

# **RDA5851 Bluetooth Multi-Media Single-Chip Terminal**

## **FEATURES**

### ● **External Memory Interface**

- ◆ Integrated 32Mb 2.8V Flash on chip, and also Supports external SPI Flash
- ◆ Integrated PSRAM on chip, 16Mb size
- ◆ Power efficient using retention technology to avoid floating lines
- ◆ Flexible IO voltage

### ● **Multimedia**

- ◆ Support camera interface up to 3Mpix sensors with 8 bit parallel or 1/2/4 data series interface, Support CSI camera interface
- ◆ Support LCD module interface with 8 bit parallel interface or SPI series interface
- ◆ Support up to 480X640 resolution
- ◆ 4-layers blending graphical engine capable of resizing and YUV2RGB conversion
- ◆ Proprietary 16/32-bit digital signal processing engine to improve computation performance

### ● **Power Management**

- ◆ Power On reset control
- ◆ Internal 32K OSC for standby/ shutoff/ sleep state
- ◆ Battery charger (from USB or AC charger)
- ◆ Integrated all internal voltages from VBAT
- ◆ Provide all LDOs for external components

### ● **User Interface**

- ◆ 8x8 Keypad scanner with multiple key detection, support ADC serial interface Keypad
- ◆ Alerter
- ◆ Light Pulse Generator for blinking LED
- ◆ Pulse Width Modulator for Keyboard or backlight control
- ◆ Touch screen interface
- ◆ LED drivers for LCD and keyboard backlight
- ◆ Calendar (Real Time Clock) with alarm

### ● **Connectivity**

- ◆ USB 1.1 Device
- ◆ 2 UART interface
- ◆ 1 SD controller
- ◆ 1 SD/SPI controller
- ◆ SPI with multiple chip select
- ◆ I2C controller
- ◆ General Purpose I/Os
- ◆ 2 GPADC, 10bits, 2 channels

### ● **Audio**

- ◆ 2 channels voice ADC, 8kHz, 13 bits/sample for headset and on-board microphone
- ◆ Voice DAC, 8kHz, 13 bits/sample for receiver
- ◆ High fidelity Stereo DAC, up to 48kHz, 16 bits per sample
- ◆ Stereo Audio speaker driver
- ◆ 1.5W differential output stereo amplifier for loudspeaker, Class K
- ◆ Stereo analog audio line input

### ● **Debug**

- ◆ Host debug interface allowing non intrusive in depth investigation
- ◆ GDB debugger
- ◆ Execution logger and profiling through debug port
- ◆ High level text based debugging using Host debug or USB

### ● **FM**

- ◆ Integrated Broadcast FM tuner which can be tuned world-wide frequency band

### ● **Bluetooth**

- ◆ Integrated Bluetooth SoC complaint with 2.1 + EDR standard

## GENERAL DESCRIPTION

### **A high performance, high integrated multi-media system-on-chip solution with Bluetooth connectivity.**

RDA5851 is a high performance, highly integrated multi-media system-on-chip solution with bluetooth connectivity.

Integrating all essential electronic components, including baseband, bluetooth transceiver, power management, FM receiver onto a single system on chip, RDA5851 offers best in class bill of material, space requirement and cost/feature ratio for multi-media wireless connectivity platform.

Built around a cost effective 32-bit XCPU RISC core running at up to 312MHz with 4k of Instruction cache and 4k of Data cache, RDA5851 offers plenty of processing power for multimedia applications. A high performance proprietary 16/32-bit digital signal processing engine can further improve overall performance and user experience when performing complex multimedia tasks.

It is also packed with impressive connectivity for easy scalability of the system, allowing glue less interfaces to camera and multimedia companion chips, SDMMC Memory Cards and SPI devices, LCD modules and USB (slave, full speed).

Additionally, RDA5851 integrates a FM tuner and a Bluetooth module which completely include digital, analogue and RF function. And they can easily work only with a few passive components as filter or matching network..

RDA5851 is available in a small footprint, fine pitch, 12 X10, 203 ball TFBGA package.

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## A. ARCHITECTURE OVERVIEW

RDA5851 is a single chip multi-media solution which integrates PMIC, Audio CODEC, FM, and Bluetooth, as well as all the system requirements for a multi-media platform.

### 1. Analog modules

- Analog block:
  - PLL generates 624MHz from 26MHz
  - Differential 13 bit Audio ADC and 16 bit stereo DAC
  - 1.5W Class K stereo loudspeaker amplifier
  - Audio line in
  - Full Speed USB PHY 1.1
  - 2 Channel General Purpose ADC
- PMU
  - Complete integrated mobile handset power management system
  - Integrated LDO voltage regulators
  - Configurable supplies to interface with external devices
  - Implement both LCD back light and keypad LED drivers
  - Support 3 SIM interfaces
- FM Tuner:
  - Support worldwide frequency band 65-108MHz
  - Digital low-IF tuner
  - Fully integrated digital frequency synthesizer
  - Autonomous search tuning
  - Digital auto gain control (AGC)
  - Digital adaptive noise cancellation
  - Programmable de-emphasis (50/75 ms)
  - Receive signal strength indicator (RSSI)
  - Bass boost
  - Volume control
- Bluetooth:
  - Completely integrates bluetooth radio transceiver and baseband processor
  - Also includes sub-controller software stack
  - Compliant with Bluetooth 2.1 + EDR specification

### 2. Digital Module

RDA5851 Digital Baseband is based on two processors: the system processor (XCPU) and the multi-media dedicated processor (BCPU). Each of these processor is on an AHB bus (AMBA AHB compliant). Those buses can communicate through an AHB to AHB interface module. Each AHB bus has a dedicated APB bus (AMBA APB compliant).

- **Memory Bridge**

- internal ROM 20kB for critical constants and code, XCPU boot monitor
- internal SRAM 64kB for critical data and code. Shared communication memory between the 2 CPUs
- External Bus Controller (EBC)
  - 16 bit data bus, up to 32MB memory space

- **System Modules**

- System CPU (XCPU)
  - RDA RISC Core
    - 32x32 bits Multiplier Accumulator (MAC)
    - 16/32 bit instruction set
  - 4 kByte Instruction Cache
  - 4 kByte Data Cache
- DSP Co-Processor (VoC)
  - Bi-MAC, dual operation unit
  - 16-bit instruction set with 32-bit extension
  - 20 kByte + 20 kByte data RAM on 32 bits
  - 32 kByte instruction RAM on 32 bits
- Direct Memory Access (DMA)
  - All size, all alignment and all source and destination possible
  - 32-bit word pattern mode
- Page Spy
  - Six memory spaces can be spied
- System Intelligent Flow Controller (Sys IFC) 7 channels
  - AHB2APB bridge
  - Four 8-bit or 32-bit DMA channels to accelerate data transfer between peripherals and memory
  - Dedicated specialized channels for DBG Host
- Audio Interface (AIF)
  - Tone generator
  - 4 samples In and Out Fifos
  - I2S / DAI Interface
    - Serial Input / Output at 8/16 ks/s
    - Can be used for test purpose in DAI mode
  - Audio Interface
    - 13 bit RX Data from audio ADC
    - 16 bit TX Data to stereo DAC
- SPI Flash Controller
  - Up to size 512Mb x 1, or 256Mb x 1, or 128Mb x 2

- **System Peripherals**

- System, PLL and Clock Control (Sys & PLL & Clk Ctrl)
  - Provides general controls over the whole system, including:
    - Reset controls
    - Power management controls
    - Clock selection

Some debug features

- Host Port
  - Software Flow Control (XON/XOFF)
  - Host Port auto-reset when a break is detected
  - Multiplexed trace mechanism
  - Clock input allowing up to 1840kbps baud rate independent from the system clock
  - Secured protocol with 8 bits CRC (no error correction)
- Serial Peripheral Interface (SPI)
  - Master interface with multi-chip selects
  - 16 bytes FIFO
- I2C Master Peripheral Interface (I2C)
  - Master interface
- General Purpose Input Output (GPIO)
  - Up to 21 GPIOs
  - 6 GPIOs can generate interruptions
- General Purpose Output (GPO)
  - Up to 7 general purpose outputs for external control
- Keypad
  - 8x8 matrix support with de-bouncing and interrupt generation
  - Key On input with de-bouncing and interrupt generation
- Pulse Width Modulation (PWM)
  - 1 PWL, 1 PWT and 1 LPG
- GOUDA
  - 4 distinct video sources can be blended to produce final output
  - Region Of Interest (ROI) handling for partial refresh of the LCD screen
  - Background color (color filled where no layer is defined)
  - Embedded LCD controller for direct output (LCD commands buffer in dedicated SRAM)
- SD/MMC Card Controller
  - can support 2 peripherals
  - SD Card specification Version 2.0
  - SDIO Version 1.10
  - MMC specification Version 3.1
- Camera Sensor Controller
  - On the fly cropping and decimation
  - Supports up to 3M pixel sensor with ISP
  - Supports any arbitrary size scaling down from 4096x4096
  - latch RAM FIFO Size 160\*16 bit
  - Support data format: RGB565, YUV422 and compression data
  - 8-bit parallel data interface from camera sensors
- Timers
  - 1 Real Time Clock Timer (Calendar)
  - 1 24 bits general purpose interval Timers at 16384Hz
  - 1 32 bits uptime counter at 16384Hz
  - 1 Watchdog Timer
- Debug Port
  - CPU Execution Logger (EXL): Generate strobe and output the selected CPU's program counter



- Program Execution Time Stamp (PXTS): Allow to profile running code
- Hardware Signal Spy, selection of several hardware signal connected to pins.
- Access to the last PC of the selected CPU when a watchdog reset occurs
- General Purpose Analog to Digital Converter (GP ADC)
  - 2 channel inputs
  - generate IRQ when programmed threshold is passed
- Timing Control Unit (TCU)
  - Quarter bit precision
  - 60 entries event table
- System AHB Monitor (Sys AHB Monitor)
  - Measure some bandwidth information from the System AHB bus:
    - Global Bus usage
    - Master Bus usage and latency
    - Slave Bus usage and access duration
    - Special resource measurement
  - Write detection to a single word location
- System IRQ Controller (Sys IRQ)
  - Several masking levels:
    - Module level
    - IRQ Control level
- BIST
  - Internal RAMs and ROM test to reduce testing cost in production
- COM Registers
  - Communication registers for inter-CPU communication and synchronization
- USB Controller
  - Fully compliant to USB Specification Version 1.1
  - Slave Full Speed (12Mbps) Device

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## B. BLOCK DESCRIPTION

### B.I System Modules

#### B.I.1 System CPU (XCPU)

The XCPU RISC is a 16/32-bits processor. Using a Reduced Instruction Set Architecture, an efficient 6-stage instruction pipeline and separated Instruction and Data caches, it provides high performance to the system. The Pipeline Stages are as follows:

- **PC.** Program Counter. Calculate the address of the next instruction and send it to the instruction cache.
- **IF.** Instruction Fetch. In this stage the instruction cache is being accessed and the instruction information is retrieved.
- **RF.** Register File. The register file is being accessed and the instruction is decoded.
- **EX.** Execution. The instruction is executed
- **DC.** Data Memory read and write access.
- **WB.** Write Back. Results are written back to the register file.

#### Features

- RDA RISC Core.
  - 32x32-bit Multiplier.
  - 32x32-bit -> 64-bit Multiplier Accumulator (MAC) in 2 cycles (pipelined).
  - Read / Write Buffer.
  - 16/32 bit instruction set.
- 32 interrupt sources.
- 4 kByte Instruction Cache.
- 4 kByte Data Cache.
- 16 byte streaming buffer to accelerate uncached instruction accesses.

#### Block Diagram

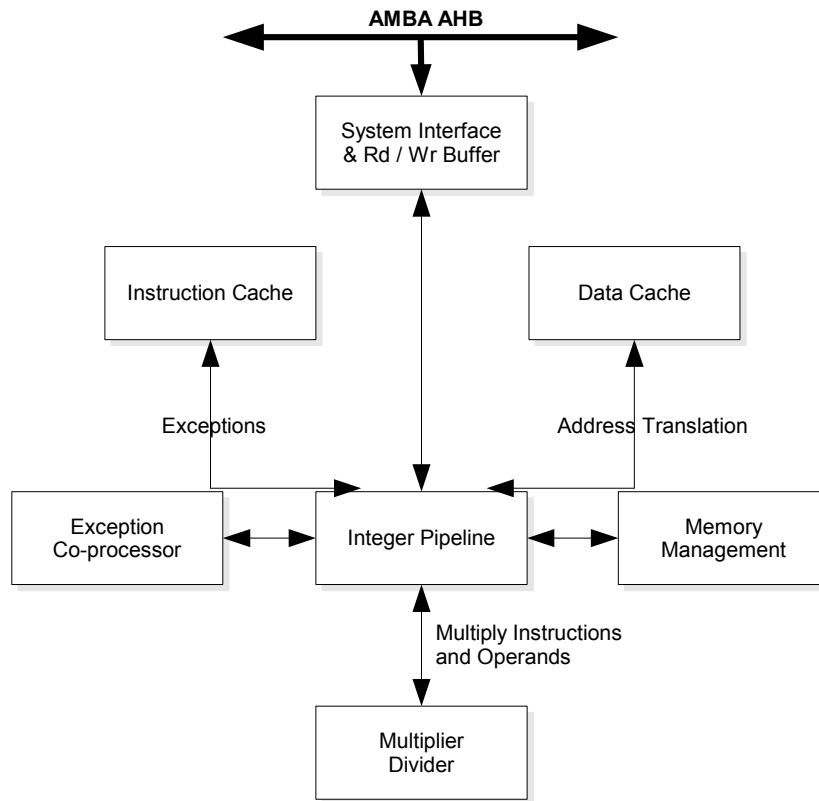


Figure B.1: XCPU Block Diagram

### 32-bit Instruction Set

#### Instruction Formats

The RISC processor supports three instruction formats:

R – Register base instruction format

- RD – Target register
- RS – First operand
- RT – Second operand
- SHAMT – Shift amount for shift instructions
- S Code – Instruction code for R type Instructions

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0				RS				RT				RD				SHAMT				S Code											

I – Immediate operand instruction format

- Opcode – Instruction Code
- RS – Source or Base register
- RT – Target Register or Reg-Immediate

- Immediate – 16 bit Immediate or Displacement

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Opcode						RS				RT				Immediate																	

J – Jump instruction format

- Opcode –Instruction Code
- Jump Immediate – Immediate 26 bit for jump instruction address

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Opcode						Jump Immediate																									

### Supported Instructions

#### Arithmetic Instructions.

Name	Type	Description	Opcode	S-Code
ADD	R	RD = RS + RT	0x00	0x20
ADDU	R	Unsigned[RD = RS + RT]	0x00	0x21
SUB	R	RD = RS – RT	0x00	0x22
SUBU	R	Unsigned[ RD = RS – RT]	0x00	0x23
ADDI	I	RT = RS + Signed(Immediate)	0x08	n/a
ADDIU	I	RT = RS + Unsigned(Immediate)	0x09	n/a

**Logical Instructions.** Logical instructions are all bit wise operations.

Name	Type	Description	Opcode	S-Code
AND	R	RD = RS and RT	0x00	0x24
OR	R	RD = RS or RT	0x00	0x25
XOR	R	RD = RS xor RT	0x00	0x26
NOR	R	RD = not(RS or RT)	0x00	0x27
ANDI	I	RT = RS and Zero-extend(Immediate)	0x0c	n/a
ORI	I	RT = RS or Zero-extend(Immediate)	0x0d	n/a
XORI	I	RT = RS xor Zero-extend(Immediate)	0x0e	n/a

#### Shift Instructions.

Name	Type	Description	Opcode	S-Code
SLL	R	$RD = RS \ll SHAMT$	0x00	0x00
SRL	R	$RD = RS \gg SHAMT$	0x00	0x02
SRA	R	$RD = \text{signed}(RS) \gg SHAMT$	0x00	0x03
SLLV	R	$RD = RS \ll (RT)$	0x00	0x04
SRLV	R	$RD = RS \gg (RT)$	0x00	0x06
SRAV	R	$RD = \text{signed}(RS) \gg (RT)$	0x00	0x07

**Conditional Set Instructions.** These instructions are used for magnitude conditional test. If the condition is true, the result register is set to 0x1 otherwise it is set to 0x0.

Name	Type	Description	Opcode	S-Code
SLT	R	$RD = 0x1 \text{ if}(RS < RT)$	0x00	0x2a
SLTU	R	$RD = 0x1 \text{ when unsigned } (RS < RT)$	0x00	0x2b
SLTI	I	$RD = 0x1 \text{ when } (RS < \text{signed}(\text{Immediate}))$	0x0a	n/a
SLTIU	I	$RD = 0x1 \text{ when unsigned } (RS < \text{signed}(\text{Immediate}))$	0x0b	n/a

**Branch Instructions.** BEQ and BNE test 2 operands for equal and non equal conditions. The rest of the branch instructions test a single operand with 0. BLTZAL and BGEZAL save the address of the instruction following the delay slot in R31.

Name	Type	Description	Opcode	S-Code
BEQ	I	Branch to $((\text{Immediate} + 1) \ll 2)$ when $RS = RT$	0x04	
BNE	I	Branch to $((\text{Immediate} + 1) \ll 2)$ when $RS \neq RT$	0x05	
BGEZ	I	Branch to $((\text{Immediate} + 1) \ll 2)$ when $RS \geq 0$	0x01	0x01
BLEZ	I	Branch to $((\text{Immediate} + 1) \ll 2)$ when $RS \leq 0$	0x06	n/a
BGTZ	I	Branch to $((\text{Immediate} + 1) \ll 2)$ when $RS > 0$	0x07	n/a
BLTZ	I	Branch to $((\text{Immediate} + 1) \ll 2)$ when $RS < 0$	0x01	0x00
BLTZAL	I	Branch to $((\text{Immediate} + 1) \ll 2)$ when $RS < 0$	0x01	0x10
BGEZAL	I	Branch to $((\text{Immediate} + 1) \ll 2)$ when $RS \geq 0$	0x01	0x11

**Jump Instructions.** Jump is performed by combining bit (31:28) of PC with the J\_IMME field of the instructions and 0b00 to form the target address. Link instructions also save the address of the instruction following the branch delay slot in R31.

Name	Type	Description	Opcode	S-Code
J	J	Jump	0x02	n/a
JAL	J	Jump and link	0x03	n/a
JR	R	Jump register	0x00	0x08
JALR	R	Jump register and link	0x00	0x09

**Move To and From Multiply and Divide registers.**

Name	Type	Description	Opcode	S-Code
MFHI	R	Move from High	0x00	0x10
MTHI	R	Move to High	0x00	0x11
MFLO	R	Move from Low (RS = Low)	0x00	0x12
MTLO	R	Move to Low (Low = RS)	0x00	0x13

**Multiply and Divide Instructions.**

Name	Type	Description	Opcode	S-Code
MULT	R	Multiply (Low, High) = RS x RT	0x00	0x18
MULTU	R	Multiply unsigned (Low, High) = RS x RT	0x00	0x19
DIV	R	Divide (Low, High) = RS x RT	0x00	0x1a
DIVU	R	Divide unsigned (Low, High) = RS x RT	0x00	0x13

**Load Upper Immediate.**

Name	Type	Description	Opcode	S-Code
LUI	I	RT[31:16] = Immediate	0x0f	

**Load and Store Instructions.** The address for the load or store is calculated by adding the DISP field to the content of RS. The value read from or written to the memory is from RT.

Name	Type	Description	Opcode	S-Code
LB	I	Load Byte (sign extend)	0x20	
LH	I	Load Half (sign extend)	0x21	
LW	I	Load Word	0x23	
LBU	I	Load Byte (unsigned)	0x24	
LHU	I	Load Half (unsigned)	0x25	
SB	I	Store Byte	0x28	
SH	I	Store Half	0x29	
SW	I	Store Word	0x2b	

**Miscellaneous.** In addition to the standard instructions described above, the RISC processor supports the following instructions.

Name	Type	Description	Opcode	S-Code
CACHE	n/a	See the code below.	0x2f	

Cache instruction format:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Opcode						OP1						Address											Code								

Name	Description
Code Bits [2:0]	Command code as follows: "000" invalidate all lines of both caches ('A' is ignored) "001" invalidate all lines of icache ('A' is ignored, dcache is unaffected) "010" invalidate all lines of dcache ('A' is ignored, icache is unaffected) "011" not specified, do not use. "100" invalidate an lcache line whos address is specified by register OP1 "101" invalidate a single line specified by 'A' from icache "110" invalidate a single line specified by 'A' from dcache "111" invalidate a Dcache line whos address is specified by register OP1
Address Bits [13:3] or bits [11:3] or bits [9:3]	The cache line byte address to invalidate. The actual bits used are (RAM_HIGH downto TAG_LOW). The XCPU has a 4K of data and instruction cache with 4W line, so the bits used are (11 downto 3). The BCPU has a 1K of data and instruction cache with 4W line, so the bits used are (9 downto 3).
OP1 Bits [25:21]	Register operand. The content of the CPU register is used as the Address parameter.
Opcode Bits [31:26]	Value: 0x2f.

**MAC Instructions.** The multiply and accumulate (MAC) option adds supports for the following instructions.

Name	Type	Description	Opcode	S-Code
MADD	R	Signed multiply and accumulate. $\{hi, lo\} = \{hi, lo\} + RS * RT$	0x00	0x1c
MADDU	R	Unsigned multiply and accumulate. $\{hi, lo\} = \{hi, lo\} + RS * RT$	0x00	0x1d
MSUB	R	Signed multiply and subtract. $\{hi, lo\} = \{hi, lo\} - RS * RT$	0x00	0x1e
MSUBU	R	Unsigned multiply and subtract. $\{hi, lo\} = \{hi, lo\} - RS * RT$	0x00	0x1f

### 16-bit Instruction Set

The 16 Bit Instruction mode is an option in the configuration file. This chapter assumes that the user chose to enable this mode. The 16 bit instruction set is provided for situations where reducing code size is a priority.

#### 16 Bit and 32 Bit Instruction Modes

The processor determines the Instruction Mode base on bit 0 of the address of the instruction. When bit 0 of the address of the instruction is 0, the processor is in 32 bit mode, and it interprets the instruction as a 32 bit instruction. When bit 0 of the address of the instruction is set, the processor is in 16 bit mode, and it interprets the instruction as a 16 bit instruction.

In this 32 bit mode:

1. The instruction counter is incremented by 4 from 1 instruction to the next.
2. For Branch and Link instructions, the processor save the address of the instruction + 8 as the return address. This is the instruction after the delay slot.
3. The processor will take an Illegal Instruction Exception, if either bit 0 or bit 1 are set.

In this 16 bit mode:

1. The instruction counter is incremented by 2 from 1 instruction to the next.
2. For Branch and Link instructions, the processor save the address of the instruction + 4 as the return address. This is the instruction after the delay slot.
3. The processor passes bit 1 of the instruction address to the memory subsystem. Bit 0 is always sent as 0 to the memory subsystem.

**Switching between 32 Bit and 16 Bit modes.**

To switch between the modes, bit 0 of the instruction address must be changed from 1 to 0 and back. There are 2 basic mechanisms to achieve this.

**JALX instruction.** This instruction exists in both 32 bit and 16 bit modes. In addition to changing the execution path to the target address, it also toggles bit 0 of the instruction and hence the mode.

**JR, JALR instructions.** These instructions take the 32 bit contents of a register and use it as the target address. Bit 0 of the register can be set to reflect the mode of the instructions at the target address.

