3. System Module

Contents

Transceiver NSD-5

Introduction

The NSD-5 is a single-band radio transceiver unit for the CDMA 1900 MHz network. TX operates at 5V. The transceiver consists of System/RF module, User Interface module, and assembly parts.

The RF interface, which is documented in this chapter, provides internal signal definition and an internal interface that defines the characteristics of RF intra-module signals.

The baseband section defines the signal parameters between baseband intra-modules, as well as the interface between baseband and RF. This section of the chapter also defines the communication protocol between some of the submodules.

The third section of this chapter describes the interface between UI and baseband. Characteristics of interface signals between UI and baseband are defined as well.

The fourth section of the chapter covers the interface between system (transceiver) and external accessories, including plug-and-play (PPH), headset, and battery.

Modes of Operation

There are five different operation modes:

- power-off mode
- idle mode
- active mode
- charge mode
- local mode

In the power-off mode, only the circuits needed for power-up are supplied.

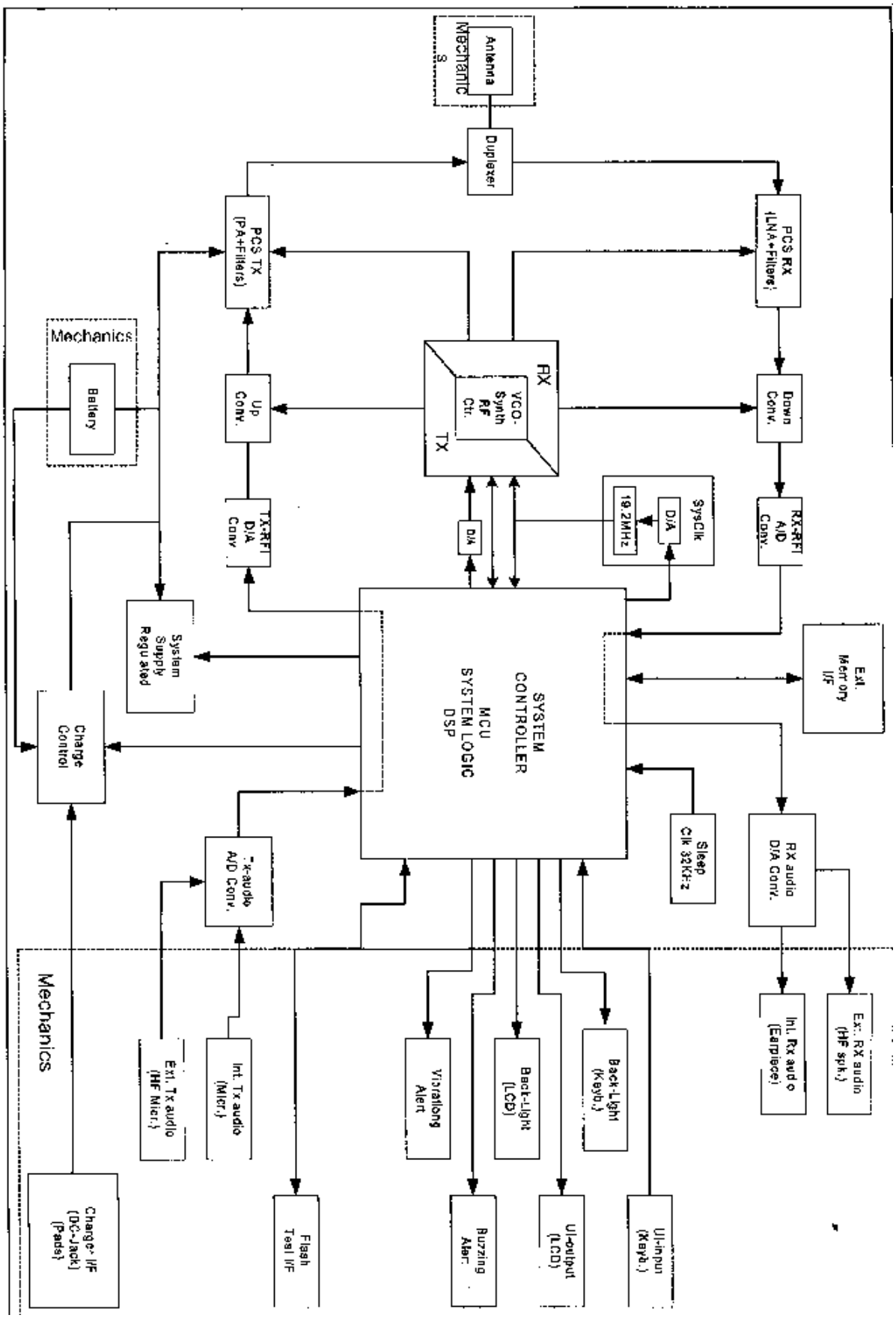
In the idle mode, circuits are powered down and only the sleep clock is running.

In the active mode, all the circuits are supplied with power — although some parts might be in the idle state part of the time.

The charge mode is effective in parallel with all the previous modes. The charge mode itself consists of two different states: charge and maintenance mode.

The local mode is used for alignment and testing.

Interconnection Diagram



System Module

Circuit Description

The transceiver electronics consist of the Radio Module, RF + System blocks, the UI PCB, the display module, and audio components. The keypad and the display module are connected to the Radio Module with connectors. System blocks and RF blocks are interconnected with PCB wiring. The Transceiver is connected to accessories via a bottom system connector with charging and accessory control.

The RF block is designed for a handportable phone which operates in the CDMA 1900 system. The purpose of the RF block is to receive and de-modulate the radio frequency signal from the base station and to transmit a modulated RF signal to the base station.

Connectors

System Connector

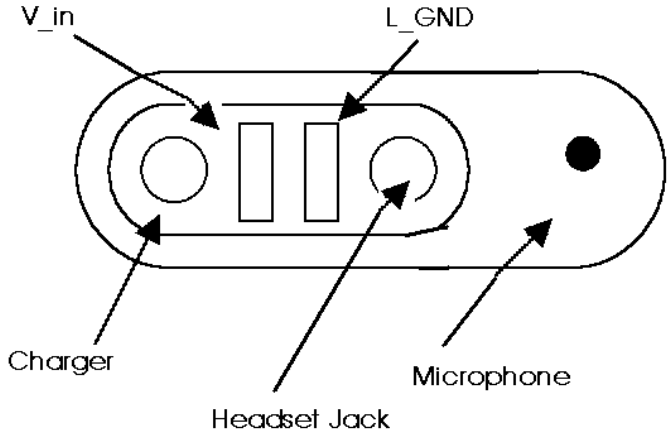


Figure 1: Bottom Connector

Note: Intelligent Battery Interface, IBI, is an accessory interface on the battery side of the phone including the same signals as the bottom connector. The accessory (e.g., an IBI accessory) can be a battery pack with special features or an accessory module attached between the phone and a normal battery pack.

Baseband Module and Interface

Block Diagram

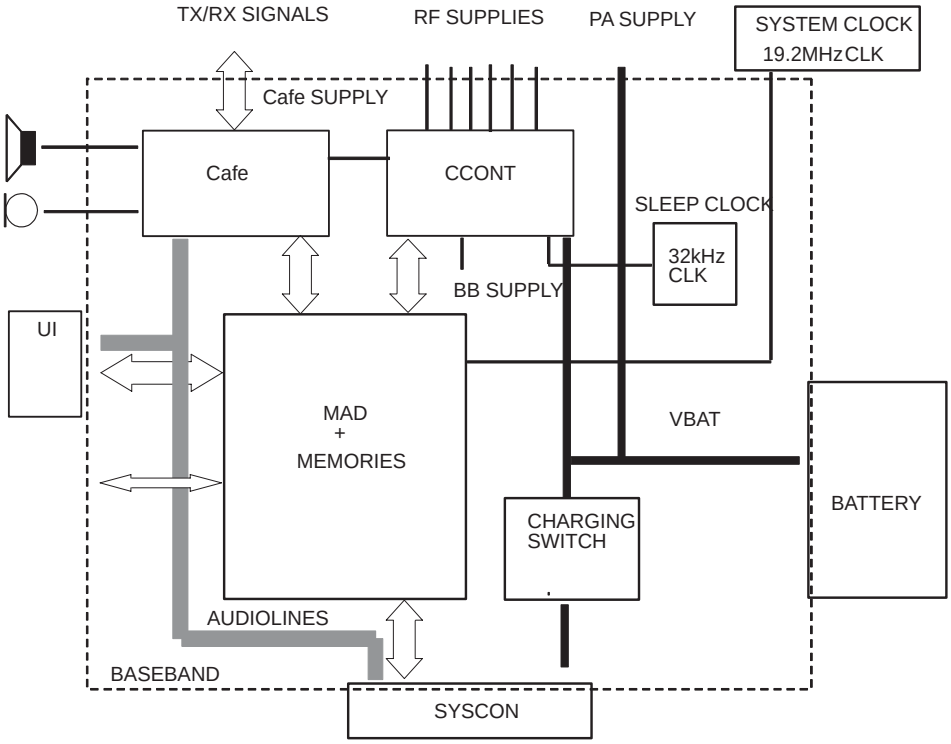


Figure 2: Baseband Module and Interface Block Diagram

Baseband Elements

Baseband refers to all technology elements in the phone design, which do not include RF functions. The Baseband Module therefore includes audio, logic control, signal processing, power supply, and user interface functions. Baseband functionality of this product consists of third generation Digital Core Technology (DCT3) design solutions.

Baseband ASICS Description

MAD4

The MAD4 submodule includes the MAD4 ASIC (MCU, DSP, System Logic), external memories, and VIBRA circuitry.

The MCU block is used for general purpose processing applications such as UI control, timers, PUP control, RX modem interface, audio control, evaluation of sensor data from CCONT A\D, and battery charging control.

The DSP accommodates all communication protocols, such as CDMA data processing. DSP also handles speech signal processing (e.g., vocodor).

The System Logic component includes: peripheral interface (MCU Parallel I/O, Serial I/O [FBUS/MBUS]) and PWM control; accessory interface (FBUS); external memories interface; RF interface and control; clocking, timing, and interrupts; sleep control; CAFE control; user interface control; reset generator; clock generator; and test interface.

Baseband-related External Interface

For detailed information on interfaces to CCONT, CAFE, UI, and accessories, consult the CCONT, CAFE, and accessory modules in this chapter.

FBUS

FBUS (Fast Bus) is a serial interface between the DSP and data accessories and between the DSP and multipath analyzer. FBUS also is used as a data path during flash code downloading. This interface is a full-duplex, asynchronous, two-line bus. Figure 3 illustrates the timing for the FBUS.

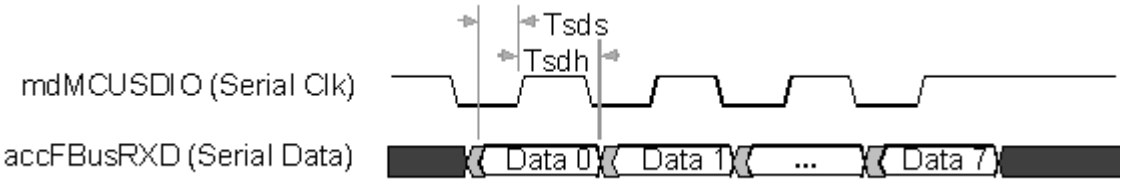


Figure 3: USART synchronous mode receive (flashing mode)

Parameter	Definition	Minimum	Maximum	Unit
Tsds	Data setup to rising edge	90	110	ns
Tsdh	Data hold from rising edge	90	110	ns

MBUS

MBUS is a serial data bus of MCU, which is used for flash downloading (clock), testing, and communication with external devices. Supported baud rates are 9.6, 19.2, 38.4, and 57.6 kbit/s.

JTAG Interface

JTAG Interface is used for MAD4 ASIC emulation including DSP and MCU emulation.

MAD4/External Memories Interface

Functional Description

The external memory consists of FLASH, SRAM, and EEPROM.

FLASH is used to contain the main program code for the MCU and EEPROM default values (local factory values). It has 2M x 16-bit size and uBGA package.

EEPROM stores tuning parameters and other systems permanently. Its size is 128k bytes.

The external memory interface is shared between the DSP and MCU processors. Both 8-bit and 16-bit external memories are supported. The interface supplies 22 address bits to allow the MCU/DSP to address up to 4 Mbytes of linear address space for ROM1, ROM2, and parallel EEPROM and 1 Mbyte of linear address space for SRAM (defined by the chip-select signals). The DSP will use only the lower 16 bits of the address, and a bank register is provided to set the 64K-word window for external memory accesses. A read strobe, write strobe, and four-chip selects are provided for external memories.

Table 1 illustrates the signal characteristics of the interface. Also see the MAD4 Technical Specification (Reference 1) for decoding memory map and chip selects.

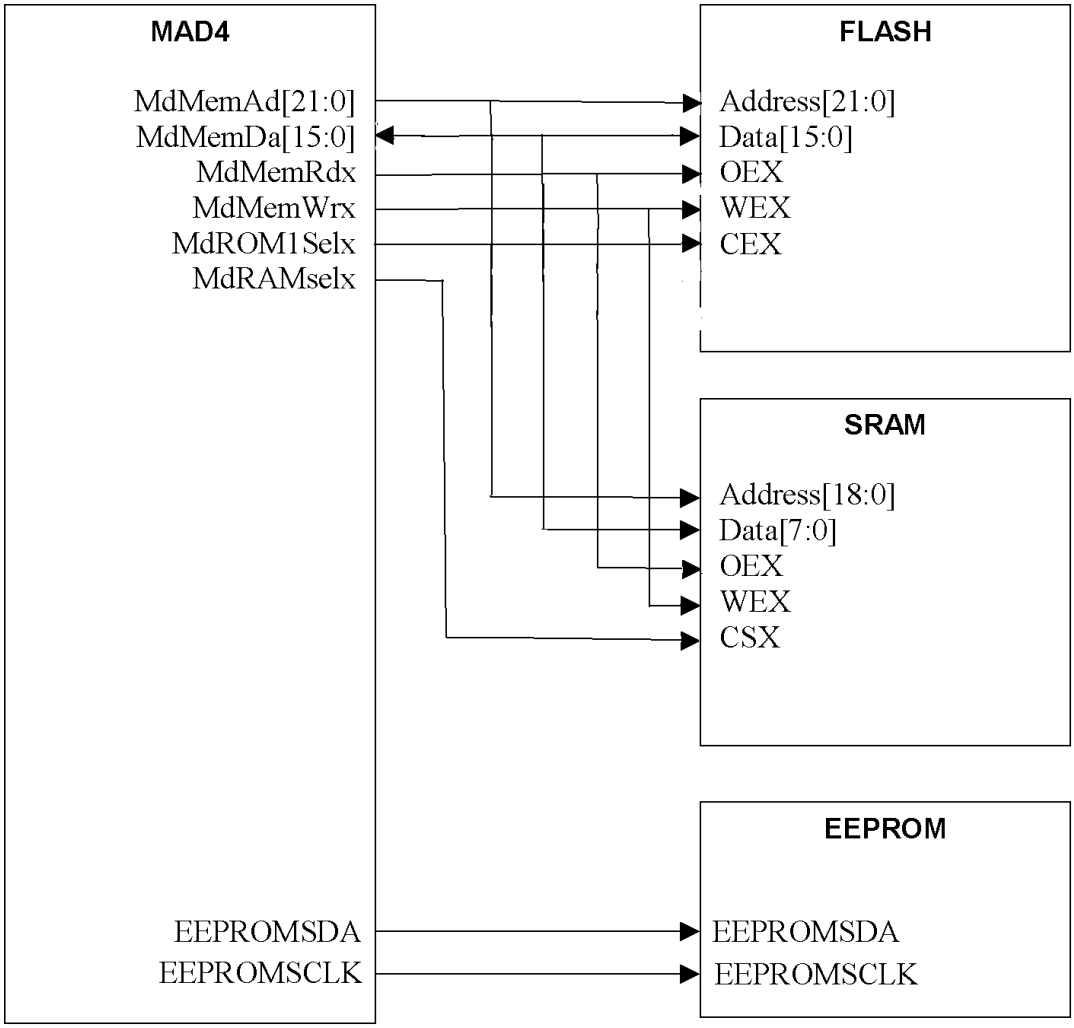


Figure 4: Memory interface

Signal	Level (V) Low	High	Functional description
MEMAD(21:0)	< 0.62	> 2.24	MCU/DSP address bus to external memory
MEMDA(15:0)	< 0.62	> 2.24	MCU/DSP bidirectional data bus to external memory
MEMRDX	< 0.62	> 2.24	Read strobe to external memory
MEMWRX	< 0.62	> 2.24	Write strobe to external memory
ROM1SELX	< 0.62	> 2.24	FLASH chip select
ROM2SELX	< 0.62	> 2.24	Not used
RAMSELX	< 0.62	> 2.24	SRAM chip select
EEPROMSDA	< 0.62	> 2.24	EEPROM serial data

Signal	Level (V) Low	High	Functional description
EEPROMSCLK	< 0.62	> 2.24	EEPROM serial data clock

Table 1: Electrical characteristics of the external memory interface

Functional Timing Parameters

Memory access timing is treated asynchronously. There are two reasons for this type of access. First, the external memories are inherently asynchronous. Second, two separate processors running at different frequencies share the memories.

