

Document Title

A3117M0 Data Sheet, Bluetooth Low Energy SoC

Revision History

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1. General Description

A3117M0 is a high performance and low cost 2.4GHz FSK/GFSK system-on-chip (SoC) wireless transceiver. With on chip fraction-N synthesizer, it is designed for Bluetooth Low Energy (Bluetooth 5.0 Single mode).

A3117M0 has various powerful functions and excellent performance of a leading 2.4GHz FSK/GFSK RF transceiver. A3117M0 has various operating MODEs, making it highly suited for systems where ultra-low power consumption is required.

A3117M0 supports AES128 engine and CCM. For low current consumption, A3117M0 is integrated with both LDO and DC-DC (buck) so that this device can be operated more efficient when BATH voltage range from 2.7V to 3.6V. User can configure one of them (LDO or DC-DC) as a powered source for device operations.

A3117M0 integrates ARM M0 core MCU with 48MHz speed operation, 256K Bytes In-system programmable flash memory, 72KB internal SRAM, USB 2.0 high speed compatible controller and various powerful functions.

2. Typical Applications

- 2400 ~ 2483.5 MHz ISM frequency hopping system
- Smart remote controller
- Home and building automation
- Wireless keyboard and mouse
- Wireless toy and gaming
- Helicopter and airplane radio controller
- Bluetooth smart device

3. Features

RF

- Frequency band: 2400 – 2483MHz.
- FSK and GFSK modulation
- High sensitivity:
 - ◆ -97dBm at 500Kbps data rate
 - ◆ -94dBm at 1Mbps data rate
 - ◆ -91dBm at 2Mbps data rate
- Programmable data rate 5K ~ 2Mbps
- Fast settling time synthesizer for frequency hopping system
- Support 16MHz crystal
- Easy to use.
 - ◆ Change frequency channel by one register setting
 - ◆ 8-bits Digital RSSI for clear channel indication
 - ◆ Auto RSSI measurement
 - ◆ Auto WOR (wake up when receive RX packet)
 - ◆ Auto WOT (wake up to transmit TX packet)
 - ◆ Auto Calibrations
 - ◆ Auto IF function
 - ◆ Auto Frequency Compensation
 - ◆ Auto CRC Check
 - ◆ Separated 256 bytes RX and TX FIFO

Low Power

- Wide Range Operation Voltage from 2.0V ~ 3.6V
- RX current consumption with MCU stop and DC-DC turn on: 6.4mA @BATH= 3.3V
- TX current consumption with MCU stop and DC-DC turn on: 9mA @ 5dBm, BATH=3.3V
- Power saving MODE without sleep timer, no SRAM retention (1.3 uA)
- Power saving MODE with sleep timer, 16K SRAM retention (2.1uA)

Microcontroller

- High performance ARM-M0 MCU, 48Mhz operation.
- 256KB Flash memory with copy protection, 72KB SRAM

Peripherals

- TFT DMA controller and 8080 output interface(I80)
- USB 2.0 high speed compatible interface.
- High speed SPI 24Mhz
- UART, I²C, SPI serial communication
- Operation clock: 1, 1/2, 1/4, 1/8, 1/16, 1/32, 1/64 of crystal oscillator
- Two 32-bit timers and one 32-bit dual MODE timer
- Four Channel PWM
- Watchdog timer
- Two 16-bit Sleep timer
- In-Circuit Debugger
- USB 2.0 high speed compatible controller for Interrupt input/output.
- In-System programming/ In-Application programming
- 23/31 GPIO for QFN40/48
- Built-in thermal sensor for monitoring relative temperature
- Built-in eight channels 12-bits ADC for general purpose analog input (0V ~ 1.8 V)
- Built-in Low Battery Detector

Layout

- Package size (QFN5X5, 40 pins/ QFN6X6 48 pins/ QFN7X7 56 pins)