**The 16 Bit Mode Instructions**

The following instructions are supported:

Name	15 .. 11	10	9	8	7	6	5	4	3	2	1	0
ADDIU2	0 1 0 0 1	rx			imm8							
ADDIU3	0 1 0 0 0	rx			ry		0	imm4				
ADDIUPC	0 0 0 0 1	rx			imm8							
ADDIU2SP	0 1 1 0 0	0	1	1	imm8							
ADDIU3SP	0 0 0 0 0	rx			imm8							
ADDU3	1 1 1 0 0	rx			ry		rz			0	1	
AND	1 1 1 0 1	rx			ry		0	1	1	0	0	
B	0 0 0 1 0	offset										
BEQZ	0 0 1 0 0	rx			offset							
BNEZ	0 0 1 0 1	rx			offset							
BREAK	1 1 1 0 1	code						0	0	1	0	1
BTEQZ	0 1 1 0 0	0	0	0	offset							
BTNEZ	0 1 1 0 0	0	0	1	offset							
CMP	1 1 1 0 1	rx			ry		0	1	0	1	0	
CMPI	0 1 1 1 0	rx			imm8							
DIV	1 1 1 0 1	rx			ry		1	1	0	1	0	
DIVU	1 1 1 0 1	rx			ry		1	1	0	1	1	
EXTEND	1 1 1 1 0	imm(10:5)					imm(15:11)					
JAL	0 0 0 1 1	0	target(20:16)				target(25:21)					
JAL 2nd	target(15:0)											



Name	15 .. 11	10	9	8	7	6	5	4	3	2	1	0
JALR	1 1 1 0 1		rx		0	1	0	0	0	0	0	0
JALRC	1 1 1 0 1		rx		1	1	0	0	0	0	0	0
JALX	0 0 0 1 1	1	target(20:16)				target(25:21)					
JALX 2nd		target(15:0)										
JRRA	1 1 1 0 1	0	0	0	0	0	1	0	0	0	0	0
JRRAC	1 1 1 0 1	0	0	0	1	0	1	0	0	0	0	0
JRRX	1 1 1 0 1		rx		0	0	0	0	0	0	0	0
JRRXC	1 1 1 0 1		rx		1	0	0	0	0	0	0	0
LI	0 1 1 0 1		rx		offset							
LB	1 0 0 0 0		rx		ry			offset				
LBU	1 0 1 0 0		rx		ry			offset				
LH	1 0 0 0 1		rx		ry			offset				
LHU	1 0 1 0 1		rx		ry			offset				
LW	1 0 0 1 1		rx		ry			offset				
LWPC	1 0 1 1 0		rx		offset							
LWSP	1 0 0 1 0		rx		offset							
MFHI	1 1 1 0 1		rx		0	0	0	1	0	0	0	0
MFLO	1 1 1 0 1		rx		0	0	0	1	0	0	1	0
MOVEmt32	0 1 1 0 0	1	0	1	r32(2:0)			r32(4:3)		rz		
MOVEmf32	0 1 1 0 0	1	1	1	ry			r32				
MULT	1 1 1 0 1		rx		ry			1	1	0	0	0
MULTU	1 1 1 0 1		rx		ry			1	1	0	0	1
NEG	1 1 1 0 1		rx		ry			0	1	0	1	1
NOT	1 1 1 0 1		rx		ry			0	1	1	1	1
OR	1 1 1 0 1		rx		ry			0	1	1	0	1
RESTORE	0 1 1 0 0	1	0	0	0	ra	s0	s1	frame size			
SAVE	0 1 1 0 0	1	0	0	1	ra	s0	s1	frame size			
SB	1 1 0 0 0		rx		ry			offset				
SDBBP	1 1 1 1 0		code					0	0	0	0	1
SEB	1 1 1 0 1		rx		1	0	0	1	0	0	0	1
SEH	1 1 1 0 1		rx		1	0	1	1	0	0	0	1
SH	1 1 0 0 1		rx		ry			offset				
SLL	0 0 1 1 0		rx		ry			sa			0	0
SLLV	1 1 1 0 1		rx		ry			0	0	1	0	0
SLT	1 1 1 0 1		rx		ry			0	0	0	1	0
SLTI	0 1 0 1 0		rx		imm8							
SLTIU	0 1 0 1 1		rx		imm8							
SLTU	1 1 1 0 1		rx		ry			0	0	0	1	1

Name	15 .. 11	10	9	8	7	6	5	4	3	2	1	0
SRA	0 0 1 1 0		rx			ry			sa		1	1
SRAV	1 1 1 0 1		rx			ry		0	0	1	1	1
SRL	0 0 1 1 0		rx			ry			sa		1	0
SRLV	1 1 1 0 1		rx			ry		0	0	1	1	0
SUBU	1 1 1 0 1		rx			ry			rz		1	1
SW	1 1 0 1 1		rx			ry				offset		
SWSPRX	0 1 1 0 0		rx						offset			
SWSPRA	0 1 1 0 0	0	1	0					offset			
XOR	1 1 1 0 1		rx			ry		0	1	1	1	0
ZEB	1 1 1 0 1		rx		0	0	0	1	0	0	0	1
ZEH	1 1 1 0 1		rx		0	0	1	1	0	0	0	1

## Memory Map

### Processor Address Mapping

The addresses are all byte addresses. The Size description is also in byte. The processor offers four different memory spaces.

Segment Name	Base Address	Size	Description
kseg2	0xc000,0000	0x4000,0000	1 GB mapped and cached
kseg1	0xa000,0000	0x2000,0000	0,5 GB unmapped and uncached
kseg0	0x8000,0000	0x2000,0000	0,5 GB unmapped and cached
kuseg	0x0000,0000	0x8000,0000	2 GB mapped and cached

Note that kuseg and kseg2 are available only with the use of a MMU. As there is no MMU in RDA5851, attempts to access those memory segments will trigger an exception.

### Memory Access Types

In case of cache miss, a cached access will occur and a full line of 4 x 32 bits (= 16 bytes) will be loaded.

An uncached access will be a single access or a streaming buffer fill (16 bytes), in case of a streaming buffer miss, if this feature is enabled. A configuration bit allows to enable / disable the streaming feature.

### Multiplier & Divider

The RISC processor's multiplier unit implements a 2 cycle fall through algorithm.

The divider uses a step divide algorithm, which takes 36 cycles to complete a divide operation.

## B.I.2 Memory Bridge

The memory bridge is the interface to general memory used by the system, including internal rom, internal sram and access to external memory.

### Features

- Dual AHB Slave
  - A rom/sram controller
  - An Asynchronous FIFO to external controller
- The bridge is implemented as a crossbar between the 2 AHB and the 2 controller (rom/sram and FIFO)
- The rom/sram controller can insert wait cycle to the AHB Slave (to manage read/write conflicts and to allow using slower instance if needed).
- The rom/sram controller integrate a BIST engine to test the ROM by computing a CRC and test the rams with the March C algorithm
- All AHB burst size are supported
  - Wrap will be split at wrap address
  - Burst longer than the data buffer size of the FIFO will be split
  - Read INCR will read a fixed data size
- FIFO data buffer can store 2 requests either read or write (each 4x32 bytes) from either AHB slave interface.
- APB slave for configuration

### External Bus Controller Features

- The controller handles 16 bits data bus width only, however 8 bit memory chips can still be used; by groups of 2. 8 bit peripherals must be connected to the 8 LSBs of data and accessed through even addresses only.
- Manage page mode SRAM or FLASH.
- Manage burst mode PseudoSRAM.
- Manage AD-Mux and AD-Mux burst mode PseudoSRAM.
- 1 Control Register Enable (M\_CRE) Output pin in same power domain than other memory IO for PseudoSRAM register control.
- FIFO interface for address/data path
- APB interface for configuration (subset of the mem bridge APB address space)

### AHB Master Features

- AHB Compliant master
- except the 1K crossing limit defined by AMBA (additional logic required)
- Memory space divided in 5 spaces with a base address for each (aligned on n Word address, n=FIFO data buffer size)
- Do not use WRAP (due to FIFO organization)
- use INCR4, SINGLE or INCR (for 2 or 3 data only) burst type
- FIFO interface for address/data path
- APB interface for configuration (subset of the mem bridge APB address space)
- External clock is provided from outside the IP (and synthesized in the outside clock tree)

## Operations

### Dual AHB Operation

The Slave allow simultaneous access to rom/sram controller and FIFO from the two slaves. Access to the rom/sram controller are sequenced using WAIT on AHB (HReady low). Access to the FIFO are sequenced using split when the FIFO busy on the other AHB slave (other split conditions are described bellow in FIFO Operation section).

Arbitration in case of simultaneous access to the same controller: Should try to serve each side (BB and Sys) alternatively.

Simultaneous access to rom/sram controller: memorize the last accepted burst. when the two arrives exactly simultaneously reply wait to the memorized side and process the other side.

Simultaneous access to FIFO: First serve read of data if data are available for this read. Serve the side that did not enter the FIFO on last Burst in priority.

### FIFO Operation

The FIFO can store 2 requests either read or write from either AHB Slave interface. But only one at a time. For each request there is an associated Write Data Buffer and a Read Data Buffer.

If the FIFO is full the master is split, this master will be released when one spot is free in the FIFO (all masters split because FIFO was full are released at the same time).

#### Write

A burst is stored to the Data buffer until the burst is finished. If the Data buffer is full or the Wrap address of a wrap burst is reached, the Split response is send (the master will be released in the same condition as above).

#### Read

The request is stored (address, length ...) and the master is split.

The master will be released when the Data buffer has been filled by the external controller (EBC or AHB Master). When the Master comes back, the Data are provided, if the master end the burst the transfer is complete (even if there is still some data in the buffer, in this case they are lost) if the master request more than the available Data it receive the Split response and will be released in the same conditions as for FIFO full: the request is not stored.

FIFO Flush status: Read in FIFO at special address space does not impact the external controller but returns when the command has reached the end of the FIFO (so the read returns only when previous writes are done, no pooling is required)

If external controller has error (disabled space for EBC or AHB Error response for master) the FIFO data reads as and error code. "0xD15AB1ED"

### EBC Operation

FIFO access are translated to external memory access.

Configuration of Chip select are validated only between access (atomic change)

- Flash block address remapping and M\_CRE control registers are placed in the FIFO space to keep accesses in sequence and avoid using FIFO Flush each time.

### B.I.3 Direct Memory Access (DMA)

The DMA controller relieves the CPU from doing generic memory transfers. A data FIFO is integrated to allow burst transfers. It can generate an interrupt to the system CPU at transfer completion.

Read and Write transfers are supported from and to any memory mapped location (external memory, internal SRAM, modules FIFO...). The addresses can be word, halfword or byte aligned. The DMA can also be used in pattern mode. In this case, a 32-bit word will be used to fill the destination memory zone.

#### Features

- Support for linear memory transfers.
- Support for word, halfword and byte aligned addresses.
- Burst transfer mode and internal FIFO for best performances.
- Autonomous transfer up to 64K byte per transfer.
- Interrupt generation at completion of the transaction.
- Can fill a part of the memory with a 32-bit pattern.

### B.I.4 Page Spy

This module is a System spy that detects read or write access into predefined ranges of memory addresses and triggers an interrupt in case of selected access.

#### Features

- Six memory spaces can be spied.
- Memory space described with a start address (inclusive) and an end address (exclusive) and mode (detect read, write or both).
- For each space a status register gives the master that triggered the spy, the address that caused it and the mode.

### B.I.5 System Intelligent Flow Controller (Sys IFC)

The System Intelligent Flow Controller (SYS\_IFC) is a bridge between the system bus and the peripheral bus. The IFC also provides DMA capabilities to allow data transfer from or to peripherals. It supports 7 DMA standard channels for 8-bit or 32-bit and a dedicated DMA channel for the RF SPI module.

#### Features

- 7 independent DMA channels. internal FIFO of four 32-bit words per channel.
- 1 dedicated DMA channel for the debug host
- Burst mode on AHB bus to enhance transfer rate
- Support 2 types of transfer: memory to peripheral and peripheral to memory
- Incremental address for AHB master access and non-incremental address for APB access.
- Dynamic allocation of the 7 DMA channels, request lines among the following peripherals:
  - a) SCI

- b) SPI1
- c) SPI2
- d) SPI3
- e) TRACE UART (DBG Host)
- f) UART
- g) UART2
- h) SDMMC
- i) Camera

- Hardware semaphore registers which indicate to the CPU which channel must be used and a global status register indicating which channel is free.
- AHB to APB bridge, write buffer for a single write access the master isn't stalled, no wait state inserted

## AHB2APB bridge operation

The SYS\_IFC include a bridge between the AHB bus and the APB bus. The SYS\_IFC bus is the only one master on the APB bus. The APB bus is a low bandwidth and low power bus mainly used to configure peripheral register or transfer data with the IFC DMA.

### Arbitration

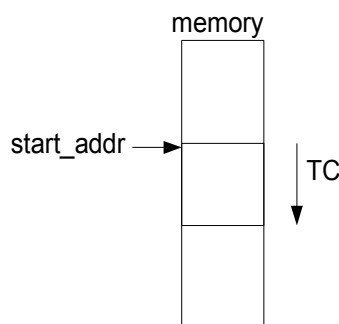
The IFC includes some DMA capability which can access to APB bus, in case of 2 accesses simultaneously (AHB slave and DMA channel), request from the AHB has the highest priority. But if processor requests an access to the APB, and the DMA already have an access in progress, the processor will be stalled until the DMA access is finished.

## DMA Operations

The SYS IFC includes 7 DMA channels. Each channel can perform data movements between devices in the AHB bus and peripheral on the APB bus.

### Typical transfer

The DMA feature is used to automatically transfer data from memory to peripheral or from peripheral to memory. A typical transfer is defined by a start address, the number of bytes to transfer (TC), a direction (Rx or Tx) and a peripheral address.



**Figure B.2: Typical transfer operation**

START\_ADDR register gives the first address of the data to transfer.

TC register gives the number of bytes to transfer.

The direction and the peripheral to access is given by the field REQ\_SRC in the control register.

### Typical data flow for memory to peripheral transfer

1. Check which channel to use and which channel is busy.
2. Configure in the given channel of the IFC, the AHB start address.
3. Configure in the given channel of the IFC, the number of bytes to transfer (TC register)
4. Program the peripheral in which to write and enable the IFC channel to start.
5. The IFC start a read burst access on its AHB master interface.
6. If the programmable DMA request line (of the peripheral associated to this transfer) is high (meaning the peripheral needs data), writes are performed on the APB interface and the current transfer counter (TC) is decremented. This sequence is made until the FIFO of the IFC is empty.
7. When the FIFO of the IFC is empty; another read burst access is performed on the AHB bus and return to the step (6).
8. If the transfer is complete (current transfer counter reaches zero), the associated Done signals goes high and the channel is disabled (if the autodisable bit is set)

This is the same flow for peripheral to memory transfer.

#### **Auto-disable bit**

At the end of the transfer when TC=0 the channel is not necessary disabled. The state of the autodisable bit determines whether or not the channel is automatically disabled. This allows for one resource to keep the channel, and this resource can launch a new transfer just by writing a new value to the TC.

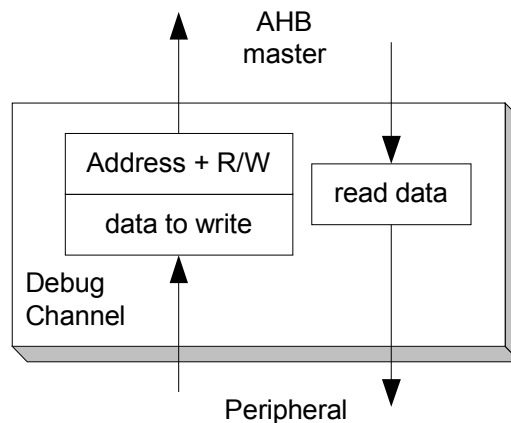
#### **Incremental TC**

It is possible during the transfer to write several time in the TC register. The new TC value will be added to the current value of the TC and the total number of bytes transferred is a the addition of all writes in TC. For example, at first the processor programs the IFC with TC=50, and the IFC start the transfer. Later during the transfer the processor again writes TC=30. The total number of transfers will be 80 bytes which is  $80=50+30$ .

### Debug channel operations

The SYS IFC includes an additional channel dedicated for debug purpose only. This feature allows access to all the resources of the chip through the Debug Host Port. The debug channel receive request from the host port. A typical debug request is composed of an address, a command (read or write), a size and a data to write. The read/write command is the MSB bit of the address (0 for read, 1 for write). The size of the transfer is given by bit 30 and 29 of the address. The debug channel include a 2 words receive FIFO for receiving debug request from a peripheral and a one word transmit FIFO.

The following figure shows a brief diagram of the architecture.



**Figure B.3: Debug channel block diagram**

For a write debug command, the host peripheral transmits by a first DMA request the Address, the R/W bit and the Size and by a second DMA request the DATA to write. Then the debug channel makes an AHB write access to desired resource.

For a read debug command, the host peripheral transmits by a first DMA request the Address, the R/W bit and the Size and by a second DMA request a data to only fill the internal debug command FIFO. The data loaded in the FIFO during this second access is not used. With the address loaded, the IFC performs an AHB read access, the recovered data is stored in the transmit FIFO. When the host peripheral performs a DMA transmit request, a write access is performed on the APB bus for sending data to the peripheral.

## B.II System Peripherals

### B.II.1 System and Clock Control

The system control provides general controls over the whole system, including reset controls, power management controls, clock selection, and some debug features.

#### Features

- Registers for reset control, clock control, fast clock div control, AHBC, some debug feature(like Debug Breakpoints, Lock / Unlock the protected registers),.
- Automatic clock gating signal generation for APB module (PCLK\_DATA and PCLK\_CONF)
- XCPU and CPU special signals for clock management and breakpoint management

#### Reset Control

After a hardware reset, the XCPU will automatically boot and perform the system initialization. The CPU is held in reset until released by the XCPU.



The reset control allows resetting independently most of the modules of the design. In normal use, there should be no need to reset an individual module and caution must be taken when doing so to avoid crashing the system. This is provided mainly for debug purposes.

A global software reset feature is provided. This feature allows resetting the whole system from the software running on any of the CPUs. The effect of the software reset is the same as a hardware reset except that it does not reset the host interface.

A watchdog timer allows recovering from software crashes. Once enabled, the watchdog timer must be reloaded periodically by the software. If the software fails to do so because of a software crash, the watchdog timer will reach 0 and trigger a software reset automatically. The system will then restart. When the XCPU reboots, it can detect that a watchdog has triggered a reset and can save the context at the time of the watchdog expiration (Program counter, register values, stack location), this should allow for easier software debug.

It is also possible to trigger a software reset from the host interface. A special feature allows preventing the XCPU from booting after this reset. This allows avoiding the XCPU to set the system in an invalid configuration in case the boot code is not valid (flash not programmed or badly programmed) and gaining access to the whole system from the host port to find the cause of the issue or reprogram the boot code in flash.

## Clock management

The system has three main sources for the internal clocks generation:

- a 32.768kHz generated by 26MHz clock
- a 26MHz clock from the RF transceiver
- a PLL that generates 624MHz from 26MHz provided by the clock Squarer, this PLL allows to generate a 26MHz, 39MHz, 52MHz, 78MHz, 89MHz, 104MHz, 113MHz, 125MHz, 139MHz, 156MHz, 178MHz, 208MHz, 250MHz, 312MHz;

The other clock source can go only to some part of the design:

- a dedicated clock input for the HST clock : used by the host module.
- an audio clock input (BCK) : used for the I2S audio module, note that this pin is actually bidirectional (depending on the connection to a I2S master or I2S slave, this pin is configured as a clock input i\_BCK or a clock output o\_BCK).

All internal clocks in the design except the clocks for host and in some case audio, derive from one of the three main clock sources. The selection is made through configuration registers. Thanks to glitch free muxes, it is possible to change the internal clock frequency on the fly. Caution must be taken when changing the main clock frequency as some interfaces clocks are divided versions of this main clock. For example, the SPI baud rate directly depends on the main clock frequency so when changing the main clock, it is recommended to make sure that the SPI is not transmitting during the change.

To reduce the power consumption, it is possible to gate the clock signal going to most of the modules individually when a module is not in use. Enabling or disabling the clock going to a module can be automatic (all the modules needing to run over short period of times are able to control their clock themselves. For example the DMA only has a clock while doing a transfer) or manual (for the modules running all the time once they are enabled. For example, the audio interface which needs to output samples continuously once enabled)

## Debug features

### Hardware breakpoints

This feature allows defining one hardware breakpoint for each CPU. This breakpoint can be either on an instruction fetch, a data read or a data write.

When the breakpoint is reached, the CPU is stalled. A status bit allows to know if the breakpoint has been reached or not. When the CPU is stalled, all its internal registers are accessible through the host port. If the breakpoint is released, the CPU resumes its execution.

### **Debug clock**

It is possible to output any internal clock of the design on the pin `DBG_CLK` (also used for EXL/PXTS Clock) for debug purposes (check frequency, power saving feature...). The Debug clock register is defined in the `debug_port` module.

## **B.II.2 Trace (Normal UART) and Host (Debug UART) Port**

RDA5851 Debug Host module contains 1 normal Universal Asynchronous Receiver Transmitter channels (UART) and 1 Debug UART. The two UARTs share the same Tx/Rx engines, which sends and receives byte data from serial interface. Each UART has its own control sub-module and own APB interface. RDA5851 Debug Host module parses the incoming data from serial interface to switch between the normal UART and the Debug UART.

- *Normal UART*

The normal UART can be used for traces and other purposes. For APB interface, it is exactly the same to the other UARTs in the RDA5851 system. However, if Debug UART is enabled, it should have the same serial interface configuration as the Debug UART. Some of its configuration options will be masked in this case. To Adapt different clock frequency, the normal UART uses asynchronous FIFO, which uses gray code to represent the read and write pointer positions.

- *Debug UART*

The Debug UART is specially designed for communicating debug information with a PC host. The serial interface of Debug UART is a simplified version of the normal UART and is less configurable. Each sample is sent serially, has 1 start bit (always zero), 8 data bits, and 1 stop bits (always one). Breaks (data line held low) can be generated and detected allowing resynchronizing the two devices.

### **Features**

- Auto normal/Debug UART select by parsing incoming message.
- Separate UART APB and Debug UART APB interfaces.

Normal UART features:

- Fully programmable transfer word format.
  - 7 or 8 data bits.
  - 1 or 2 stop bits.
  - Odd, even, mark, space or none parity.
- Smooth stop feature (the UART stops after the end of the current word transfer).
- Break generation and detection.
  - Break length programmable.
  - Interrupt can be generated.
- Supports Automatic Software Flow Control (XON/XOFF).
- Programmable receive and transmit fifos (16 bytes deep).
- Supports low speed IrDA 1.0 SIR mode by adding external hardware.
- DMA capabilities (through the System IFC) to allow fully automated data transfers.

- Wide selection of programmable interrupts to allow interrupt driven data transfer management.
  - Rx or Tx Fifo trigger reached.
  - Timeout: No characters in or out of the Rx Fifo during the last 4 character times and there is at least one character in the Rx Fifo during this time.
  - DMA timeout: After Rx Sys IFC DMA is started, no characters in or out of the Rx Fifo during the last 4 character times.
  - End of the Sys IFC DMA transfer.
  - CTS detection.
  - Tx or Rx overflow, parity or framing (bad sample format received) error or break.
- Loop Back capabilities for test purposes.
- Up to 1843.2 Kbit/s for serial and 115.2 Kbit/s for IrDA.

Debug UART features:

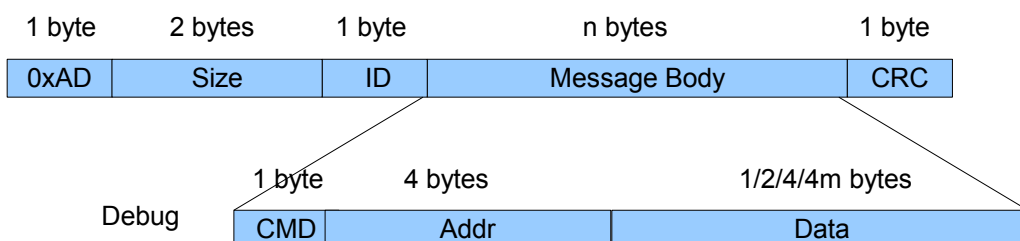
- Transfer word format.
  - 1 start bit.
  - 8 data bits.
  - 1 stop bit.
- Tx Break generation when pin reset and Rx break detection.
- HW reset event.
- Programmable events allowing CPU directly write to Debug UART.
- Some serial interface read/write internal registers.
- DMA capabilities (through the System IFC Debug Channel) for automated data transfers.
- Up to 1843.2 Kbit/s for serial.