The following two figures (Figure 5 and Figure 6) provide timing information on MAD4 memory access. See MAD4 Technical Specifications (Reference 1) and DCT3 MAD4 Resource Manager Specification and Implementation (Reference 2) for additional timing information on external memory read/write cycles.

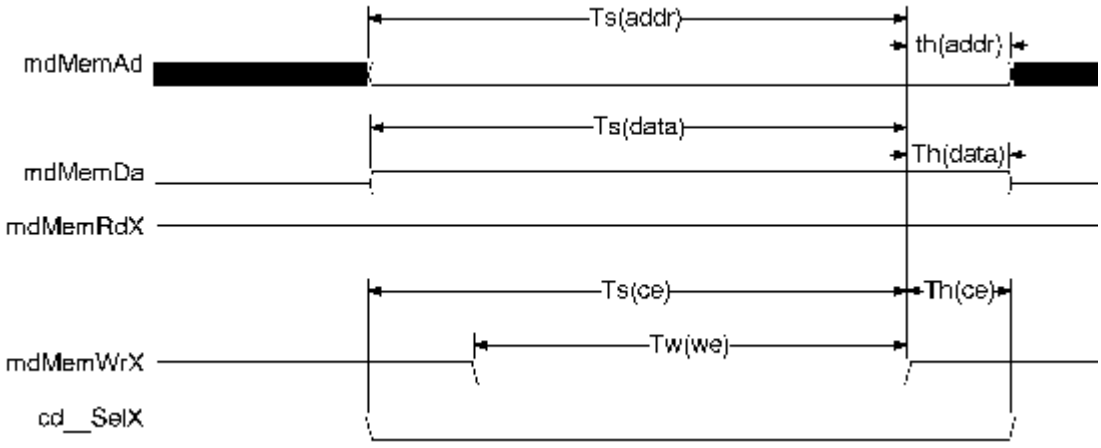
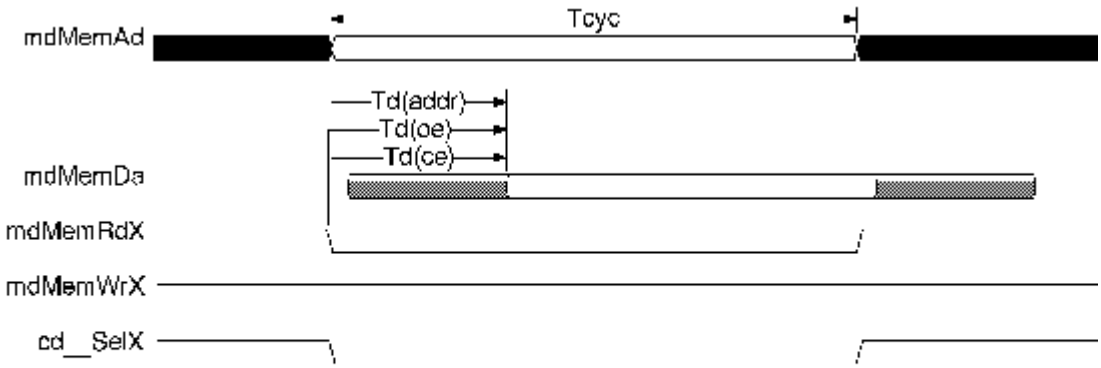


Figure 5: External memory write cycle



Td: Time delay (propagation delay)
Ts: Set Up Time
Tw: Pulse Width

Figure 6: External memory read cycle

Parameters	Flash memory		SRAM	
	Min (ns)	Max (ns)	Min (ns)	Max (ns)
Memory Write				
Ts(addr)	70		80	
Th(addr)	0		0	
Ts(data)	60		40	
Th(data)	0		0	
Ts(ce)	70		80	
Th(ce)	0		0	
Tw(we)	70		70	
Memory Read				
Tcyc	110		100	
Td(addr)		110		100
Td(oe)		30		50
Td(ce)		110		100

Table 2: Timing information for Read/Write cycle required/provided by memory chips

MAD4/VIBRA Interface

VIBRA is a vibrating motor, used as a silent alarm device. It is driven by 11kHz or 22kHz PWM signal, with a variable duty cycle to control the average current into the motor, which in turn controls the intensity of the alarm. The duty cycle is set by software and depends on the motor and the limits of the duty cycle.

MAD4/RF Interface

MAD4/RF Synthesizer Interface

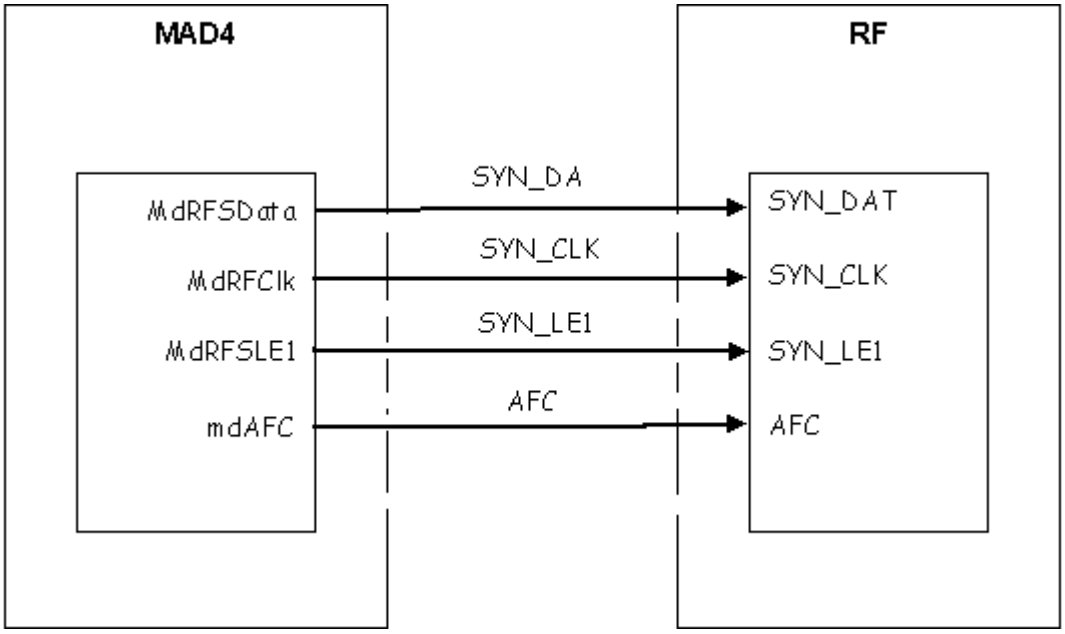


Figure 7: RF/MAD synthesizer interface

Functional Description

Figure 7 defines the MAD4/RF synthesizer interface. The synthesizer interface is capable of programming National LMX2330L Dual PLL Frequency Synthesizer. See Figure 8 and Reference 1 for synthesizer timing information such as set-up and hold time.

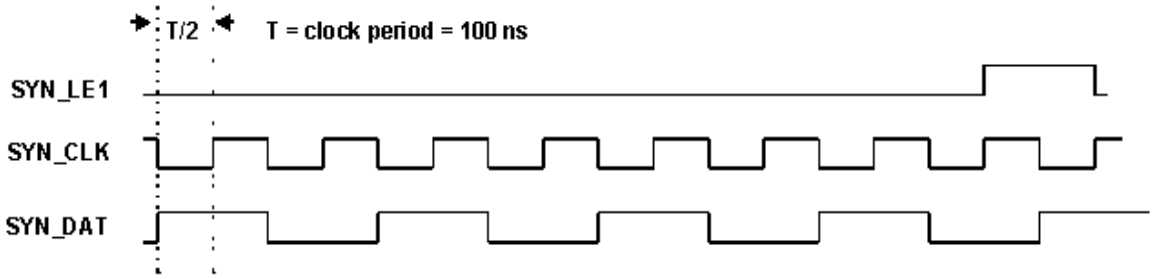


Figure 8: Synthesizer serial timing

Signal Definitions

SYN_DAT

Data sent from MAD pin E17 (mdRFSData) to the synthesizer divider and counters. It has 2.8V CMOS logic level.

High	Low	Reset/Inactive	Current	Filtering
Vdd - 0.6V	0 - 0.5V	Low/low	> 50 ns 1 mA max	None

SYN_CLK

19.2000 MHz clock sent from MAD pin E16 (mdRFSClk) to synthesizer. The rising edge of the clock is used to clock data into the synthesizer.

High	Low	Reset/Inactive	Current	Filtering
Vdd - 0.6V	0 - 0.5V	Low/low	> 50 ns 1 mA max	None

SYN_LE1

Loading enable signal from MAD pin F16 (mdRFSLE1) to RF for the dual synthesizer. See data sheet of the synthesizer for details.

High	Low	Reset/Inactive	Current	Filtering
Vdd - 0.6V	0 - 0.5V	Low/low	> 50 ns 1 mA max	None

AFC

Signal from MAD pin B17 (mdAFC) to RF VCTCXO to provide 19.2 MHz reference frequency adjustment. It is active in CDMA. When the level is above 1.2V, the frequency is increased.

Type	Range	Resolution	Current	Filtering
PDM	0 - 2.8V	9bits @ 9.6MHz clock	< 1 mA	BB: RC = 4.7×10^{-5} Sec RF: RC = 1.0×10^{-4} Sec

MAD4/RF Receiver and Transmitter Interface

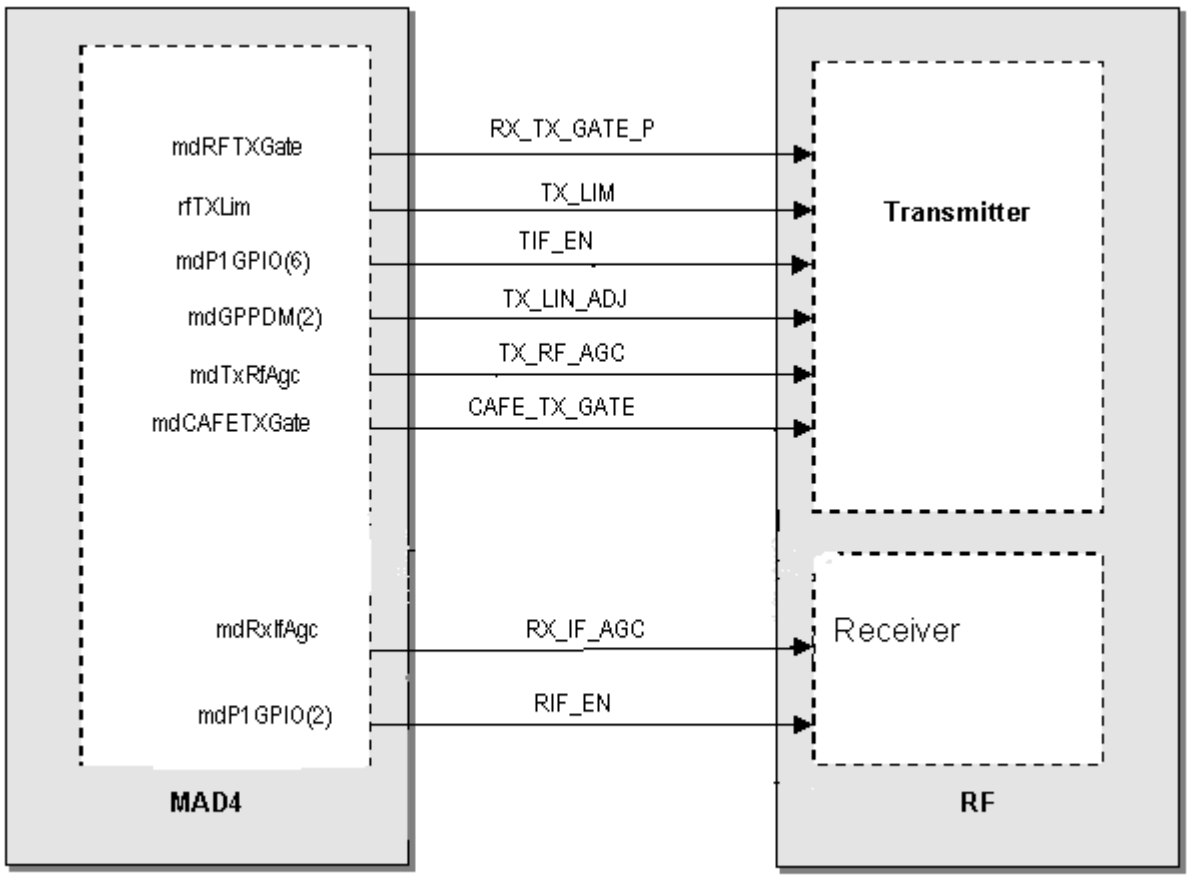


Figure 9: MAD/RF TX/RX interface

Functional Description

Figure 9 shows the interface between MAD4 and RF receiver and transmitter. It includes transmitter enable/disable, and RF power controlling. Some of the control signals have 2.8 CMOS level, while others have a PDM signal, which can be used to control RF behavior. The MAD4 PDM output is 2.8 V CMOS digital signal with pulse duration modulated with 9.6 MHz clock. Baseband provides low pass filter to smooth the signal and avoid digital noise into RF ground plane.

Signal Definitions

TIF_EN

High	Low	Load impedance	Polarity	Rising Time	Filtering
Vdd - 0.6V	0 - 0.5V	Min: 20k Typ: 200k	Low: Disable	< 25 ns (10% - 90%)	None

RF_TX_GATE_P

Signal from MAD4 pin B14 (RF_TX_GATE_P) to RF transmitter to activate the bias of cel-

lular PA section and switch regulator providing cellular PA driver. PA is activated discontinuously in CDMA mode.

High	Low	Polarity	Rising time	Filtering
Vdd - 0.6V	0 - 0.5V	High: TX on Low: TX off	< 25 ns (10% - 90%_)	BB: RC = 1.0 x 10^{-5} sec

TX_LIM

Signal from RF transmitter to MAD4 pin E15 (rfTxLim) to indicate maximum allowed output power is being exceeded, therefore to dynamically adjust the maximum commanded transmitter gain in CDMA mode.

High	Low	Polarity	Rising time
Vdd - 0.6V	0 - 0.5V	High: Power exceeded Low: Power not exceeded	< 10 ns

TX_LIM_ADJ

Signal from MAD4 pin D16 (mdGPPDM2) to RF transmitter to set trig point of indicator where maximum transmit power is exceeded in CDMA.