4. Pin Configurations

4.1 QFN40 5x5 (pin to pin to A8107M0)

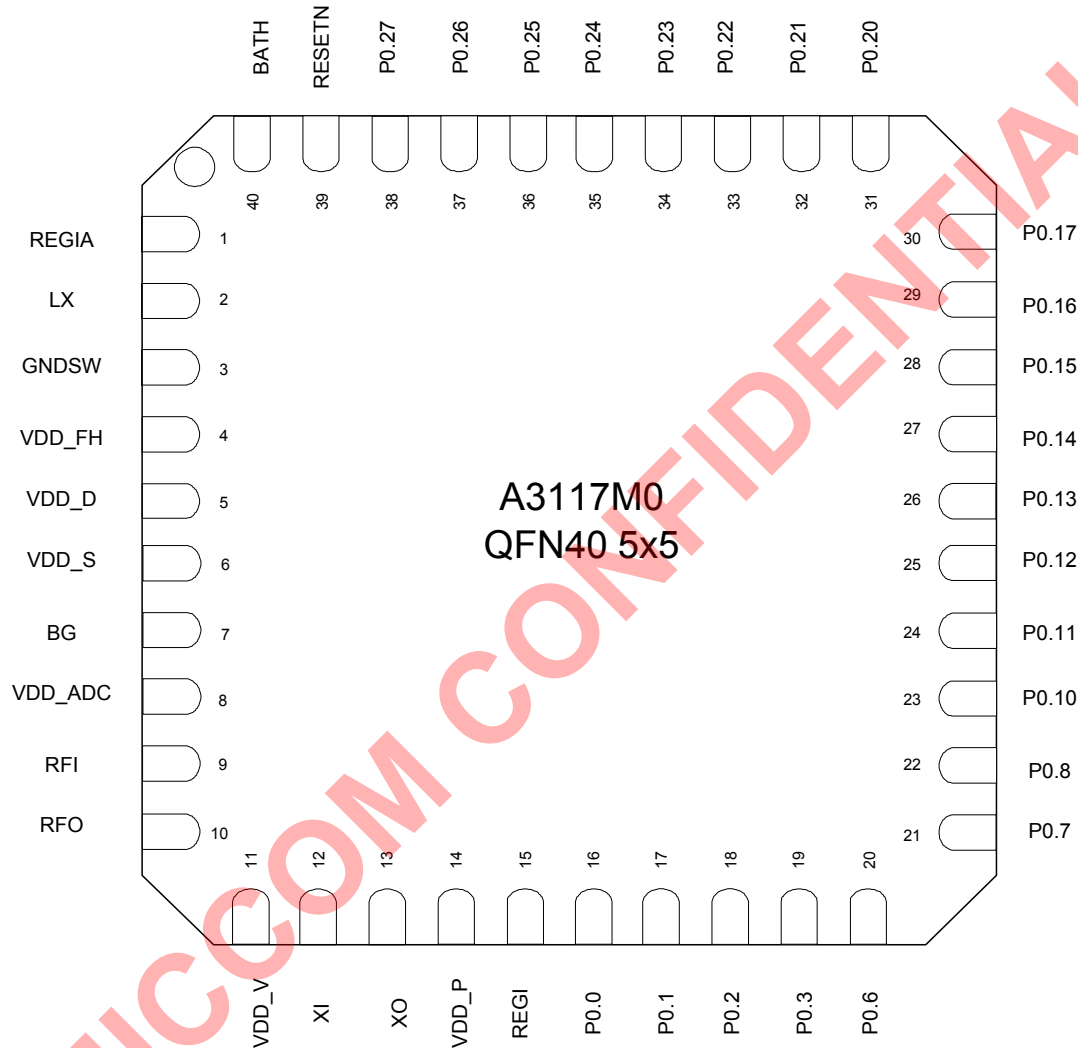


Figure 4.1 A3117M0 QFN40 5x5 Package

4.2 QFN48 6x6 (pin to pin to A8107M0)

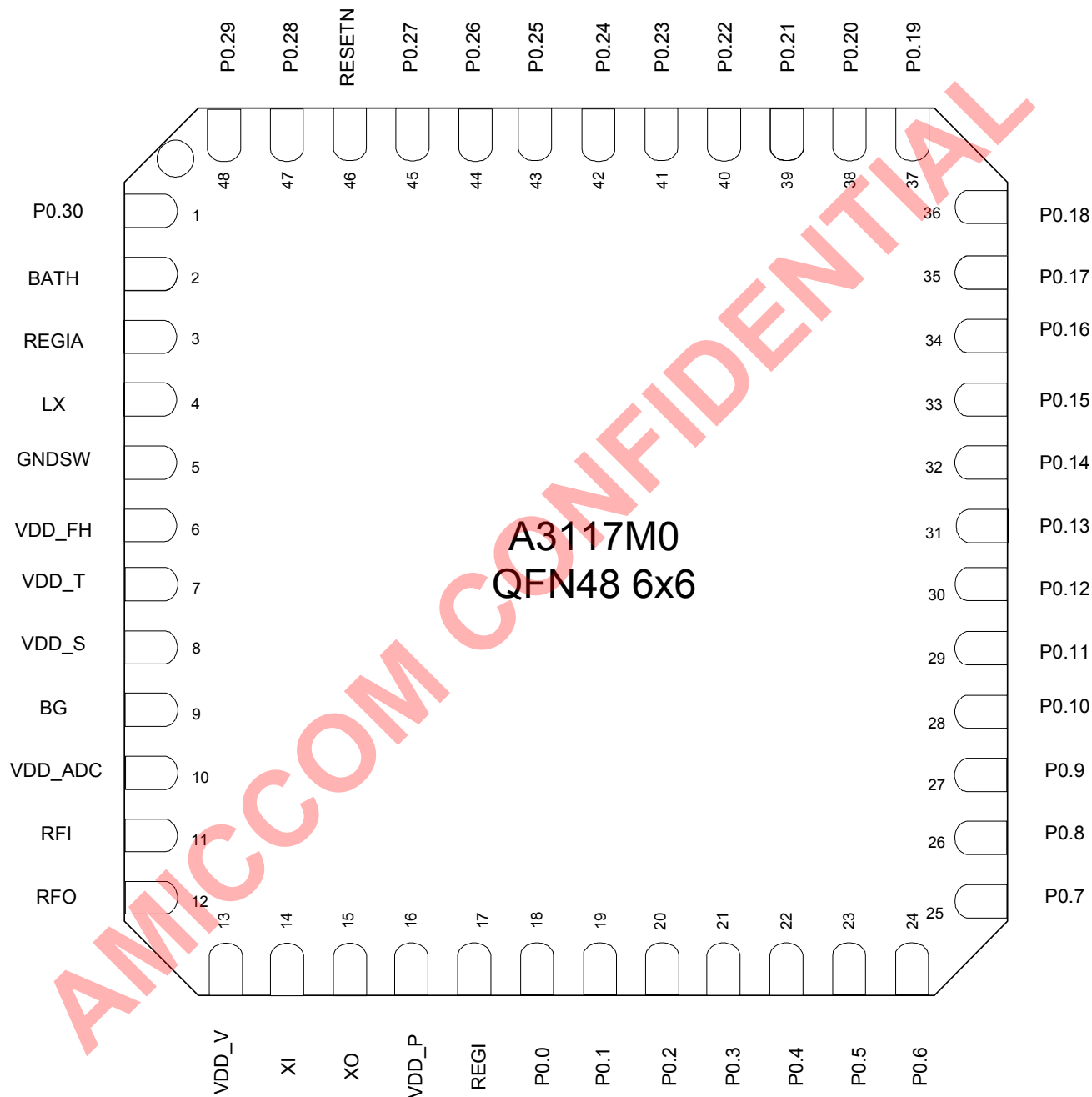


Figure 4.2 A3117M0 QFN48 6x6 Package

4.3 QFN48 6x6 with USB2.0 function

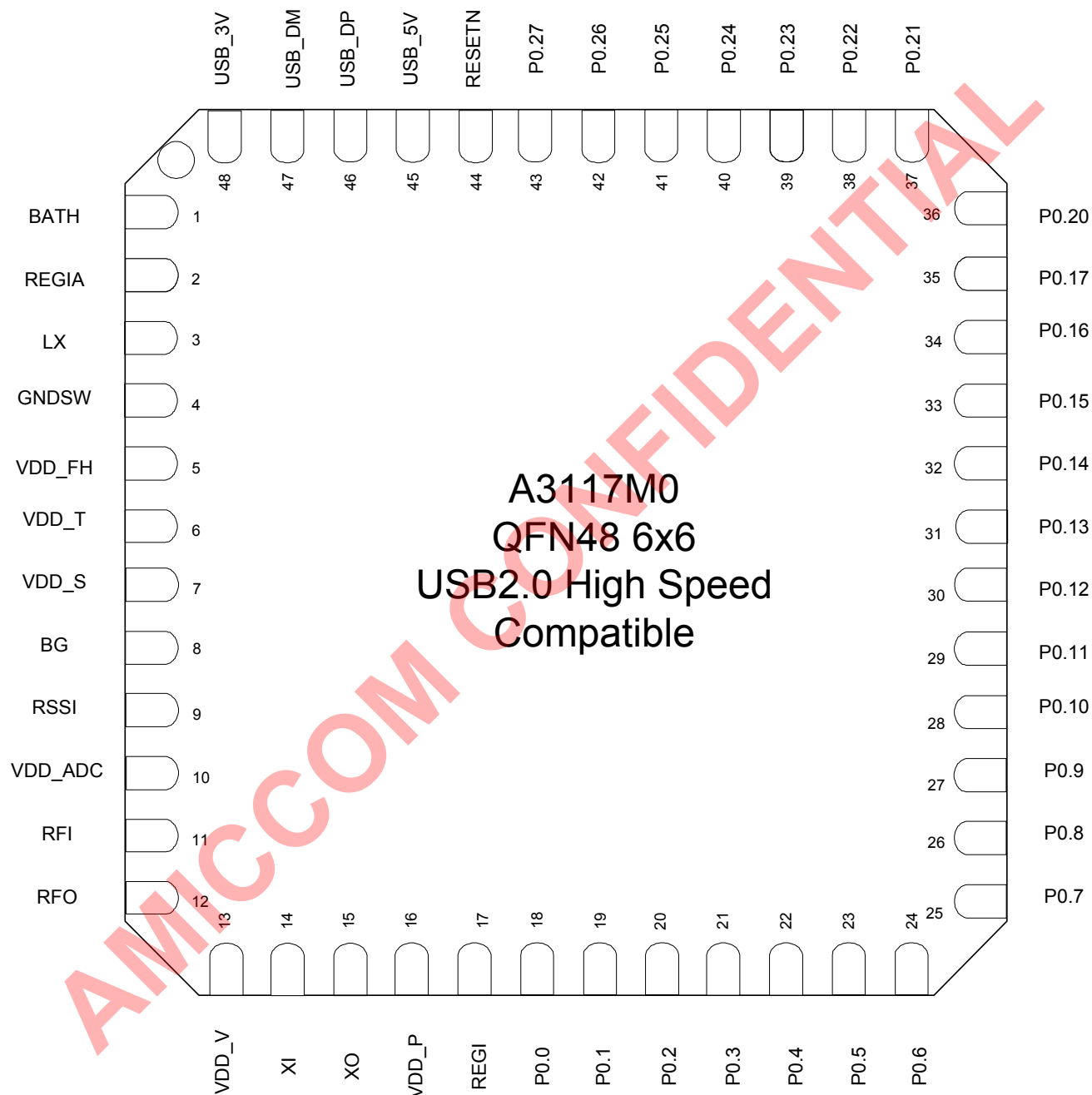


Figure 4.3 A3117M0 QFN48 6x6 Package with USB2.0

4.4 QFN56 7x7 with USB2.0 function

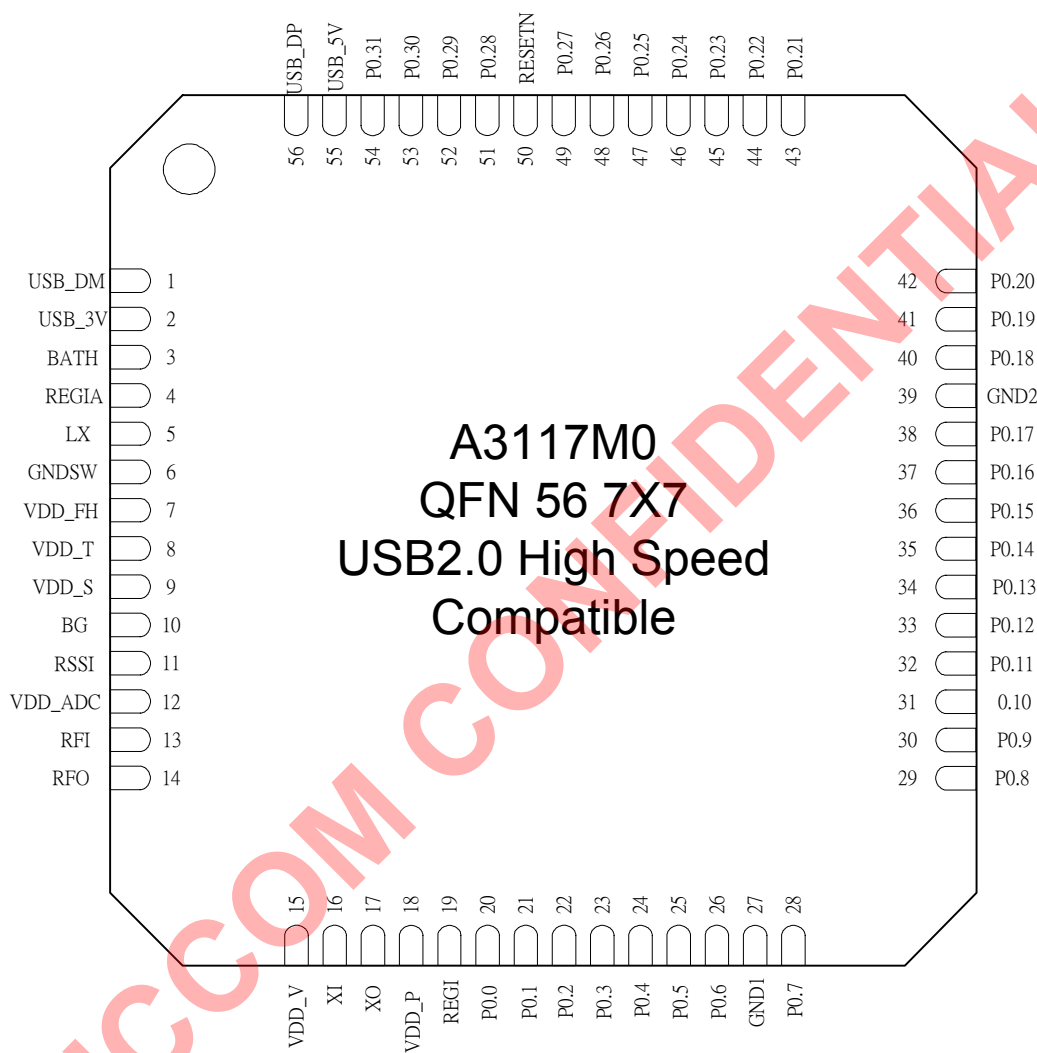


Figure 4.4 A3117M0 QFN56 7x7 Package with USB2.0

5. Pin Descriptions (I: input; O: output, I/O: input or output)

5.1 A3117M0 QFN40 5x5 Package

Pin No.	Symbol	I/O	Function Description
1	REGIA	AO	DC-DC regulator output for buck
2	LX	AIO	DC-DC Inductor connection pin
3	GNDSW	AI	Ground
4	VDD_FH	AO	Flash high voltage output
5	VDD_D	AO	VDD_D supply voltage output
6	VDD_S	AO	VDD_S supply voltage output
7	BG	AO	Band gap output
8	VDD_ADC	AO	VDD_ADC supply voltage output
9	RFI	AI	RF input
10	RFO	AO	RF output
11	VDD_V	AI	VCO supply voltage input
12	XI	AI	Crystal oscillator input
13	XO	AO	Crystal oscillator output
14	VDD_P	AO	PLL supply voltage output
15	REGI	AI	Regulator input
16	P0.0	DIO	SPI1_CS
17	P0.1	DIO	SPI1_MISO
18	P0.2	DIO	SPI1_MOSI
19	P0.3	DIO	SPI1_SCK
20	P0.6	DIO	SWDIO
21	P0.7	DIO	SWCLK
22	P0.8	DIO/AI	TIMER0_EIN / ADC2 / BB_GIO1
23	P0.10	DIO	PWM2 / I ² C_SCL / FLASH_MASK
24	P0.11	DIO	PWM3 / I ² C_SDA / LCD_TE
25	P0.12	DIO/AI	ADC4 / ICE_MODE / LCD_RDY
26	P0.13	DIO/AI	ADC5/BB_GIO1 / LCD_D[2]
27	P0.14	DIO/AI	ADC6/BB_GIO2 / LCD_D[1]
28	P0.15	DIO/AI	ADC7/BB_CK0 / LCD_D[0] / s_LCD_SDA
29	P0.16	DIO	UART0_RX / LCD_CSX
30	P0.17	DIO	UART0_TX / LCD_D/CX
31	P0.20	DIO	UART2_RX / PWM0 / LCD_WRX/ s_LCD_SCL
32	P0.21	DIO	UART2_TX / PWM1 / LCD_D[7]