### Message Frame

In case of Debug UART is disabled, the message has no format requirement. If Debug UART is enabled, the General message received by the Debug Host should be of the following format:

- 1 Start byte.
- 2 Size bytes.
- 1 Flow Identification byte.
- N Message Body bytes.
- 1 CRC byte.

The start byte is 0xAD, which starts a message frame. The 2 size bytes indicates the length of the message ( the length of how many bytes after SIZE field, equals to N Message Body byte + 1 CRC byte = N+1). The Flow Identification byte identifies what kind of Flow is this message, the definition of the Flow Ids can be found in the REMOTE specifications. The message body field length is variable, and has different data structure according to the Flow ID. The CRC field is calculated by an XOR between the Flow ID and each Message body byte.



**Figure B.4: General Message Format**

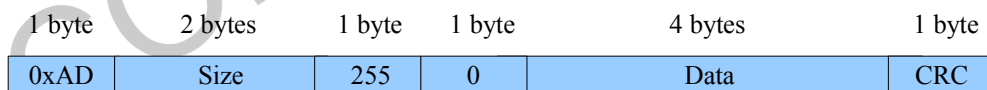
For Debug Messages, the Flow\_ID = 255, and the Message Body field is composed of:

- 1 command byte ( bit 7,bits 2 to 0 used).
  - x00 for byte.
  - x01 for half word.
  - x10 for word.
  - x11 for block.
  - 1xx for internal registers.
  - Bit 7 for Write\_H (0 for read, 1 for write)
  - 4 address bytes (bits 28 to 0 used).
  - Byte, half word, word or 4m data bytes(block) in case of write, 1 data byte in case of read (RID).
- Block mode is only for write, in case of read, only byte, half word and word data is supported. The read return message of Debug Message is:



**Figure B.5: Read Return Message Format**

- If the CPU send an event, the RID is 0, the format will be:



**Figure B.6: Event Message Format**

### IFC DMA Data

The Debug UART read and write data from memory by using the IFC DMA. It will encapsulate the received message into a 4-byte command and a 4-byte data. The 4-byte command includes the read or write indicator (bit 31), the type(bit 30 to 29) and the address(bit 28 to 0). The 4-byte data is formed from data field in the message (in case of byte and half word, replicate the data to fill the 4 bytes). When the Command and Data is ready, the Debug UART will generate an IFC Debug Request. In case of block data, the address is recalculate for each 4-byte data.

### Normal/Debug UART Select

- Clock Select

The Debug Host detects if there is a host clock. If the host clock exists (an UART Dongle is plugged), it will enable the Debug UART and use this clock for both Debug UART and normal UART. There is also a software configure Force\_Host\_On signal, which force to enable the Debug UART, in this case, if no host clock is detected, the CLK\_UART will be used for the both 2 UARTs. If no host clock is detected and Force\_Host\_On signal is inactive low, the Debug UART will be disabled, and CLK\_UART is used for the normal UART. The following table illustrates the clock selection and the enabling of different function groups. In the table, the columns on left have the priority.

	HST_CLK Plugged	Force_HST_ON	UART_CLK only
HOST_Func Enabled	Yes	Yes	No
Clock used	CLK_Host	CLK_UART	CLK_UART
Mask UART Config	Yes	Yes	No

- RX UART Select

If host clock exists, the Debug Host parses the Incoming Data from Rx engine permanently. The messages with Flow ID = 255 is a Debug flow and thus host will select the Debug UART, otherwise, the normal UART. The Rx parser will send to Debug Uart only the message body, but if Normal Uart is destined, the Rx parser will send the whole package including the head and CRC.

The Debug Uart has separate Rx and Tx state machines. By de-assert UART RTS, The Rx state machine will be blocked before the next command if previous Debug IFC channel DMA is not finished, to avoid lost of the old command's address and data.

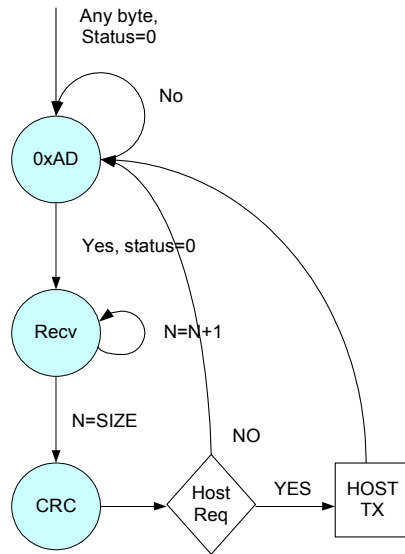
Another case which needs to block Rx is: a new read command comes but previous read has not finished sending its data. In fact, each read operation uses both Rx and Tx machines: The Rx state machine finishes by sending the read request to IFC. On the other side, Tx state machine is triggered either by a event sending request or by read data ready signal. If the current Tx state machine has not finishes, the Rx process will need to wait in order not to lose the old RID and read data.

A CRC checker is enabled if the Rx flow is for Debug UART. When command is Read, if the CRC is bad, the command received will be rejected and not be sent to IFC. When Write, if the destination is host internal register and CRC is bad, the command will be ignored. If the destination is memory, the command will be executed before CRC is calculated. The CRC check result will be put to the CRC check result internal register and can be read through the serial interface. For normal UART, the CRC is checked by software.

- TX UART Select

By default, The Debug UART TX is given priority, so if the normal UART continues to send messages, the TX will switch to Debug UART once the current message is finished. Further more, there is an internal register bit Debug\_Force\_Prio which is by default to be active high. In this case, whenever the host wants to send anything, it can insert them into the normal Uart package.

If the Debug\_force\_prio is inactive low, A parser in the normal UART TX path analyzes if the current read operation for normal UART is finished or not, in order that the process is not disturbed by a read request or event from Debug UART. In this case, the arbitration process for TX UART select can be illustrated in the following:



**Figure B.7: Tx Switch STM**

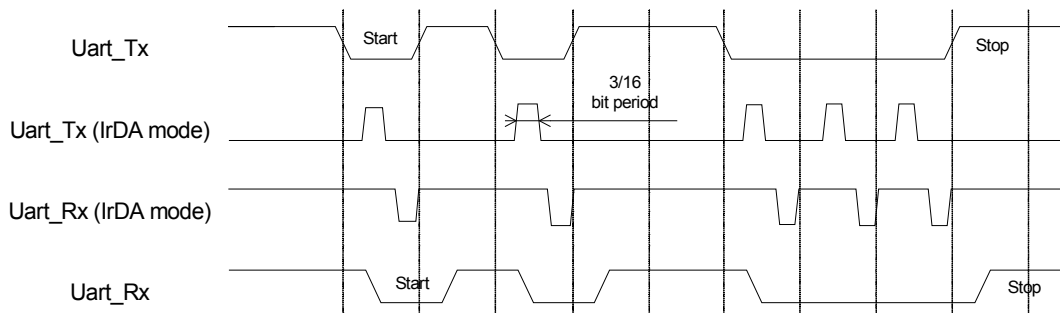
When the normal UART receives any data from the APB, it will clear the status to 0 which no more grant the Debug UART for TX and waits for start byte 0xAD. Once it finds a 0xAD, the parser will count until number of data declared in SIZE field has been received before it checks the CRC. The CRC result will be put in an internal register and can be read from the host interface. Then the status will be reset to 1, and the Debug UART can send its data if there is a request.

### IrDA SIR Operation

IrDA 1.0 SIR mode is available only if the Debug UART is not enabled and can be activated when the user opens a UART. IrDA 1.0 SIR mode supports bi-directional data communications with remote devices using infrared radiation as the transmission medium. IrDA 1.0 SIR mode specifies a maximum baud rate of 115.2 KBaud.

Transmitting an infrared pulse corresponds to a zero, while one is represented by not sending any pulse. The width of a infrared pulse is 3/16 th of a normal serial bit time (depending on the baudrate). Each sample begins with a pulse (the start bit)

Received data is inverted (due to the IrDA physical purposes). Therefore, the Uart\_Rx port, has the correct UART polarity. See the following figure for more details.



**Figure B.8: IrDA SIR Data Format**



The UART module operation when IrDA SIR mode is enabled is similar to when the mode is disabled, with one exception: data transfers can only occur in half-duplex fashion when IrDA SIR mode is enabled. This is because the IrDA SIR physical layer specifies a minimum of 10ms delay between transmission and reception. This 10ms delay must be handled by the software.

## Break Generation and Reset

A break is generated by the sending UART holds the TXD line to 0 for quite a long time. It can be used to avoid the case RTS line is always inactive and thus blocks the data to be sent any more. When a break is detected, it will reset the state machine of the Rx/Tx engines. If Host is enabled, the break will be sent to both two UART. For debug UART, It will write into the CFG internal register bit Disable\_UART to temporarily disconnect the normal UART to the serial interface (in this state, all data destined for normal UART received by RX engine will be discarded, all data in the normal UART FIFO are still kept but will not send to the TX engine, the RTS from normal UART will also be disconnected to the RX engine), this will allow the Debug UART to diagnostic what happens in case of normal UART errors. It will also reset the Debug Host baud-rate. For normal UART, the break will also generate an error IRQ, which can ask soft to perform operations such as a reset for the FIFO etc. The normal UART can be enabled later by clear the Disable UART bit.

If the reset source is coming from pin reset, a break should be sent by the debug host to let the other-side UART configure the baud-rate. This break lasts at least 12 bit long in 115.2K baud-rate, which should be the lowest baud-rate. A hardware reset event should be sent by the debug host in case of system reset.

## Clock Detector

This sub-module detects if the Host clock is present or not. This module is located in clock control module, it will generate a Host\_Clock\_On signal. The Host\_Clock\_On signal helps to select the system clock or host clock as the input for debug host. When Host\_Clock\_On is active high, host clock is used, otherwise, UART clock. The Host\_Clock\_On signal is also send to Debug host to enable or disable the host functionality.

The clock Detector uses 32.768KHz clock to detect 14.7468MHz host clock. There is a 10 bit counter in the host clock domain, and the highest bit is used to generate a 14.4KHz slow clock. The 32KHz clock detects the rising edge of this slow clock, and launch a 2-bit incremental counter. Every time a rising edge detected, the counter will be added by one, until the counter reaches 3. At this moment, the Host\_clock\_on signal will be asserted and host clock is considered to be connected. There is another 6-bit timeout counter, each time a new rising edge is detected, the timeout counter will be reset to "111111", otherwise, it will be decremented by one at each 32KHz clock rising edge. If the timeout counter reaches 0, the incremental counter will be reset and Host\_clock\_on signal will be de-asserted, the host clock is considered to be disconnected.

## Software flow control

If sending of characters must be postponed, the character XOFF is sent on the line, to restart the communication again XON is used. Sending the XOFF character only stops the communication in the direction of the device which issued the XOFF.

The XON/XOFF character can be programmed by register bits. However, two bytes have been predefined in the ASCII character set to be used with software flow control. These bytes are named XOFF and XON, because they can stop and restart transmitting. The byte value of XOFF is 19, it can be simulated by pressing Ctrl-S on the keyboard. XON has the value 17 assigned which is equivalent to Ctrl-Q.

Backslash '\' can be added before XON, XOFF and '\r' to signifies their original values instead of flow control marks.

### B.II.3 Serial Peripheral Interface (SPI)

This module is a master interface for a synchronous serial link, it can be configured to be compatible with Motorola SPI or to comply with some various synchronous serial protocols.

RDA5851 includes 2 general purpose SPIs and 1 SPI dedicated to PMU, Analog block integrated modules.

#### Features

- SPI1 has 3 chip selects
- SPI2 has 2 chip selects
- 2 selectable data input.
- programmable clock polarity.
- programmable data frame size (from 4 to 32 bits).
- 16 x 8 bits transmit FIFO.
- 16 x 8 bits receive FIFO.
- a few delay options (time between CS, clocks and data).
- received pattern matching before filling RX FIFO (SD-MMC read block feature)
- transmit zero when TX FIFO empty (for generating dummy data during pattern matching read)
- can be controlled by LPS (an new frame is not started until LPS allows it)
- direct pin control to force value to 0, 1 or input.
- special read mode with output enable control of the DO pin (selected input should be multiplexed with DO pin to use this feature)

### B.II.4 I2C

I2C is a two-wire, bi-directional serial bus that provides a simple and efficient method of data exchange between devices. It is most suitable for applications requiring occasional communication over a short distance between many devices. The I2C standard is a true multi-master bus including collision detection and arbitration that prevents data corruption if two or more masters attempt to control the bus simultaneously.

The interface defines 3 transmission speeds:

- Normal: 100Kbps
- Fast: 400Kbps
- High speed: 3.5Mbps

Only 100Kbps and 400Kbps modes are supported directly.

RDA5851 Chip includes 3xI2C masters.

#### Features

- Compatible with Philips I2C standard



- Multi Master Operation
- Software programmable clock frequency
- Clock Stretching and Wait state generation
- Software programmable acknowledge bit
- Interrupt or bit-polling driven byte-by-byte data-transfers
- Arbitration lost interrupt, with automatic transfer cancellation
- Start/Stop/Repeated Start/Acknowledge generation
- Start/Stop/Repeated Start detection
- Bus busy detection
- Supports 7 and 10bit addressing mode
- Operates from a wide range of input clock frequencies

## Operations

- **I2C System configuration**

The I2C system uses a serial data line (SDA) and a serial clock line (SCL) for data transfers. All devices connected to these two signals must have open drain or open collector outputs. The logic AND function is exercised on both lines with external pull-up resistors.

Data is transferred between a Master and a Slave synchronously to SCL on the SDA line on a byte-by-byte basis. Each data byte is 8 bits long. There is one SCL clock pulse for each data bit with the MSB being transmitted first. An acknowledge bit follows each transferred byte. Each bit is sampled during the high period of SCL; therefore, the SDA line may be changed only during the low period of SCL and must be held stable during the high period of SCL. A transition on the SDA line while SCL is high is interpreted as a command (see START and STOP signals).

- **I2C protocol**

### START signal

When the bus is free/idle, meaning no master device is engaging the bus (both SCL and SDA lines are high), a master can initiate a transfer by sending a START signal. A START signal, usually referred to as the S-bit, is defined as a high-to-low transition of SDA while SCL is high. The START signal denotes the beginning of a new data transfer. A Repeated START is a START signal without first generating a STOP signal. The master uses this method to communicate with another slave or the same slave in a different transfer direction (e.g. from writing to a device to reading from a device) without releasing the bus.

The I2C master generates a START signal when the STA-bit in the Command Register is set and the RD or WR bits are set. Depending on the current status of the SCL line, a START or Repeated START is generated.

### Slave address transfer

The first byte of data transferred by the master immediately after the START signal is the slave address. This is a seven-bits calling address followed by a RW bit. The RW bit signals the slave the data transfer direction. No two slaves in the system can have the same address. Only the slave with an address that matches the one transmitted by the master will respond by returning an acknowledge bit by pulling the SDA low at the 9<sup>th</sup> SCL clock cycle.

Note: The I2C master supports 10bit slave addresses by generating two address transfers. See the Philips I2C specifications for more details.

The I2C master treats a Slave Address Transfer as any other write action. Store the slave device's address in the Transmit Register and set the WR bit. The I2C master will then transfer the slave address on the bus.

### Data Transfer

Once successful slave addressing has been achieved, the data transfer can proceed on a byte-by-byte basis in the direction specified by the RW bit sent by the master. Each transferred byte is followed by an acknowledge bit on the 9th SCL clock cycle. If the slave signals a No Acknowledge, the master can generate a STOP signal to abort the data transfer or generate a Repeated START signal and start a new transfer cycle.

If the master, as the receiving device, does not acknowledge the slave, the slave releases the SDA line for the master to generate a STOP or Repeated START signal.

To write data to a slave, store the data to be transmitted in the Transmit Register and set the WR bit. To read data from a slave, set the RD bit. During a transfer the core set the TIP flag, indicating that a Transfer is In Progress. When the transfer is done the TIP flag is reset, the IF flag set and, when enabled, an interrupt generated. The Receive Register contains valid data after the IF flag has been set. The user may issue a new write or read command when the TIP flag is reset.

### Stop signal

The master can terminate the communication by generating a STOP signal. A STOP signal, usually referred to as the P-bit, is defined as a low-to-high transition of SDA while SCL is at logical '1'.

- **Arbitration Procedure**

### Clock Synchronization

The I2C bus is a true multi-master bus that allows more than one master to be connected on it. If two or more masters simultaneously try to control the bus, a clock synchronization procedure determines the bus clock. Because of the wired-AND connection of the I2C signals a high to low transition affects all devices connected to the bus. Therefore a high to low transition on the SCL line causes all concerned devices to count off their low period. Once a device clock has gone low it will hold the SCL line in that state until the clock high state is reached. Due to the wired-AND connection the SCL line will therefore be held low by the device with the longest low period, and held high by the device with the shortest high period.

### Clock stretching

Slave devices can use the clock synchronization mechanism to slow down the transfer bit rate. After the master has driven SCL low, the slave can drive SCL low for the required period and then release it. If the slave's SCL low period is greater than the master's SCL low period, the resulting SCL bus signal low period is stretched, thus inserting wait-states.

## B.II.5 General Purpose Input Output

RDA5851 GPIO modules has configurable number of General Purpose Input or Output ports (GPIO) and General Purpose Output port(GPO). There are up to 32 GPIOs and 12 GPOs. GPIO are used to control external chips, or to get external events. They can be used as inputs or outputs. As input, 8 of them can be configured to trigger an interruption (GPIO0 to GPIO7). The IRQ could be generated on edge or level.

### Features

- \*Up to 32 GPIOs configurable as input or output.
- \*Up to 12 GPOs.
- 8 of the GPIOs can generate interrupt. Various Interrupt triggered mode.
  - Rising/Falling edge.

- High/Low level.

\*Maybe not all of the GPIOs/GPOs can be used because a few are not packaged to the pin pad due to the limitation of the total pin numbers. Please refer to the details of reference design.

## B.II.6 Keypad

The RDA5851 keypad is a matrix of 8 rows and 8 columns. Keypad module provides key press, key release detecting mechanism. Each time a key is pressed, keypad module will sense it and will begin to scan the keypad by alternatively driving each column until all keys are released. Besides the keypad matrix, the module also detects key ON, which is an independent input.

The Keypad will send IRQ when either key press or key release event occurs. It can also send IRQ repeatedly when one or several keys are pressed long time. Debounce mechanism is provided to avoid glitches, the time of debounce is programmable.

Any combination of two keys pressed can be detected simultaneously, if certain rules are expected, up to 10 keys can be detected at the same time. However, the following case should be avoided: Note the key at column  $i1$  and row  $i2$  as key( $i1, i2$ ). If key( $a,b$ ) and key( $c,d$ ) is pressed at the same time, then press either key( $a,d$ ) or key( $b,c$ ) will cause a detection error. The key scanner will consider all of the four keys have been pressed.

### Features

- Generate IRQ for both key press and release events.
- Generate IRQ if one or several keys are pressed long time. The IRQ is repeated with a configurable interval from 1\*debounce time to 64\*debounce time.
- provide debounce mechanism. Configurable debounce time maximum 480 ms.
- Detect two simultaneous key press with any combination. Detect up to 10 keys at the same time if certain patterns are excluded. (i.e. Keypad module can detect entire one row and one column without crossed key).
- Key ON detection.
- Possible to disable some rows and columns of keypad matrix.

## B.II.7 Pulse Width Modulation (PWM)

The PWM module generates four independent PWM outputs, utilizing three specialized modulation schemes. There are two Pulse Width Light (PWL) outputs designed for driving LEDs with varying brightness, one Pulse Width Tone (PWT) output for generating tones, and one Light Pulse Generator (LPG) output for blinking an LED at visibly recognizable frequencies.

### Features

- Pulse Width Tone (PWT)
  - Generates square wave output capable of driving piezo electric speaker
  - Variable frequency between 349Hz and 5276Hz with 12 half-tone frequencies per octave
  - Volume control (coarse)
- Light Pulse Generation (LPG)
  - Adjustable blinking period from 125 ms to 3 seconds
  - Adjustable on-time from 15 ms to ¼ second.

- Two separate Pulse Width Light (PWL)
  - Pseudo random bit sequence with output on-time proportional to a programmed threshold value
  - Minimizes flicker

## Typical Operation

The PWT module generates a 'symmetric' square wave whose duty cycle is variable between 0 and 50% (as opposed to the pseudo-random output in the case of PWL). The generated tones have been tested for half-tone frequency increments between 349Hz and 5276Hz. Basic volume control can be achieved by varying the duty cycle, but the actual values depend on the final frequency and the buzzer being used. Also, changing the duty cycle will change the harmonics, and thus will have an effect on the pitch of the note, but for very coarse operation, this mechanism should suffice.

The Light Pulse Generator (LPG) can be used for blinking a LED at adjustable periods for various signaling purposes. The period is variable between 125 ms through 3 seconds. The length of time the LED will stay on is also programmable multiples of 256/16kHz up to ¼ of a second.

The two PWL modules are optimized for driving back lights and LEDs where pseudo-random pulses with a programmable average on-time are desired. The resulting output will be non-symmetric and will help reduce flicker effects. A low-pass filter can be added to convert the PWL output to an analog value.

## B.II.8 Calendar

The Calendar module provides date and time information. It works on the 32.768 KHz oscillator with independent power supply. Calendar module is able to generate an IRQ repetitively at certain interval, which can be programmed to 1 second, 1 minute or 1 hour. In addition to provide timing data, alarm interrupt is generated and it is also used to power-up the baseband core by sending wakeup signal. The year span is supported from 2000 to 2127, the maxim day of each month is stored in the calendar block, which depends on the leap year condition.

### Features

- Independent power supply.
- Counters for second, minute, hour, day, month, year and day of week.
- Maxim day of each month stored in module, leap year supported.
- Alarm generate, wakeup triggered by alarm. Alarm IRQ.
- Periodical IRQ for certain intervals.

## B.II.9 Timers

RDA5851 includes 1 OS timer, 1 watchdog timer and 1 hardware delay timers. The OS timer serves for OS, and has Ticks of 16384 Hz. It is a decrement timer and the initial value can be programmed. When the OS timer reaches 0, it will cause an interruption. After that, the OS timer will either stop or restart with the initial value (loop mode) or wrap to maximum value (wrap mode).

The watchdog timer can be used to protect against system failure or software mistakes by reinitializing the system. When it's no longer servicing the watchdog timer, the Watchdog Timer operations are almost identical to the OS Timer. In addition when the counter reaches 0 it can trigger a System Reset. To use the Watchdog function, the software should reload the Watchdog Timer on a periodic basis to avoiding the Watchdog Timer to reach 0 and trigger an interrupt or a system reset (depending on configuration).

The hardware delay timer is an incremental timer. It has Ticks of 16384 Hz. This timer is free running, and the value will be reset to 0. The timer value will wrap to 0 after 0xfffff, and will generate an IRQ when wrap. The hardware delay timer can also generate an interval IRQ which can be configured to every 1/8 second, 1/4 second, 1/2 second, or 1 second.

The timers module has two IRQs. One dedicated for OS timer, the other is used by all the other timers. (including watchdog timer, hardware delay timer)

### Features

- 1 24-bit decremental timer for OS.
- 1 32-bit incremental hardware delay timer.
- 1 24-bit decremental watchdog timer.
- Multiple IRQ sources: timers wrap, interval arrives.