Type	Range	Resolution	Load impedance	Filtering
PDM	0.3V - 2.8 V	8bits @ 9.6 MHz clock	1M	BB: RC = 1.0 x 10^{-4} sec

TX_IF_AGC

Signal from MAD4 pin A15 (mdTxIfAgc) to IF VGA to control the gain of the transmit IF section.

Type	Range	Resolution	Filtering
PDM	0.3V - 2.8 V	9bits @ 9.6 MHz clock	BB: RC = 2.2 x 10^{-5} sec

Signal from MAD4 pin C14 (mdTxIfAgc) to RF VGA to control the gain of the transmit RF section. It tracks TX_IF_AGC signal with separate slope adjustment.

Type	Range	Resolution	Filtering
PDM	0.3V - 2.5 V	8bits @ 9.6 MHz clock	BB: RC = 2.2 x 10^{-5} sec

RIF_EN

Signal from MAD pin D2 (mdP1GPIO(2)) to RIF to enable RIF and to provide AGC reference with PDM high voltage.

RX_IF_AGC

Signal from MAD4 pin A16 (mdRxIfAgc) to RIF pin AGC to control the gain of the receive IF section. It is activated only by CDMA.

Type	Range	Resolution	Load impedance	Filtering
PDM	0 - 2.8V	8bits @ 9.6 MHz clock	Min: 10k	BB: RC = 1.0 x 10^{-4} sec

CAFE Module/Interface

CAFE Module Description

Introduction

CAFE module provides an interface between the digital portion of the phone (CDMA digital data and control signal processing) and the analog portion (RF). It consists of CAFE ASIC and some discrete components around the ASIC. It also provides an interface between MCU/DSP and external audio accessory.

Inside CAFE ASIC, there are several sub-blocks: CDMA receive A/D converter, CDMA receive FIR filter, CDMA transmit D/A converter, PLL clock recovery circuitry, and audio CODEC. Externally, the module contains some data buses and control lines, as well as some clock signals.

Figure 10 provides a brief overview of the interface.

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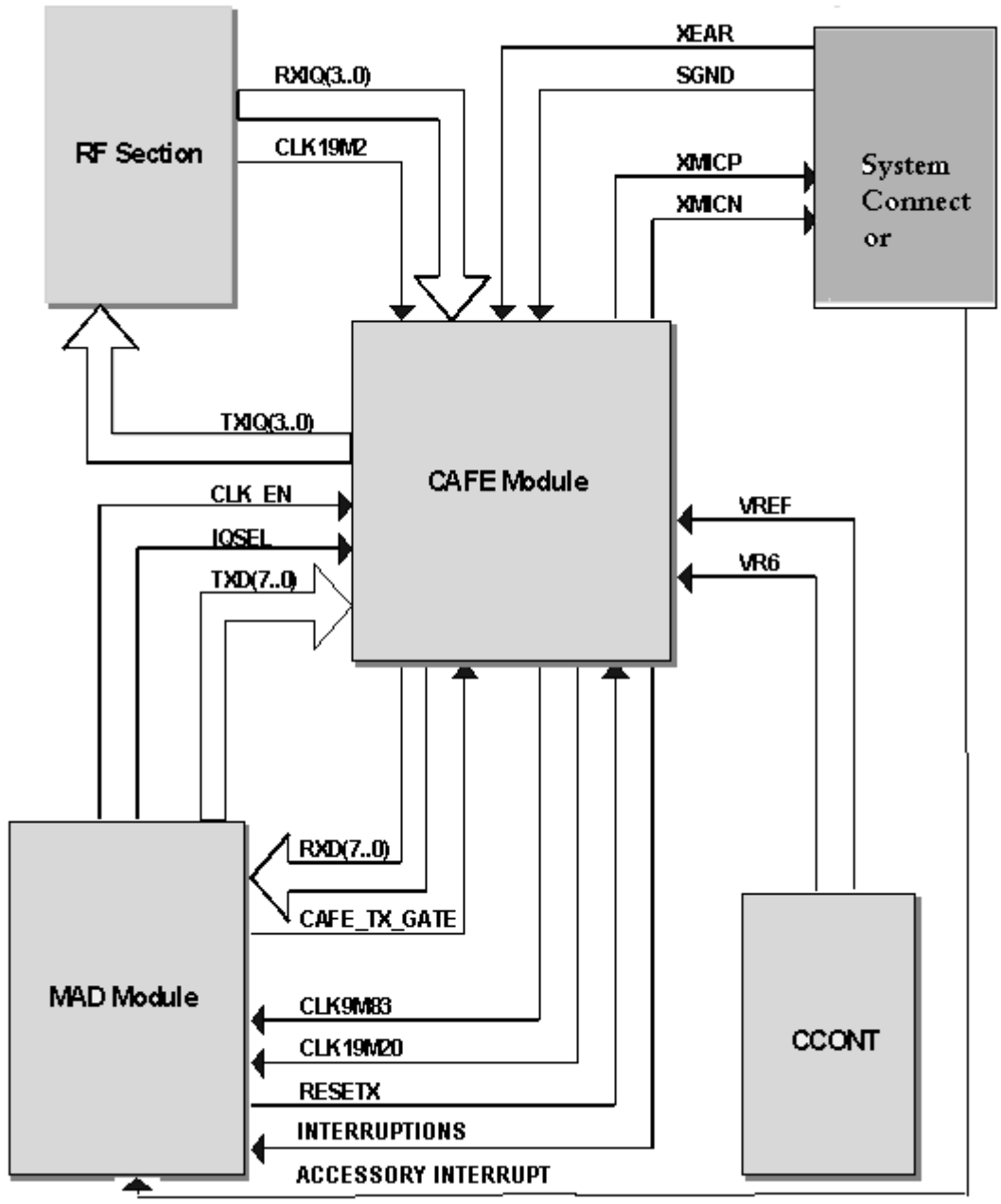


Figure 10: CAFE module block diagram

Detailed Module Description

CDMA Mode

When the phone is in CDMA mode, I and Q components of the received IF signals from RIF are differentially AC coupled to CAFE ASIC. The input signal levels, impedance, and capacitance are described in Reference 3. For more information, refer to that document.

The received signals are A/D converted to 4-bit digital signals inside the CAFE ASIC and then are sent to the MAD4 ASIC through data bus RXD[11:0]. The 4-bit in-phase compo-

nent, RXI, is RXD[11..8]. For load impedance and input/output rise/fall time and other electric characteristics, refer to Reference 3 [CAFE application].

The transmitted signal is fed to the CAFE ASIC through data bus TXD[7:0] from MAD4 ASIC. The digital signal is registered inside CAFE ASIC. In-phase and quadrature components are separated from each other by using IQSEL from MAD4, and are D/A converted to analog signals. The transmitted signals (I and Q components) are then converted to differential signals and sent to TIF of RF section. The output signal levels are described in the section "CDMA I and Q transmit channel D/A converters and post filters" of the CAFE design specification (Reference 3). Signal CAFE_TX_GATE is used to control the power for transmits DAC and filters inside the CAFE ASIC. When it is high, the power to those two blocks is turned on; otherwise, the power is turned off.

Clock

A 19.2 MHz sine wave clock is sent from RF to CAFE ASIC. It is squared inside the CAFE to provide 19.2 MHz square wave clock to MAD4. There is about 1.4V DC offset to the 19.2 MHz sine wave clock. It has to be DC-coupled to the CAFE ASIC. A phase-locked loop is used to generate a 9.83 MHz signal. This clock also is sent to MAD4 and used as CDMA system clock, which is eight times the chip clock (1.2288 MHz). The electric characteristics of the clock recovery circuit are described in the CAFE specification.

Audio

There are two kinds of audio inputs to the CAFE ASIC. The first is from the built-in microphone. The second is from an external accessory. The signal from the built-in microphone, MICP and MICN, is sent to CAFE differently, using pin F10 and pin E10. The differential input signal range is from 200mVpp to 2.0Vpp, and depends on the gain setting inside the CAFE. (CAFE provides up to 20 dB gain.) The internal microphone is biased by a DC signal from pin D11. It also could be biased by VR1_SW.

The audio signal from an external accessory part (XMICP/XMICN) is differentially sent to CAFE through pin F11 and pin E11. The external microphone bias is provided by AUXOUT at pin B11 when CODEC_XMIC_BIAS = 1 in control register 2.

The audio receive path consists of D/A converter, lowpass filter and output attenuator with three selectable outputs. Only one output can be activated at a time. The bias at the outputs can be independently controlled to be ON at all outputs to avoid switching transients. EAR output from pin A9 and pin B10 of CAFE ASIC is intended to drive the phone earpiece having typical 32-ohm resistance in the audio band. Output is differential, with positive (EARP) and negative (EARN) output terminals.

HF output is intended to drive the phone external audio circuitry (XEAR). Output is signal-ended, but it also has another pin (HFCM), which drives the signal ground for it.

External microphone input and external speaker output can be detected by signal HOOKINT, EAD, and EAD_HEADINT. For detailed information, consult the audio accessory specification (Reference 7).

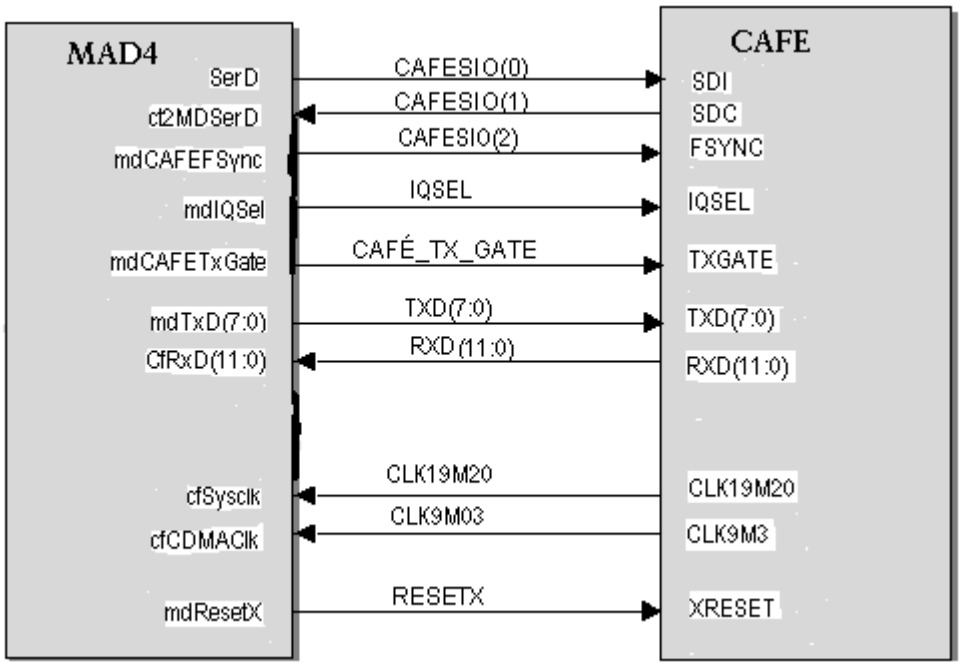


Figure 11: MAD/CAFE interface diagram

General Description

As shown in Figure 11, the interface between MAD4 and CAFE consists of a parallel transmit bus (TxD), parallel receive bus (RxD) data, two serial data paths for both CAFE control and CODEC audio transmit/receive data, and an 8 kHz frame sync for the serial data bus.

The interface also includes the system clock and other required clocks. CAFE provides MAD4 19.2 MHz system clock (CLK19M20) and the 9.8304 MHz CDMA clock (CLK9M83). MAD4 creates internal clocks from the system clock. The 8 kHz sync signal is 320 kHz period wide pulse (serial data interface rate). All data transmission and reception in the MAD ASIC will be clocked in/out with the rising edge of the clocks and all data transmission and reception in CAFE will be clocked in/out with the falling edge of the clocks. MAD4 also supplies CAFE with an active "low" power reset signal (mdResetX).

Signal	Parameter	Min	Typical	Max	Function
CAFESIO(0)	"1" (V) "0" (V) T_{SDOD}	2.24 0	2.70 0.30	Vbb 0.62 20 ns	MAD to CAFE serial data for CAFE control, and digitized rreceived audio data to CODEC
CAFESIO(1)	"1" (V) "0" (V) T_{SD1H} T_{SDISU}	2.24 0 20 ns 20 ns	2.70 0.30	Vbb 0.62	CAFE to MAD serial data bus to read CAFE control register data and send digitized audio data to MCD

Signal	Parameter	Min	Typical	Max	Function
CAFESIO(2)	"1" (V) "0" (V) Tf (ns) Tr (ns)	2.24 0 TBD TBD	2.70 0.30	Vbb 0.62 TBD TBD	8 kHz frame sync clock from MAD to CAFE to synchronize CAFE serial interface to MAD
IQSEL	"1" (V) "0" (V) T_{IQSU} (ns)	2.24 0 20	2.70 0.30	Vbb 0.62	I and Q selection from MAD to CAFE. "1" is for I data and "0" is from Q and AMPS data
CAFE_TX_GATE	"1" (V) "0" (V) T_{TXGON} T_{TXGOFF} T_{TXGS} (ns) T_{TXGH} (ns)	2.24 0 10 us 10 us 10 10	2.70 0.30	Vbb 0.62	CAFE internal transmit enable signal from MAD to CAFE (Active "High")
TXD(7:0)	"1" (V) "0" (V) T_{DH} (ns) T_{DSU} (ns)	2.24 0 20 20	2.70 0.30	Vbb 0.62	8-bit parallel transmit data from MAD to CAFE for both CDMA and AMPS modes
RXD(11:0)	"1" (V) "0" (V) T_{DRXD} (ns)	2.24 0	2.70 0.30	Vbb 0.62 20	12-bit parallel receives data from CAFE to MAD for both CDMA and AMPS mode
CLK19M20	"1" (V) "0" (V) Tper (ns)	2.24 0 52.08	2.70 0.30	Vbb 0.62 52.08	19.2MHz system clock from CAFE to MAD
CLK9M83	"1" (V) "0" (V) Tper (ns)	2.24 0 101.73	2.70 0.30	Vbb 0.62 101.73	9.8304MHz CDMA system clock from CAFE to MAD
RESETX	"1" (V) "0" (V) Tf (ns) Tr (ns)	2.24 0 TBD TBD	2.70 0.30	Vbb 0.62 TBD TBD	CAFE reset (active "low") from MAD to CAFE

Tf:Falling time
Tr:Rising time
$T_{SDOD:}$Delay time for data from CAFE to MAD4, from CLK19M20 to data valid
$T_{SDIH:}$Hold time for serial data from MAD4 to CAFE
$T_{SDISU:}$Setup time for serial data from MAD4 to CAFE
$T_{IQSU:}$Setup time for IQSEL
$T_{TXGON:}$TXGATE turn on time before first valid data
$T_{TXGOFF:}$TXGATE turn off time after last valid data
$T_{TXGS:}$Setup time for TXGATE
$T_{TXGH:}$Hold time for TXGATE
$T_{DH:}$Hold time for TXD(7:0)
$T_{DSU:}$Setup time for TXD(7:0)
$T_{DRXD:}$Delay from CLK9M80 falling edge to valid RX data
$T_{per:}$Clock period

Table 3: MAD/CAFE interface signals

CAFE/MAD4 Serial Data Interface

MAD/CAFE serial data interface allows both DSP and MCU processors within MAD4 to read/write CAFE control registers. It also provides a serial interface with MAD4 for the CODEC to receive and transmit audio data.

The serial data is transferred at a 320KHz data rate. The frame structure for the serial interface is based on an 8 kHz wide period where the control data is transferred in the first half of the frame period and the audio data is transferred in the second half of the frame period for both directions.

For details on the interface protocol, refer to the CAFE ASIC specification.