33	P0.22	DIO/AIO	RTCI
34	P0.23	DIO/AIO	RTCO
35	P0.24	DIO	General IO / LCD_D[6]
36	P0.25	DIO	General IO / LCD_D[5]

37	P0.26	DIO	General IO / LCD_D[4]
38	P0.27	DIO	General IO / LCD_D[3]
39	RESETN	AI	RESETN input
40	BATH	AI	DC-DC converter voltage input for buck mode

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5.2 A3117M0 QFN48 6x6 Package

Pin No.	Symbol	I/O	Function Description
1	P0.30	DIO	General IO
2	BATH	AI	DC-DC converter voltage input for buck mode
3	REGIA	AO	DC-DC regulator output voltage
4	LX	AIO	DC-DC Inductor connection pin
5	GNDSW	AI	Ground
6	VDD_FH	AO	Flash high voltage output
7	VDD_T	AO	VDD_T supply voltage output
8	VDD_S	AO	VDD_S supply voltage output
9	BG	AO	Band gap output
10	VDD_ADC	AO	VDD_ADC supply voltage output
11	RFI	AI	RF input
12	RFO	AO	RF output
13	VDD_V	AI	VCO supply voltage input
14	XI	AI	Crystal oscillator input
15	XO	AO	Crystal oscillator output
16	VDD_P	AO	PLL supply voltage output
17	REGI	AI	Regulator input
18	P0.0	DIO	SPI1_CS
19	P0.1	DIO	SPI1_MISO
20	P0.2	DIO	SPI1_MOSI
21	P0.3	DIO	SPI1_SCK
22	P0.4	DIO	I ² C_SCL / SPI2_MISO
23	P0.5	DIO	I ² C_SDA / SPI2_MOSI
24	P0.6	DIO	SWDIO
25	P0.7	DIO	SWCLK
26	P0.8	DIO/AI	TIMER0_EIN / ADC2 / BB_GIO1
27	P0.9	DIO/AI	TIMER1_EIN / ADC3 / BB_GIO2 / SPI2_SCK
28	P0.10	DIO	PWM2 / I ² C_SCL / FLASH_MASK
29	P0.11	DIO	PWM3 / I ² C_SDA / LCD_TE
30	P0.12	DIO/AI	ADC4 / ICE_MODE / LCD_RDY / SPI2_CS
31	P0.13	DIO/AI	ADC5/BB_GIO1 / LCD_D[2]
32	P0.14	DIO/AI	ADC6/BB_GIO2 / LCD_D[1]
33	P0.15	DIO/AI	ADC7/BB_CK0 / LCD_D[0] / s_LCD_SDA
34	P0.16	DIO	UART0_RX / LCD_CSX
35	P0.17	DIO	UART0_TX / LCD_D/CX
36	P0.18	DIO/AI	UART1_RX / ADC0
37	P0.19	DIO/AI	UART1_TX / ADC1
38	P0.20	DIO	UART2_RX / PWM0 / LCD_WRX / s_LCD_SCL