## B.II.10 Debug Port (EXL, PXTS, Signal Spy)

The DEBUG\_PORT module:

- Provide 4 watches.
- Storing the last execution address of the selected CPU in the event of a watchdog reset. This value is not reset on any system reset and can be read when the system was recovered from the watchdog reset.
- Data packet transfer: debugging tool configurable in 4 different modes:

### Features

- Access to the last PC of the selected CPU when a watchdog reset occurs.
- **Mode Debug\_Port\_Off** : This mode switch off the module
- **Mode Exl** : This mode record all the CPU Jump start address send to the Romulator. Generate a strobe and output the selected CPU's PC.
- **Mode Pxts** : This mode record all the serial events analyzed by Coolprofile. Generate a Strobe and output the Pxts tag. Through Pxts Enable decoding, we will be able to select one Pxts\_tag into 16 Pxts\_tag defined.
- **Mode Pxts\_Exl**: this mode enable both mode PXTS and EXL. PXTS mode has a highest priority compare to mode EXL.
- **Mode Signal\_Spy** : This mode spy the signals for the debug purpose (Describe the IOCore muxing for IO mode configuration)

## B.II.11 General Purpose Analog to Digital Converter (GP ADC)

The GPADC module controls the analog module of general purpose analog to digital converter, which is capable of measuring one of 2 analog external inputs of the chip. The 2 external inputs can be connected to sensors to measure battery voltage, battery temperature, temperature, accessory ID, remote control, or other low frequency analog signal within the specified voltage range.

The GPADC is active periodically at a variable rate if at least one channel is enabled. The value of each channel is readable through the APB interface.

## Features

- Up to 2 analog external channels.
- Automatic measurement at variable rate.
- Interrupt when programmed threshold is passed.

## Operation

By default, GPADC works in functional mode, GPADC is active periodically at a variable rate and measures all the enabled channel (up to 2) each time.

There is also a test mode for debug purpose, in which GPADC receives a start measure command from APB, and do a measurement once.

Usually, the one GPADC is used for mic detect, and another is for user defined function.

## B.II.12 Timing Control Unit and Low Power Synchronizer (TCU+LPS)

The Timing Control Unit handle the scheduling of individual events with a quarter bit precision.

The TCU is based on a quarter counter ( $13/12 \text{ MHz} = 1.083 \text{ MHz}$ ), which wraps at a programmable value. An interruption is generated when the counter wraps (Frame interrupt). The current value of this counter is available at any time. The wrap value can be set at any time. To assure a predictable behavior this value should only be set by the programmer "far" from the wrap time, to make sure this new value will be taken into account the next time.

The programmer can define events associated to particular counter values (dates). When the counter equals the given date, the action associated to the event will take place.

The event are contained in a table of events split into a programming table and an active table. Only the events in the active table are compared to the counter value. The programming table table allows to prepare a full sequence of events which will be transfered to the active table when the counter wraps.

A force signal allows to transfer events from the programming table to the active table immediately.

The LPS Low Power Synchronizer is a part of the TCU, it is responsible for maintaining the time base while running at a slower clock (32kHz) for power saving.

### TCU Features

- Quarter bit precision.
- 60 entries event table.
- Programmable counter wrap value.

### LPS Features



- Allow skipping frames by masking the TCU Frame Interrupt.
- Calibration of the 32kHz clock against the System Clock with an accuracy of 4 System clocks during a programmable time to reach wanted rate accuracy.
- Low power counters (32kHz) can maintain timebase while System clock is suspended.
- A hardware state machine can assist the CPU for the power up after each exit of the low power mode.

## B.II.13 System AHB Monitor (Sys AHBC Mon)

This monitor connected to the System AHB bus can measure several bandwidth and latency information.

### Features

- 8 configurable time windows:
- 4 asynchronous for gradually going from accuracy to reactivity of the measures.
- 4 based on frame for GMS related measurements
- Peak or mean measures.
- Selection between several resources:
- Global bus usage.
- Bus usage and latency of access for a particular master.
- Bus usage, number of access and duration of access for a slave.
- High time, number of rise and duration of high time for a resource selected via the signal select of the debug port.

### Mean calculation

Measures are always relative to the time window. Mean latency or duration has to be calculated by dividing the total latency / duration measured by the number of accesses.

### Special resource monitoring

The Signal\_Select0 and Signal\_Select1 signals can be monitored to estimate latency of IRQ handling, or measure any latency/usage of software part. This last case can be achieved by setting Signal\_Select0 to Watch(n) in the debug port configuration, monitoring the Signal\_Select0 signal; by setting and clearing the Watch(n) during code to profile, you can measure the mean time spent.

## B.II.14 System IRQ Controller (Sys IRQ)

In RDA5851, the interruptions are generated by the modules, they can be filtered at the module level (the mask must be configured in each corresponding module's registers), then they are filtered by the System or Base Band IRQ Controller (the mask is set in System IRQ Control or Base Band IRQ Control registers). The interrupts must be cleared in the corresponding module.

For power saving, one CPU can shut down its own clock. A special wakeup mask allows re-enabling the clock when an interruption enabled in this mask is triggered..

### Features

- A mask at the module level.
- A mask at the IRQ Control level.
- A second Mask for Pulse IRQ (that are not masked in the module)
- Wakeup mask.
- Sleep Register
- Driving IRQ inputs to the CPU (6 lines)

## B.II.15 USB Controller

### Features

- Fully compliant to USB Specification Version 1.1
- Slave Full Speed (12Mbps) Device
- Integrated USB Transceiver
- Supports Control, Interrupt, Bulk and Isochronous transfer
- 4 Endpoint with FIFO:
  - One Bi-directional Control Endpoint (EP0)
  - Three soft configurable Bi-directional Endpoints
- SRAM FIFO : 264 words (32bits)

## B.II.16 Graphic Overlay United Display Accelerator (GOUDA)

The GOUDA module handles various graphic operations used to compose and display images on LCD.

These operations : colour space conversion, resizing, landscape/portrait rotation and layer blending and overlay are very CPU-cycle consuming, and also especially bandwidth hungry as for every single operation, one or several images have to be loaded, processed and temporarily rewritten into memory before being actually sent to the LCD display.

GOUDA module relieves the CPU by both handling the pixel processing itself and also by using the minimum memory bandwidth as it only loads once needed data and outputs the final result directly.

GOUDA can handle 4 video layers and output the resulting image composition directly to the LCD interface. The graphic subsystem has the following capabilities:

- 4 distinct video sources can be blended to produce final output :
  - Layer 0 (aka video layer) :
    - Input formats : YUV4:2:0 planar (IYUV, YV12), YUV4:2:2 pixel-packed (UYVY, YUY2), RGB565
    - YUV to RGB565 conversion (CCIR601 component video standard definition)
    - Image resizing (separate H and V ratios, from 1/4<sup>th</sup> to 4x each direction, 8bit fractional step)
    - adjustable layer depth
    - per-layer alpha blending
    - chroma-key with simple range handling (bit-masking based)
  - Layer 1-3 (aka overlay layers):
    - Input formats : RGB565, ARGB8888
    - fixed depth
    - per-layer alpha blending
    - chroma-key with simple range handling (bit-masking based)
    - per-pixel alpha blending (for ARGB)
- Region Of Interest (ROI) handling for partial refresh of the LCD screen.



- Background colour (colour filled where no layer is defined)
- Embedded LCD controller for direct output (LCD commands buffer in dedicated SRAM).

Output to AHB also available for both LCD on memory bus or frame buffer compositing.

The GOUDA module provides two sets of interface for supporting parallel and SPI LCD. And pins of two interfaces are re-used to minimize the total amounts of chip's pins. The pin re-used map is described as following table,

Parallel interface	Series interface
LCD_RS	SPI_LCD_CLK
LCD_RD	SPI_LCD_CS
LCD_DATA0	SPI_LCD_DIO
LCD_DATA1	SPI_LCD_SDC
Other pins	

## B.II.17 Camera Controller

The Camera module is an interface between the APB bus and a camera sensor.

The controller only handles the data and synchronization signals of the sensor. The control is usually done through an I2C interface which is not integrated in the camera controller module.

### Features

- On the fly cropping and decimation.
- Supports up to 3M pixel sensor with ISP.
- Supports any arbitrary size scaling down from 4096x4096
- latch Ram FIFO Size 160\*16 bit
- Support data format: RGB565, YUV422 and compression data
- Support 8-bit parallel interface
- Support SPI interface with 1/2/4 data mode.
- Support CSI Camera interface

### Data Formats

Following are some data format examples:

- YUV422 (YUYV)

Data	First pixel	First Pixel	Second Pixel	Second Pixel	Third Pixel	Third Pixel
Even/Odd	Y[7:0]	U[7:0]	Y[7:0]	V[7:0]	Y[7:0]	U[7:0]

- YUV422 (YVYU)

Data	First pixel	First Pixel	Second Pixel	Second Pixel	Third Pixel	Third Pixel
Even/Odd	Y[7:0]	V[7:0]	Y[7:0]	U[7:0]	Y[7:0]	V[7:0]

- YUV422 (UYVY)

Data	First pixel	First Pixel	Second Pixel	Second Pixel	Third Pixel	Third Pixel
Even/Odd	U[7:0]	Y[7:0]	V[7:0]	Y[7:0]	U[7:0]	Y[7:0]

- YUV422 (VYUY)

Data	First pixel	First Pixel	Second Pixel	Second Pixel	Third Pixel	Third Pixel
Even/Odd	V[7:0]	Y[7:0]	U[7:0]	Y[7:0]	V[7:0]	Y[7:0]

- RGB565

Bytes	D7	D6	D5	D4	D3	D2	D1	D0
even	R7	R6	R5	R4	R3	G7	G6	G5
odd	G4	G3	G2	B7	B6	B5	B4	B3

**Cropping & Decimation**

Input data from CMOS sensors are first cropped with specified start and end point, which may then followed by a decimation. Decimation can be done in both horizontal and vertical directions. For horizontal decimation, it depends on whether data format is RGB or YUV.

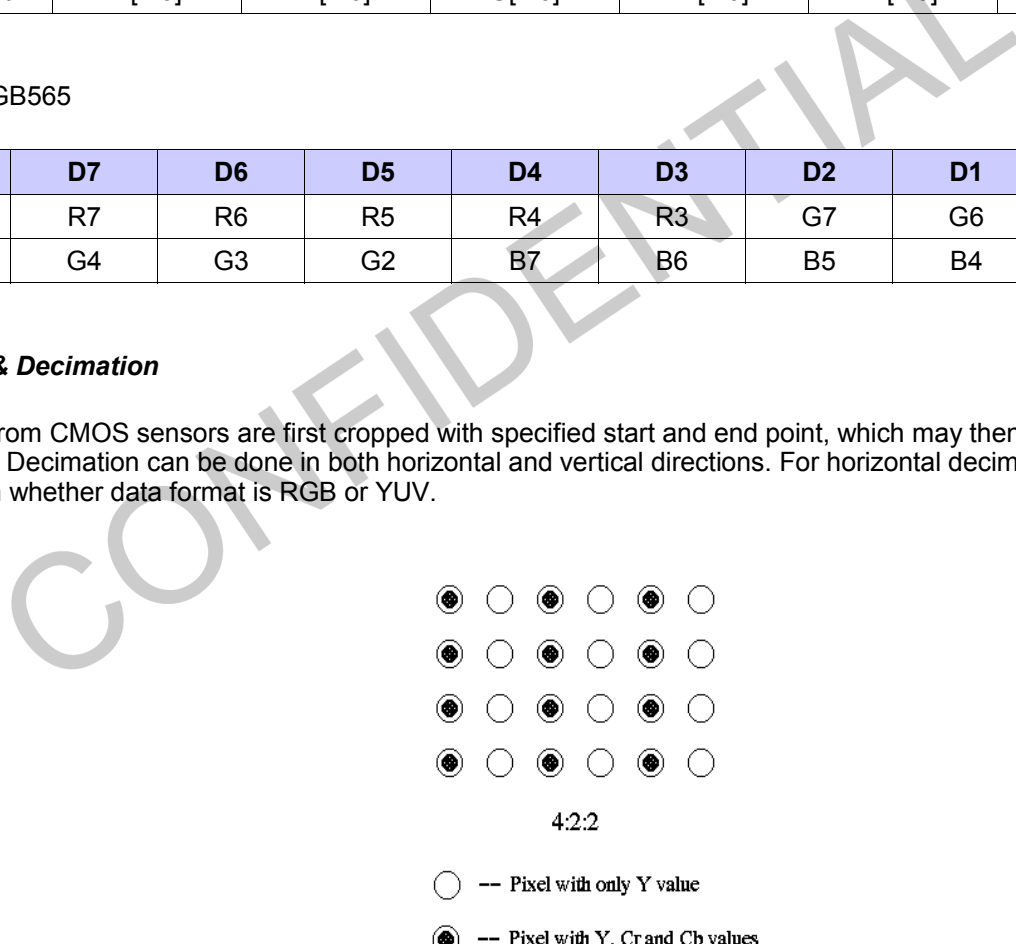


Figure B.9: YUV 4:2:2 Subsampling

If data format is RGB565, horizontal decimation is done at pixel level. For example, if 1:2 rate is chosen:

Src Data: R<sub>0</sub>G<sub>0</sub>B<sub>0</sub> R<sub>1</sub>G<sub>1</sub>B<sub>1</sub> R<sub>2</sub>G<sub>2</sub>B<sub>2</sub> R<sub>3</sub>G<sub>3</sub>B<sub>3</sub> R<sub>4</sub>G<sub>4</sub>B<sub>4</sub> R<sub>5</sub>G<sub>5</sub>B<sub>5</sub>

Dst Data: R<sub>0</sub>G<sub>0</sub>B<sub>0</sub> R<sub>2</sub>G<sub>2</sub>B<sub>2</sub> R<sub>4</sub>G<sub>4</sub>B<sub>4</sub>

If data format is YUV422, horizontal decimation is should regroup some pixels. For example, if 1:2 rate is chosen:

Src Data: Y<sub>0</sub>U<sub>0</sub>Y<sub>1</sub>V<sub>0</sub> Y<sub>2</sub>U<sub>1</sub>Y<sub>3</sub>V<sub>1</sub> Y<sub>4</sub>U<sub>2</sub>Y<sub>5</sub>V<sub>2</sub> Y<sub>6</sub>U<sub>3</sub>Y<sub>7</sub>V<sub>3</sub> Y<sub>8</sub>U<sub>4</sub>Y<sub>9</sub>V<sub>4</sub> Y<sub>10</sub>U<sub>5</sub>Y<sub>11</sub>V<sub>5</sub>

Dst Data: Y<sub>0</sub>U<sub>0</sub>Y<sub>2</sub>V<sub>0</sub> Y<sub>4</sub>U<sub>2</sub>Y<sub>6</sub>V<sub>2</sub> Y<sub>8</sub>U<sub>4</sub>Y<sub>10</sub>V<sub>4</sub>

Another example, if YUV422 1:3 rate is chosen:

Src Data: Y<sub>0</sub>U<sub>0</sub>Y<sub>1</sub>V<sub>0</sub> Y<sub>2</sub>U<sub>1</sub>Y<sub>3</sub>V<sub>1</sub> Y<sub>4</sub>U<sub>2</sub>Y<sub>5</sub>V<sub>2</sub> Y<sub>6</sub>U<sub>3</sub>Y<sub>7</sub>V<sub>3</sub> Y<sub>8</sub>U<sub>4</sub>Y<sub>9</sub>V<sub>4</sub> Y<sub>10</sub>U<sub>5</sub>Y<sub>11</sub>V<sub>5</sub>

Dst Data: Y<sub>0</sub>U<sub>0</sub>Y<sub>3</sub>V<sub>0</sub> Y<sub>6</sub>U<sub>3</sub>Y<sub>9</sub>V<sub>3</sub>

For Vertical decimation, data format RGB565/555/444 or YUV422 will be the same, vertical decimation is done at line level. For example, if 1:2 rate is chosen:

Src Data: Line<sub>0</sub> Line<sub>1</sub> Line<sub>2</sub> Line<sub>3</sub> Line<sub>4</sub> Line<sub>5</sub>

Dst Data: Line<sub>0</sub> Line<sub>2</sub> Line<sub>4</sub>

### FIFO

Rx Data FIFO is in APB domain. So FIFO\_Write signal from CAM\_PIXCLK domain will be synchronized to APB domain. This requires APB clock frequency faster than CAM\_PIXCLK frequency \* 0.75. For example, if RGB565 QXGA 15 frame/s is required, APB CLK freq should > 3.1M pixel \* 2 byte per pixel \* 15 frame per sec \* 0.75 = 70 MHz.

### Interface

The Camera module provides two types of interface for camera sensor. One is the traditional 8-bit parallel interface, the other is SPI interface which uses less signal. The two interfaces are share the same pin so that it does not increase the total amounts of chip pins.

The typical connect of 1 data series interface is as following, here the GC6113 and PA6167/6175 are chose for examples.

Parallel Interface	SPI interface	GC6113 (1 data mode)	PAS6167/6175	CSI Interface
CAM_D0	/			
CAM_D1	SPI_CAM_CTS		CTS	
CAM_D2				CSI_DN2
CAM_D3				CSI_DP2
CAM_D4	SPI_CAM_OF		OVERFLOW_M	CSI_DN1
CAM_D5	SPI_CAM_RD		OVERFLOW_S	CSI_DP1
CAM_D6	SPI_CAM_SSN		SSN	CSI_CKP
CAM_D7	SPI_CAM_SCK	SCK	SCLK	CSI_CKN

CAM_PCLK	SPI_CAM_DI	SDO0	SDO	
CAM_VSYNC				
CAM_CLK	CAM_CLK	MCLK	SYS_CLK	
CAM_RST	I2C_SCL	SBCL	I2C_SCL	
CAM_PDN	I2C_SDA	SBDA	I2C_SDA	

## B.II.18 SD/MMC Controller

This module connects inner bus and outer SD or MMC card. It receives the inner command and data, transfers it to outer SD or MMC card, and transfer response or data back.

### Features

- SD Card Specification Version 2.0
- SDIO Version 1.10
- MMC specification Version 3.1
- Hot insertion and removal of media cards will be considered by GPIO module

## B.II.19 Audio Interface Analog + I2S (AIF)

The Audio Interface (AIF) module is the audio interface between the RDA5851 system and multimedia chip.

AIF can work in master mode in which it generates synchronization signals needed by the multimedia chip, which contains the audio ADC and DAC to convert the serial digital output data to analog audio signal and the input analog signal to serial digital audio data. It can also works in slave mode which uses synchronization signals sent from multimedia chip. Please see below for more details about serial data format.

AIF includes both serious and parallel interface. It is able to support multiple sample rate including 8 kHz, 11.025 kHz, 12kHz, 16 kHz, 22,05 kHz, 24kHz, 32kHz, 44,1 kHz, 48kHz and various data format. AIF can also generate common DTMF, comfort tones and side tone with a configurable gain.

### Features

- Common features.
  - 4\*32-bit RX and 4\*32-bit TX FIFO.
  - All common DTMF and Comfort Tones can be generated and gained from -15 dB to 0 dB.
  - Side Tone fully configurable: Mute or amplification from -36 dB to +6 dB.
  - Loop back capabilities for test purposes.
- Serial Interfaces.
  - 16-bit mono or stereo samples.
  - MSB/LSB configurable.

- Configurable as master or slave.
- LRCK/BCLK ratio from 16 to 31.
- Supports multiple sample rates (8 kHz; 11.025 kHz; 12kHz; 16 kHz; 22,05 kHz; 24kHz; 32kHz; 44,1 kHz; 48kHz).
- Fully configurable clock polarity: Data can be sampled or sent independently at either rising edge or falling edge of the clock.
- Configurable TX/RX data delays: Digital audio data in can be aligned or 1/2/3 cycles delayed to LRCK edge. Digital audio data out can be aligned or 1 cycle delayed to LRCK edge. 1 cycle supplementary delay is possible for TX data in slave mode.
- Support Audio mode: I2S compatible but can have more configurations.
- Support voice mode: One cycle strobe pulse at the beginning of each new sample. Compatible to Maxim 9851/9853 voice mode.
- DAI interface.
  - 13-bit mono sample.
  - Generate 104 kHz master clock.
  - Starts after a pulse on the DAI\_RST line.
- Parallel Interface
  - 13-bit mono samples from ADC.
  - 16-bit x 2 stereo samples to stereo DAC.
  - Separate TX and RX strobe lines for synchronization.

## B.III Digital Modules

### B.III.1 Voice Coprocessor (VoC)

The Voice Co-Processor (VoC) is designed to process different Vocoders (FR, HR, EFR, AMR) It is developed as a target-specific DSP core, including basic function-call support, able to execute the code with very little (or no) control intervention from the CPU. It is controlled and configured by the CPU through the AMBA bus.

#### Features

- Bi-MAC, single test/logic Computational Unit with two 16x16 -> 32-bit multipliers
- Eight 16-bit general purpose registers, that can be combined in four 32-bit general purpose registers.
- All 16-bit registers can be used as pointers, four of them are incremental (for easy array addressing).
- Four 32-bit general purpose registers.
- 2 x 20 Kbytes data RAM + 32 Kbytes instruction RAM.
- Double stack with random access: for 32-bit & 16-bit values (push, pop).
- Function call support (jal, return).
- Two zero-cycle loop counters.
- Pointer & Direct addressing modes.
- DMA sub-module for block transfers between external memory and VoC memories.
- Simple DAI Interface for Analog test Audio Loop (Loop between DAI interface and Analog Interface designed to test the Audio Filters implemented by VoC)
- Clock speed : 26MHz, 39MHz, 52MHz, 78MHz, 89MHz, 104MHz, 113MHz, 125MHz, 139MHz, 156MHz, 178MHz, 208MHz, 250MHz, 312MHz.

## B.IV Analog Modules

### SPI Interface for Analog IP control

All the IPs connected to DBB feature an SPI interface dedicated to IP control.

The Power Management Unit(PMU) and the Analog module(ABB) are controlled by the same SPI of DBB (with different chip-select).

For simplicity sake and ease of use, the SPI protocol settings for PMU and ABB.

The chosen SPI setting is the following:

- Data from DBB are issued on falling edge of clock and can be latched on rising edge by the slave.
- Data from the slave are issued on rising edge of the clock and will be latched on falling edge of clock.
- the SPI frame is 26 bits long : first bit is the R/W selection, then 9 bits of address  $A_8$  to  $A_0$ , then 16 bits of data  $D_{15}$  to  $D_0$ .
- Maximum SPI\_CLK frequency : 26 MHz

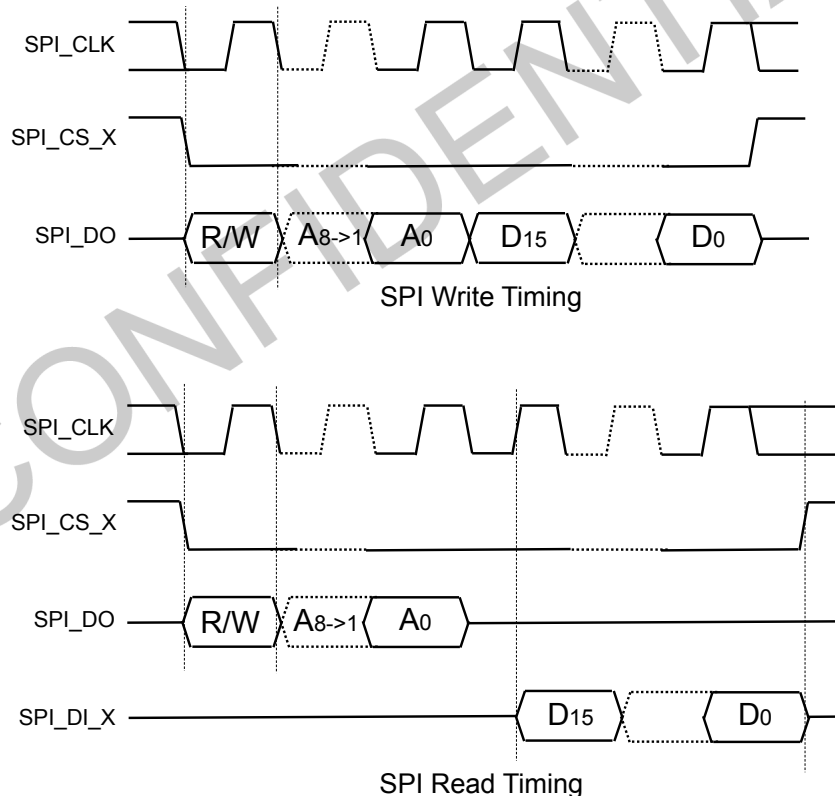


Figure B.10: SPI Write & Read Timing

### Power Management Unit

The PMU is controlled from the DBB through SPI (see for details).