CAFE/MAD4 TX Interface

The MAD/CAFE TX interface consists of an 8-bit data bus output from MAD4 to CAFE to be D/A converted to analog signal. The data transfer rate is 9.8304 MHz. The data to be transmitted is clocked out of MAD4 at the rising edge of the 9.8304 MHz clock and clocked into CAFE at the falling edge of the clock.

In CDMA mode, the data consists of alternating TXI and TXQ data. IQSel signal is used by CAFE to select the appropriate I/Q component. When IQSel = '1', the data is TXI component; when IQSel = '0', the data is TXQ component.

For more information, see CAFE design specification.

TX Gate Enable

CAFE_TX_GATE is an active high-enable signal used to enable/disable CAFE internal TX DACs. This signal is provided by the CDMA transmit block within MAD4 and is synchronized to the 9.8304MHz clock.

CAFE/MAD4 Clock/Reset Interface

The active low signal (RESETX) is used as an asynchronous reset for CAFE to set all internal registers to a known state when the system starts up.

CAFE provides MAD4 with two clocks. One is the system clock, which is 19.2MHz. The other is a CDMA clock that is 9.8304MHz. MAD4 generates its internal lower rate clocks for interface data transmission and reception. It also supplies an 8 kHz frame sync pulse (CAFESIO2) to CAFE, which is used to create its own internal clocks for interface transmission and reception. These are synchronized to the equivalent clocks within the MAD ASIC.

The following figure (Figure 12) shows the correlation and alignment of internal/external clocks within these two ASICs.

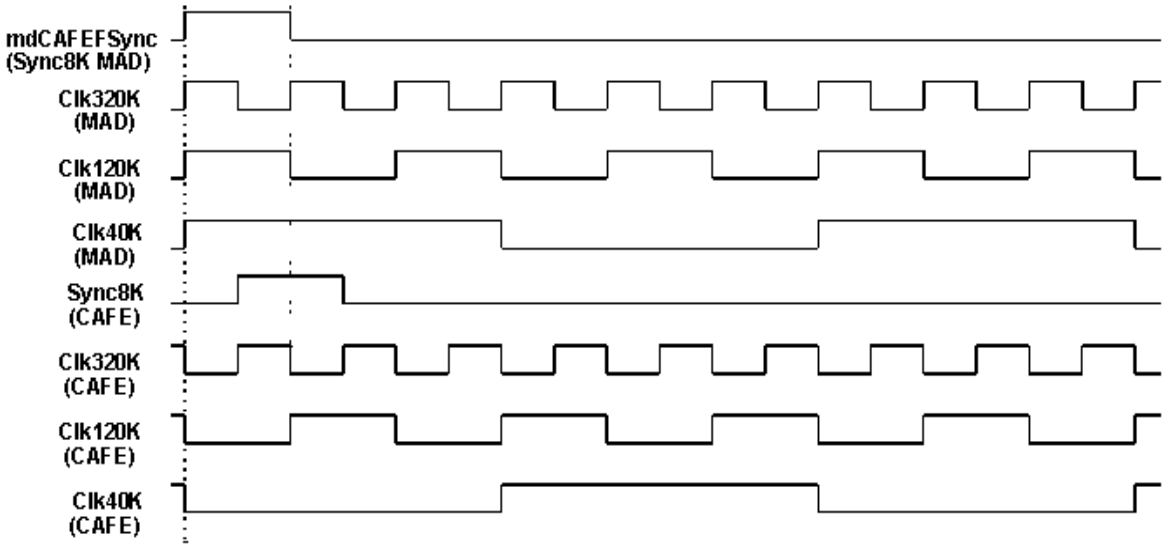


Figure 12: MAD/CAFE clock correlation/synchronization

CAFE/RF Interface

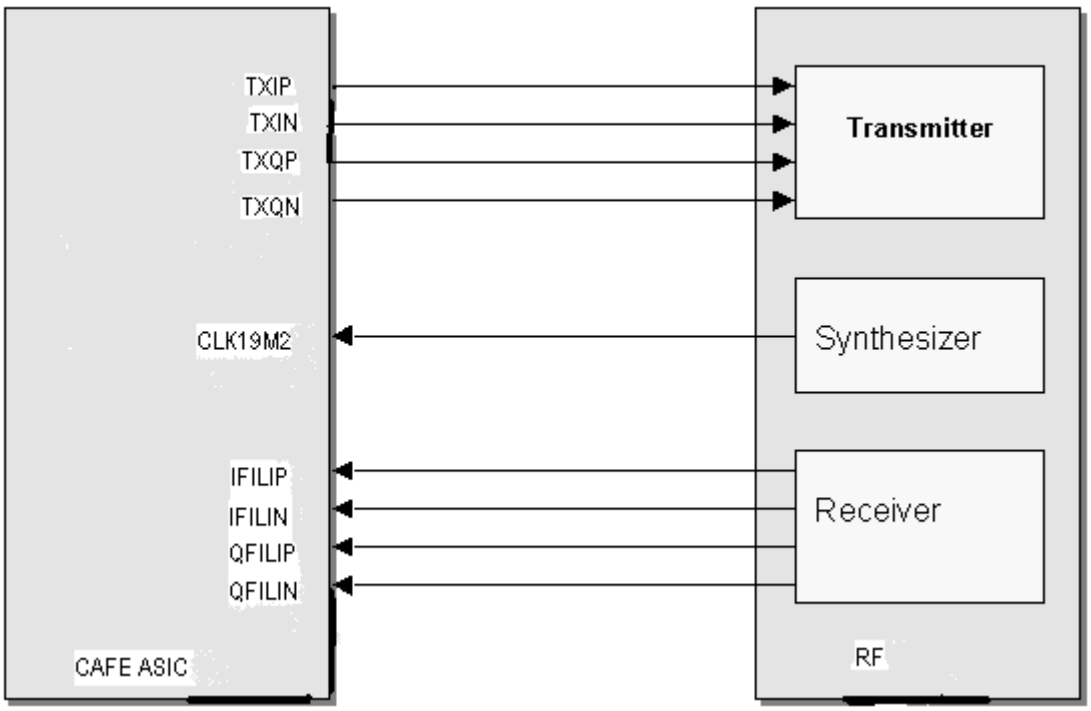


Figure 13: RF/CAFE interface

General Description

As shown in Figure 13, the interface between the RF parts and CAFE has the following signals (Table 4).

Signal	Parameter	Min	Typ	Max	Description
CLK19M22	Freq (MHz)	19.2 +/- 2.5 ppm			19.2MHz system clock input from VCTCXO to clock squaring circuit
	Phase Noise (dBc/Hz)	10Hz	100Hz	1000Hz	
		-70	-110	-130	
	Settling Time			5ms	
TX_IP	Level (Vpp) Noise (uVrms)	0.97	1.0	1.03 <450	CDMA TX filter I channel differential output to TIF I/Q modulator input
TX_IN	Level (Vpp) Noise (uVrms)	0.97	1.0	1.03 <450	CDMA TX filter I channel differential output to TIF I/Q modulator input
TX_QP	Level (Vpp) Noise (uVrms)	0.97	1.0	1.03 <450	CDMA TX filter Q channel differential output to TIF I/Q modulator input
TX_QN	Level (Vpp) Noise (uVrms)	0.97	1.0	1.03 <450	CDMA TX filter Q channel differential output to TIF I/Q modulator input
RX_IP	Level (mVpp) Noise Figure (dB)	48(1)	20	25	CDMA RX filter I channel input from RIF I/Q demodulator output
RX_IN	Level (mVpp) Noise Figure (dB)	48(1)	20	25	CDMA RX filter I channel differential input from RIF I/Q demodulator output
RX_QP	Level (mVpp) Noise Figure (dB)	48(1)	20	25	CDMA RX filter Q channel differential input from RIF I/Q demodulator output
RX_QN	Level (mVpp) Noise Figure (dB)	48(1)	20	25	CDMA RX filter Q channel differential input from RIF I/Q demodulator output

(1) Center on Vref = 1.244V

Table 4: Electrical characteristics of the CAFE/RF interface signals

RX/CAFE CDMA RX Interface

The digital receive channel consists of two equal branches (RXI, RXQ). Each branch has differential input and the signal is AC coupled. See Table 5 for details.

For I and Q channels	Symbol	Min	Typ	Max	Unit
Passband frequency (-0.5 dB point)	fpb	620	630	640	kHz
Stopband frequency	fsb			900	kHz
Max differential input voltage range in passband	VI_{pb}			20	mVpp

For I and Q channels	Symbol	Min	Typ	Max	Unit
Max differential input voltage range in stopband	VI_{sb}			1	Vpp
Input impedance	ZIN	10	13	16	kΩ

Table 5: RXI, RXQ receive channel characteristics

RF/CAFE CDMA TX Interfaces

The digital transmit channel consists of two equal branches (TXI, TXQ). Each branch has differential output and the output signal is AC coupled. Table 6 lists some of the transmit channel characteristics. For more information, consult the CAFE design specification (Reference 3).

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
Vout	Output voltage Range (differential to the load)	Centered on Vref = 1.45V	0.97	1.0	1.03	Vpp
IM3	3rd order intermodulation distortion	Two tone test: 430 kHz, 600 kHz			-46	dB
S/N	Signal to noise ratio	At passband	48			dB
ZL	Load impedance		10			kΩ
CL	Load capacitance				20	pF
HD	Harmonic distortion				-48	dB
	Noise in 1.25 MHz - 10 MHz frequency band				45	uVrms
$F_{-0.5dB}$	Passband			630		kHz
F_{stop}	Stop band			4.3		MHz
A_{stop}	Stop band attenuation referred to pass band gain			35		dB
GD	Group delay	At passband		430		us
GDD	Group delay distortion	At passband		80		ns
GDM	Group delay match between branches			10		ns

Table 6: TXI, TXQ transmit channel characteristics

Power Management (CCONT) Module and Interface

CCONT Module Functional Description

Power management and distribution is handled by the CCONT ASIC. CCONT is a multi-

function power management ASIC which has seven 2.8V linear regulators for the RF section of the phone. One 2.8V regulator is used to power up the baseband of the phone. Additionally, one adjustable regulator can be used to power up certain parts of the baseband. There also is a 5V charge pump, 5V regulator, and 3/5V regulator.

The main functions of CCONT are: voltage regulation, power up/down procedures, reset logic, charging control (PWM), watchdog, sleep control, A/D conversion, and a real time clock.

- Six user-controlled, 2.8V regulators
- Baseband regulator
- Programmable output voltage regulator for MAD core
- Voltage reference
- 32kHz oscillator and real-time clock
- +5V output
- 3V/5V switchable output
- Power-up control circuits, power-on reset
- Charger control circuits
- Charging switch and regulator
- 10-bit 8 input A/D converter (9 inputs with temp MUX)
- Serial bus control of all functions
- Alarm clock and charger interrupt
- Battery interface

CCONT Regulators

Battery voltage (VBAT) is connected to CCONT, regulating all the supply voltages (VBB, VR1-VR7, VMAD, VR1_SW, VSIM, and V5V). CCONT default start-up mode turns on VR1, VBB, VMAD, VR6, and Vref during power-up.

VMAD provides the MAD4 ASIC with a lower core voltage. VMAD is connected to those pins on MAD4 that power the core.

During the sleep mode, most regulators are turned off except VBB and VR6 (when VBAT is higher than 3.0V). During this period, VR6 is switched from VBB since VBB is supplying power for VR6. For more information about RF power distribution, see Reference 5.

The maximum total output current from CCONT is 330mA (not including VR7). This is due to thermal considerations at maximum battery voltage during charging. However, during TX, when most outputs are enabled, the maximum current of each regulator can be obtained. Software limits the average battery voltage to 3.8V (minimal charging).

Table 7 defines the regulator outputs of CCONT.

Output	Control signal	To	Noise level (nVrms/$\sqrt{Hz}$)	Max current (mA)	Range (Voltage)		
					Min	Typ	Max
VR1	CLK_EN **OR** CtrlReg1(0)	Synthesizer	200	80	2.67	2.80	2.85

Output	Control signal	To	Noise level (nVrms/$\sqrt{Hz}$)	Max current (mA)	Range (Voltage)		
					Min	Typ	Max
VR1_SW	RFReg(2)	XMIS bias voltage	200	10	2.67	2.80	2.85
VR2	RFReg(1)	Receiver	200	80	2.67	2.80	2.85
VR3	RFReg(0)	Synthesizer	200	50	2.67	2.80	2.85
VR4	(CAFE_TX_GATE **AND** BAND_SEL) **OR** RFReg(3)	Transceiver	200	80	2.67	2.80	2.85
VR5	/BAND_SEL **OR** RFReg(4)	TX power detection	200	80	2.67	2.80	2.85
VR6	RFReg(5)	CAFE	200	80	2.67	2.80	2.85
VBB	Always on	Baseband	200	125	2.67	2.80	2.85
VREF	CtrlReg1(1)	CCONT, CAFE	30 uVrms	200 uA	1.244 1.478	1.251 1.500	1.258 1.523
VMAD	CVReg	MAD4 (Core, MCU, DSP)	N/S[a]	50	1.30	1.75	2.65
5V	Serial data bus	Transmitter	N/S[a]	25	4.8	5.0	5.2
Vpp _CCONT	CtrlReg1(2)	Flash memory	N/S[a]	25	2.8 4.8	3.0 5.0	3.2 5.2

(a) N/S: Not specified in data sheets.
(b) Maximum total current from all CCONT regulators is 330 mArms. The maximum current when both VR1 and VR1_SW are used is 80 mA.

Table 7: CCONT regulator outputs

Watchdog

MAD4 must reset the CCONT watchdog regularly. CCONT watchdog time can be set through SIO between 0 and 63 seconds at 1 second steps. After power–up the default value is 32 seconds. If the watchdog expires, CCONT will cut off all supply voltages. After total cut–off the phone can be re–started through any normal power–up procedure. CCONTs watchdog functionality may be temporarily disabled by holding CCONTs PWRONX/WDDISX pin at logic low.

Power Up

There are four ways to power on the phone.

1. Power Up by Power Button

2. Power Up With Charger Connected

3. Power Up by IBI

4. Power Up With RTC

Each of four methods is described in general in the following sections. When the battery is connected to phone, nothing will happen until the power–up procedure is initiated; for instance, by pressing the power button or by connecting a charger. After that the 32kHz crystal oscillator of CCONT is started (can take up to 1 sec), and the default regulators are powered up.

If a power down is done and the battery remains connected, the 32 kHz crystal oscillator keeps running in the CCONT.