39	P0.21	DIO	UART2_TX / PWM1 / LCD_D[7]
40	P0.22	DIO/AIO	RTCI
41	P0.23	DIO/AIO	RTCO
42	P0.24	DIO	General IO / LCD_D[6]
43	P0.25	DIO	General IO / LCD_D[5]
44	P0.26	DIO	General IO / LCD_D[4]
45	P0.27	DIO	General IO / LCD_D[3]
46	RESETN	AI	RESETN input
47	P0.28	DIO	General IO
48	P0.29	DIO	General IO

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5.3A3117M0 QFN48 6x6 Package with USB2.0

Pin No.	Symbol	I/O	Function Description
1	BATH	AI	DC-DC converter voltage input for buck mode
2	REGIA	AO	DC-DC regulator output voltage
3	LX	AIO	DC-DC Inductor connection pin
4	GNDSW	AI	Ground
5	VDD_FH	AO	Flash high voltage output
6	VDD_T	AO	VDD_T supply voltage output
7	VDD_S	AO	VDD_S supply voltage output
8	BG	AO	Band gap output
9	RSSI	AO	RSSI
10	VDD_ADC	AO	VDD_ADC supply voltage output
11	RFI	AI	RF input
12	RFO	AO	RF output
13	VDD_V	AI	VCO supply voltage input
14	XI	AI	Crystal oscillator input
15	XO	AO	Crystal oscillator output
16	VDD_P	AO	PLL supply voltage output
17	REGI	AI	Regulator input
18	P0.0	DIO	SPI1_CS
19	P0.1	DIO	SPI1_MISO
20	P0.2	DIO	SPI1_MOSI
21	P0.3	DIO	SPI1_SCK
22	P0.4	DIO	I ² C_SCL / SPI2_MISO
23	P0.5	DIO	I ² C_SDA / SPI2_MOSI
24	P0.6	DIO	SWDIO
25	P0.7	DIO	SWCLK
26	P0.8	DIO/AI	TIMER0_EIN / ADC2 / BB_GIO1
27	P0.9	DIO/AI	TIMER1_EIN / ADC3 / BB_GIO2 / SPI2_SCK
28	P0.10	DIO	PWM2 / I ² C_SCL / FLASH_MASK
29	P0.11	DIO	PWM3 / I ² C_SDA / LCD_TE
30	P0.12	DIO/AI	ADC4 / ICE_MODE / LCD_RDY / SPI2_CS
31	P0.13	DIO/AI	ADC5/BB_GIO1 / LCD_D[2]
32	P0.14	DIO/AI	ADC6/BB_GIO2 / LCD_D[1]
33	P0.15	DIO/AI	ADC7/BB_CK0 / LCD_D[0] / s_LCD_SDA
34	P0.16	DIO	UART0_RX / LCD_CSX
35	P0.17	DIO	UART0_TX / LCD_D/CX
36	P0.20	DIO	UART2_RX / PWM0 / LCD_WRX/ s_LCD_SCL
37	P0.21	DIO	UART2_TX / PWM1 / LCD_D[7]
38	P0.22	DIO/AIO	RTCI

39	P0.23	DIO/AIO	RTCO
40	P0.24	DIO	General IO / LCD_D[6]
41	P0.25	DIO	General IO / LCD_D[5]
42	P0.26	DIO	General IO / LCD_D[4]
43	P0.27	DIO	General IO / LCD_D[3]
44	RESETN	AI	RESETN input
45	USB_5V	AI	USB Vbus input
46	USB_DP	AIO	USB Data Plus
47	USB_DM	AIO	USB Data Minus
48	USB_3V	AI	USB supply voltage input

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5.4 A3117M0 QFN56 7x7 Package with USB2.0

Pin No.	Symbol	I/O	Function Description
1	USB_DM	AIO	USB Data Minus
2	USB_3V	AI	USB supply voltage input
3	BATH	AI	DC-DC converter voltage input for buck mode
4	REGIA	AO	DC-DC regulator output voltage
5	LX	AIO	DC-DC Inductor connection pin
6	GNDSW	AI	Ground
7	VDD_FH	AO	Flash high voltage output
8	VDD_T	AO	VDD_T supply voltage output
9	VDD_S	AO	VDD_S supply voltage output
10	BG	AO	Band gap output
11	RSSI	AO	RSSI
12	VDD_ADC	AO	VDD_ADC supply voltage output
13	RFI	AI	RF input
14	RFO	AO	RF output
15	VDD_V	AI	VCO supply voltage input
16	XI	AI	Crystal oscillator input
17	XO	AO	Crystal oscillator output
18	VDD_P	AO	PLL supply voltage output
19	REGI	AI	Regulator input
20	P0.0	DIO	SPI1_CS
21	P0.1	DIO	SPI1_MISO
22	P0.2	DIO	SPI1_MOSI
23	P0.3	DIO	SPI1_SCK
24	P0.4	DIO	I ² C_SCL / SPI2_MISO
25	P0.5	DIO	I ² C_SDA / SPI2_MOSI
26	P0.6	DIO	SWDIO
27	GND1	AI	Ground
28	P0.7	DIO	SWCLK
29	P0.8	DIO/AI	TIMER0_EIN / ADC2 / BB_GIO1
30	P0.9	DIO/AI	TIMER1_EIN / ADC3 / BB_GIO2 / SPI2_SCK
31	P0.10	DIO	PWM2 / I ² C_SCL / FLASH_MASK
32	P0.11	DIO	PWM3 / I ² C_SDA / LCD_TE
33	P0.12	DIO/AI	ADC4 / ICE_MODE / LCD_RDY / SPI2_CS
34	P0.13	DIO/AI	ADC5/BB_GIO1 / LCD_D[2]
35	P0.14	DIO/AI	ADC6/BB_GIO2 / LCD_D[1]
36	P0.15	DIO/AI	ADC7/BB_CK0 / LCD_D[0] / s_LCD_SDA
37	P0.16	DIO	UART0_RX / LCD_CSX
38	P0.17	DIO	UART0_TX / LCD_D/CX
39	GND2	AI	Ground

40	P0.18	DIO/AI	UART1_RX / ADC0
41	P0.19	DIO/AI	UART1_TX / ADC1
42	P0.20	DIO	UART2_RX / PWM0 / LCD_WRX/ s_LCD_SCL
43	P0.21	DIO	UART2_TX / PWM1 / LCD_D[7]
44	P0.22	DIO/AIO	RTCI
45	P0.23	DIO/AIO	RTCO
46	P0.24	DIO	General IO / LCD_D[6]
47	P0.25	DIO	General IO / LCD_D[5]
48	P0.26	DIO	General IO / LCD_D[4]
49	P0.27	DIO	General IO / LCD_D[3]
50	RESETN	AI	RESETN input
51	P0.28	DIO	General IO
52	P0.29	DIO	General IO
53	P0.30	DIO	General IO
54	P0.31	DIO	General IO
55	USB_5V	AI	USB Vbus input
56	USB_DP	AIO	USB Data Plus

