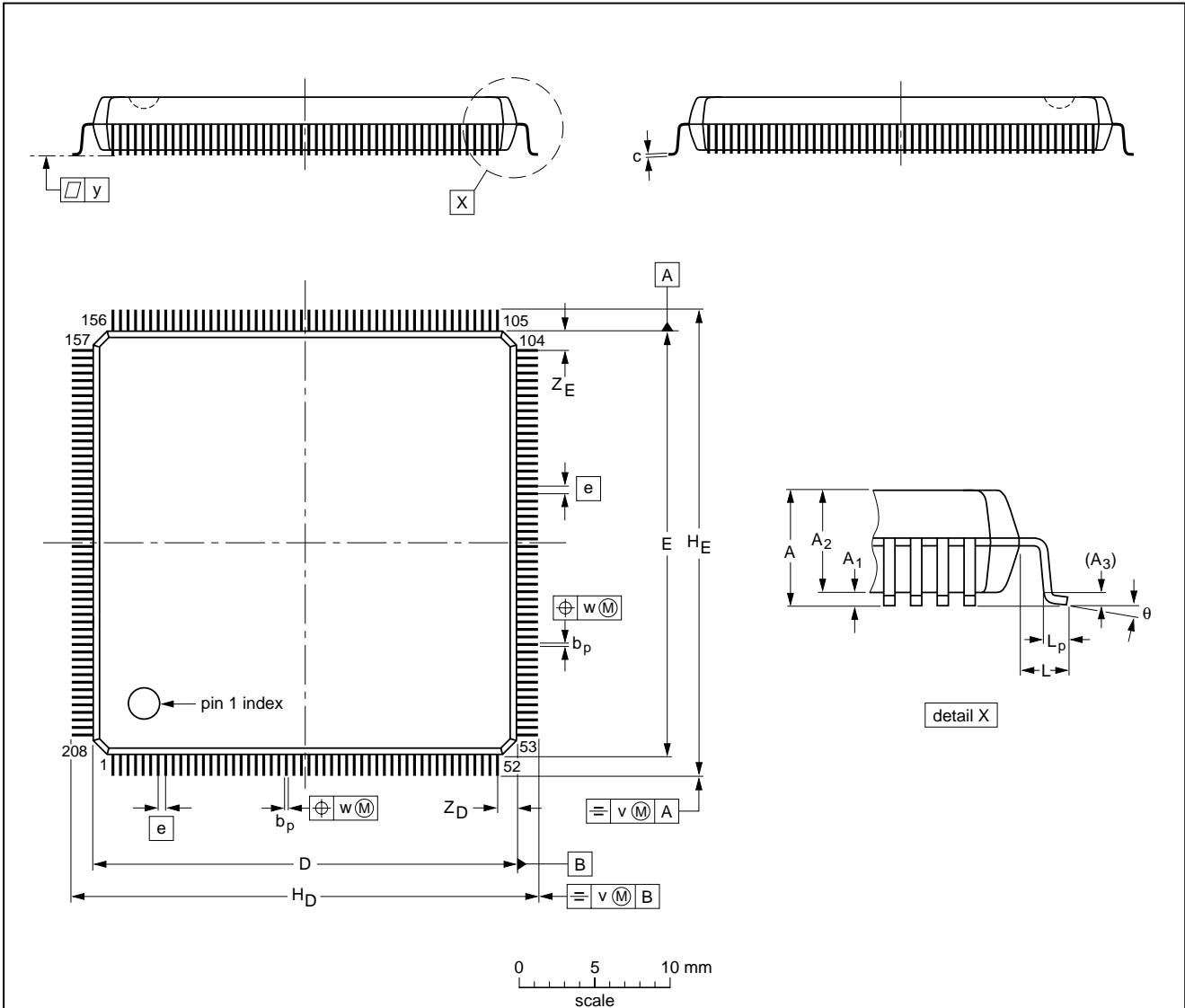
DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A₁	A₂	A₃	bₚ	c	D(1)	E(1)	e	H_D	H_E	L	Lₚ	v	w	y	Z_D(1)	Z_E(1)	θ
mm	4.10	0.50 0.25	3.6 3.2	0.25	0.27 0.17	0.20 0.09	28.1 27.9	28.1 27.9	0.5	30.9 30.3	30.9 30.3	1.3	0.75 0.45	0.2	0.08	0.08	1.39 1.11	1.39 1.11	8° 0°

The column headers in the table use the notation: A_1, A_2, A_3, b_p, $D^{(1)}$, $E^{(1)}$, H_D, H_E, L_p, $Z_D^{(1)}$, $Z_E^{(1)}$.