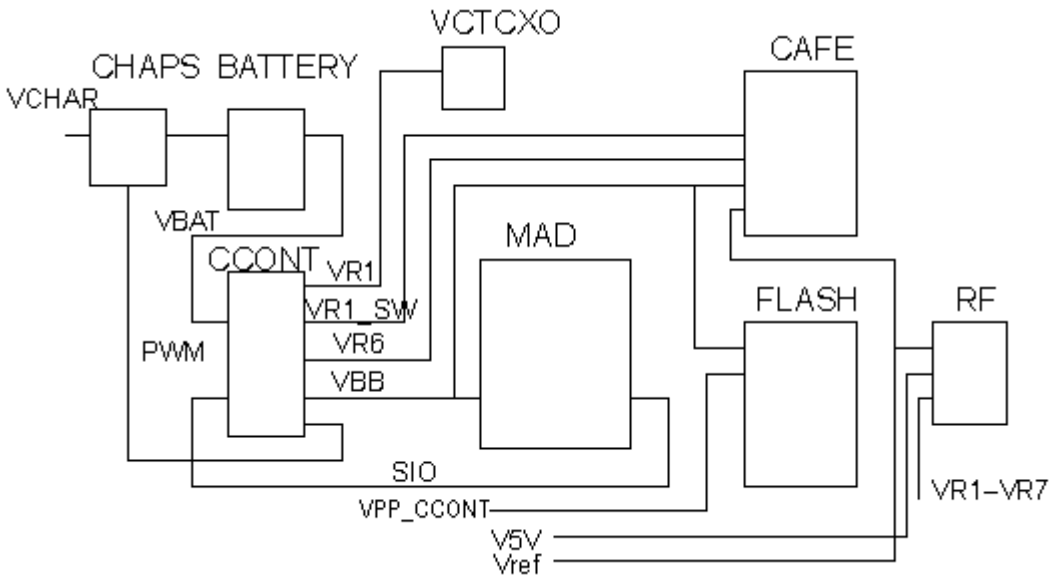
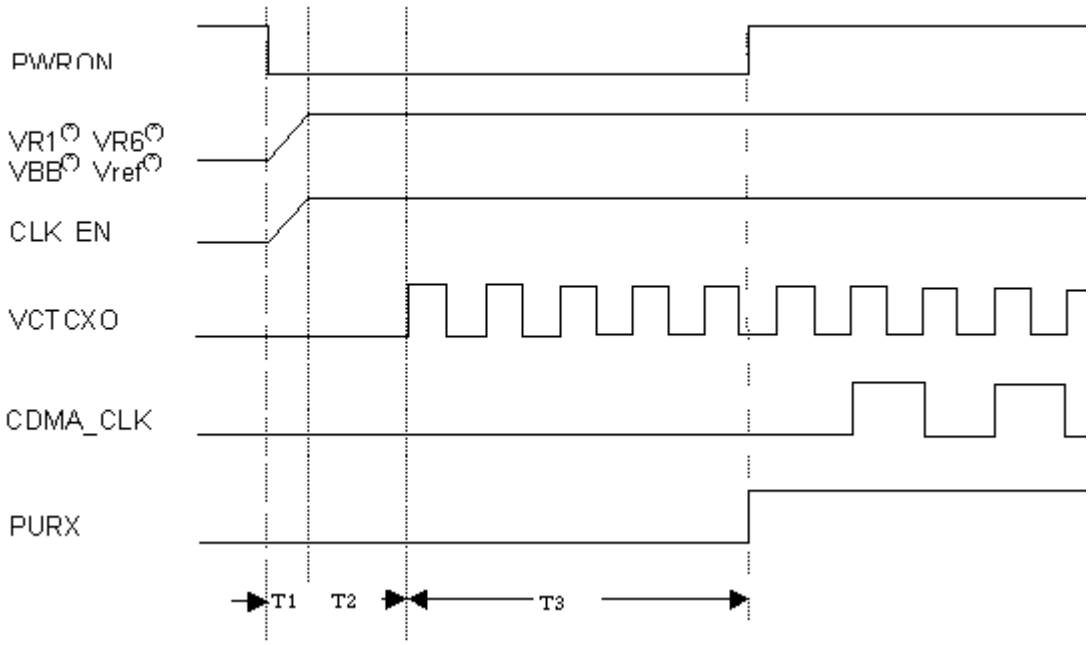


Figure 14: Power Distribution Diagram

Power Up by Power Button



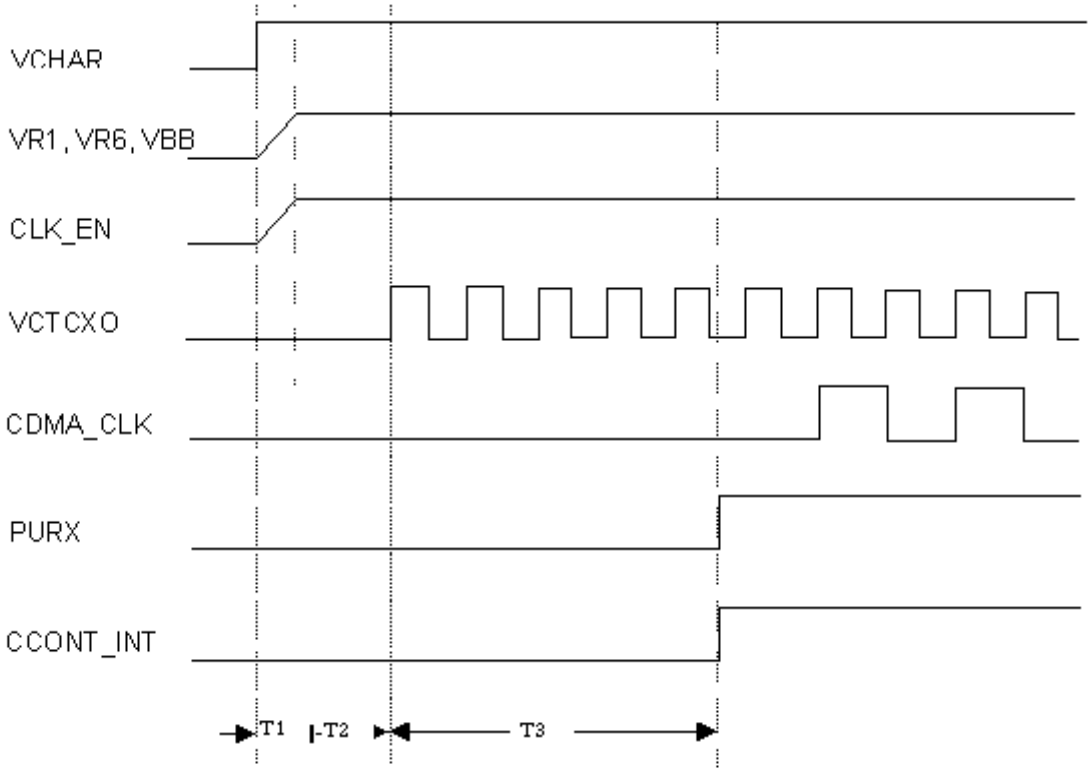
t_1< 1 ms
$t_2$11 - 6 ms, VCXO settled
t_3: 62 ms, PURX delay generated by CCONT
(*)VR1 VR6 and Vref might be later than VBB

Figure 15: Timing of power-up sequence by power button

After PWR–key has been pushed, CCONT sends PURX reset to MAD4 and turns on VR1, VBB, and VR6 regulators (if battery voltage has exceeded 3.0 V). VR1 supplies VCTCXO, VBB supplies MAD, and VR6 supplies CAFE. After the initial delay, t_2, VCTCXO starts to give a proper 19.2MHz clock to CAFE, which further divides it to 9.83MHz for MAD4. CAFE will output the 9.83MHz clock only after the PURX reset has been removed. After delay, t_3, CCONT releases PURX and MAD4 can take control of the operation of the phone.

After MAD4s reset is released, MCU–SW detects that the PWR–key is still pushed and shows the user that the phone is powering up by turning on the LCD and the lights. MCU–SW then powers up the RF receiver part. See Figure 16 for timing information.

Power Up When Charger Connected



t_1: < 1 ms
t_2: 1 - 6 ms, VCXO settled
t_3: 62 ms, PURX delay generated by CCONT

Figure 16: Timing of power-up sequency by a charger

The power-up procedure is similar to the process described in the previous section, with the exception that the rising edge of VCHAR triggers the power up in CCONT.

CCONT sets output CCONT_INT, MAD4 detects the interrupt and reads CCONT status register to find the reason for the interrupt (charger in this case). After reading the A/D register to determine that the charger voltage is correct, MAD should initiate charging activities. The phone will remain in the so-called "acting dead" state, which means that only the battery bars are displayed on the LCD. The user perceives that the phone is off. If the power-on button is pushed, the LCD display will come on and startup will be the same as normal power on.

CCONT_INT is generated both when the charger is connected, and when the charger is disconnected. It goes high when a valid charger is connected or the alarm clock times out (real time clock). Once high, the MAD must actively reset this via the serial port. If two interrupts occur at the same time, the interrupt line will not go high until all interrupts have been cleared.

If the battery is empty (lower than 3.0V), CHAPS gives an initial charge (with limited current) to the battery before the battery voltage rises above 3.0V. After the battery voltage reaches 3.0V, the power-up procedure described in the previous section takes place. See Figure 16 for timing information.

Power Up by IBI

IBI can power CCONT up by setting BTEMP to logical "1". The recommended pulse width of the pulse is longer than 10 msec. After that, BTEMP acts as normal A/D input. Otherwise, the power-up procedure is the same as with the charger.

Power Up With RTC

RTC can power up the phone by setting the CCONT internal signal RTCPwr to logical "1" Otherwise, the power-up procedure is the same as with the charger.

Charging – CHAPS

CHAPS comprises the hardware for charging the battery and protecting the phone from over–voltage in charger connector. CHAPS operates in temperature ranges from -30^{o} to 130^{o} C. The software can stop charging based on the battery temperature to protect the battery from being damaged (e.g., the cutoff temperature for the nickel battery is 47^{o} C; the cutoff temperature for the lithium battery is 85^{o} C). Figure 17 gives a brief block diagram of the charging submodule.

The main functions of CHAPS are:

- protection against transient, over–voltage, and reverse charger voltage
- limited start–up charge current for a totally empty battery
- limit voltage when battery removed
- software protection against overcharging current

CHAPS is basically a PWM (Pulse Width Modulation) controlled switch, which connects the charger to VBAT. MAD4 controls CHAPS by writing PWM values to CCONT PWM register over a serial bus. CCONT then outputs a PWM, which is used by CHAPS to control the switch. In the case of an external fast charger, the PWM is not available at the system connector to control the charger. There are only two wires connected to the charger. In the case of a dead battery, shorted battery, or a battery below 3.0V, CHAPS supplies a controlled leakage current of about 180mA through the switch to attempt to bring the battery voltage up.

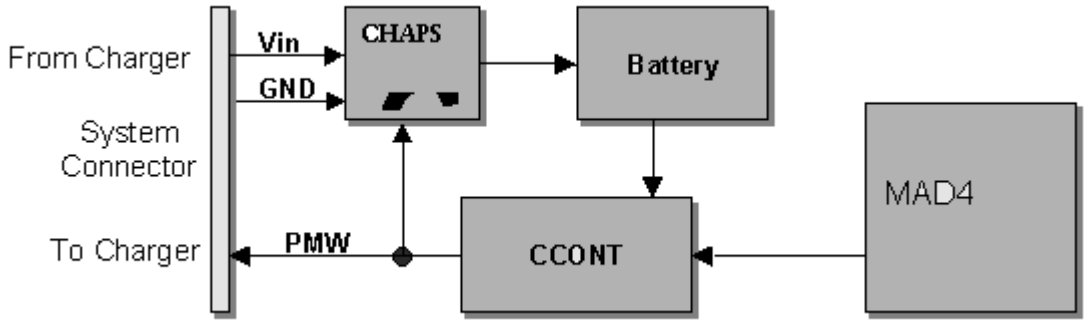


Figure 17: Charging block

With 2–wire charging, the charger provides constant output current, and the charging is controlled by the PWMOUT signal from CCONT to CHAPS. PWMOUT signal frequency is 1 Hz, and the charging switch in CHAPS is pulsed on and off at this frequency. The pulse width of PWMOUT is controlled through the serial data bus.

There is a protection mechanism in CHAPS to protect the phone from over-charging the phone's voltage. When a charger is connected to the phone, if VBAT exceeds preset limits in CHAPS, the switch immediately turns OFF (soft switching is bypassed). There are two voltage limits: VLIM1 and VLIM2. VLIM input = "0" selects VLIM1; VLIM input = "1" selects VLIM2.

Symbol	Parameter	Min	Typ	Max
VLIM1 (V)	Output voltage cutoff limit (during transmission or Li-battery)	4.4	4.6	4.8
VLIM2 (V)	Output voltage cutoff limit (no transmission or Ni-battery)	4.8	5.0	5.2

When the switch turns off due to an overvoltage condition, it stays off until the input voltage falls below the specified limit (VCH<VBAT). Phone software will stop the charging as fast as it detects that there is no battery present.

CCONT/MAD4 and CCONT/Others Interface Signals

Table 8 lists all of the inputs and outputs of the Power Management section.

Signal	To	Signal Level (V) High	Low	Rising time	Falling time	Function
MAD4						
CLK_EN	CCONT	> 2.4	< 0.62	16 ns	16 ns	Enable VR1 and CAFE CDMA clock output
CCONTCSX	CCONT	> 2.4	< 0.62	16 ns	16 ns	Serial bus select
UIF_CCONT_SDIO	CCONT	> 2.4	< 0.62	10	10	Serial bus data
UIF_CCONT_SCLK	CCONT	> 2.4	< 0.62	10	10	Serial interface clock, also used for LCD
CCONT_INT	MAD	> 2.1	< 0.5	25	25	Interrupt signal to MAD
PURX	MAD	> 2.1	< 0.5	25	25	Power up reset
SLEEPCLK	MAD	> 2.1	< 0.5	25	25	32 kHz clock
VLIM	CHAPS	> 2.24	< 0.62	N/S [a]	N/S [a]	Chaarge voltage limit control
CAFE_TX_GATE	from MAD	> 2.24	< 0.62	16 ns	16 ns	
RF						
PA_TEMP	from TX	N/A[b]	N/A[b]	N/A[b]	N/A[b]	PA temperature mux'ed with VCXO_TEMP

Signal	To	Signal Level (V) High	Signal Level (V) Low	Rising time	Falling time	Function
MAD4						
Regulator Outputs				N/A(b)	N/A(b)	See CCONT regulators for details
Battery						
VBAT	from battery	VBAT	VBAT	N/A(b)	N/A(b)	Battery input
BSI	from battery	N/A(b)	N/A(b)	N/A(b)	N/A(b)	Battery type
BTEMP	from battery	N/A(b)	N/A(b)	N/A(b)	N/A(b)	Battery temperature, muxed with VIBRA
CAFE						
EAD_HEADINT	from CAFE	N/A(b)	N/A(b)	N/A(b)	N/A(b)	External accessory interrupt
SGND		N/A(b)	N/A(b)	N/A(b)	N/A(b)	Audio ground
OTHERS						
PWRONX		> 2.1	< 0.5	N/A(c)	N/A(c)	Power on, watchdog disable
V_IN	from charger	V_IN	V_IN	N/A(b)	N/A(b)	Charger input
L_GND	from charger	0	0	N/A(b)	N/A(b)	Charger ground
CHRG_CTRL	CHAPS	> 2.1	< 0.5	N/A(a)	N/A(a)	PWM control signal

(a) N/S (not specified in the data sheets)
(b) Analog signals. The level depends on input. No rising/falling time.
(c) Depends on switched speed.

Table 8: Power Management Inputs/Outputs

User Interface

Functional Description

As shown in Figure 18, the MAD4 serial interface is used to control the serial LCD on the user interface (UI) board and also to provide access to CCONT's registers. The DataSelX and DataClk are generated by MAD4 during both transmit and receive cycles. Each device has its own chip select signal and must hold its data pin in a high-impedance state if its chip select is not active. Data must be valid on the rising edge of DataClk during both the transmit and receive cycles.

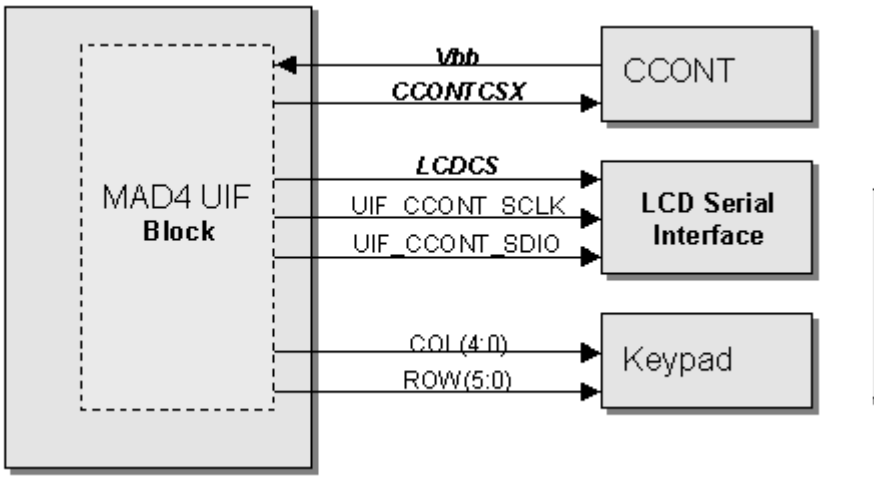


Figure 18: UI system interface block diagram

The LCD driver requires 9-bit data from the MAD UIF block. The MSB indicates whether the following 8-bit is data or command. When this bit is high, the following 8-bits are display data; otherwise, when it is low, the following 8 bits are control data.