6. Chip Block Diagram

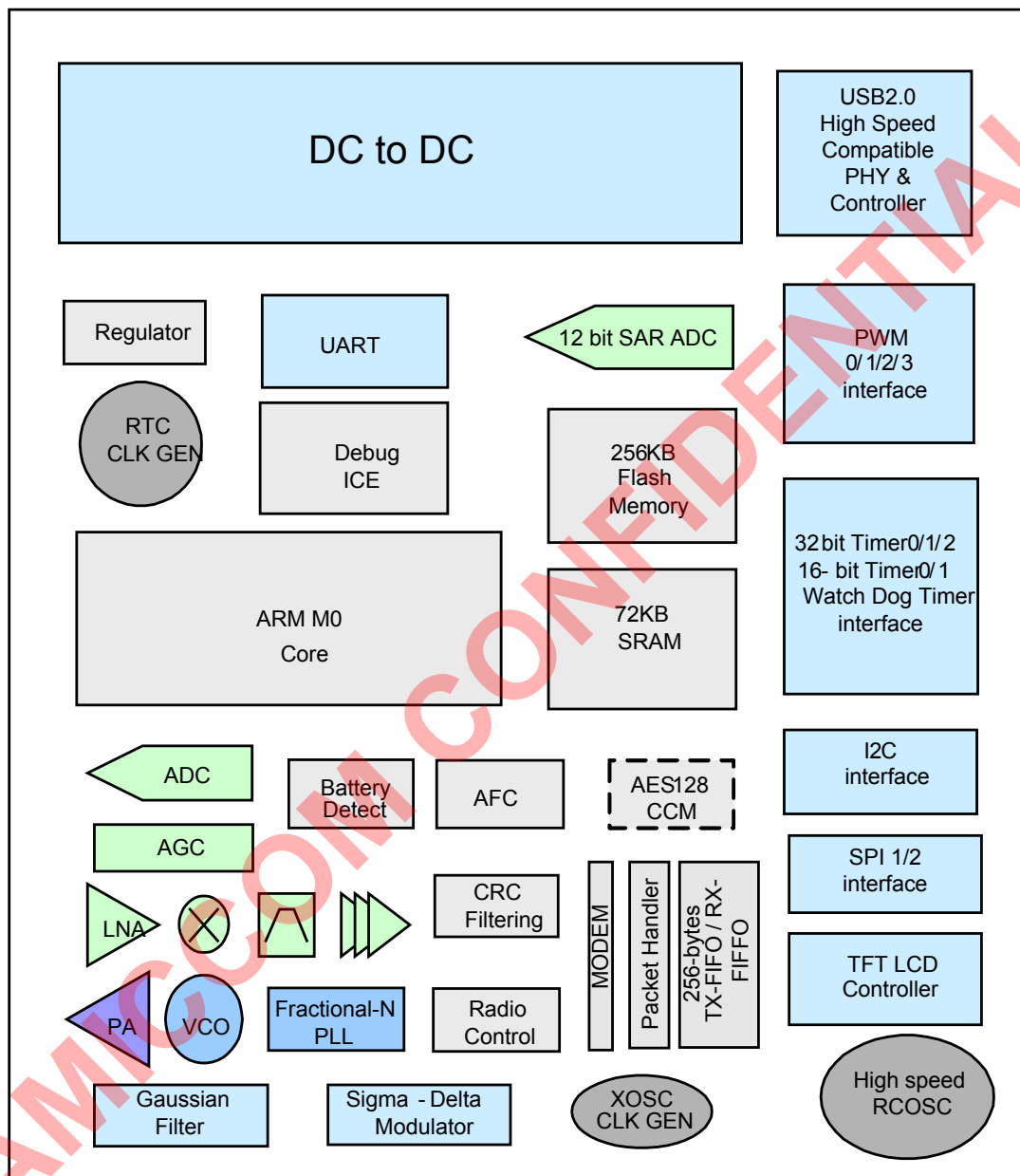


Figure 6.1 A3117M0 Block Diagram

7. Absolute Maximum Ratings

Parameter	With respect to	Rating	Unit
Supply voltage range (VDD)	GND	-0.3 ~ 3.6	V
Digital IO pins range	GND	-0.3 ~ VDD+0.3	V
Voltage on the analog pins range	GND	-0.3 ~ 2.1	V
Input RF level		14	dBm
Storage Temperature range		-55 ~ 125	°C
ESD Rating	HBM	± 2K	V
	MM	± 100	V

*Stresses above those listed under “Absolute Maximum Rating” may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

*Device is ESD sensitive. Use appropriate ESD precautions. HBM (Human Body MODE) is tested under MIL-STD-883F Method 3015.7. MM (Machine MODE) is tested under JEDEC EIA/JESD22-A115-A.

*Pin RFO pass HBM +/- 1.75KV

*Device is Moisture Sensitivity Level III (MSL 3).



8. Electrical Specification

(Ta=25°C, BATH = 3.3V, unless otherwise noted)

Parameter	Description	Min.	Typ.	Max.	Unit
General					
Operating Temperature		-40		85	°C
Supply Voltage (BATH)	BATH supply input	2.0		3.6	V
Current Consumption (MCU in stop MODE, and RF in sleep MODE)	PM1 with sleep timer		3.3		uA
	PM2 with sleep timer		3.3		uA
	PM3 with sleep timer, 16K SRAM retention		2.1		uA
	PM3 without sleep timer, 16K SRAM off		1.3		uA
Current Consumption (MCU in normal MODE) Without DC-DC MCU Clock @16MHz	Sleep MODE		3		mA
	Standby MODE		4.7		mA
	PLL MODE		9.1		mA
	RX MODE (AGC Off)		14.8		mA
	RX MODE (AGC On)		15.1		mA
	TX MODE (@5dBm output)		19.9		mA
Current Consumption (MCU in STOP MODE) Without DC-DC	Standby MODE		1		mA
	PLL MODE		5.5		mA
	RX MODE (AGC Off)		11.3		mA
	RX MODE (AGC On)		11.6		mA
	TX MODE (@5dBm output)		16.4		mA
Current Consumption (MCU in STOP MODE) With DC-DC	Standby MODE		0.8		mA
	PLL MODE		3.2		mA
	RX MODE (AGC Off)		6.4		mA
	RX MODE (AGC On)		6.7		mA
	TX MODE (@5dBm output)		9		mA
Synthesizer block					
Crystal settling time	Idle to standby (XTAL SMD2016)		0.6		ms
Crystal frequency			16		MHz
Crystal tolerance			±20		ppm
Crystal Load Capacitance			9		pF
Crystal ESR				80	ohm
PLL settling time	Standby to PLL		75		μs
Transmitter					
Carrier Frequency		2400		2483.5	MHz
Maximum Output Power			4		dBm
RF Power Control Range			20		dB
Out Band Spurious Emission ¹	30MHz~1GHz			-36	dBm
	1GHz~12.75GHz			-30	dBm
	1.8GHz~ 1.9GHz			-47	dBm
	5.15GHz~ 5.3GHz			-47	dBm
Frequency deviation	500Kbps		186K		Hz
	1M		250K		Hz
	2M		500K		Hz
Data rate		5K		2M	Bps

TX settling time	Standby to TX		120		μ s
Receiver					
Receiver sensitivity @ BER = 0.1%	Data rate 2M (F_{IF} = 2MHz)		-91		dBm
	Data rate 1M (F_{IF} = 1MHz)		-94		dBm
	Data rate 500K (F_{IF} = 1MHz)		-97		dBm
IF frequency bandwidth			1200/2400		KHz
IF center frequency			1000/2000		KHz
Interference	Co-Channel (C/I_0)		11		dB
	1 st Adjacent Channel (C/I_1)		2		dB
	2 nd Adjacent Channel (C/I_2)		-18		dB
	3 rd Adjacent Channel (C/I_3)		-28		dB
	Image (C/I_{IM})		-12		dB
Maximum Operating Input Power	@RF input (BER=0.1%)			0	dBm
RX Spurious Emission	30MHz~1GHz			-52	dBm
	1GHz~12.75GHz			-47	dBm
RSSI Range with AGC turn on	@RF input	-100		-10	dBm
RX settling time	Standby to RX		130		μ s
12Bit SAR ADC					
Input voltage range		0		1.8	V
External reference voltage			1.8		V
Input capacitor			25		pF
Bandwidth			200		KHz
EOB, effective number of bits			10		bit
INL			+/- 2		LSB
DNL			+/- 1		LSB
Conversion time		128		8	μ s
Current consumption			0.4		mA
ADC accuracy	With BG trimming		+/- 1		%
Regulator					
Regulator settling time			200		μ s
Band-gap reference voltage			1.21		V
Regulator output voltage			1.21		V
Digital IO DC characteristics					
High Level Input Voltage (V_{IH})		0.8*VDD		VDD	V
Low Level Input Voltage (V_{IL})		0		0.2*VDD	V
High Level Output Voltage (V_{OH})	@ I_{OH} = -0.5mA	VDD-0.4		VDD	V
Source current	@ V_{OH} = 2.4V, HDV=0		10		mA
Source current	@ V_{OH} = 2.4V, HDV=1		30		mA
Low Level Output Voltage (V_{OL})	@ I_{OL} = 0.5mA	0		0.4	V
Sink current	@ V_{OL} = 0.4V, HDV=0		5		mA
Sink current	@ V_{OL} = 0.4V, HDV=1		14.5		mA
DC-DC Buck converter					
Input voltage range		2.0		3.6	V
Output voltage		1.5	1.6	1.8	V
Efficiency (with 100 ohm load @ 3.0V input.)	PWM MODE		89		%
Efficiency (with 100 ohm load @ 3.6V input.)	PWM MODE		86		%
Maximum load current				50	mA