### B.IV.0.0.a Power System Management

The PMU performs a POR either when POWKEY is asserted (i.e. Power-ON/OFF button pressed) or when the WAKEUP line is raised (RTC Alarm) or when the charger (or USB) is plugged.

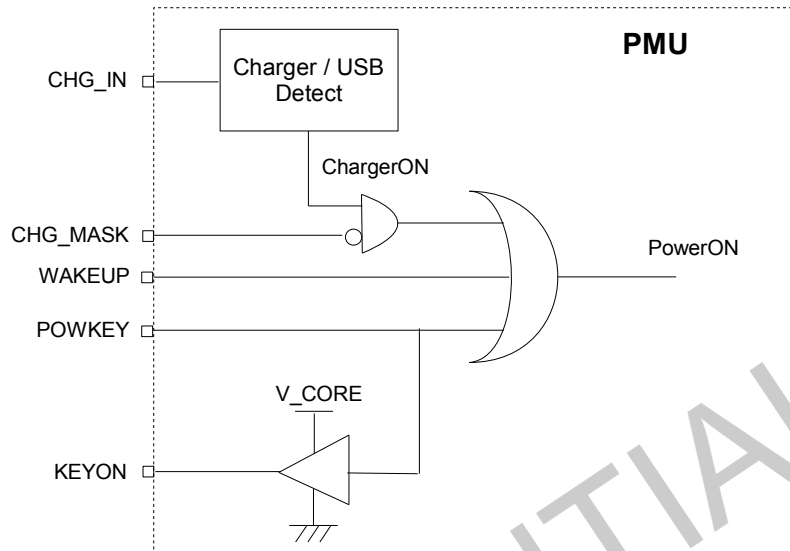


Figure B.11: PMU Power ON

In the presented principle schematic, PowerON is an internal signal of the PMU that reflects that the system needs power. It can either be raised when the Power-ON key is pressed, when the WAKEUP line from DBB is raised or when the charger (or USB) is plugged. When a rising edge of PowerON is detected, the PMU should go through its POR sequence.

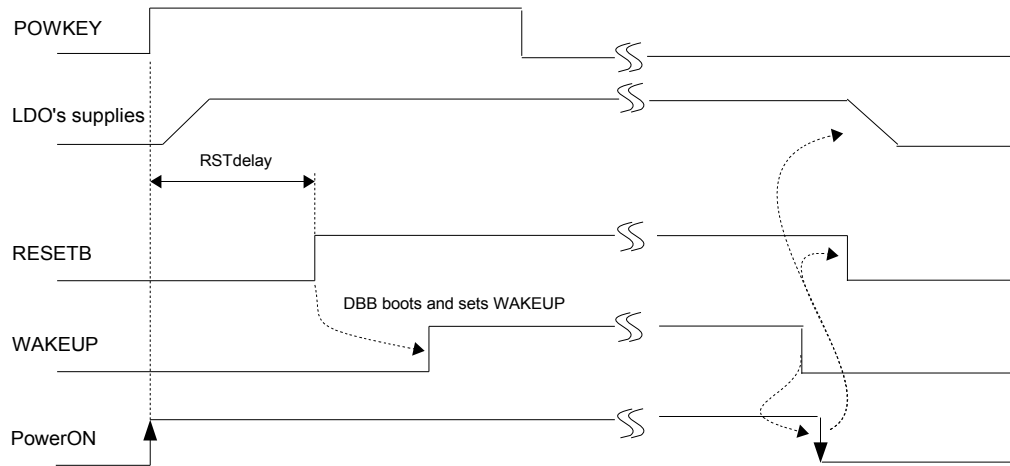
The POR sequence consists in turning ON the relevant power supplies then wait for RST delay that is long enough to ensure that all LDOs are in steady state and that all the chip is correctly powered, then raise the RESETB signal.

In case the POR is triggered by POWKEY, it's DBB responsibility to set the WAKEUP line high when it considers that POWKEY has been pressed long enough. As POWKEY is a VBAT level input, a V\_CORE version of POWKEY (named KEYON) is generated for DBB.

POR can also be initiated when the WAKEUP line is being raised directly because of an RTC Alarm (the POWKEY is not pressed).

As long as PowerON is high, the PMU provides voltages supplies that are specified by the current Power-Profile that describes the LDO and DC/DC settings.



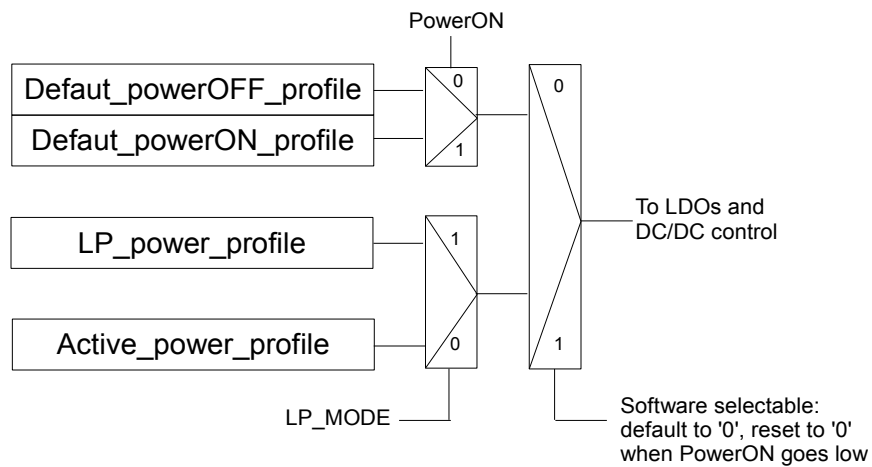


**Figure B.12: POR triggered by POWKEY press**

#### B.IV.0.0.b

The PMU implements multiple power profiles defining the LDOs and DC/DC activation in various modes.

- **Default\_powerOFF\_profile:** used when the system is OFF( system has been shut-off or first time battery is plugged...). In this case only V\_RTC is provided.
- **Default\_powerON\_profile:** used when PowerON is asserted and the POR is triggered, all LDOs that have “reset state ON” are activated.
- **Active\_power\_profile:** used once system has booted and decided to switch from Default\_powerON\_profile. This profile is programmable.
- **LP\_power\_profile:** used when the system goes to low-power mode (switch from Active to Low-power through LP\_MODE line). This profile is programmable.



**Figure B.13: Principle schematic for Power-Profiles usage**

If the PowerON line goes low, the RESETB signal will be set to Low level then all power supplies excepted V\_RTC are switched OFF.

It can be useful to be able to go back to Default\_powerOFF\_profile (i.e. shut-off all supplies except RTC) even when a charger is plugged. The CHG\_MASK (RTC domain) line is used for this purpose, by masking the ChargerON line.

V\_USB is not power-on automatically when USB is detected. The USB PHY remains OFF until the software decides to turn it ON.

### B.IV.0.0.c LDOs

Name	Type	Voltage	Max Current	Usage (power domain)
V_CORE	DC-DC	1.2V	300mA	Core
V_CORE	LDO	1.2V	20mA	Core
V_BOOST	DC-DC		600mA	LCD backlight, VBAT_ABB, or Audio PA
V_PAD	LDO	1.8V / 2.8V	200mA	Digital IO
V_ANA	LDO		200mA	Analog module
V_MEM	LDO	1.8V / 2.8V	200mA	External Combo flash / ram
V_SPIMEM	LDO	1.8V / 2.8V	200mA	External SPI Memory
V_ASW	LDO	1.8V / 2.8V	200mA	Supplies periphery device
V_CAM	LDO	1.8V / 2.8V	200mA	Camera
V_LCD	LDO	1.8V / 2.8V	200mA	LCD module
V_MMC	LDO	2.8V / 3.2V	150mA	Memory Card
V_VIB	LDO	2.3V / 3.3V	300mA	Vibrator
V_USB	LDO	3.3V	300mA	USB PHY
V_MIC	LDO	1.4V/1.75V	200mA	Microphone
V_RTC	LDO	1.2V	0.6mA	Real time clock

#### **B.IV.0.0.d LED Drivers**

The PMU implements both LCD backlight and Keypad LED drivers.

There are 4 current sink sources provided for the LCD backlight use, which named as LED1-4.. Each of them can sink 30mA.

The Keypad LED drivers include 3 sink sources as KP\_LED<sub>R</sub>, KP\_LED<sub>G</sub>, and KP\_LED<sub>B</sub>. Each of them can provide 30mA sink current. KP\_LED\_OUT is voltage feedback current regulator which is suggested to connect to the anode of the keypad LEDs.

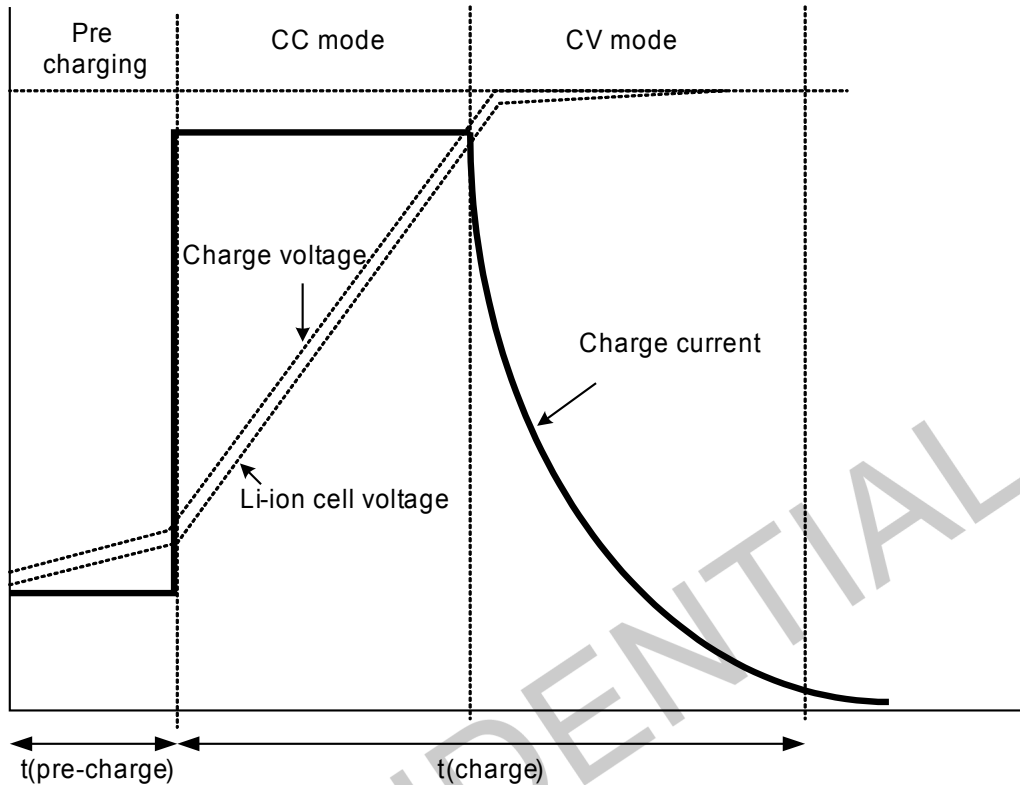
Both LCD backlight and Keypad LED drivers can be adjusted driver capability by software via changing current or PWM settings.

#### **B.IV.0.0.e Charger Circuit**

The RDA5851 integrates the most of charger circuits, except for a few components such as one PMOS, one accurate resistor and one diode, which should be applied externally.

When the charger is on, this block controls the charging phase and turns on the appropriate LDOs according to the battery status. If the voltage is greater than 4.2~ 4.4 V, charging is stopped immediately to prevent permanent damage to the battery.

Battery charging states include No Charge mode, Constant Current (CC) charge mode (pre-charge, constant current), and Constant Voltage (CV) charge mode. No matter what state the phone is in, the PMIC charger handles the charging state transition. A typical charging process is described as what the Figure 5 shows.



**Figure B.14: Charging I-V Curve**

The charge current is calculated by the following expression,

$$I_{\text{charge}} = I_{\text{ref}} * (200/0.2)$$

$I_{\text{ref}}$  is 0.05mA in pre\_charge mode and 0.5mA in constant mode, and these two mode can be switched by internal charger circuit.

#### B.IV.0.0.f Touchscreen Interface

The touchscreen provide a mode where X and Y measures (and associated switching) are performed automatically, the results being stored in dedicated registers.

The measure will be trigged by an SPI command sent by DBB. The touchscreen interface will then:

- switch the X+, X-, Y+ and Y- lines to perform the X measurement,
- wait for a programmable time (accounting for settling time to the final steady-state value prior to the ADC sampling),
- then perform the X measure and store it (and also set the End Of Conversion for X).
- switch the X+, X-, Y+ and Y- lines to perform the Y measurement
- wait for a programmable time (same time as for X)
- then perform the Y measure and store it (and also set the End Of Conversion for Y)
- generate the End of Measurement Interrupt, EOMIRQ to DBB (see B.IV).

When the touchscreen interface is in IDLE mode (when it is not performing measurements), it will be able to detect that the touchscreen panel is pressed through the X+, X-, Y+ and Y- lines. The PENIRQ line reflects the detection result. When the touchscreen interface is performing measurements the PENIRQ line is not expected to be valid and can be set to '0'.

### B.IV.0.0.g Interrupt management

The PMU has two lines of interruption to DBB:

- the PENIRQ line dedicated to touchscreen
- the PMU\_INT line that handles several other causes of interruption.

## Analog module (ABB)

### B.IV.0.0.h PLL and clock squarer

ABB includes a PLL that generates 624MHz from a 26MHz input (x24 integer frequency multiplier). It also includes a “clock squarer” that buffers the clock coming from the internal transceiver to provide a clean version (at V<sub>CORE</sub> levels) of this clock.

The following drawing summarizes the PLL clock path:

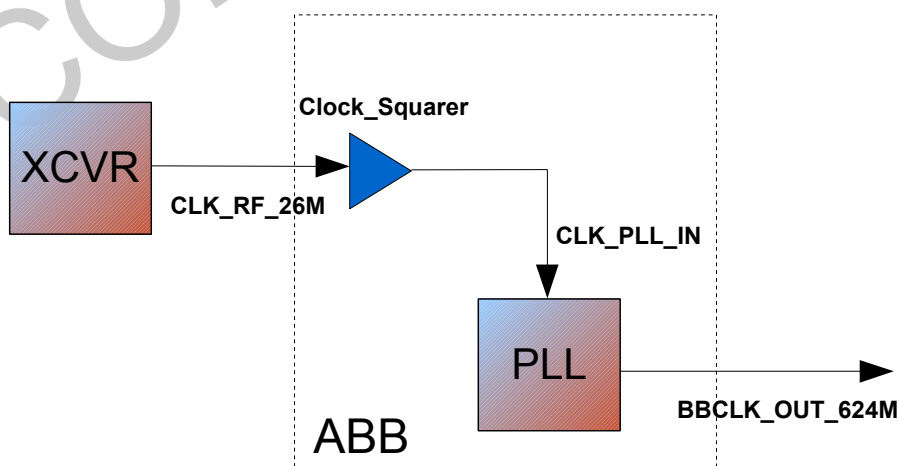
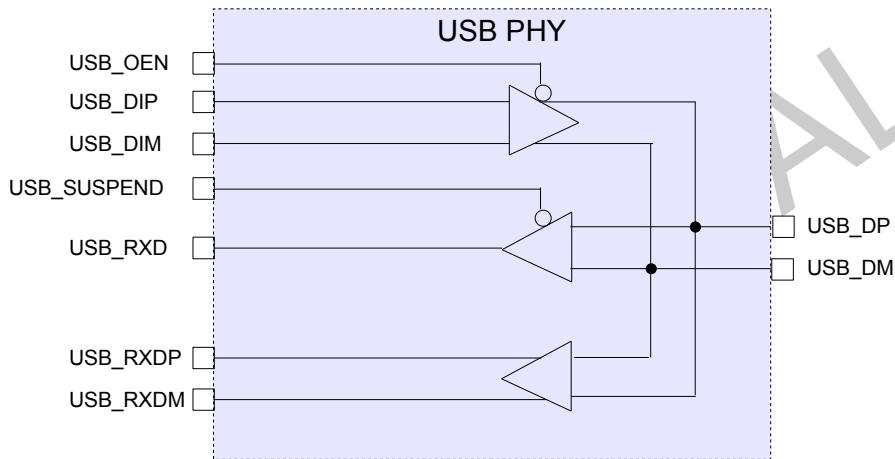


Figure B.15: PLL Clock Path

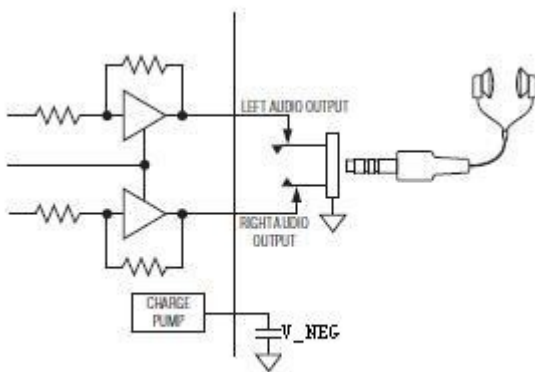
**B.IV.0.0.i AUDIO**

The Audio part includes ADC, DAC, Audio Amplifiers and Audio Muxes. The following diagram provides a global view of audio blocks. Voice data can be input from microphone. Voice and audio data can be output to a stereo DAC and connected to peripherals such as receiver, headset and loudspeaker. It is able to support multiple sample rate audio data including 8 kHz, 11.025 kHz, 12kHz, 16 kHz, 22,05 kHz, 24kHz, 32kHz, 44,1 kHz, 48kHz.

**B.IV.0.0.j USB PHY**



**Figure B.16: USB PHY FS 1.1**



DIP and DIM pins are really reflecting DP and DM, therefore the following decoding must be done in DBB USB controller:

**B.IV.0.0.k General Purpose ADC**

ABB includes a 2-channels A to D converter. A functional timing diagram is given below:

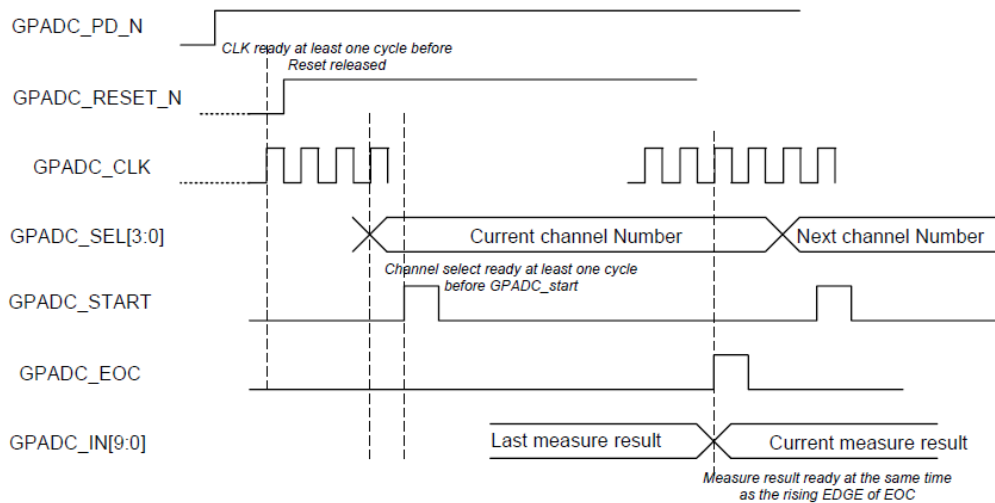


Figure B.17: GPADC Timing Diagram

## B.V FM

### General Description

RDA5851 Integrates a broadcast FM stereo radio tuner with fully integrated synthesizer, IF selectivity and MPX decoder. The tuner requires the least external component. It has a powerful low-IF digital audio processor, this make it have optimum sound quality with varying reception conditions. It can be tuned to the worldwide frequency band.

#### Features

- Low Power Consumption
  - Total Current consumption Lower than 22 mA at 3.0 V power supply
- Support worldwide frequency band
  - 65-108MHz
- Digital low-IF tuner
  - Image-reject down-converter
  - High performance A/D converter
  - IF selectivity performed internally
- Fully integrated digital frequency synthesizer
  - Fully integrated on-chip RF and IF VCO
  - Fully integrated on-chip loop filter
- Autonomous search tuning
- Support 32.768KHz crystal oscillator
- Digital auto gain control (AGC)
- Digital adaptive noise cancellation
  - Mono/stereo switch
  - Soft mute
  - High cut
- Programmable de-emphasis (50/75 ms)
- Receive signal strength indicator (RSSI)
- Bass boost



- Volume control
- FM Record through digital audio interface
- Line-level analog output voltage
- 32.768 KHz 12M,24M,13M,26M,19.2M,38.4MHz Reference Clock
- SPI control bus interface
- Directly support 32Ω resistance loading

### Block Description

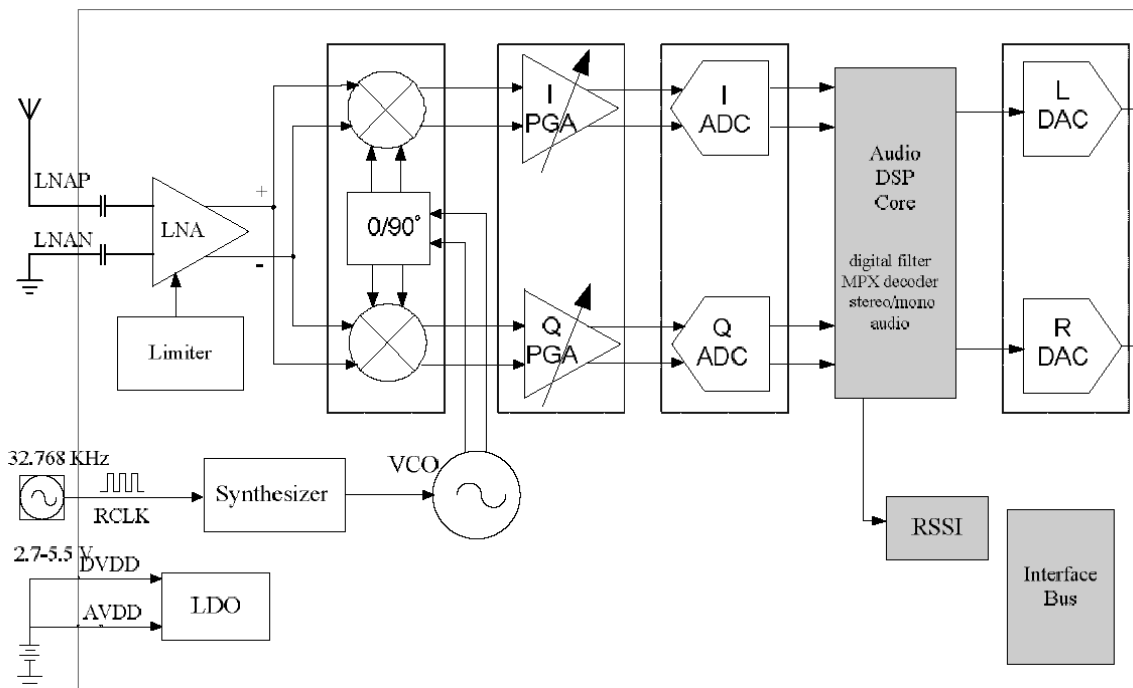


Figure B.18: FM Tuner Block Diagram

The FM receiver uses a digital low-IF architecture that avoids the difficulties associated with direct conversion while delivering lower solution cost and reduces complexity, and integrates a low noise amplifier (LNA) supporting the FM broadcast band (65 to 108MHz), a quadrature image-reject mixer, a programmable gain control (PGA), a high resolution analog-to-digital converters (ADCs).