The chip enable line also has to be modified to accommodate the interface. The new /CE is from one of the GPIO pins (port 1, bit5).

The user interface also monitors the PWR key and keyboard, as well as controlling the LCD, backlight, microphone, earpiece, and alert (buzzer, VIBRA, LED).

Signal Definitions

Table 9 defines the electrical characteristics of the user interface signals. For details on the interface signals, refer to the design specifications for MAD4 and UI.

Signal	To	Signal Level (V) High	Low	Rising time	Falling time	Function
COL(4:0)	Keypad	> 2.24	< 0.62	NA[a]	NA[a]	drives the keyboard colums
ROW(5:0)	Keypad	> 2.24	< 0.62	NA[a]	NA[a]	sample keyboard rows and drives the LCD interface
LCD-CS	LCD	> 2.24	< 0.62	10 ns	10 ns	chip select for the LCD

Signal	To	Signal Level (V) High	Low	Rising time	Falling time	Function
UIF_CCONT_SCLK	LCD/CCONT	> 2.24	< 0.62	10 ns	10 ns	serial port clock
UIF_CCONT_SDIO	LCD/CCONT	> 2.24	< 0.62	10 ns	10 ns	serial data
CCONTCSX	CCONT	> 2.24	< 0.62	16 ns	16 ns	chip-select to the CCONT serial device

(a) RC filters with time constant = 100 ns used on these signals for ESD protection.

Table 9: Electrical characteristics of the user interface

Functional Timing

Serial Port Functional Timing

Figures (19) and (20) provide LCD serial interface timing information. Reference 1 gives a detailed description of the functional timing requirements for the serial port interface. See Reference 6 for a detailed description and timing of the serial protocol for the CCONT device. See Reference 1 for a detailed description and timing of the serial protocol for the serial LCD device.

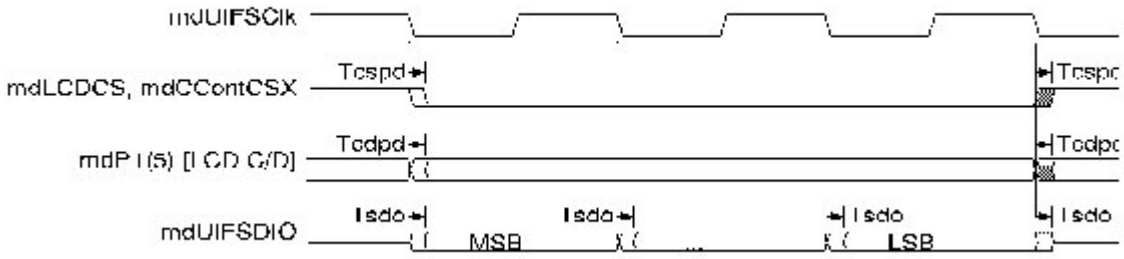


Figure 19: Serial port transmit timing

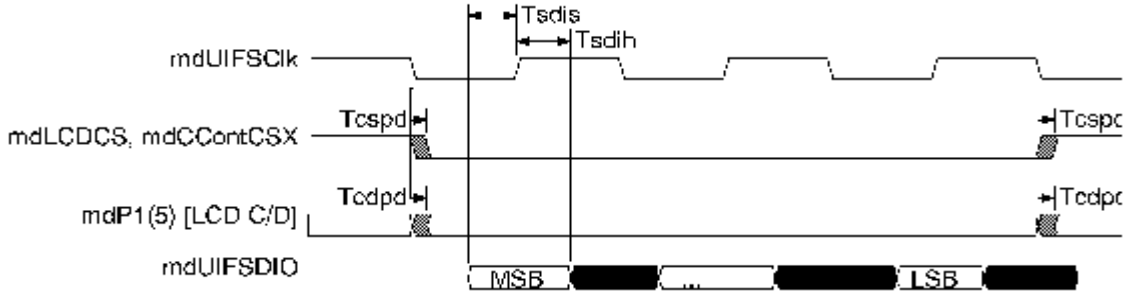


Figure 20: Serial port receive timing

Parameters	Definition	Minimum	Maximum	Unit
Tcspd	Falling edge to chip select	100		ns
Tcdpd	Falling edge to command/data select	100		ns
Tsdo	Falling edge to data out	0		ns

Parameters	Definition	Minimum	Maximum	Unit
Tsdis	Data in setup to rising edge	10		ns
Tsdih	Data in hold from rising edge	10		ns

Table 10: Serial port timing

System/Accessory Interface

Description

External accessory interface specifies a connector and set of signals that allow the phone to be used with a variety of standard peripherals (See Figure 21 following).

XEAR, XMICP, XMICN, EAD_HEADINT, and SGND are used to connect hands-free, headset, and other accessories that require analog audio signal connections.

The VIN is used for battery charging.

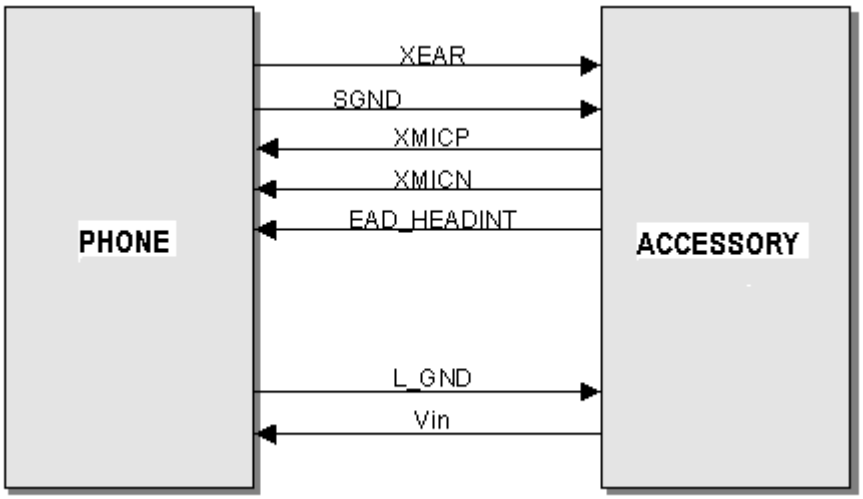


Figure 21: External accessory interface

Signal Definitions

The interface signals include XEAR, XMICP, XMICN, EAD_HEADINT, SGND, L_GND, and VIN. The function of these signals are defined as follows:

XEAR	Audio output signal to the external speaker on the HFU or headset
SGND	Audio output return (ground) path
XMICP	External microphone input
XMICN	External microphone input return (ground) path
EAD_HEADINT	External audio accessory interrupt input to MAD4

VIN	Charging input
L_GND	Charging ground

IR Interface

If the phone supports internal infrared connection, the phone is set manually to infrared mode, via the user interface SW selection. This is the only way to configure the phone for the infrared mode. The infrared connection is always a point-to-point connection.

Once the infrared mode is selected, the phone begins to operate via the infrared connection using the IrDA protocol.

The disconnection of the infrared mode also is a manual operation involving the user interface SW selection. If another accessory using cable is connected to the phone when the phone is in infrared mode, that accessory is disregarded until the phone has been disconnected from the infrared mode.

Audio Accessories

There are two types of audio accessories: headset and plug-and-play hands-free car kit.

XIMCP, XMICN, XEAR, and SGND are signals used for the external audio accessories. XMICP and XMICN provide the differential input from the external microphone to the CAFE. XEAR signals ended audio output to the external speaker. SGND is the ground for the external speaker.

The headset accessory is simple to use. It consists of only an earpiece, a microphone, and a HOOK-switch button, which can be used to answer a call or to end a call. The level of signal HOOKINT can detect the status of the HOOK. When the button is pushed, a negative pulse is generated at HOOKINT to inform MCU that there is an interrupt from external audio accessory to initiate or terminate a call.

The plug-and-play hands-free car kit is an active audio accessory that contains an integrated loudspeaker and an option to connect an external microphone (unless the phone's built-in microphone is used).

The HF_MUTE signal is used to mute the external HF speaker.

A balanced configuration is used for the headset, which is accomplished by using two 1 kOhm for biasing the microphone.

When a headset is connected to the phone, EAD_HEADINT is pulled up since the spring contact on the jag is open. MCU then checks the level on the EAD line through the CCONT to determine which kinds of accessories are connected.

When a plug-and-play hands-free unit is connected, the voltage EAD is higher since there is no microphone inside the plug-and-play and the plug-and-play provides approximately 2.1 to 2.7 Vdc voltage to the XMICP. Depending on the status of the external microphone for the plug-and-play, the MCU determines whether to use the built-in

microphone or the external microphone.

When the PPH1 is used, the MCU software ignores the interrupt from HOOKINT since the PPH1 uses the TALK key on the phone to answer/end a call.

Table 11 describes the detection for the audio accessories. For more detailed information, refer to Reference 7.

AUXOUT = "1.5 V" HF_MUTE = "L"	EAD_HEADINT	HOOKINT	EAD (mV)	P&PHF Speaker Muter
No accessory	L(1)	H	< 100	N/A
LPS - 3	H	H	431 - 742	Un - mute
JBA - 6	H	H	395 - 485	Un - mute
HS (button open)	H	H	431 - 742	N/A
HS (button close)	H	L	290 - 362	N/A
PPH (built-in mic) Charging On Charging Off	H H	L or H L or H	1102 - 1261 (2) 1102 - 1261	Un - mute Un - mute
PPH (exter mic) Charging On Charging Off	H H	L or H L or H	915 - 1067 (2) 915 - 1067	Un - mute Un - mute
PPH without power	H	L or H	353 - 440	N/A

Note:(1) L (logic low) is 0 - 0.5V and H (logic high) is Vdd - 0.6V
(2) This value will change, depending on charging and PCB layout because of the grounding between charger and audio accessory. WhenPPH-1 is used, the charger should be connected and on.

Table 11: External audio accessory detection

Battery Interface

Signal Characteristics

In addition to VBAT output and the ground, the battery has two additional outputs: BTEMP and BSI. BTEMP is used to indicate the battery temperature and BSI is used to indicate the battery type. BTEMP also is used as an input of VIBRA pulse width modulated signal for a battery with a built-in VIBRA. The Janette battery interface provides detailed descriptions of these signals. For more information refer to this document.

BSI and BTEMP Connections

BTEMP Connections

A pull-up resistor to Vref is located on the phone side on the BETMP line. NTC pull-down resistor is used in nickel batteries to give battery temperature information to the phone. This is used by charging algorithm to change charging mode or terminate charging if the battery temperature gets too high. The voltage level from this resistor divider is connected to CCONT A/D input. See Figure 22 block diagram of the interface.

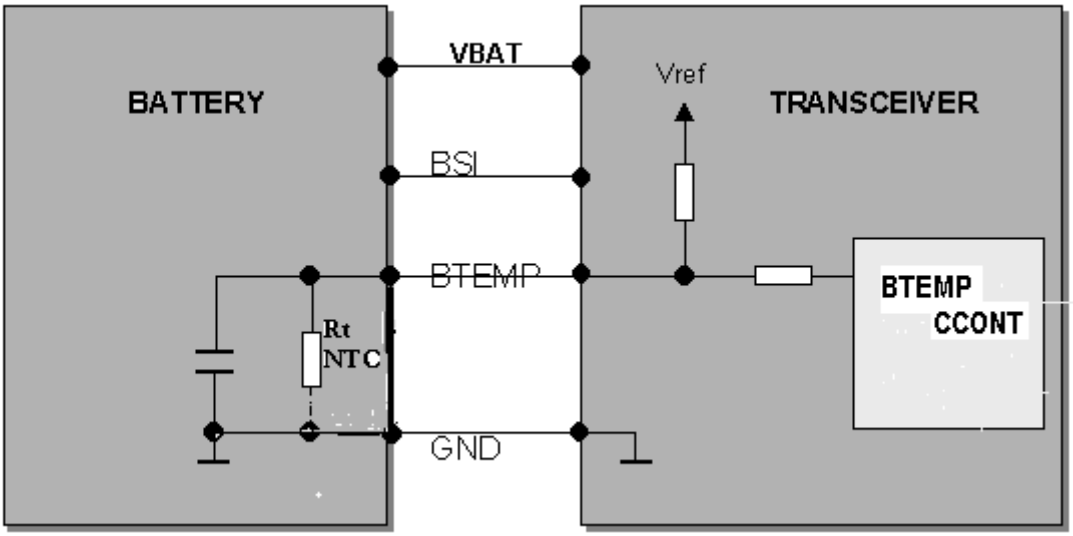


Figure 22: The interface between battery and transceiver (|)

BTEMP Connections, IBI Accessories

All accessories that can be connected between the transceiver and the battery or that itself contain the battery are called IBI accessories.

Either the phone or the IBI accessory can turn the other on, but both possibilities are not allowed in the same accessory.

IBI accessory can power on the phone by pulling the BTEMP line up to 3V for at least 10ms.

BSI Connections

There is a pull-up resistor to VREF on the BSI line. A pull-down resistor is used in the battery pack (See Figure 23). Different pull-down resistance is used to indicate different battery types. The voltage level from this resistor divider is connected to CCONT BSI A/D converter input. The following items can be detected by using a different resistor in the battery pack: lithium battery voltage and dummy battery (used for testing).

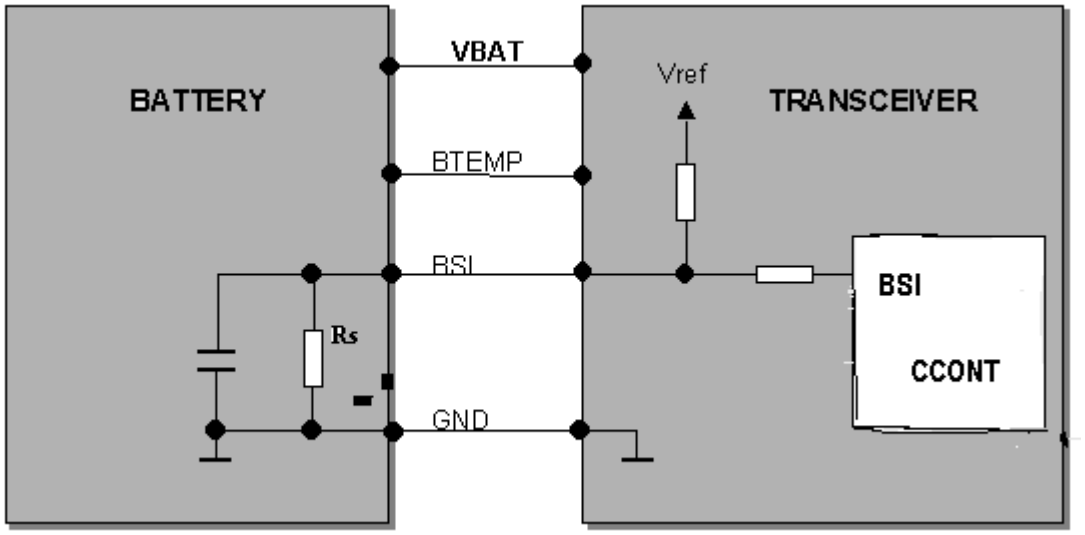


Figure 23: The interface between battery and transceiver (||)

RF Module Overview

The RF Module is compliant with the requirements of J-STD-018. Constructed on a six-layer PCB that is 1.0mm thick, the dielectric separating the layers is RCCu. All other dielectrics measure FR4.