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT316-1		MS-029				~~99-12-27~~ 00-01-25

13 SOLDERING

13.1 Introduction to soldering surface mount packages

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *"Data Handbook IC26; Integrated Circuit Packages"* (document order number 9398 652 90011).

There is no soldering method that is ideal for all surface mount IC packages. Wave soldering is not always suitable for surface mount ICs, or for printed-circuit boards with high population densities. In these situations reflow soldering is often used.

13.2 Reflow soldering

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

Several methods exist for reflowing; for example, infrared/convection heating in a conveyor type oven. Throughput times (preheating, soldering and cooling) vary between 100 and 200 seconds depending on heating method.

Typical reflow peak temperatures range from 215 to 250 °C. The top-surface temperature of the packages should preferable be kept below 230 °C.

13.3 Wave soldering

Conventional single wave soldering is not recommended for surface mount devices (SMDs) or printed-circuit boards with a high component density, as solder bridging and non-wetting can present major problems.

To overcome these problems the double-wave soldering method was specifically developed.

If wave soldering is used the following conditions must be observed for optimal results:

- Use a double-wave soldering method comprising a turbulent wave with high upward pressure followed by a smooth laminar wave.
- For packages with leads on two sides and a pitch (e):
  - larger than or equal to 1.27 mm, the footprint longitudinal axis is **preferred** to be parallel to the transport direction of the printed-circuit board;
  - smaller than 1.27 mm, the footprint longitudinal axis **must** be parallel to the transport direction of the printed-circuit board.

  The footprint must incorporate solder thieves at the downstream end.

- For packages with leads on four sides, the footprint must be placed at a 45° angle to the transport direction of the printed-circuit board. The footprint must incorporate solder thieves downstream and at the side corners.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Typical dwell time is 4 seconds at 250 °C.
A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

13.4 Manual soldering

Fix the component by first soldering two diagonally-opposite end leads. Use a low voltage (24 V or less) soldering iron applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C.

When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

13.5 Suitability of surface mount IC packages for wave and reflow soldering methods

PACKAGE	SOLDERING METHOD	
	WAVE	REFLOW[1]
BGA, LFBGA, SQFP, TFBGA	not suitable	suitable
HBCC, HLQFP, HSQFP, HSOP, HTQFP, HTSSOP, SMS	not suitable[2]	suitable
PLCC[3], SO, SOJ	suitable	suitable
LQFP, QFP, TQFP	not recommended[3][4]	suitable
SSOP, TSSOP, VSO	not recommended[5]	suitable

Notes

1. All surface mount (SMD) packages are moisture sensitive. Depending upon the moisture content, the maximum temperature (with respect to time) and body size of the package, there is a risk that internal or external package cracks may occur due to vaporization of the moisture in them (the so called popcorn effect). For details, refer to the Drypack information in the *"Data Handbook IC26; Integrated Circuit Packages; Section: Packing Methods"*.

2. These packages are not suitable for wave soldering as a solder joint between the printed-circuit board and heatsink (at bottom version) can not be achieved, and as solder may stick to the heatsink (on top version).

3. If wave soldering is considered, then the package must be placed at a 45° angle to the solder wave direction. The package footprint must incorporate solder thieves downstream and at the side corners.

4. Wave soldering is only suitable for LQFP, TQFP and QFP packages with a pitch (e) equal to or larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.

5. Wave soldering is only suitable for SSOP and TSSOP packages with a pitch (e) equal to or larger than 0.65 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.5 mm.

14 DATA SHEET STATUS

DATA SHEET STATUS[1]	PRODUCT STATUS[2]	DEFINITIONS
Objective data	Development	This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.
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Notes

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