Power on Reset Electrical Characteristics

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		BATH	Condition				
V_{POR}	BATH Start Voltage to ensure Power-on Reset	—	—	—	—	100	mV
$R_{POR\ AC}$	BATH Raising Rate to ensure Power-on Reset	—	—	0.04	—	—	V/ms
t_{POR}	Minimum Time for BATH to remain at V_{POR} to ensure Power-on Reset	—	—	3	—	—	ms

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9. Register List

A3117M0 contains Peripheral Register and RF Register.

9.1 Register

9.1.1 Battery detect Register (Address: 0x50000000)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W	Reserved							
R								
Reset	0							
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W	Reserved							
R								
Reset	0							
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	Reserved							
R								
Reset	0							
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--	--	--	--	BVT2	BVT1	BVT0	BDS
R	--	--	--	BDF	BVT2	BVT1	BVT0	BDS
Reset	0	0	0	0	0	1	1	0

BVT [2:0]: Battery voltage detect threshold.

[000]: 1.875.

[001]: 1.95V.

[010]: 2.025V.

[011]: 2.1V.

[100]: 2.175V.

[101]: 2.25V.

[110]: 2.325V.

[111]: 2.4V.

BDS: Battery detect enable.

[0]: Disable.

[1]: Enable. It will be clear after battery detection done.

BDF: Battery detection flag.

[0]: Battery voltage less than threshold.

[1]: Battery voltage greater than threshold.

9.1.2 Power control Register 1 (Address: 0x50000008)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W	WUNIE[3]	WUNIE[2]	WUNIE[1]	WUNIE[0]			RESETNF	PORF
R						LVDF	RESETNF	PORF
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W	RTCPUN	BATS	REFS	SWR	RGC[2]	RGC[1]	RGC[0]	ECHC
R								
Reset	0	0	0	0	1	0	1	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	CBG[2]	CBG[1]	CBG[0]	PDNS	STA	ENDL[2]	ENDL[1]	ENDL[0]
R								

Reset	1	1	0	1	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	QDS	REGAE	CE_3us_ON	MCU_3us	PACTL	RGS	RGV[1]	RGV[0]
R	QDS	REGAE		MCU_3us			RGV[1]	RGV[0]
Reset	0	0	0	0	0	0	0	0

WUNIE [3:0]: Reserved for internal usage.

BATS: Reserved for internal usage. Shall be set to [0].

REFS: Reserved for internal usage. Shall be set to [0].

LVDF (Low voltage detect) flag : Write EBOD = 1 to clear.
 = 1: Occurred Low Voltage Reset
 = 0: No Low Voltage reset

RESETNF (RESETN flag) : Write any data to clear.
 = 1: Occurred RESETN reset
 = 0: No RESETN reset

PORF (power-on reset flag) : Write any data to clear.
 = 1: Occurred Power-on Reset
 = 0: No Power-on Reset

RTCPUN: Reserved for internal usage. Shall be set to [0].

SWR: Reserved for internal usage.

RGC[2:0]: Low power band-gap current select. Recommend RGC = [01]

ECHC: Reserved for internal usage.

CBG[2:0]: Reserved for internal usage.

PDNS: Power manager to turn on REGOD Recommend PDNS = [0]

STA: Reserved for internal usage only. Shall be set to [0].

ENDL[2:0]: Reserved for internal usage only

QDS (Quick discharge) : Reserved for internal usage

REGAE (RegA Enable) : Reserved for internal usage

CE_3us_ON: Normal TRX Wakeup MCU in 3us.

MCU_3us: Wakeup MCU in 3us enable.

PACTL: Reserved for internal usage only. Shall be set to [0].

RGS: Reserved for internal usage.

RGV [1:0]: VDD_D and VDD_A voltage setting in non-Sleep MODE. Recommend RGV = [11].
 [00]: 1.35V.
 [01]: 1.3V.
 [10]: 1.25V.
 [11]: 1.2V.

9.1.3 Power control Register 2 (Address: 0x5000000C)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W	RGP1	RGP0	RGD1	RGD0	MTD	RGA	RFA	PDNSR
R								
Reset	0	0	0	0	0	0	0	1
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W	MTP						ENPV	QDSP
R								
Reset	0	0	0	0	0	0	1	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	SWE	SWD	SWC	CADS	SVREFF	CBGF2	CBGF1	CBGF0
R								
Reset	0	0	0	0	0	1	1	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	EBOD	ENAV	QDSA	ENDV	QDSD	CEL	SVREF	CELA
R								
Reset	1	1	0	1	0	0	0	0

RGP[1:0] : REGOP voltage adjust

[00]: 1.32898V*

[01]: 1.29151V

[10]: 1.24244V

[11]: 1.19074V

RGD[1:0] : REGOD voltage adjust

[00]: 1.3264V*

[01]: 1.2343V

[10]: 1.2809V

[11]: 1.1892V

MTD : REGOD power off select

[0]: Power ON

[1]: Power OFF

RGA : BOD sensitive of supply voltage select

[0]: enhance 1

[1]: enhance 2

(× Cost more current consumption)

RFA : BOD disable in PM mode

[0]: Normal mode

[1]: Disable in PM mode

PDNSR : REGOT power down select

[0]: Power OFF

[1]: Power ON

MTP : REGOP power off select

[0]: Power OFF in PM mode

[1]: Power OFF if ENPV =0

ENPV : REGOP tie to REGOS

[0]: Tie together

[1]: Open

QDSP : REGOP quick discharge in PM mode

[0]: Disable

[1]: Enable

SWE: Reserved for internal usage

SWD: Reserved for internal usage

SWC: Reserved for internal usage

CADS: Reserved for internal usage

SVREFF: Reserved for internal usage

CBGF[2:0]: Reserved for internal usage.

EBOD: Reserved for internal usage.

ENAV: REGOA and REGOS connection.

QDSA: quick discharge select for REGOA.

ENDV: REGOA is connected to REGOD.

QDSD: quick discharge select for REGOD.

CEL: Digital voltage select in standby MODE. Recommend CEL = [0].

SVREF: Reserved for internal usage. Recommend SVREF = [0].

CELA: Reserved for internal usage.

PM MODE: Low power operation select.