Environmental Specifications

The ambient temperature range is from -30°C to +85°C.

Vibration and Free Fall

Specifications are listed in the NMP Standard Product Requirements.

Humidity and Water Resistance

Specifications are listed in the NMP Standard Product Requirements.

Technical Specifications

Block diagram of the RF section, including the 1900MHz transmitter and receiver and the synthesizer.

TX frequency: 1850MHz - 1910MHz

RX frequency: 1930MHz - 1990MHz

TX IF frequency: 208.1MHz

RX IF frequency: 128.1MHz

Maximum Ratings

The maximum battery voltage during the transmission should not exceed 4.5V. Higher battery voltages may destroy the power amplifier and other circuitry. The minimum battery voltage is 3.2V.

RF Connector

If nothing is plugged into the phone, the RF is connected to the single band antenna. When the RF connection is made, the RF path is switched mechanically from the antenna to the cable plugged in. Note: the RF connector is designed for RF tuning in the factory; it is fragile and could be pulled off easily, destroying the PWB if care is not taken.

Single Band Internal Antenna

A single band 1900MHz internal antenna has been developed for the U.S. PCS band. Antenna gain is 2-3dBi across the band. The transmitter output power is tuned to 23.2dBm to 23.5dBm at the RF connector.

Transmitter

The following sections describe the PCS transmitters working from the baseband signals to the duplexers.

Duplexer

The front of the duplexer is covered with a shield. It is crucial that this shield is well soldered down to avoid rejection problems. Solder joints along the mono block front (i.e., shield side) also are critical for rejection, while solder joints at the rear of the duplexer serve only for mechanical securing. Due to the problem of silver leaching, the corners of the duplexer should NOT be soldered. Only flat sections of the part should be soldered.

Parameter	Transmitter Port	Receiver Port
Insertion loss	3.3dB	3.7dB
Ripple (slope)	2.7dB	2.7dB
1850 - 1910MHz rejection		48dB
1930- 1990MHz rejection	44dB	

Table 12: Typical performance of the Scorpion duplexer

Power Amplifiers Module 1900MHz

The power amplifier is a GaAs HBT device. The PCS PA is reference designator N604. This is a two-stage device with interstage matching; it does not require an external output or input match. It is packaged in a standard module plastic package with a heat sink slug underneath. The metal slug on the underside, which serves primarily as a heat sink, also serves as a RF ground connection. A grid of vias is present under the slug to help conduct heat into the PCB. All layers have a maximum amount of copper under the PAs to assist with heat dissipation.

The PA is connected directly to Vbatt. The PA is switched on and off by controlling its

bias. Since a voltage of greater than 3.8V was required for the bias, the 5-volt output from CCONT has been utilized. The collectors of both stages of the PA are based from the battery source. The reference current provided by the current source (formed by V601 and V602) controls gain of PA module by means of the Iref pin. The Tx-Gate signal is used to switch a current mirror to switch the PA with approximately 4 mA current. If there is no RF input to the PA, then it will draw approximately 100mA.

1900MHz PA	
Gain	25dB

Table 13: Typical gain of the PA

1900MHz Transmitter Interstage Filtering

Due to the small separation between the U.S. PCS Tx Band (1930 - 1990MHz) and the Rx band (1850 - 1910MHz), it is extremely difficult to filter the Tx noise from the Rx band to a level acceptable to the receiver. The split band filter provides the Rx band rejection. A single SAW filter cannot provide the rejection due to the wide PCS band and the small separation between the Tx and Rx in PCS band. The split band filter output is connected to a SPDT RF switch.

1900MHz Upconverter

The 1900MHz upconverter has been designed with discrete circuitry for PWB space reasons and yield issues with the original MA/COM upconverter used in DCT3 (Apache).

A discrete solution has been designed with the IFA, mixer, RFA, and VVA in the same configuration as in the Apache IC. The VVA used is AT119. The gain distribution between the IFA and RFA has changed from DCT3. A discrete mixer CMY211 is used for upconversion and it has a much better IIP_3 as compared to the mixer inside Apache IC. This allows IFA gain to be increased and RFA gain to be decreased, which will dramatically improve the Tx SNR (signal-to-noise ratio) at low powers. This results in far better low power Rho as compared to DCT3.

The ACPR over the entire range of Tx power is also better than DCT3. Current consumption of the entire upconverter is around 35mA. The discrete upconverter consists of V604 (IFA), N605 (mixer), and V605 (RFA).

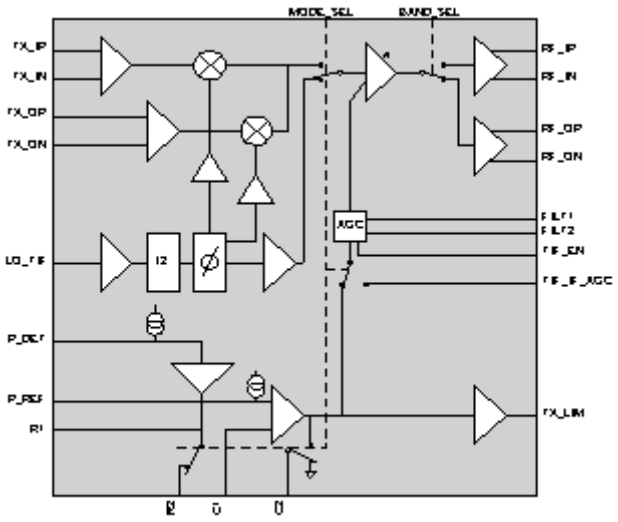
Driver

The PCS driver used is a single-input, double-output amplifier. The outputs can be selected through a digital control (CH). All inputs and outputs are single-ended, 50 ohm, and matched. This amplifier is used in the Tx chain to increase the power of CDMA signals to the PA module. It consumes a low amount of current.

Transmitter Intermediate Frequency (TIF)

The TIF IC generates the intermediate frequency (IF) for the 1900MHz transmitter. This IC reference designator (N604) incorporates the IQ modulator for CDMA mode, 85dB of dynamic range control, and a switch for the two transmitters. Also included in the TIF IC is most of the circuitry required for the power detection for CDMA over power detection

.



Receiver

The following sections describe the Rx section chain from duplexer down to the I/Q signals for CDMA fed to the baseband.

Front End

In DCT3, the Stealth LNA and downconverter was used with an external bipolar LNA. In Zim, the Alfred front end (N701) is used (same as that of Columbia). The 800MHz section of Alfred IC is unused. It is critical that the LO must be present 5ms before Alfred is powered on. The software has been informed about this. This is a very linear part. Alfred is a trimode dualband receiver front end (with 800MHz section not used). It houses LNAs and downconverters (a combination of RFA, passive mixer, and IFA) for each band. The internal LO buffer provides the necessary gain to the UHF Rx LO to the level the mixer wants to see. The mixer output feeds the IF filter single-ended. The LNAs have single-ended inputs and outputs. External matching components are provided for both the LNA and the mixer. The LNA is bypassable.

Mode		NF	IIP_3	Current
high gain	12dB	1.5dB	7dBm	5mA
LNA bypass	-5dB	4dB	20dBm	0.1mA

Table 14: PCS 1900MHz LNA Specs

Min LO drive	-7dBm
Max LO drive	-3dBm
Gain	=16dB
NF	=4dB
IIP_3	2dBm
Current	=13mA

Table 15: PCS 1900MHz Downconverter Specs

Interstage SAW Filter

The Rx interstage filter used is Z702. Insertion loss = 4.1dB.

Attenuation

DC - 1700MHz = 20dB

1850MHz - 1910MHz = 15dB

2058MHz - 2118MHz = 15dB

2186MHz - 2246MHz = 22dB

2246MHz - 6000MHz = 10dB

IF SAW Filter

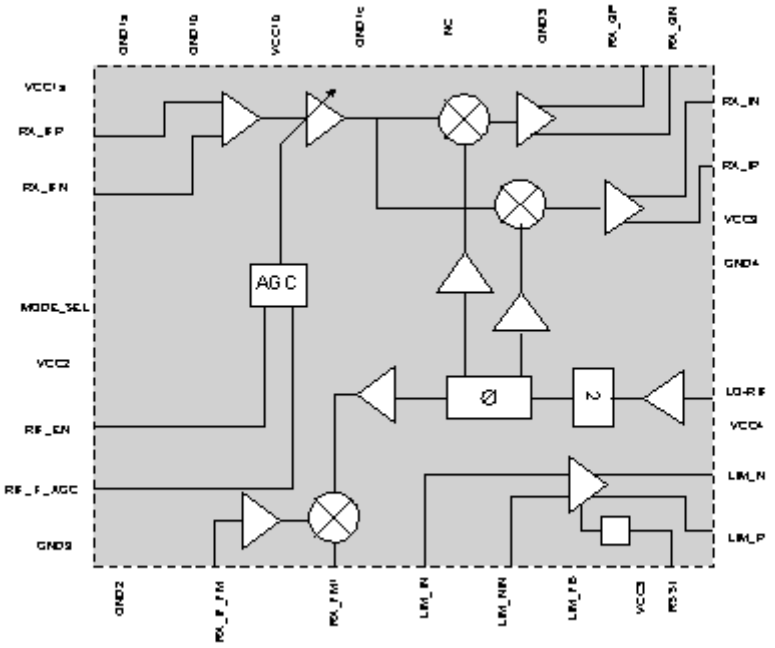
The IF SAW filter used is Z703.

Key Parameters

Center frequency	128.1MHz
Insertion loss	6dB to 10dB
3dB pass bandwidth	+/- 615KHz
Attenuation +/- 1.25MHz	37dB

Receiver Intermediate Frequency (RIF)

The RIF IC incorporates the following functions: CDMA AGC, IQ Demodulator. These functions are explained in the sections that follow. The RIF IC is powered from the VR3 regulator from CCONT and consumes approximately 24mA of current. The RIF IC reference designator (N730) is packaged in an LFBGA 36.



CDMA AGC

The RIF IC contains a wide dynamic range AGC circuit for CDMA. The AGC provides +42.5 to -42.5dB of gain controlled by the PDM line RX_IF_AGC.

IQ Demodulator

The IQ demodulator mixes the 128.1MHz IF signal down to DC with two mixers, one at quadrature to the other. The LO is at 256.2MHz and is divided by two in the demodulator.

Synthesizer

The synthesizer module supplies local oscillator signals for up/down conversion, channel selection, AFC control, and system clock requirements. Devices are manufactured by Fujitsu and National Semiconductor. The dual synthesizer is LMX2330L; the single synthesizer is MB15C130. The four submodules include:

1st Rx/2nd Tx UHF LO Synthesizer

This submodule contains a UHF VCO, a loop filter, and the RF half a dual synthesizer IC. The function of this section is Tx/Rx channel selection. The step size is dependent on the channel spacing of the band to be tuned. In the Rx path, the LO drives the down-converter. In the Tx path, the LO drives the up-converter. Dual-buffered output VCOs are being used.

1st Tx VHF LO Synthesizer

This submodule contains a VHF VCO, a loop filter, and the IF half of a dual synthesizer. This synthesizer is only tuned to a single frequency. The LO converts baseband data at the input of the I/Q modulator to the 1st IF. The lock detect signal is filtered and sent to

the baseband for Tx out-of-lock detection.

2nd Rx VHF LO Synthesizer

This submodule contains a VHF VCO, a loop filter, and a single synthesizer. This synthesizer is only tuned to a single frequency. The LO converts the received signal to baseband data. This submodule will use a mask programmable synthesizer (Fujitsu).

System Reference Oscillator (VCTCXO)

This submodule is the reference clock for the engine. It is a voltage-controlled temperature compensated crystal oscillator that can be pulled over some range of its output frequency. This allows for an AFC function to be implemented for any frequency accuracy requirements. The oscillator is temperature compensated to maintain tight center frequency control. Closed loop AFC operation will allow very close frequency tracking of the base station to be done in PCS mode. This will enable the unit to track out aging effects and give the required center frequency accuracy for CDMA in PCS bands.

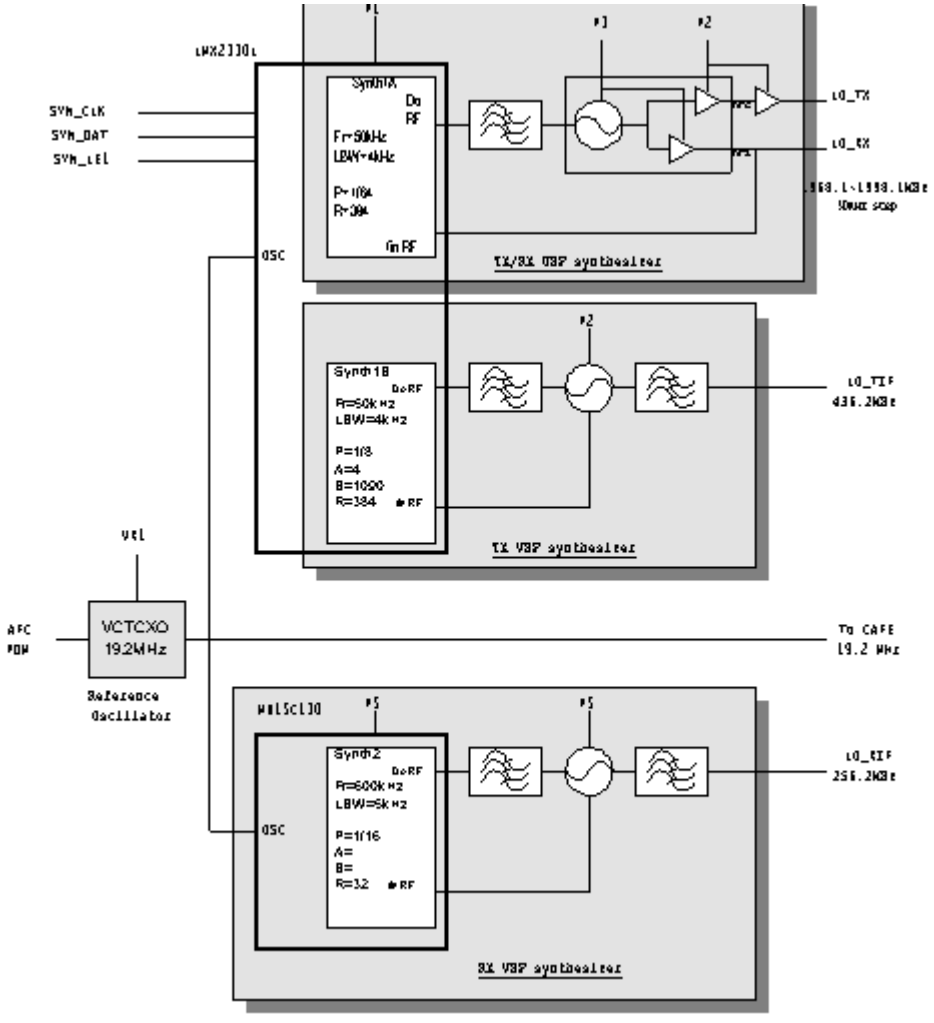


Figure 24: The block diagram of synthesizer

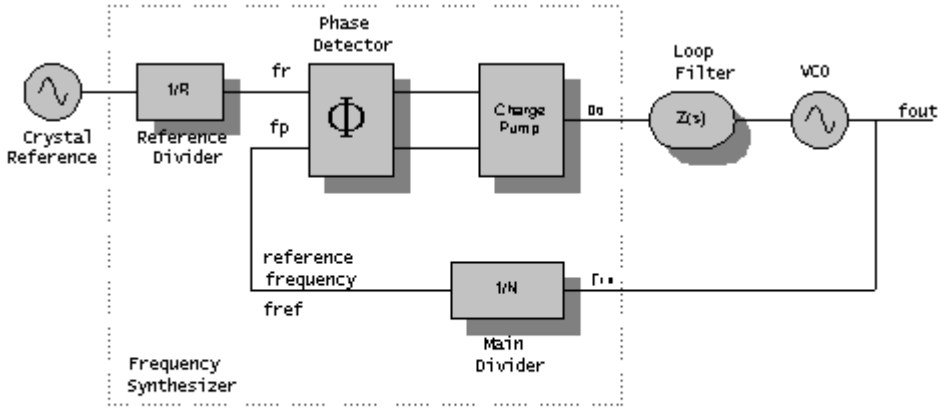


Figure 25: Block diagram of basic phase locked loop

The LMX2330L of monolithic, integrated, dual frequency synthesizers, including prescalers, is to be used as a local oscillator for RF and first IF of a dual conversion transceiver. In this explanation of LMX2330L IC, RF means the frequency range of the TX/RX UHF and IF is the frequency range of the TX-VHF.