The LNA has differential input ports (LNAP and LNaN) and supports any input port by set according registers bits. Its default input common mode voltage is GND.

The limiter prevents overloading and limits the amount of intermodulation products created by strong adjacent channels.

The quadrature mixer down converts the LNA output differential RF signal to low-IF, it also has image-reject function.

The PGA amplifies the mixer output IF signal and then digitized with ADCs.

The DSP core finishes the channel selection, FM demodulation, stereo MPX decoder and output audio signal. The MPX decoder can autonomously switch from stereo to mono to limit the output noise.

The frequency synthesizer generates the local oscillator signal which divide to quadrature, then be used to down-convert the RF input to a constant low intermediate frequency (IF). The synthesizer reference clock is 32.768 kHz. The synthesizer frequency is defined by register bits with the range from 65MHz to 108MHz.

### Receiver Characteristics

(VDD = 2,7 to 5,5V, T<sub>A</sub> = -25°C to 85 °C, unless otherwise specified)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
<b>General Parameters</b>						
F <sub>in</sub>	FM Input Frequency	BAND=00	87		108	MHz
		BAND=01	76		91	MHz
		BAND=02	76		106	MHz
		BAND=03	65		76	MHz
V <sub>rf</sub>	Sensitivity <sup>1,2,3</sup>	(S+N)/N=26dB		1	1.5	μV EMF
R <sub>in</sub>	LNA Input Resistance <sup>7</sup>			150		Ω
C <sub>in</sub>	LNA Input Capacitance <sup>7</sup>		2	4	6	pF
IP3 <sub>in</sub>	Input IP3 <sup>4</sup>	AGCD=1	80		-	dBμV
α <sub>am</sub>	AM Suppression <sup>1,2</sup>	M=0.3	40		-	dB
S <sub>200</sub>	Adjacent Channel Selectivity	± 200kHz	45		-	dB
V <sub>AFL</sub> ; V <sub>AFL</sub>	Left and Right Audio Frequency output Voltage	Volume [3:0]=1111		200		mV
(S+N)/N	Maximum Signal Plus Noise to Noise Ratio <sup>1,2</sup>		55	60	-	dB
α <sub>scs</sub>	Stereo Channel Separation		35	-	-	dB
THD	Audio Total Harmonic Distortion <sup>1,3,6</sup>			0.03	0.05	%
α <sub>AOI</sub>	Audio Output L/R Imbalance				0.1	dB
R <sub>L</sub>	Audio Output Loading Resistance	Single-ended	32	-	-	Ω
<b>Pins L<sub>NAN</sub>, L<sub>NAP</sub></b>						
V <sub>com_rfin</sub>	Pins L <sub>NAN</sub> and L <sub>NAP</sub> Input Common Mode Voltage			0		V
V <sub>com</sub>	Audio Output Common Mode Voltage		0.95	1	1.05	V

Notes:

1. F<sub>in</sub>=65 to 108MHz, F<sub>mod</sub>=1KHz, de-emphasis=75μs, MONO=1; L=R unless noted otherwise.
2. Δf = 22.5KHz.
3. B<sub>A</sub> = 300Hz to 15KHz, RBW <= 10Hz.
4. |f<sub>2</sub>-f<sub>1</sub>| > 1MHz, f<sub>0</sub> = 2xf<sub>1</sub>-f<sub>2</sub>, AGC disable, F<sub>in</sub> = 76 to 108MHz.
5. P<sub>RF</sub> = 60dbμV.
6. Δf = 75KHz.
7. Measured at V<sub>EMF</sub> = 1mV, F<sub>RF</sub> = 65 to 108MHz.

## B.VI Bluetooth

### General Description

RDA5851 Integrates a highly integrated Bluetooth SoC with radio transceiver and baseband processor, which is compliant with Bluetooth 2.1 + EDR specification and provides an optimal solution for data and voice application. It has been designed on highest level of integration to extremely reduce the number of external component.

#### Features

- CMOS single-chip fully-integrated radio and baseband
- Compliant with Bluetooth 2.1 + EDR specification
- Bluetooth Piconet and Scatternet support
- Support AFH
- Meet class1, class2 and class3 transmitting power requirement
- Provides +4dbm transmitting power
- NZIF receiver with -90dBm sensitivity
- Up to 4Mbps high speed UART HCI support
- Low power consumption
- Minimum external component

#### Block Description

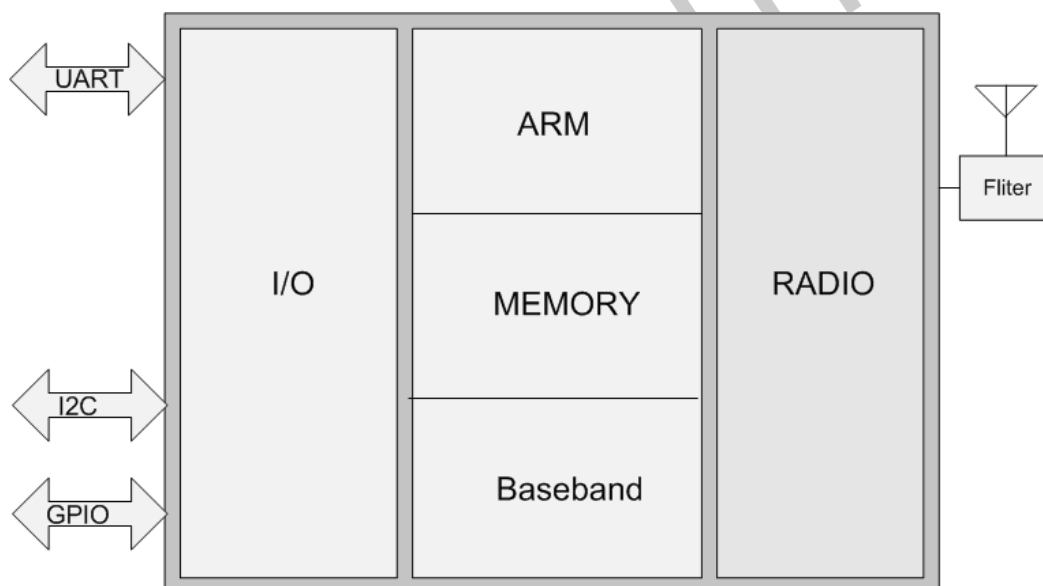


Figure B.19: Bluetooth Block Diagram

As shown in Figure above, the Bluetooth module on-chip integrates radio unit, baseband core, ARM7 core and memory which provides a complete lower Bluetooth protocol stack including the LC, LM and HCI interface.

The description of individual section is following,

- Radio Front
  - Build-in TX/RX switch
  - Fully integrated synthesizer without any external component
  - Support DCXO or external reference clock direct input
  - Class1 , class2 and class3 transmit output power supported and over 30dB dynamic control range
  - Supports  $\pi/4$  DQPSK and 8DPSK modulation
  - High performance in receiver sensitivity and over 80dB dynamic range
  - Integrated channel filter

- Baseband
  - Internal RAM allows fully speed data transfer, mixed voice and data, and fully piconet operation
  - Logic for forward error correction, header error control, access code correlation, CRC, demodulation , encryption bit stream generation, whitening and transmit pulse shaping
  - Support eSCO and AFH
  - Support up to Bluetooth v2.1 + EDR
  - Support A-law,  $\mu$ -law and CVSD digitize audio CODEC in PCM interface
- Stack
  - Compliant with Bluetooth 2.1 + EDR specification

**Performance Characteristics**

**Power consumption specification (VBAT = 4.0 V, T<sub>A</sub> = +27°C, unless otherwise specified)**

STATE	DESCRIPION	Condition	TYP.	UNIT
DH1 / DM1			26	mA
DH3 / DM3			28	mA
DH5 / DH5			29	mA
HCI only active			5.5	mA
Sleep			100	uA
Shut off			15	uA

**Receiver Characteristics --- Basic Data Rate (VBAT = 4.0 V, T<sub>A</sub> = +27°C, unless otherwise specified)**

SYMBOL	PARAMETER	CONDITION	MIN	TYP.	MAX	UNIT
General Specification						
	Sensitivity @ 0.1% BER		/	-90	/	dBm
	Maximum input @ 0.1% BER		0	/	/	dBm
	C/I co-channel		/	10	/	dB
Adjacent channel selectivity C/I		F = F <sub>0</sub> + 1 MHz	/	/	-5	dB
		F = F <sub>0</sub> - 1 MHz	/	/	0	dB
		F = F <sub>0</sub> + 2 MHz	/	/	-33	dB
		F = F <sub>0</sub> - 2 MHz	/	/	-30	dB
		F = F <sub>0</sub> + 3 MHz	/	/	-45	dB
		F = F <sub>0</sub> - 3 MHz	/	/	-40	dB
		F = F <sub>image</sub>	/	/	0	dB
Out-of-band blocking		30MHz–2000MHz	-10	/	/	dBm
		2000MHz–2400MHz	-27	/	/	dBm
		2500MHz–3000MHz	-27	/	/	dBm
		3000MHz–12.5GHz	-10	/	/	dBm
	Inter-modulation		-35	/	/	dBm
	Spurious output level		-150	/	/	dBm

**Transmitter Characteristics --- Basic Data Rate (VBAT = 4.0 V, T<sub>A</sub> = +27°C, unless otherwise specified)**

SYMBOL	PARAMETER	CONDITION	MIN	TYP.	MAX	UNIT
General Specification						
	Max RF output power		/	4	/	dBm
	Power control range		30	/	/	dB
	20dB bandwidth		/	0.9	/	MHz
Adjacent channel transmitter power	F = F0 + 1 MHz		/	-35	/	dBm
	F = F0 - 1 MHz		/	-34	/	dBm
	F = F0 + 2 MHz		/	-55	/	dBm
	F = F0 - 2 MHz		/	-55	/	dBm
	F = F0 + 3 MHz		/	-58	/	dBm
	F = F0 - 3 MHz		/	-58	/	dBm
	F = F0+ > 3 MHz		-58	/	/	dBm
	F = F0- > 3 MHz		-58	/	/	dBm
	$\Delta f_{1avg}$ Maximum modulation		/	164	/	kHz
	$\Delta f_{2max}$ Minimum modulation		/	145	/	kHz
	$\Delta f_{2avg}/\Delta f_{1avg}$		0.8	/	/	/
	ICFT		/	4	/	kHz
	Drift rate		/	0.1	/	kHz/50 us
	Drift (1 slot packet)		/	-2	/	kHz
	Drift (5 slot packet)		/	-2	/	kHz

**Receiver Characteristics --- Enhanced Data Rate (VBAT = 4.0 V, T<sub>A</sub> = +27°C, unless otherwise specified)**

SYMBOL	PARAMETER	CONDITION	MIN	TYP.	MAX	UNIT
<b><math>\pi/4</math> DQPSK</b>						
	Sensitivity @0.01% BER		/	-89	/	dBm
	Maximum input @ 0.1% BER		0	/	/	dBm
	C/I co-channel		/	/	13	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz		/	/	5	dB
	F = F0 - 1 MHz		/	/	0	dB
	F = F0 + 2 MHz		/	/	-30	dB
	F = F0 - 2 MHz		/	/	-20	dB
	F = F0 + 3 MHz		/	/	-40	dB
	F = F0 - 3 MHz		/	/	-40	dB
	F = F_image		/	/	-7	dB
<b>8DPSK</b>						
	Sensitivity @0.01% BER		/	-83	/	dBm

Maximum input @ 0.1% BER		0	/	/	dBm
C/I co-channel		/	/	18	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	/	/	5	dB
	F = F0 - 1 MHz	/	/	5	dB
	F = F0 + 2 MHz	/	/	-25	dB
	F = F0 - 2 MHz	/	/	-13	dB
	F = F0 + 3 MHz	/	/	-33	dB
	F = F0 - 3 MHz	/	/	-33	dB
	F = F_image	/	/	0	dB

**Transmitter Characteristics --- Enhanced Data Rate (VBAT = 4.0 V, T<sub>A</sub> = +27°C, unless otherwise specified)**

SYMBOL	PARAMETER	CONDITION	MIN	TYP.	MAX	UNIT
<b>General Specification</b>						
	Max RF output power		/	2	/	dBm
	Relative transmit control		/	1.6	/	dB
	π/4 DQPSK max w0		/	7.4	/	kHz
	π/4 DQPSK max wi		/	6.7	/	kHz
	π/4 DQPSK max  wi + w0		/	2.4	/	kHz
	8DPSK max w0		/	7.1	/	kHz
	8DPSK max wi		/	4.4	/	kHz
	8DPSK max  wi + w0		/	2.7	/	kHz
π/4 DQPSK Modulation Accuracy	RMS DEVM		/	4.7	/	%
	99% DEVM		/	/	30	%
	Peak DEVM		/	8.8	/	%
8PSK Modulation Accuracy	RMS DEVM		/	4.6	/	%
	99% DEVM		/	/	20	%
	Peak DEVM		/	11.3	/	%
In-band spurious emissions	F = F0 + 1 MHz		/	-14.7	/	dBm
	F = F0 - 1 MHz		/	-15.2	/	dBm
	F = F0 + 2 MHz		/	-51	/	dBm
	F = F0 - 2 MHz		/	-52.2	/	dBm
	F = F0 + 3 MHz		/	-55.5	/	dBm
	F = F0 - 3 MHz		/	-55.8	/	dBm
	F = F0+ > 3 MHz		/	/	-55	dBm
	F = F0- > 3 MHz		/	/	-55	dBm



EDR Differential Phase Coding		/	100	/	%

CONFIDENTIAL



## C. MEMORY MAP

Memory Name	Description	Address	Size
External CS1	External memory	0x02000000 ~ 0x03ffffff	32MB
FIFO_regs	Internal register	0x018c0000 ~ 0x018fffff	256KB
VOC	Voice codec	0x01940000 ~ 0x0197ffff	256KB
CPU SRAM	CPU internal sram	0x01980000 ~ 0x01987fff	32KB
SYS APB	Sys apb slave	0x01a00000 ~ 0x01a7ffff	512KB
USB	Usb controller	0x01a80000 ~ 0x01abffff	256KB
XCPU RAM	Xcpu internal sram	0x01ac0000 ~ 0x01adffff	128KB
GOUDA	Graphic processor	0x01ae0000 ~ 0x01ae3fff	16KB
MPMC REG	MPMC REG	0x01ae4000~0x01ae7fff	16KB
MAILBOX	MAILBOX	0x01b00000~0x01b00800	2KB
Internal sram	Internal sram	0x01c00000 ~ 0x01c0ffff	64KB
Regs for bcpu patch	Regs for bcpu patch	0x01d00000~0x01d00100	256B
Internal rom	Internal rom	0x01e00000 ~ 0x01e04fff	20KB
External spi flash	External spi flash	0x08000000 ~ 0x0fffffff	128MB
External psram	External psram	0x02000000 ~ 0x03ffffff	32MB
XCPU APB			
Sys_ctrl		0x01A00000	
Irq		0x01A01000	
Timer		0x01A02000	
Gpio		0x01A03000	
Ebc		0x01A04000	
Keypad		0x01A05000	
Pwm		0x01A06000	
I2c		0x01A07000	
Dma		0x01A08000	
Ifc		0x01A09000	
Calendar		0x01A0a000	
Comregs		0x01A0b000	

Page_spy		0x01A0c000	
Debug_port		0x01A0d000	
Rf_spi		0x01A0e000	
Tcu		0x01A0f000	
Sci		0x01A10000	
Spi		0x01A11000	
Spi2		0x01A12000	
Spi3		0x01A13000	
Debug_uart		0x01A14000	
Uart		0x01A15000	
Uart2		0x01A16000	
Sdmmc		0x01A17000	
Camera		0x01A18000	
Xcpu_reg		0x01A19000	
Xcpu_tag		0x01A1a000	
Xcpu_idata		0x01A1b000	
Xcpu_ddata		0x01A1c000	
Sys_ahb_mon		0x01A1d000	
Bb_ahb_mon		0x01A1e000	
Bist		0x01A1f000	
IFC2		0x01A20000	
Gouda		0x01A21000	
I2C2		0x01A22000	
I2C3		0x01A23000	
EXT_APB		0x01A24000	
Spi Flash Reg		0x01A25000	
Nand Flash Cs0		0x01A26000	
Nand Flash Cs1		0x01A27000	
Nand Flash Cs2		0x01A28000	
Nand Flash Cs3		0x01A29000	
Nand Flash RS		0x01A2a000	
Sdmmc2		0x01A2b000	
Debug_host		0x01A3f000	
AIF		0x01907000	

## D. PINS DESCRIPTION

### D.I Pin-out

Pin Name	I/O	Type	First Usage	Second Usage	Third Usage	Power Domain	Ball No
<b>LCD Parallel Interface</b>							
LCD_DATA_0	I/O	D	Data Bus	SPI_LCD_DIO		LCD	J5
LCD_DATA_1	I/O	D	Data Bus	SPI_LCD_SD C		LCD	H3
LCD_DATA_2	I/O	D	Data Bus			LCD	H8
LCD_DATA_3	I/O	D	Data Bus			LCD	J4
LCD_DATA_4	I/O	D	Data Bus			LCD	H7
LCD_DATA_5	I/O	D	Data Bus			LCD	H2
LCD_DATA_6	I/O	D	Data Bus			LCD	H5
LCD_DATA_7	I/O	D	Data Bus			LCD	H4
LCD_WR	O	D	Write Strobe			LCD	G2
LCD_RS	O	D	Register Select	SPI_LCD_CLK		LCD	G7
LCD_CS_0	O	D	Chip Select 0			LCD	G8
LCD_RD	O	D	Read Strobe	SPI_LCD_CS		LCD	G5
LCD_CS_1	O	D	Chip Select 1	GPO_7		LCD	G4
<b>External Memory Controller</b>							
M_SPI_CLK	O	D	CLK for SPI flash			MEM	B12
M_SPI_D0	I/O	D	Data0 for SPI flash			MEM	A12
M_SPI_D1	I/O	D	Data1 for SPI flash			MEM	A13
M_SPI_D2	I/O	D	Data2 for SPI flash			MEM	B13
M_SPI_D3	I/O	D	Data3 for SPI flash			MEM	B11
M_SPI_CS	O	D	Chip Select 0 for SPI flash			MEM	C12
M_SPI_CS_1	O	D	Chip Select 1 for SPI flash			MEM	C11
<b>Camera</b>							
CAM_PCLK	I/O	D	Camera Pixel Clock	SPI_CAM_DI		CAM	J15
CAM_HREF	I/O	D	Camera Horizontal Synchronous Output	SPI2_DI_1		CAM	H12
CAM_VSYNC	I/O	D	Camera Vertical Synchronous Output	SPI2_DI_0		CAM	F13
CAM_CLK	O	D	Camera Clock			CAM	J13
CAM_RST	O	D	Camera Reset	I2C_SCL		CAM	G13
CAM_PDN	I/O	D	Camera Power Down	I2C_SDA		CAM	H13

Pin Name	I/O	Type	First Usage	Second Usage	Third Usage	Power Domain	Ball No
CAM_DATA_0	I/O	D	Camera Data bus	SPI2_CS_0		CAM	K16
CAM_DATA_1	I/O	D	Camera Data bus	SPI_CAM_CTS		CAM	J17
CAM_DATA_2	I/O	D	Camera Data bus	SPI2_DO	CSI_DN2	CAM	J16
CAM_DATA_3	I/O	D	Camera Data bus	SPI2_CLK	CSI_DP2	CAM	E12
CAM_DATA_4	I/O	D	Camera Data bus	SPI_CAM_OF	CSI_DN1	CAM	E13
CAM_DATA_5	I/O	D	Camera Data bus	SPI_CAM_RD	CSI_DP1	CAM	C14
CAM_DATA_6	I/O	D	Camera Data bus	SPI_CAM_SS_N	CSI_CKP	CAM	E15
CAM_DATA_7	I/O	D	Camera Data bus	SPI_CAM_SCK	CSI_CKN	CAM	C13
<b>I2C2</b>							
I2C2_SCL	I/O	D	I2C2 Clock	GPIO_24		STD	M15
I2C2_SDA	I/O	D	I2C2 Data	GPIO_25		STD	L15
<b>Memory Card Interface</b>							
SSD_CLK	O	D	SD Clock			MMC	E10
SSD_CMD	I/O	D	SD Command			MMC	F11
SDAT_0	I/O	D	SD data bit 0			MMC	E11
SDAT_1	I/O	D	SD data bit 1			MMC	F10
SDAT_2	I/O	D	SD data bit 2			MMC	K10
SDAT_3	I/O	D	SD data bit 3			MMC	J9
<b>SPI</b>							
SPI1_CLK	I/O	D	SPI_1 Clock.	GPIO_12	SSD2_CLK	STD	K12
SPI1_CS_0	I/O	D	SPI_1 Chip Select 0	GPIO_6	KEYIN_7	STD	J11
SPI1_CS_1	I/O	D	SPI_1 Chip Select 1	GPIO_14	I2C3_SDA	STD	M13
SPI1_DIO	I/O	D	SPI_1 Data InOut	GPIO_15	SSD2_DAT1	STD	G11
SPI1_DI	I/O	D	SPI_1 Data In	GPIO_16	I2C3_SCL	STD	H11
<b>Time Controlled Output</b>							
TCO_3	O	D	Time Controlled Outputs 3	GPO_8	SSD2_DAT2	STD	N14
TCO_4	O	D	Time Controlled Outputs 4	GPO_9	SSD2_DAT3	STD	K13
<b>Debug Host</b>							
HST_CLK	I	D	Host Clock input			STD	N12
HST_RXD	I	D	Host data receive.			STD	M14
HST_TXD	O	D	Host data transmit.			STD	P11
<b>KEYPAD</b>							
KEYIN_0	I	D	Key matrix input line 0	GPIO_20	SSD2_SDAT1	STD	L5
KEYIN_1	I	D	Key matrix input line 1			STD	K7
KEYIN_2	I	D	Key matrix input line 2			STD	L4