	MCU STOP
PM1	ENAV=1, QDSA=0, ENDV=1, QDSD=0
PM2	ENAV=0 or 1, QDSA=1, ENDV=1, QDSD=0
PM3	ENAV=0 or 1, QDSA=1, ENDV=0 or 1, QDSD=1

ENAV doesn't care if QDSA=1; ENDV doesn't care if QDSD=1

9.1.4 Reset Register (Address: 0x50001000)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	RESETN	FWPRN	FRPRN	FDATARN	BFCRN			
R								
Reset	0	0	0	0	0	0	0	0

RESETN: Write to this register to issue reset command. (Write "1" to reset)

FWPRN: FIFO Write Point Software Reset. (Write "1" to reset)

FRPRN: FIFO Read Point Software Reset. (Write “1” to reset)

FDATARN: FIFO Data Reset. (Write “1” to reset)

BFCRN: IF Filter Bank Calibration Software Reset. (Write “1” to reset)

9.1.5 Strobe Register (Address: 0x50001004)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	STRB7	STRB6	STRB5	STRB4	STRB3	STRB2	STRB1	STRB0
R								
Reset	1	0	1	0	0	0	0	0

STRB[7:0]: Strobe command register.

[0x80]: Sleep MODE.

[0x90]: Idle MODE.

[0xA0]: Standby MODE.

[0xB0]: PLL MODE.

[0xC0]: RX MODE.

[0xD0]: TX MODE.

Reserve for other settings.

9.1.6MODEC Register (Address: 0x50001008)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W						BREV	FIFOREV	IDREV
R						BREV	FIFOREV	IDREV
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W			AIF	DFCD		FMT	FMS	
R			AIF	CD		FMT	FMS	
Reset	0	0	0	0	0	0	0	0

BREV: Bit reverse enable.

[0]: Disable.

[1]: Enable

FIFOREV: FIFO reverse enable.

[0]: Disable.

[1]: Enable

IDREV: ID reverse enable.

[0]: Disable.

[1]: Enable

AIF (Auto IF Offset): RF LO frequency will auto offset one IF frequency while entering RX MODE.

[0]: Disable.

[1]: Enable.

CD / DFCD:

DFCD (Data Filter by CD): The received package will be filtered out if Carrier Detector signal is inactive.

[0]: Disable.

[1]: Enable.

CD (Read): Carrier detector signal.

[0]: Input power below threshold.

[1]: Input power above threshold.

FMT: Reserved for internal usage only. Shall be set to [0].

FMS: Direct/FIFO MODE select.

[0]: Direct MODE.

[1]: FIFO MODE.

9.1.7 Status Register (Address: 0x50001010)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W				EOPF				
R	PDN_RX	PDN_TX		EOPF	FSYNC	FPF	ENCF	SYNC
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W								
R	WTR	FECF	CRCF	CER	XER	PLLER	TRSR	TRER
Reset	0	0	0	0	0	0	0	0

PDN_RX: RX status flag.

PDN_TX: TX status flag.

EOPF: EOP status flag.

FSYNC: FSYNC status flag.

FPF: FPF status flag.

ENCF : AES operation, CCM Encryption and Decryption status flag.

SYNC: SYNC status flag.

WTR: WTR status flag.

FECF: FEC flag.

[0]: FEC pass.

[1]: FEC error.

CRCF: CRC flag.

[0]: CRC pass.

[1]: CRC error.

CER: RF chip enable status.

[0]: RF chip is disabled.

[1]: RF chip is enabled.

XER: Internal crystal oscillator enabled status.

[0]: Crystal oscillator is disabled.

[1]: Crystal oscillator is enabled.

PLLER: PLL enabled status.

[0]: PLL is disabled.

[1]: PLL is enabled.

TRSR: TRX Status Register.

[0]: RX state.

[1]: TX state.

Serviceable if TRER=1 (TRX is enable).

TRER: TRX state enabled status.

[0]: TRX is disabled.

[1]: TRX is enabled.

9.1.8FIFO Register (Address: 0x50001020)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W	FPM1	FPM0						
R	FPM1	FPM0						
Reset	0	1	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W			PSA5	PSA4	PSA3	PSA2	PSA1	PSA0
R			PSA5	PSA4	PSA3	PSA2	PSA1	PSA0
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	FEP7	FEP6	FEP5	FEP4	FEP3	FEP2	FEP1	FEP0
R	FEP7	FEP6	FEP5	FEP4	FEP3	FEP2	FEP1	FEP0
Reset	0	0	1	1	1	1	1	1

FPM [1:0]: FIFO Pointer Margin

PSA [5:0]: Used for Segment FIFO.

FEP [7:0]: FIFO End Pointer for TX FIFO and Rx FIFO.

9.1.9RF GPIO Register (Address: 0x50001028)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W								GIOBSEL
R	P_GPIO2	P_GPIO1	P_CKO					GIOBSEL
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W	CKOE	CKOI	ECKOE		CKOS3	CKOS2	CKOS1	CKOS0
R	CKOE	CKOI	ECKOE		CKOS3	CKOS2	CKOS1	CKOS0
Reset	0	0	1	0	0	1	1	1
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	GIO2E	GIO2I		GIO2S4	GIO2S3	GIO2S2	GIO2S1	GIO2S0
R	GIO2E	GIO2I		GIO2S4	GIO2S3	GIO2S2	GIO2S1	GIO2S0
Reset	0	0	0	0	0	1	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	GIO1E	GIO1I		GIO1S4	GIO1S3	GIO1S2	GIO1S1	GIO1S0
R	GIO1E	GIO1I		GIO1S4	GIO1S3	GIO1S2	GIO1S1	GIO1S0
Reset	0	0	0	0	0	0	0	0

P_GPIO2: GIO2 pin output.

P_GPIO1: GIO1 pin output.

P_CKO: CKO pin output.

GIOBSEL: RF GIO pin output select.

[0]: Disable.

[1]: Enable.

CKOE: Clock Output Enable.

[0]: Disable.

[1]: Enable.

CKOI: CKO pin output signal invert.

[0]: Non-inverted output.

[1]: Inverted output.

ECKOE: External Clock Output Enable for CKOS [3:0]= [0100] ~ [0111].

[0]: Disable.

[1]: Enable.

CKOS[3:0]: CKO pin output select.

[0000]: DCK (TX data clock).

[0001]: RCK (RX recovery clock).

[0010]: MCU clock.

[0011]: EOP, EOVB, EOFBC, EOADC, EOVC, OKADC, RSSC_OK (Internal usage only).

[0100]: USB 48MHz clock

[0101]: USB 6MHz clock

[0110]: XRC clock

[0111]: XREF_PLL clock

[1000]: WCK.(4Khz)

[1001]: PF8M(8MHz)

[1010]: TMRCK(32Khz)

[1011]: SYCK(8Mhz)

[1100]: TMRCK_OVF(Sleep Timer0 clock)

[1101]: TMRCK_OVF(Sleep Timer1 clock)

[1110]: CSCK/2

[1111]: SYCK*2

GIO2E: GIO2 pin output enable.

[0]: Enable
[1]: Disable.

GIO2I: GIO2 pin output signal invert.

[0]: Non-inverted output.

[1]: Inverted output.

GIO2S [4:0]: GIO2 pin function select.

GIO2S	TX state	RX state
[00000]	ARCWTR (Wait until TX or RX finished)	
[00001]	EOAC (end of access code)	FSYNC (frame SYNC)
[00010]	TMEO or TMDEO (TX modulation enable)	CD (carrier detect)
[00011]	Preamble Detect Output (PMDO)	
[00100]	MCU wakeup signal (TWWS)	
[00101]	Quadrature phase demodulator input (DMIQ)	
[00110]	FPF (FIFO pointer flag)	
[00111]	TRXD In/Out (Direct MODE)	
[01000]	RXD (Direct MODE)	
[01001]	TXD (Direct MODE)	
[01010]	Quadrature phase demodulator external input (EXDI1)	
[01011]	External FSYNC input in RX direct MODE	
[01100]	DEC	
[01101]	PDN_TX	
[01110]	IPNL, Reserved	
[01111]	End flag of CCM decode.	
[10000]	DSTL, Reserved	
[10001]	VRX, Reserved	
[10010]	VT[1]	
[10011]	USB interrupt	

GIO1E: GIO1 pin output enable.

[0]: Enable
[1]: Disable.

GIO1I: GIO1 pin output signal invert.

[0]: Non-inverted output.

[1]: Inverted output.

GIO1S [4:0]: GIO1 pin function select.