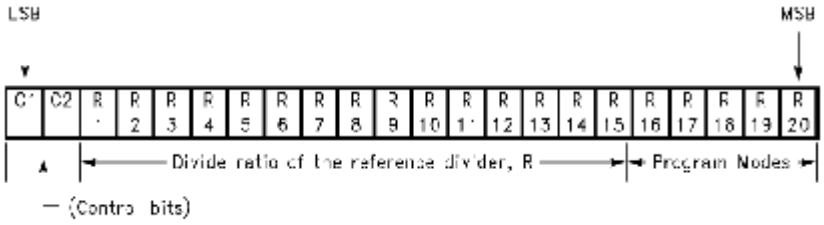
The LMX2330L contains dual modulus prescalers. A 64/65 can be selected for the RF synthesizer and a 8/9 prescaler can be selected for the IF synthesizer. LMX2330L, which employs a digital phase locked loop technique, combined with a high-quality reference oscillator, provides the tuning voltages for voltage-controlled oscillators to generate very stable low noise signals for RF and IF local oscillators. Serial data is transferred into the LMX2330L via a three-wire interface (data, enable, clock).

Functional Description of LMX2330L

Two 15-bit R counters and the 15- and 18-bit N counters. The data stream is clocked (on the rising edge of clock) into the DATA register, MSB first. The data stored in the shift register is loaded into one of four appropriate latches on the rising edge of LE. The last two bits are the control bits. The DATA is transferred into the counters as follows:

Programmable Reference Dividers (IF and RF R Counters)

If the control bits are 00 or 01 (00 for IF and 01 for RF), data is transferred from the 22 bit shift register into a latch, which sets the 15-bit R counter. Serial data format is shown here:



Control Bits		DATA Location
C1	C2	
0	0	IF R Counter
0	1	RF R Counter
1	0	IF N Counter
1	1	RF N Counter

Table 16: Control bits vs data location

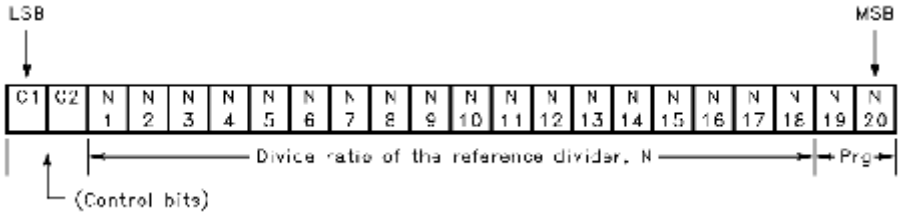
Divide Ratio	R 15	R 14	R 13	R 12	R 11	R 10	R 9	R 8	R 7	R 6	R 5	R 4	R 3	R 2	R 1
3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
23767	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 17: 15-bit programmable reference divider ratio (R Counter)

R1 to R15: These bits select the divide ratio of the programmable reference divider. Data is shifted in MSB first.

Programmable Divider (N Counter)

The N counter consists of the 7-bit swallow counter (A counter) and the 11-bit programmable counter (B counter). If the control bits are 10 or 11 (10 for RF counter), data is transferred from the 22-bit shift register into a 4-bit or 7-bit latch (which sets the swallow [A] counter) and an 11-bit latch (which sets the 11-bit programmable [B] counter), MSB first. Serial data format follows. The IF N counter bits 5, 6, and 7 are “don't care” bits. The RF N counter does not have any “don't care” bits.



7-Bit Swallow Counter Divide Ratio (A Counter)

RF

Divide Ratio A	R 7	R 6	R 5	R 4	R 3	R 2	R 1
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	1
.	.	.	.	.	.	.	.
127	1	1	1	1	1	1	1

IF

Divide Ratio A	R 7	R 6	R 5	R 4	R 3	R 2	R 1
0	X	X	X	0	0	0	0
1	X	X	X	0	0	0	1
.	.	.	.	.	.	.	.
15	X	X	X	1	1	1	1

X = Don't Care condition

11-Bit Programmable Counter Divide Ratio (B Counter)

Divide Ratio B	R 18	R 17	R 16	R 15	R 14	R 12	R 11	R 10	R 9	R 8
3	0	0	0	0	0	0	0	0	1	1
4	0	0	0	0	0	0	0	1	0	0
.	.	.	.	.	.	.	.	.	.	.
2047	1	1	1	1	1	1	1	1	1	1

Determination of Output Frequency

$f_{VCO} = [(P \times B) \times f_{OSC}/R$

f_{VCO} = Output frequency of external voltage controlled oscillator (VCO)

B: Preset divide ratio of binary 11-bit programmable counter (3 to 2047)

A: Preset divide ratio of binary 7-bit swallow counter
($0 \leq 127$ {RF}, $0 \leq A \leq 15$ {IF}, $A \leq B$)

f_{OSC}: Output frequency of the external reference frequency oscillator

R: Preset divide ratio of binary 15-bit programmable reference counter (3 to 32767)

P: Preset modulus of dual modulus prescaler (for IF: P=8 or 16; for RF: P = 32 or 64)

N = (Px B)+A

Programmable Modes

Several modes of operation can be programmed with bits R16-R20, including the phase detector polarity, charge pump TRI-STATE, and the output of the Fo LD pin. The prescaler and powerdown modes are selected with bits N19 and N20. The programmable modes are shown below. Truth table for the programmable modes and Fo LD output are shown below.

C1	C2	R16	R17	R18	R19	R20
0	0	IF phase detector polarity	IF I_{CPo}	IF D_o TRI-STATE	IF LD	IF F_o
0	1	RF phase detector polarity	RF I_{CPo}	RF D_o TRI-STATE	RF LD	RF F_o

C1	C2	N19	N20
1	0	IF prescaler	Pwdn IF
1	1	RF prescaler	Pwdn RF

	Phase Detector Polarity	Do TRI-STATE	I_{CPo}	IF Prescaler	RF Prescaler	Pwdn
0	Negative	Normal Operation	LOW	9/0	32/33	Pwdn Up
1	Positive	TRI-STATE	HIGH	16/17	64.65	Pwdn Dn

Depending upon VCO characteristics, R16 bit should be set accordingly (see the following figure):

When VCO characteristics are positive like (1), R16 should be set HIGH.

When VCO characteristics are negative like (2), R16 should be set LOW.

We used positive polarity VCO in our PLL circuits.

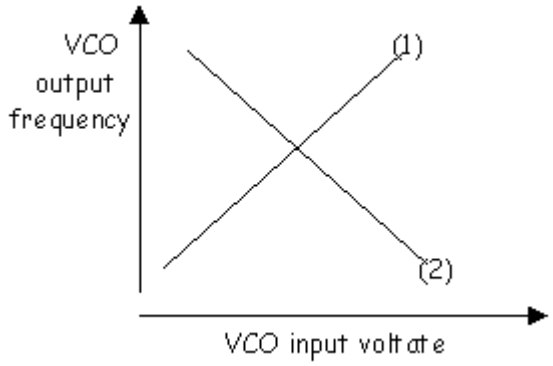
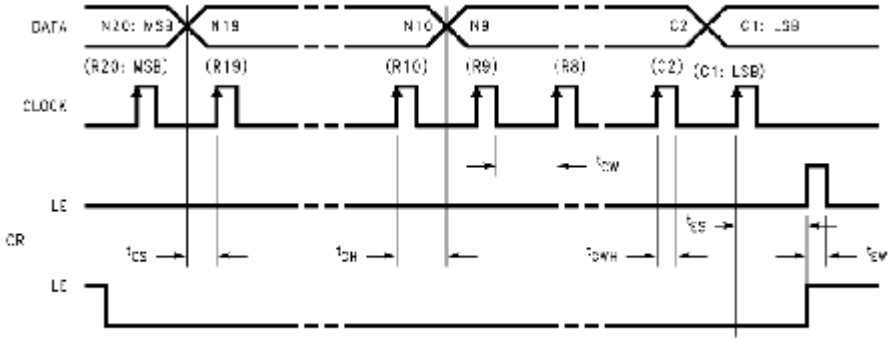


Figure 26: The polarity of VCO

Serial Data Input Timing



Data in parentheses indicates programmable reference divider data. Data shifted into register on clock rising edge. Data is shifted in MSB first.

t_{cs} = Data to Clock Set-Up Time

t_{CH} = Data to Clock Hold Time

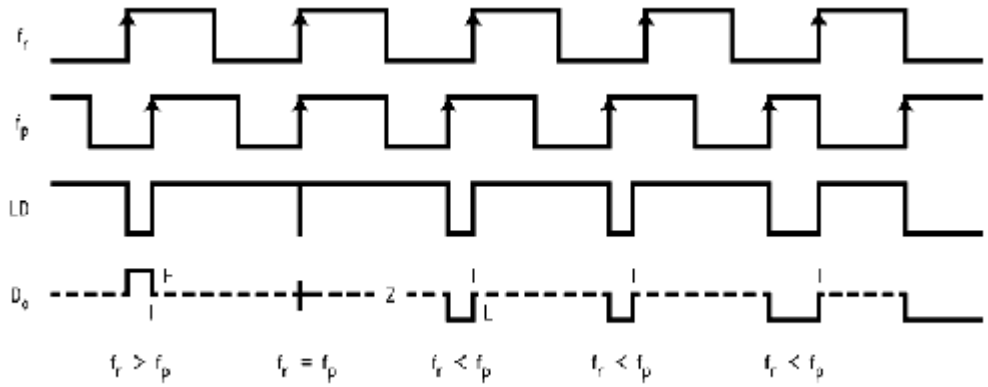
t_{CWH} = Clock Pulse Width High

t_{CWL} = Clock Pulse Width Low

t_{ES} = Clock to Load Enable Set-Up Time

t_{EW} = Load Enable Pulse Width

Phase Comparator and Internal Charge Pump Characteristics



Phase difference detection range: -2 ≠ to +2 ≠

The minimum width pump up and pump down current pulses occur at the Do pin when the loop is locked.

In case of R16 = HIGH

RF-Baseband Connections

Signal Name	From/ Control	To	Parameter	Min	Typ	Max	Unit	Function
RX_IP	RIF	CAFE	Signal voltage pk-pk		2		v	Differential I channel CDMA signal, which is filtered and passed through an ADC in CAFE
RX_IN	RIF	CAFE	Signal voltage pk-pk		2		v	Differential I channel CDMA signal, which is filtered and passed through an ADC in CAFE
RX_IQ	RIF	CAFE	Signal voltage pk-pk		2		v	Differential I channel CDMA signal, which is filtered and passed through an ADC in CAFE
RIF_EN	MAD	RIF	RIF On RIF OFF		2.7 0		v v	Control line used to enable the RIF IC
RX_IF_AGC	MAD	RIF	PDM voltage	0		2.7	v	IF gain control 8-bit PDM in MAD which is filtered to provide a DC level for RIF gain control
TIF_EN	MAD	TIF	TIF On TIF Off		2.7 0		v v	Control line used to enable the TIF IC
TX_LIM_ ADJ	MAD	TIF	PDM voltage	0		2.7	v	8-bit PDM in MAD is used to set one arm the comparator (the other the detector) in CDMA mode. It is used to set desired power.

Signal Name	From/ Control	To	Parameter	Min	Typ	Max	Unit	Function
TX_LIM	TIF	MAD	Tx higher than set on TX_LIM_ADJ Tx lower than set on TX_LIM_ADJ			0 2.7	V v	TX_LIM_ADJ and RF power detector comparator output read by MAD
TX_RF_ AGC	MAD	TX IC	PDM voltage max gain PDM voltage min gain			0 2.7	v v	8-bit PDM in MAD used to control the voltage variable attenuator
TX_IP	CAFE	TIF	Signal voltage pk-pk		1		V	8-bit PDM in MAD used to control the voltage variable attenuator
TX_IN	CAFE	TIF	Signal voltage pk-pk		1		V	Differential I channel CDMA transmit signal
TX_QP	CAFE	TIF	Signal voltage pk-pk		1		V	Differential Q channel CDMA transmit signal
TX_QN	CAFE	TIF	Signal voltage pk-pk		1		V	Differential Q channel CDMA transmit signal
TX_IF_AGC	MAD	TIF	PDM voltage max gain PDM v oltage min gain		2.7 0		v v	8-bit PDM in MAD used to control the IF gain in TIF
AFC	MAD	VCTCXO	PDM voltage	0		2.7	v	9-bit PDM in MAD used to control the VCTCXO 19.2MHz output frequency

RF Regulators

Regulators	CCONT, CHAPS	Comments
CCONT		
VR1	Synth block - VCTCXO supply	no change
VR2	Rx block Alfred. Needs to be switch on 5 ms (minimum delay) after PLL (UHF-RX) programming. Turn off sequence for VR2 and VR3 remains same. RIF moved from VR3 to VR2.	default set to nonslotted mode upon phone power-up
VR3	Rx block: RX VHF Synth block: PLL, UHF VCO	
VR4	Tx block: TX RFA (discrete) and attenauator	Puncturing should remain the same. Note: puncture input is Ored with regulator control bit to turn on/off regulator.
VR5	Tx block: Tx IFA (discrete) and mixer	Puncturing is required (same time as VR4).
VR6	CAFE	no change
VR7	TIF, UHF LO buffer, TX VHF VCO	no change
Receiver Block		
Front-end	Alfred, RX_GS (gain switch port remains). VRegP5 not used. RFSLE2 not used. RxBoost(GPPDM4) not used. Boost mode is not used. High gain mode ensures enough linearity.	Power-up sequence for Alfred requires LO stabilized. LNA switch point will be changed (eeprom setting).
RIF	RIF inputs (wrt RIF): Mode select, Outputs: LIM_P, LIM_N RIF and RSSI not required	Band_Sel and Mode_Sel can be removed in SW if desired.
TX Block		
TIF	Mode_select, Band Select (input wrt RIF) not required. Set in HW Filt_Sel_P: GPPDM3 as in Santra and Filt_Sel_N: GPPDM4 (Boost) on Santrai inverted control. Order of switching and timing does not matter.	RF_TX_Gate_C (cellband) not required.
Synthesizer Block		
PLL IC	Syn_LK1(output wrt PLL) and Syn_ACQ&SYN_PWR_DN(input wrt PLL) not used.	Free-up P1GPO4 (Syn_acq and Synth Power down) and P1GPO3 (Syn_Lk1)
UI CAFE Block		
Accessories detection	Different PnP	Pick up from Leo+
LCD Block		
		pick up from Leo+

Reference

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bulletinboard/approved/hd983/nhdx/mad4/dsgn_spc/MAD4_v3_tech_spec_2.2

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bulletinboard/hd980/controlled_docs/e1/asics/mad4/mad4_common/design/
resc_mgr_spec

3. CAFE ASIC Specification, DAS00153-EN,
/bulletinboard/hd980/controlled_docs/e2/asics/cafe/design/cafe_spec_1.5

4. Power distribution doc

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HD947/Basic Implementation of Janette Accessory Interface, R&D Copenhagen, No Doc Number, Owner: Per Bonde