Pin Name	I/O	Type	First Usage	Second Usage	Third Usage	Power Domain	Ball No
KEYIN_3	I	D	Key matrix input line 3			STD	K8
KEYIN_4	I	D	Key matrix input line 4		GPIO_21	STD	K5
KEYIN_5	I/O	D	Key matrix input line 5	PWT	GPIO_10	STD	L3
KEYOUT_0	O	D	Key matrix output line 0	SSD2_CLK		STD	K1
KEYOUT_1	O	D	Key matrix output line 1	GPIO_17	SSD2_CMD	STD	K2
KEYOUT_2	O	D	Key matrix output line 2	GPIO_11	SSD2_SDAT0	STD	J7
KEYOUT_3	O	D	Key matrix output line 3	GPIO_7		STD	K4
KEYOUT_4	O	D	Key matrix output line 4	GPIO_8		STD	J2
KEYOUT_5	I/O	D	Key matrix output line 5	LPG	GPIO_9	STD	J3
KEYIN_SENSE	I	A	Key input GPADC sense			ABB	C5
KEY_P	O	A	Key sense P			ABB	D4
KEY_N	O	A	Key sense N			ABB	D5
<b>UART</b>							
UART2_RXD	I/O	D	UART2 receive data	GPIO_8	UART1_DTR	STD	K11
UART2_CTS	I/O	D	UART2 clear to send	GPIO_5	UART1_DSR	STD	G10
UART2_TXD	I/O	D	UART2 transmit data	GPIO_13	UART1_DC	STD	H10
UART2_RTS	I/O	D	UART2 receive to send	GPIO_7	UART1_RI	STD	J10
<b>General Purpose I/O</b>							
GPIO_1	I/O	D	GPIO 1	KEYIN_6		STD	M16
GPIO_2	I/O	D	GPIO 2(Only output,default "1")	Internal BT control		STD	M17
GPIO_3	I/O	D	GPIO 3			STD	N15
<b>General Purpose Output</b>							
GPO_0	O	D	GPO 0	KEYOUT_6		STD	P13
GPO_1	O	D	GPO 1			STD	K15
GPO_5	O	D	GPO 5	KEYOUT_7		STD	P16
<b>Miscellaneous Pins</b>							
PWL_1	O	D	Pulse with Light for back light control 1	GPO_6	CLK_32K	STD	J12
CLK_OUT	O	D	Clock Output (32kHz/26MHz/156Mhz/n)			STD	N13
LPSCO_1	I/O	D	Low Power Synchronizer Controlled Output 1	GPIO_4		STD	G12
CODE_COMPRE SS_EN	I	D	Code compress function enable			STD	A15
RESETB_EXT	I	D	External Reset for chip			STD	B14
TST_H	ID	D	Test Mode			RTC	C15
BBPLL_TEST	O	D	Digital CLK output for test			ABB	K9
XVR_XTAL1	I	A	26MHz Crystal port Input			ABB	P14

Pin Name	I/O	Type	First Usage	Second Usage	Third Usage	Power Domain	Ball No
XVR_XTAL2	O	A	26MHz Crystal port Output			ABB	P15
ANA_TEST_EN	I	A	test mode			ABB	D15
<b>General Purpose ADC</b>							
GP_ADC_IN_0	I	A	GPADC input channel 0			ABB	C4
GP_ADC_IN_1	I	A	GPADC input channel 1			ABB	C3
<b>USB</b>							
USB_DM	I/O	A	USB D-			ABB	M7
USB_DP	I/O	A	USB D+			ABB	M8
<b>AUDIO</b>							
LINE_IN_L	I	A	Stereo Line input			ABB	N1
LINE_IN_R	I	A	Stereo Line input			ABB	P1
AU_AUXMIC_P	I	A	Audio Aux In+			ABB	P3
AU_AUXMIC_N	I	A	Audio Aux In-			ABB	N3
AU_MIC_P	I	A	Audio In+			ABB	P2
AU_MIC_N	I	A	Audio In-			ABB	N2
AU_RCV_P	O	A	Receiver Out +			ABB	M5
AU_RCV_N	O	A	Receiver Out -			ABB	M6
AU_LSL_P	O	A	Loudspeaker Left Out +			ABB	B10
AU_LSL_N	O	A	Loudspeaker Left Out -			ABB	A10
AU_LSR_P	O	A	Loudspeaker Right Out +			ABB	A9
AU_LSR_N	O	A	Loudspeaker Right Out -			ABB	B9
AU_HPL	O	A	Headset Left Out			ABB	N4
AU_HPR	O	A	Headset Right Out			ABB	P5
<b>FM</b>							
FMIN	I	A	FM RF differential input			FM	M2
FMIP	I	A	FM RF differential input			FM	M1
FM_GND		A	FM GND			FM	L1
<b>Bluetooth</b>							
BT_RFIP	I	A	BT RF signal input			BT	L17
BT_RFIN	I	A	BT RF signal input			BT	L16
DECAP_BTDVDD		A	BT DECAP			BT	P17
<b>Power Management Control</b>							
POWERKEY	I	A	Power-on switch enable signal. Active High.			PMU	B6
AC_R	I	A	Input from the AC charger or USB inlet			PMU	E4
GDRV	O	A	Charger drive			PMU	F4

Pin Name	I/O	Type	First Usage	Second Usage	Third Usage	Power Domain	Ball No
IS_CHG	I	A	Current Sens for Charger Control			PMU	F3
VBAT_SENSE	I	A	Battery voltage ADC detect			PMU	F2
SW_BULK	O	A	DC/DC control			PMU	A4
SW_BULK2	O	A	DC/DC control			PMU	A5
BOOST_CPP1	O	A	DC/DC control			PMU	A7
BOOST_CPP2	O	A	DC/DC control			PMU	B7
BOOST_CPN1	O	A	DC/DC control			PMU	A8
BOOST_CPP2	O	A	DC/DC control			PMU	B8
VSPIM_SEL	I	A	Selects V_SPIMEM power supply ('0':2.8V, '1':1.8V).			PMU	A6
PROG_EFUSE	I	A	High voltage input for OTP/EFUSE programming			PMU	C6
<b>Touchscreen</b>							
TSC_XP	I	A	Horizontal Measure Input			PMU	F7
TSC_XN	I	A	Horizontal Measure Input			PMU	F8
TSC_YP	I	A	Vertical Measure Input			PMU	F5
TSC_YN	I	A	Vertical Measure Input			PMU	E5
<b>LED Drivers</b>							
LED1	I	A	LED driver current sink			PMU	D2
LED2	I	A	LED driver current sink			PMU	C1
LED3	I	A	LED driver current sink			PMU	C2
LED4	I	A	LED driver current sink			PMU	D3
KP_LEDR	I	A	LED driver current sink			PMU	D1
KP_LEDG	I	A	LED driver current sink			PMU	E3
KP_LEDB	I	A	LED driver current sink			PMU	E2
BL_LED_OUT	O	A	LED driver			PMU	B3
<b>POWER</b>							
AVDD_2V4	O	A	Analog voltage			PMU	A14
VBAT_PMU1	I	A	PMU Battery Power Supply			PMU	A1
VBAT_PMU2	I	A	PMU Battery Power Supply			PMU	A2
V_CORE	O	A	Supplies BB Core. Out for decoupling / debug / backup			PMU	B4



Pin Name	I/O	Type	First Usage	Second Usage	Third Usage	Power Domain	Ball No
VBUCK2_2V4	O	A	DCDC power supply			PMU	B5
VBOOST	O	A	DCDC power supply			PMU	A3
V_SPIMEM	O	A	Supplies external SPI flash			PMU	A11
V_ANA	O	A	Out for decoupling / debug / backup			PMU	N5
V_MEM	O	A	Supplies Memory PADS I/O ring and V_MEM output PAD			PMU	P8
V_PAD	O	A	Supplies Standard PADS I/O ring. Out for decoupling / debug / backup			PMU	P12
V_CAM	O	A	Supplies Camera PADS I/O ring			PMU	K17
V_LCD	O	A	Supplies LCD PADS I/O ring			PMU	J1
V_MMC	O	A	Supplies MMC PADS I/O ring			PMU	P9
V_VIB	O	A	Supplies Vibrator			PMU	G1
V_USB	O	A	Supplies USB PHY. Out for debug / backup / decoupling			PMU	H1
V_RTC	O	A	Supplies RTC domain			PMU	F1
V_BAT_RTC	O	A	Charges Backup CAP			PMU	E1
V_MIC	O	A	Microphone Biasing			PMU	P4
V_ASW	O	A	Supplies periphery device			PMU	N8
V_NEG	O	A	Negative Voltage generator			PMU	P6
<b>GROUND</b>							
SW_GND		A	DC/DC Switch GND			PMU	B1
SW_GND		A	DC/DC Switch GND			PMU	B2
CP_GND		A	Boost GND			PMU	C8
CP_GND		A	Boost GND			PMU	C9
BT_GND		A	BT_GND			PMU	B16
BT_GND		A	BT_GND			PMU	C16
BT_GND		A	BT_GND			PMU	D16
BT_GND		A	BT_GND			PMU	E16
BT_GND		A	BT_GND			PMU	H17

Pin Name	I/O	Type	First Usage	Second Usage	Third Usage	Power Domain	Ball No
GND		A	GND			PMU	B16
GND		A	GND			PMU	C16
GND		A	GND			PMU	D16
GND		A	GND			PMU	E16
GND		A	GND			PMU	H17
CORE_GND		A	CORE_GND			PMU	C7
CORE_GND		A	CORE_GND			PMU	C10
CORE_GND		A	CORE_GND			PMU	E7
CORE_GND		A	CORE_GND			PMU	E8
CORE_GND		A	CORE_GND			PMU	E9
CORE_GND		A	CORE_GND			PMU	F9
CORE_GND		A	CORE_GND			PMU	G9
CORE_GND		A	CORE_GND			PMU	H9
CORE_GND		A	CORE_GND			PMU	M11
CORE_GND		A	CORE_GND			PMU	M12

CONFIDENTIAL

## E. ELECTRICAL CHARACTERISTICS

### E.I Absolute Maximum Rating

Name	Min	Typical	Max	Usage (power domain)
VBAT_ABB, VBAT_XCVR VBAT_PMU	/	3.8V	4.5V	For chip
DC Charger		5V	7V	For charger circuit

### E.II Temperature Characteristics

Parameter	Min	Typ	Max	Unit
Work Temperature	-25	25	70	°C
Storage Temperature	-40	/	125	°C

### E.III Audio Characteristics

Class K						
OUT RMS ON	THD	SINAD	OUT RMS OFF	OUT PWR	SNR	Battery Voltage
(v)	%	(dB)	(v)			
0.407738	0.028088	60.39795	0.000038	0.02	80.61	4
1.61769	0.089419	58.53993	0.000106	0.33	83.67	4
3.102641	1.108774	38.38455	0.000198	1.2	83.9	4
3.541256	13.22943	17.52715	0.000277	1.57	82.13	4
3.691639	19.08801	14.3687	0.000346	1.7	80.56	4
3.788224	22.92822	12.76289	0.000415	1.79	79.21	4
3.842082	25.25349	11.92124	0.000468	1.85	78.29	4
3.887335	27.4225	11.20234	0.000533	1.89	77.26	4
Class D						
OUT RMS ON	THD	SINAD	OUT RMS OFF	OUT PWR	SNR	Battery Voltage
(v)	%	(dB)	(v)			
0.40716	0.02335	61.2679	0.000034	0.02	81.57	4

1.62075	0.09883	58.1445	0.000093	0.33	84.82	4
2.4675	15.0481	16.4175	0.000181	0.76	82.69	4
2.60929	22.7619	12.8336	0.000245	0.85	80.55	4
2.6702	26.2587	11.5887	0.000306	0.89	78.82	4
2.70852	28.5461	10.8718	0.000366	0.92	77.39	4
2.73082	29.8979	10.4747	0.000414	0.93	76.39	4
2.7511	31.1126	10.1232	0.00048	0.95	75.17	4
Headphone						
OUT RMS ON	THD	SINAD	OUT RMS OFF	OUT PWR	SNR	Battery Voltage
(v)	%	(dB)	(v)			
0.23615	0.00844	46.353	0.000024	0.001743	79.86	4
0.32909	0.01013	46.3297	0.000036	0.003384	79.22	4
0.46948	0.01152	46.3691	0.000046	0.006888	80.18	4
0.6456	2.45938	31.9825	0.000066	0.013025	79.81	4
0.82236	13.9234	17.1464	0.000091	0.021134	79.12	4
1.02057	21.5071	13.3848	0.000127	0.032549	78.1	4
1.11581	26.4702	11.5432	0.000193	0.038907	75.24	4
1.16341	30.8232	10.1984	0.000326	0.042298	71.05	4
Receiver						
OUT RMS ON	THD	SINAD	OUT RMS OFF	OUT PWR	SNR	Battery Voltage
(v)	%	(dB)	(v)			
0.131718	0.02263	46.29659	0.000019	0.002169	76.82	4
0.186607	0.032254	46.29754	0.000023	0.004353	78.18	4
0.261563	0.046055	46.2518	0.000029	0.008552	79.1	4
0.370479	0.066329	46.17642	0.00004	0.017157	79.33	4
0.519742	0.096372	46.15026	0.000053	0.033766	79.83	4
0.731471	0.162468	45.74333	0.000074	0.066881	79.9	4
0.978627	4.08141	27.70084	0.000106	0.119714	79.31	4
1.121201	14.80495	16.579	0.000143	0.157136	77.89	4

E.IV

E.V DC Characteristics

Name	Min.(V)	Typical(V)	Max.(V)	Description
VBAT	3.4	3.8	4.2	Normal work
VCORE	0.9	1.2	1.8	Normal work
V_BUCK_2V4	1.4	2.4	2.8	Normal work
AVDD_2V4	2.4	2.4	2.7	Normal work
V_BOOST	4.1	4.3	4.5	Normal work
V_ANA	2.6	2.8	3.0	Normal work
V_RTC	1.1	1.2	1.5	Normal work
V_MIC	1.3	1.4	1.5	Normal work
V_USB		3.3		Normal work
V_PAD,V_MEM, V_SPIMEM, V_ASW,V_CAM	1.7	1.8	1.9	When 1.8V mode
V_LCD V_MMC V_VIB	2.6	2.8	3.0	When 3.0V mode

V\_CORE

Vcore_DCDC 2FH[15:12]	Vbat=4.2V		Vbat=3.4V	
	PWM	PFM	PWM	PFM
	Voltage(V)	Voltage(V)	Voltage(V)	Voltage(V)
0000	0.734343	0.851079	0.734317	0.851287
0001	0.803534	0.913479	0.803521	0.917133
0010	0.873937	0.982545	0.87401	0.986022
0011	0.945415	1.046256	0.94553	1.054174
0100	1.018249	1.125916	1.018255	1.123417
0101	1.086779	1.185644	1.086697	1.187782
0110	1.154799	1.245822	1.154695	1.253376
0111	1.245088	1.331853	1.244965	1.338222
1000	1.323666	1.408776	1.323419	1.412903
1001	1.42365	1.502113	1.423239	1.5059
1010	1.484614	1.560248	1.484106	1.561996
1011	1.554532	1.622902	1.554064	1.625002
1100	1.636774	1.693612	1.636572	1.696991
1101	1.683802	1.732771	1.683665	1.735503
1110	1.735693	1.776002	1.735418	1.775653
1111	1.792848	1.822333	1.792613	1.803393

**BOOST\_4V3**

Vcp_out_bit 27H[13:10]	36H[4:0]= Reserved_analog<4:0 >=00000		36H[4:0]= Reserved_analog<4:0 >=10000	
	Vbat=4.2V	Vbat=3.4V	Vbat=4.2V	Vbat=3.4V
0010	4.720	4.676	5.159	5.113
0011	4.791	4.747	5.224	5.184
0100	4.864	4.820	5.301	5.256
0101	4.938	4.894	5.373	5.326
0110	5.008	4.965	5.450	5.400
0111	5.081	5.039	5.519	5.475
1000	5.154	5.110	5.593	5.544
1001	5.224	5.183	5.664	5.616
1010	5.298	5.254	5.737	5.689
1011	5.374	5.325	5.812	5.761
1100	5.446	5.399	5.883	5.831
1101	5.521	5.469	5.952	5.902
1110	5.590	5.543	6.029	5.974
1111	5.662	5.615	6.094	6.036

**V\_BUCK2**

Vbuck2_DCDC 2FH[7:4]	Vbat=4.2V		Vbat=3.4V	
	PWM	PFM	PWM	PFM
	Voltage(V)	Voltage(V)	Voltage(V)	Voltage(V)
0000	1.372298	1.326017	1.372103	1.326514
0001	1.462675	1.418426	1.462358	1.415203
0010	1.554009	1.495003	1.553642	1.489541
0011	1.646787	1.583869	1.646447	1.569516
0100	1.74188	1.672534	1.741347	1.654777
0101	1.830813	1.751696	1.830326	1.743785
0110	1.919983	1.835457	1.919578	1.836826
0111	2.036944	1.951065	2.036566	1.94758
1000	2.139276	2.060935	2.138946	2.041343
1001	2.268955	2.171742	2.268683	2.16727
1010	2.347893	2.252698	2.347531	2.242021
1011	2.439514	2.338851	2.439071	2.342576
1100	2.548583	2.448924	2.547497	2.451623
1101	2.609603	2.512368	2.60867	2.505622
1110	2.676921	2.570107	2.675591	2.56608
1111	2.750746	2.649165	2.749533	2.629614

**V\_PAD**

VIO_Vsel 04H[12]	05H[5:3]	Vbat=4.2V	Vbat=3.4V
		Output Voltage(V)	Output Voltage(V)
1	000	1.727	1.724
	001	1.744	1.740
	010	1.761	1.758
	011	1.780	1.776
	100	1.800	1.796
	101	1.820	1.817
	110	1.844	1.840
	111	1.868	1.865
0	000	2.667251	2.666588
	001	2.666319	2.665895
	010	2.679315	2.673723
	011	2.727957	2.722229
	100	2.780148	2.774493
	101	2.835819	2.829775
	110	2.896831	2.89022
	111	2.960846	2.953016

**V\_SPIMEM**

V_SPIMEM _Sel	05H[11:9]	Vbat=4.2V	Vbat=3.4V
		Output Voltage (V)	Output Voltage (V)
High	000	1.877194	1.874062
	001	1.8944	1.890982
	010	1.912432	1.909278
	011	1.931852	1.928487
	100	1.952319	1.949049
	101	1.974344	1.97093
	110	1.998006	1.994547
	111	2.023369	2.020061
Low	000	2.72786	2.723132
	001	2.770905	2.765748
	010	2.816633	2.811368
	011	2.865366	2.859963
	100	2.917075	2.911277
	101	2.972707	2.963338
	110	3.031905	3.024916
	111	3.095477	3.083739

**V\_MEM**

05H[8:6]	Vbat=4.2V	Vbat=3.4V
----------	-----------	-----------

	Output Voltage(V)	Output Voltage(V)
000	1.813802	1.810993
001	1.83121	1.828281
010	1.849414	1.846548
011	1.869049	1.866056
100	1.88952	1.886536
101	1.911659	1.90852
110	1.935356	1.932362
111	1.960581	1.957629

**V\_LCD**

Vlcd_vsel 04H[9]	06H[8:6]	Vbat=4.2V	Vbat=3.4V
		Output Voltage(V)	Output Voltage(V)
1	000	1.884624	1.881268
	001	1.900926	1.897644
	010	1.918653	1.915154
	011	1.937167	1.933992
	100	1.957664	1.954354
	101	1.978871	1.975393
	110	2.00204	1.998532
	111	2.026158	2.022905
0	000	2.721137	2.716595
	001	2.763116	2.758507
	010	2.808443	2.803737
	011	2.856142	2.851215
	100	2.908199	2.903146
	101	2.962014	2.956682
	110	3.021087	3.015138
	111	3.083413	3.075401

**V\_CAM**

Vcam_vsel 04H[10]	06H[11:9]	Vbat=4.2V	Vbat=3.4V
		Output Voltage(V)	Output Voltage(V)
1	000	1.900696	1.897653
	001	1.916342	1.913417
	010	1.933346	1.930315
	011	1.951283	1.948154
	100	1.970642	1.967851
	101	1.991096	1.988103



	110	2.013386	2.010134
	111	2.036699	2.033604
0	000	2.684454	2.68182
	001	2.693521	2.692196
	010	2.730155	2.720973
	011	2.77925	2.768611
	100	2.832138	2.814278
	101	2.886759	2.848665
	110	2.946589	2.870453
	111	3.010126	2.883678

**V\_MMC**

VMC_vsel 04H[8]	06H[5:3]	Vbat=4.2V	Vbat=3.4V
		Output Voltage (V)	Output Voltage (V)
1	000	3.011621	3.003268
	001	3.063471	3.047207
	010	3.119571	3.080525
	011	3.177808	3.101405
	100	3.238899	3.115282
	101	3.283025	3.124006
	110	3.309923	3.129626
	111	3.310144	3.133079
0	000	2.663742	2.655401
	001	2.705838	2.696863
	010	2.751196	2.741702
	011	2.798733	2.788834
	100	2.852021	2.836747
	101	2.905989	2.874893
	110	2.965718	2.900944
	111	3.02769	2.917139

**V\_RTC**

04H[15:13]	Vbat=4.2V	Vbat=3.4V
	Output Voltage(V)	Output Voltage(V)
000	1.186234	1.184931
001	1.230272	1.229045
010	1.274606	1.273073
011	1.318833	1.317157
100	1.36277	1.360878
101	1.406876	1.404861
110	1.451079	1.448805

111	1.494915	1.492837
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**V\_VIB**

Vibr_vsel 04H[7]	06H[2:0]	Vbat=4.2V	Vbat=3.4V
		Output Voltage(V)	Output Voltage(V)
1	000	2.930721	2.928602
	001	2.983699	2.981695
	010	3.040768	3.038966
	011	3.101282	3.099892
	100	3.16886	3.167146
	101	3.237951	3.236285
	110	3.313436	3.311352
	111	3.393591	3.386707
0	000	2.930598	2.928872
	001	2.983143	2.981893
	010	3.040267	3.039417
	011	3.101032	3.099901
	100	3.168993	3.167552
	101	3.237801	3.236038
	110	3.313189	3.31135
	111	3.393581	3.38671

**V\_ASW**

Vasw_vsel 04H[11]	06H[14:12]	Vbat=4.2V	Vbat=3.4V
		Output Voltage(V)	Output Voltage(V)
1	000	1.898296	1.892917
	001	1.914543	1.909376
	010	1.932078	1.926779
	011	1.950724	1.945268
	100	1.97053	1.965045
	101	1.991559	1.986128
	110	2.014514	2.00895
	111	2.038958	2.033227
0	000	2.597639	2.591382
	001	2.640999	2.63448
	010	2.686948	2.680374
	011	2.735839	2.729014
	100	2.7881	2.78095
	101	2.843998	2.836121
	110	2.904497	2.894896
	111	2.96897	2.956203

**V\_ANA**

07H[8:6]	Vbat=4.2V	Vbat=3.4V
	Output Voltage(V)	Output Voltage(V)
000	2.268517	2.266341
001	2.318284	2.315792
010	2.374201	2.372018
011	2.435136	2.433037
100	2.502894	2.500666
101	2.577594	2.575412
110	2.664263	2.662017
111	2.760628	2.758421

**V\_USB**

07H[11:9]	Vbat=4.2V	Vbat=3.4V
	Output Voltage (V)	Output Voltage (V)
000	2.947253	2.946909
001	3.026925	3.026907
010	3.116152	3.114516
011	3.212047	3.209178
100	3.317436	3.314619
101	3.433383	3.386186
110	3.564778	3.386197
111	3.711378	3.386196

**V\_MIC**

ABB Mb_sel_bit05H[15:14]	Vbat=4.2V	Vbat=3.4V
	Output Voltage(V)	Output Voltage(V)
00	1.60	1.60
01	1.71	1.71
10	1.83	1.83
11	1.97	1.97

**BL\_LED\_OUT**

Vrgb_led_vsel 07H[5:3]	Vrgb_led_ibit 07H[2:0]	Vbat=4.2V	Vbat=3.4V	Vbat=3.9V
		Output Voltage(V)	Output Voltage(V)	Output Voltage(V)
000	100	3.858844	3.386533	3.821235
001		3.777488	3.386551	3.744894
010		3.694971	3.386536	3.664874
011		3.61652	3.386561	3.584801
100		3.529182	3.386511	3.50099

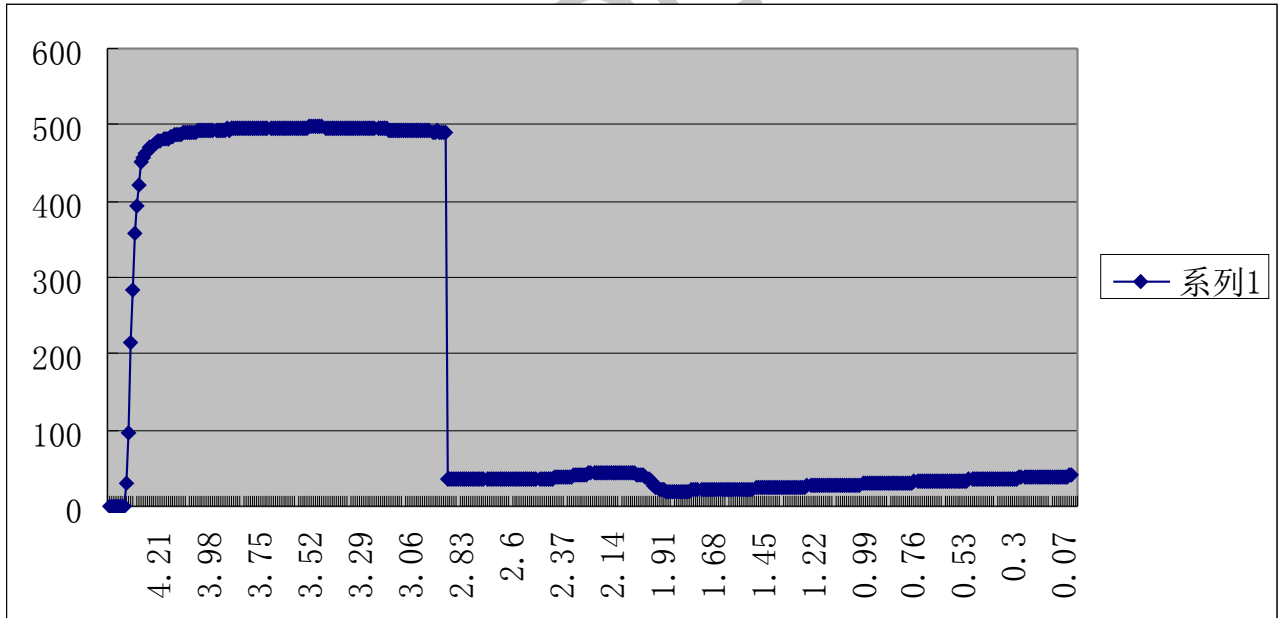
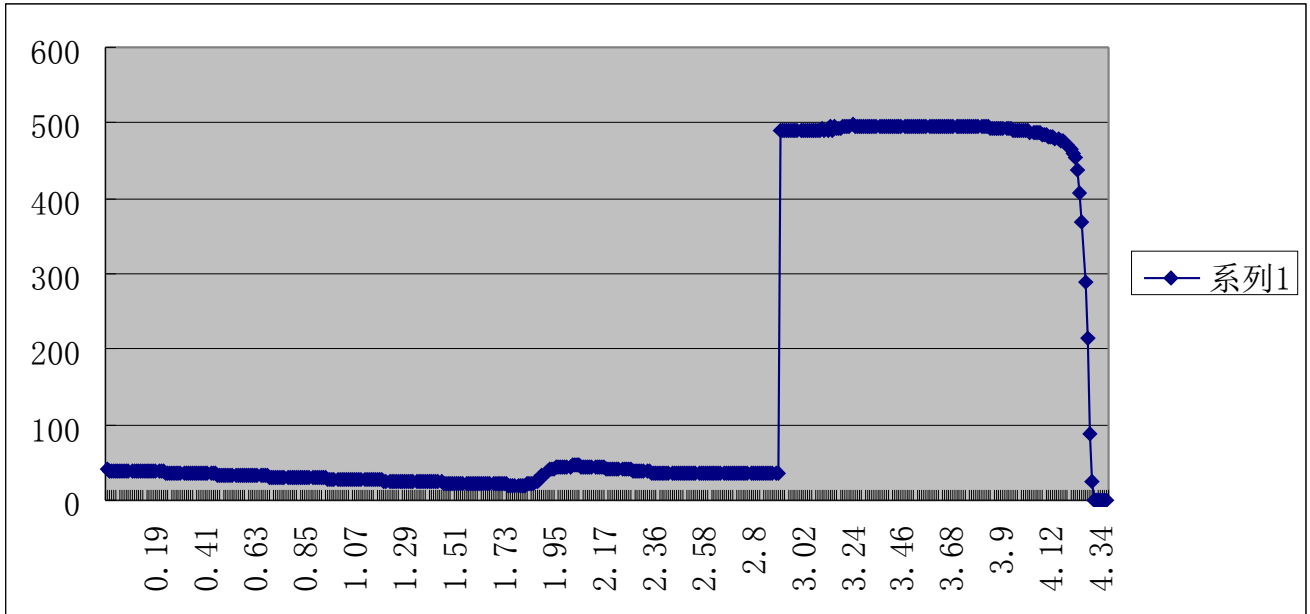
101		3.446335	3.386513	3.421506
110		3.36194	3.318819	3.338001
111		3.28034	3.239741	3.256048
Vrgb_led_vsel 07H[5:3]	Vrgb_led_ibit 07H[2:0]	Vbat=4.2V	Vbat=3.4V	Vbat=3.9V
		Output Voltage(V)	Output Voltage(V)	Output Voltage(V)
100	000	3.175092	3.139901	3.15332
	001	3.254025	3.213903	3.232406
	010	3.338909	3.294401	3.313164
	011	3.430583	3.380321	3.404199
	100	3.528182	3.386532	3.501821
	101	3.638125	3.386532	3.610481
	110	3.756213	3.386545	3.725145
	111	3.889404	3.386525	3.852747

**V\_BACKUP**

05H[14:12]	Vbat=4.2V	Vbat=3.4V
	Output Voltage(V)	Output Voltage(V)
000	2.588458	2.592573
001	2.642122	2.647193
010	2.699878	2.70839
011	2.76277	2.787603
100	2.830785	2.875284
101	2.905058	2.917465
110	2.985784	2.93846
111	3.074953	2.950116

**Charge Characteristics**

CC current	13H[9:7]=chr_cc_i_bit	chr_current (mA)
		000
	001	70
	010	109
	011	166
	100	223
	101	329
	110	474
	111	580



## E.VI Digital IO DC Characteristics

Symbol	Description	Min.(V)	Typical(V)	Max.(V)
VDD	All of power for digital usage	VDD-0.2	1.8/2.8	VDD+0.2
VIL	CMOS Low Level Input Voltage	0	-	0.3*VDD
VIH	CMOS High Level Input Voltage	0.7*VDD	-	VDD
VTH	CMOS Threshold Voltage	-	0.5*VDD	-

## E.VII Digital IO AC Characteristics (SPI Interface Timing)

Symbol	Description	Min.	Typ.	Max.	Unit
$t_{CLK}$	SCLK Cycle Time	35	-	-	ns
$t_R$	SCLK Rise Time	-	-	50	ns
$t_F$	SCLK Fall Time	-	-	50	ns
$t_{HI}$	SCLK High Time	10	-	-	ns
$t_{LO}$	SCLK Low Time	10	-	-	ns
$t_{SU}$	SDI Setup Time to SCLK $\uparrow$	15	-	-	ns
$t_{HOLD}$	SDI Hold Time to SCLK $\uparrow$	10	-	-	ns
$t_{EN1}$	SEN $\downarrow$ to SCLK $\uparrow$ Delay Time	10	-	-	ns
$t_{EN2}$	SCLK $\uparrow$ to SEN $\uparrow$ Delay Time	12	-	-	ns
$t_{EN3}$	SEN $\uparrow$ to SCLK $\uparrow$ Delay Time	12	-	-	ns
$t_W$	SEN Pulse Width	10	-	-	ns
$t_{CA}$	SCLK $\uparrow$ to SDO Delay Time	-	-	27	ns
$C_{load}$	Digital Input Pin Capacitance	-	-	5	pF
$f_{REF}$	Crystal Reference Frequency	-	26	-	MHz

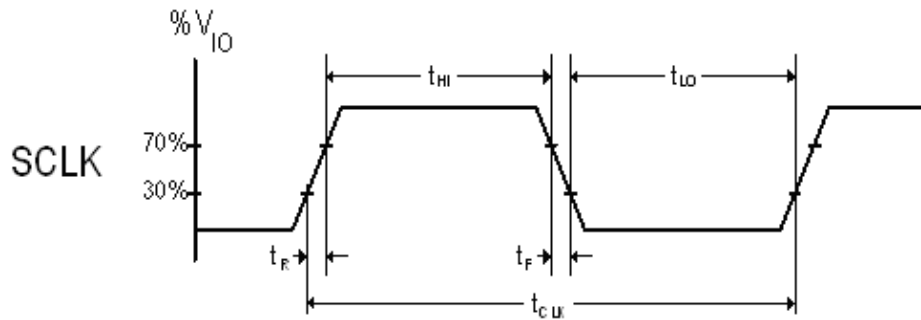


Figure E.1: SCLK Timing Diagram

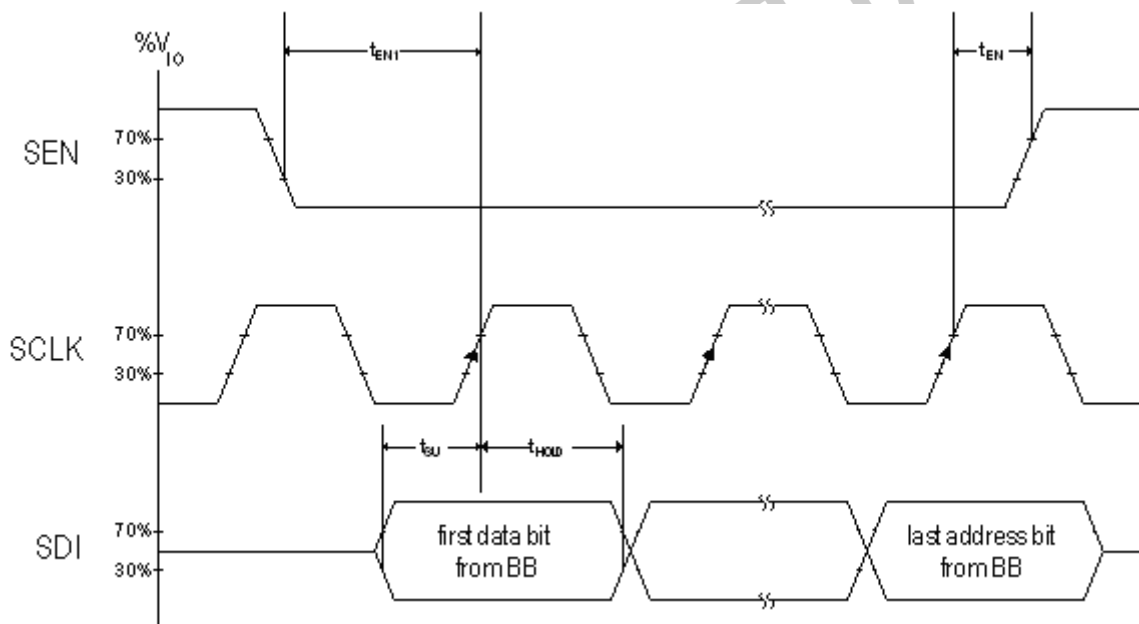


Figure E.2: SPI Write Timing Diagram

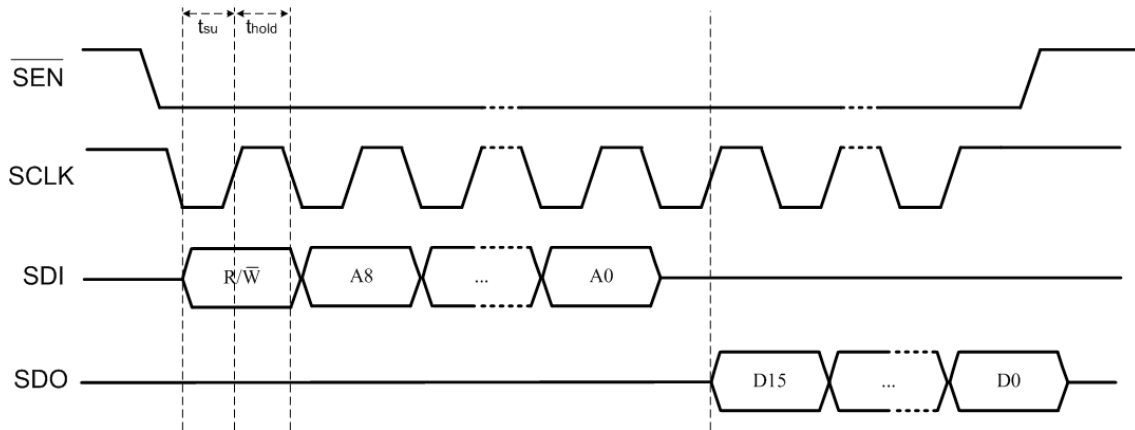


Figure E.3: SPI Read Timing Diagram

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# F. PACKAGING

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REV	DESCRIPTION	DATE	DESIGNER	REVIEWER	APPROVER
0	Original Release	07 JUL 11	JAMES	YUE YANG	D.YASOD

REF.	Min.	Nom.	Max.
A	1.15	1.23	1.31
AL	0.17	0.22	0.27
b	0.26	0.31	0.36
D	10.00 BSC		
E	12.00 BSC		
DI	8.45 BSC		
EI	10.40 BSC		
SD	0.325 BSC		
SE	0.65 BSC		
e	0.65 BSC		
F1	0.70	0.775	0.85
F2	0.72	0.80	0.88

REF.	TOLERANCE OF FORM AND POSITION
aaa	0.15
bbb	0.20
ccc	0.08
ddd	0.15
eee	0.08

Notes:

- 'e' REPRESENTS THE BASIC SOLDER BALL GRID PITCH.
- DIMENSION 'b' IS MEASURABLE AT THE MAXIMUM BALL DIAMETER AFTER REFLOW, PARALLEL TO PRIMARY DATUM C. PRE-REFLOW DIAMETER IS 0.30mm.
- PRIMARY DATUM C AND SEATING PLANE ARE DEFINED BY THE SPHERICAL CROWNS OF THE CONTACT BALLS.
- DIMENSION 'A' INCLUDES STANDOFF HEIGHT 'A1', PACKAGE BODY THICKNESS AND LID HEIGHT (IF APPLICABLE), BUT DOES NOT INCLUDE ATTACH FEATURES.
- DIMENSION 'SD/SE' IS MEASURED WITH RESPECT TO DATUMS A AND B AND DEFINES THE POSITION OF THE CENTER CONTACT BALL IN THE OUTER ROW.
- PACKAGE DIMENSIONS TAKE REFERENCE TO JEDEC MO-275 REV.A.

 UTAC (SHANGHAI) CO. LTD Suite 207 of 25 Bldg No. 275 Jin Bao Road, Jingde Road Trade Zone Shanghai, China, 20021	PACKAGE OUTLINE DRAWING		DATE	DRAWING NO.	REV
	LFRBGA 203B (12.0x10.0mm)		07 JUL 11	P-5154-12.0x10.0-207(D)-A1	0
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS DIMENSIONS AND TOLERANCES PER: ASME Y14.5M-1994	 TYPICAL PRACTICE	SIZE: A4 DRAWN BY: JAMES	SCALE: NTS	SHEET 1 OF 1	

## G. BALL OUT

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17							
A	VBAT_P MU	VBAT_P MU	VBOOST	SW_BUC K	SW_BUC K2	VSPIM_S EL	BOOST_ CPP	BOOST_ CPN	AU_LSR _P	AU_LSL_ N	V_SPIME M	M_SPI_D <0>	M_SPI_D <1>	AVDD_2 V4	CODE_C OMPRES S_EN	NC	NC							
B	SW_GN D	SW_GN D	BL_LED_ OUT	V_CORE	VBUCK2 _2V4	POWERK EY	BOOST_ CPP	BOOST_ CPN	AU_LSR _N	AU_LSL_ P	M_SPI_D <3>	M_SPI_C LK	M_SPI_D <2>	RESETB _EXT	NC	BT_GND	NC							
C	LED2	LED3	GPADC_I N<1>	GPADC_I N<0>	KEY_SE NSE	PROG_E FUSE	CORE_G ND	CP_GND	CP_GND	CORE_G ND	M_SPI_C S_1	M_SPI_C S	CAM_DA TA<7>	CAM_DA TA<5>	TST_H	BT_GND	NC							
D	KP_LED_ R	LED1	LED4	KEY_P	KEY_N										ANA_TE ST_EN	BT_GND	NC							
E	V_BAT_ RTC	KP_LED_ B	KP_LED_ G	AC_R	TSC_YN	<table border="1"> <tr> <td>CORE_G ND</td> <td>CORE_G ND</td> <td>CORE_G ND</td> <td>SSD_CLK</td> <td>SDAT&lt;0 &gt;</td> <td>CAM_DA TA&lt;3&gt;</td> <td>CAM_DA TA&lt;4&gt;</td> </tr> </table>									CORE_G ND	CORE_G ND	CORE_G ND	SSD_CLK	SDAT<0 >	CAM_DA TA<3>	CAM_DA TA<4>	CAM_DA TA<6>	BT_GND	NC
CORE_G ND	CORE_G ND	CORE_G ND	SSD_CLK	SDAT<0 >	CAM_DA TA<3>	CAM_DA TA<4>																		
F	V_RTC	VBAT_S ENSE	IS_CHG	GDRV	TSC_YP	<table border="1"> <tr> <td>TSC_XP</td> <td>TSC_XN</td> <td>CORE_G ND</td> <td>SDAT&lt;1 &gt;</td> <td>SSD_CM D</td> <td>Dummy</td> <td>CAM_VS YNC</td> </tr> </table>									TSC_XP	TSC_XN	CORE_G ND	SDAT<1 >	SSD_CM D	Dummy	CAM_VS YNC	NC	BT_GND	NC
TSC_XP	TSC_XN	CORE_G ND	SDAT<1 >	SSD_CM D	Dummy	CAM_VS YNC																		
G	V_VIB	LCD_WR	Dummy	LCD_CS1	LCD_RD	<table border="1"> <tr> <td>LCD_RS</td> <td>LCD_CS0</td> <td>CORE_G ND</td> <td>UART2_ CTS</td> <td>SPI1_DI O</td> <td>LPSCO_1</td> <td>CAM_RS T</td> </tr> </table>									LCD_RS	LCD_CS0	CORE_G ND	UART2_ CTS	SPI1_DI O	LPSCO_1	CAM_RS T	NC	BT_GND	NC
LCD_RS	LCD_CS0	CORE_G ND	UART2_ CTS	SPI1_DI O	LPSCO_1	CAM_RS T																		
H	V_USB	LCD_DA TA<5>	LCD_DA TA<1>	LCD_DA TA<7>	LCD_DA TA<6>	<table border="1"> <tr> <td>LCD_DA TA&lt;4&gt;</td> <td>LCD_DA TA&lt;2&gt;</td> <td>CORE_G ND</td> <td>UART2_ TXD</td> <td>SPI1_DI</td> <td>CAM_HR EF</td> <td>CAM_PD N</td> </tr> </table>									LCD_DA TA<4>	LCD_DA TA<2>	CORE_G ND	UART2_ TXD	SPI1_DI	CAM_HR EF	CAM_PD N	NC	NC	BT_GND
LCD_DA TA<4>	LCD_DA TA<2>	CORE_G ND	UART2_ TXD	SPI1_DI	CAM_HR EF	CAM_PD N																		
J	V_LCD	KEYOUT <4>	KEYOUT <5>	LCD_DA TA<3>	LCD_DA TA<0>	<table border="1"> <tr> <td>KEYOUT &lt;2&gt;</td> <td>Dummy</td> <td>SDAT&lt;3 &gt;</td> <td>UART2_ RTS</td> <td>SPI1_CS _0</td> <td>PWL_1</td> <td>CAM_CL K</td> </tr> </table>									KEYOUT <2>	Dummy	SDAT<3 >	UART2_ RTS	SPI1_CS _0	PWL_1	CAM_CL K	CAM_PC LK	CAM_DA TA<2>	CAM_DA TA<1>
KEYOUT <2>	Dummy	SDAT<3 >	UART2_ RTS	SPI1_CS _0	PWL_1	CAM_CL K																		
K	KEYOUT <0>	KEYOUT <1>	Dummy	KEYOUT <3>	KEYIN< 4>	<table border="1"> <tr> <td>KEYIN&lt; 1&gt;</td> <td>KEYIN&lt; 3&gt;</td> <td>BBPLL_T EST</td> <td>SDAT&lt;2 &gt;</td> <td>UART2_ RXD</td> <td>SPI1_CL K</td> <td>TCO&lt;4&gt;</td> </tr> </table>									KEYIN< 1>	KEYIN< 3>	BBPLL_T EST	SDAT<2 >	UART2_ RXD	SPI1_CL K	TCO<4>	GPO<1>	CAM_DA TA<0>	V_CAM
KEYIN< 1>	KEYIN< 3>	BBPLL_T EST	SDAT<2 >	UART2_ RXD	SPI1_CL K	TCO<4>																		
L	FM_GND	NC	KEYIN< 5>	KEYIN< 2>	KEYIN< 0>										I2C2_SD A	BT_GND	BT_RFIP							
M	FM_RFIP	FM_RFIN	NC	NC	AU_RCV_ P	AU_RCV_ N	USB_DM	USB_DP	NC	NC	CORE_G ND	CORE_G ND	SPI1_CS _1	HST_RX D	I2C2_SC L	GPIO<1 >	GPIO<2 >							
N	LINE_IN _L	AU_MIC _N	AU_AUX MIC_N	AU_HPL	V_ANA	NC	NC	V_ASW	NC	NC	NC	HST_CL K	CLK_OU T	TCO<3>	GPIO<3 >		NC							
P	LINE_IN _R	AU_MIC _P	AU_AUX MIC_P	V_MIC	AU_HPR	V_NEG	NC	V_MEM	V_MMC	NC	HST_TX D	V_PAD	GPO<0>	XVR_XT AL1	XVR_XT AL2	GPO<5>	DECAP_ BTDVDD							

Figure G.1: RDA5851 Ball out diagram

## H. GLOSSARY

Name	Description
AHB	AMBA Advanced High-performance Bus.
AHB2AHB	Bridge allowing Sys AHB to communicate with BB AHB, and vice versa.
AIF	RDA5851's Audio Interface, including PCM, DAI and Audio Analog Interface.
APB	AMBA Advanced Peripheral Bus, slow bandwidth bus.
ATR	Answer To Reset, see SCI module for details.
Comfort Tone	Tone generated by the AIF, used to indicate ringing, occupied...
CS	Chip Select.
DAI	Digital Audio Interface, part of the AIF used for test purpose.
DMA	Direct Memory Access, can copy a part of the memory at an other address.
DTMF	Dual Tone Multi Frequency generated by the AIF when a number is dialed.
EBC	External Bus Controller, to connect external RAM, polyphonic chips, MMC...
ETU	Elementary Time Unit, see SCI module for details.
GP ADC	General Purpose Analog to Digital Converter.
IFC	Base Band Intelligent Flow Controller, a bridge between AHB and APB buses.
IrDA	Infra Red communication protocol used by RDA5851's UART infra red mode.
Mailbox	Communication module between the Sys AHB bus and the BB AHB bus.
MMC	Multi Media Chips.
MMI	Man-Machine Interface, a part of the software that handle the user interface.
PCM	Pulse Code Modulation, the part of the AIF that outputs samples in serial.
PLL	Phase-Locked Loop.
SPI	Serial Peripheral Interface.
Sys	System side of RDA5851, dedicated to the application, MMI.
TCO	Time-Controlled Output. Pins controlled by the TCU.
TCU	Timing Control Unit, handle the scheduling of individual events.
UART	Universal Asynchronous Receiver Transmitter, asynchronous serial port.
VCO	Voltage Controlled Oscillator.
XCPU	System RDA's 16/32-bit RISC CPU.

## Document History

The evolution of this document is described in the following table:

Version	Date	Description
1.00	2013-01-29	Initial version.

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