GIO1S	TX state	RX state
[00000]	WTR (Wait until TX or RX finished)	
[00001]	EOAC (end of access code)	FSYNC (frame SYNC)
[00010]	TMEO or TMDEO (TX modulation enable)	CD (carrier detect)
[00011]	Preamble Detect Output (PMDO)	
[00100]	MCU wakeup signal (TWWS)	
[00101]	In phase demodulator input (DMII)	
[00110]	FMTDO (FIFO MODE TX data output)	
[00111]	TRXD In/Out (Direct MODE)	
[01000]	RXD (Direct MODE)	
[01001]	TXD (Direct MODE)	
[01010]	In phase demodulator external input (EXDI0)	
[01011]	External FSYNC input in RX direct MODE	
[01100]	INC	
[01101]	PDN_RX	
[01110]	INT5	
[01111]	CCM fail flag	
[10000]	CKOSI, Reserved	
[10001]	SWNL, Reserved	
[10010]	VT[0]	

[10110] Real time clock interrupt

9.1.10 LO channel Register (Address: 0x500010C0)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	CHN7	CHN6	CHN5	CHN4	CHN3	CHN2	CHN1	CHN0
R	CHN7	CHN6	CHN5	CHN4	CHN3	CHN2	CHN1	CHN0
Reset	0	0	0	0	0	0	0	0

CHN [7:0]: LO channel number select.

9.1.11 TX Control Register (Address: 0x50001100)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W				GDR	TMDE	TXDI	TME	FS
R								
Reset	0	0	0	0	1	0	1	0

GDR: Gaussian Filter Over-sampling Rate Select.

[0]: BT= 1.

[1]: BT= 0.5

GDR=0.

FPS[2:0]	7	6	5	4	3	2	1	0
BT	1.4	1.3	1.2	1.1	0.75	0.7	0.65	0.6

GDR=1.

FPS[2:0]	7	6	5	4	3	2	1	0
BT	0.7	0.65	0.6	0.55	0.7	0.65	0.6	0.55

TMDE: TX Modulation Enable for VCO Modulation.

[0]: Disable.

[1]: Enable.

TXDI: TX data invert. Recommend TXDI = [0].

[0]: Non-invert.

[1]: Invert.

TME: TX modulation enable.

[0]: Disable.

[1]: Enable.

FS: Filter select.

The filter shape is Gaussian filter

[0]: disable.

[1]: enable.

9.1.12 TX Power 1 Register (Address: 0x50001104)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W		PWORS	TXCS	PAC1	PAC0	TBG2	TBG1	TBG0
R								
Reset	0	0	0	1	0	1	1	1

PWORS: TX high power setting.

[0]: Disable.

[1]: Enable.

TXCS: TX Current Setting.

PAC [1:0]: PA Current Setting.

TBG [2:0]: TX Buffer Setting.

9.1.13 TX Modulation Register (Address: 0x5000110C)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W	DAMV1	DAMV0	DEVFD2	DEVFD1	DEVFD0	DEV2	DEV1	DEV0
R								
Reset	1	0	1	0	1	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W			DEVGD2	DEVGD1	DEVGD0	FPS2	FPS1	FPS0
R								
Reset	0	0	0	0	0	0	0	0

R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W						FDP2	FDP1	FDP0
R								
Reset	0	0	0	0	0	1	1	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	FD7	FD6	FD5	FD4	FD3	FD2	FD1	FD0
R								
Reset	0	0	1	0	1	1	1	1

DAMV [1:0]: Demodulator D/A Voltage Range Select. Recommend DAMV = [10].

[00]: 1/32*1.2.

[01]: 1/16*1.2.

[10]: 1/8*1.2.

[11]: 1/4*1.2.

DEVFD [2:0]: VCO Modulation Data Delay by 8x over-sampling Clock. Recommend DEVFD = [101].

DEVD [2:0]: VCO Modulation Data Delay by XCPCK Clock. Recommend DEVD = [000].

DEVG [2:0]: Sigma Delta modulator data delay setting.

FPS [2:0]: Gaussian filter BT setting.

FDP [2:0]: Frequency deviation power setting. Refer to TX control register (Address: 0x50001100h).

FD [7:0]: Frequency deviation setting.

$F_{DEV} = F_{PFD} / 2^{16} * FD * 2^{(FDP-1)}$.

Where $F_{PFD} = F_{XTAL} * (DBL+1) / (RRC [1:0]+1)$, PLL comparison frequency.

9.1.14CODE1 Register (Address: 0x50001180)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W								IDL
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W	ETH2	ETH1	ETH0	PMD1	PMD0	PML2	PML1	PML0
R								
Reset	1	0	0	1	1	1	0	1
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W								
R								
Reset	1	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W			CRC SW	MSCRC	MCS	WHTS	FECS	CRC S
R								
Reset	0	0	0	0	0	0	0	0

IDL: ID code length select. Recommend IDL= [1].

[0]: 2 bytes.

[1]: 4 bytes.

ETH [2:0]: ID code error tolerance. Recommend ETH = [01].

[000]~[111]: 0~7 bit.

PMD [1:0]: Preamble pattern detection length. Recommend PMD = [10].

[00]: 0bit.

[01]: 4bits.

[10]: 8bits.
[11]: 16bits.

PML [2:0]: Preamble length select. Recommend PML= [11].

[000]: 1 byte.
[001]: 2 bytes.
[010]: 3 bytes.
[011]: 4 bytes.
[100]: 5bytes.
[101]: 6bytes.
[110]: 7bytes.
[111]: 8bytes

CRCSW: CRC 24-bits enable.

[0]: Disable.
[1]: Enable.

MSCRC: Mask CRC (CRC Data Filtering Enable).

[0]: Disable.
[1]: Enable.

MCS: Manchester Code Enable.

[0]: Disable.
[1]: Enable.

WHTS: Data whitening (Data Encryption) select.

[0]: Disable.
[1]: Enable.

FECS: FEC select.

[0]: Disable.
[1]: Enable.

CRCS: CRC select.

[0]: Disable.
[1]: Enable.

9.1.15 RSSI Register (Address: 0x50001244)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	RTH7	RTH6	RTH5	RTH4	RTH3	RTH2	RTH1	RTH0
R	ADC7	ADC6	ADC5	ADC4	ADC3	ADC2	ADC1	ADC0
Reset	0	0	0	0	0	0	0	0

RTH [7:0]: Carrier detect threshold.

ADC [7:0]: ADC output value of temperature, RSSI or external voltage measurement.
 ADC input voltage = $0.9 * \text{ADC} [7:0] / 256 \text{ V}$.

9.1.16 ADC Control Register I (Address: 0x50008000)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W	ADC12RN							
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W								ADCINT_CLR
R								ADCINT_Flag
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	ADCIE	VADS[2]	VADS[1]	VADS[0]	ADIVL	ADCYC	ENADC	DTMP
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	BUFS	CKS1	CKS0	MODE	MVS2	MVS1	MVS0	ADCE
R	--	--	--	MODE	MVS2	MVS1	MVS0	ADCE
Reset	0	1	0	0	0	0	0	0

ADC12RN: 12-bits ADC Reset. (Write "1" to reset)

[0]: Disable.

[1]: Enable

ADCINT_Flag: 12-bits ADC interrupt flag. (Write "1" to reset)

ADCIE : 12-bits interrupt enable.

[0]: 0.

[1]: 2048

VADS[2:0]: Reserved for internal usage only. Shall be set to [0].

[0]: Disable.
[1]: Enable

ADIVL: 12-bits sargen initial value select.

[0]: 2048.
[1]: 0

ADCYC: 12-bits sargen clock counter select.

[0]: 31.
[1]: 32.

ENADC: Enable ADC.

[0]: Disable.
[1]: Enable

DTMP: 12-bits temperature select. Refer to chapter 23 for details.

[0]: Disable.
[1]: Enable

BUFS: input buffer select for 12 bit ADC. Refer to chapter 23 for details.

[0]: Disable.
[1]: Enable.

CKS[1:0]: ADC clock selected.

[00]: 4 MHz
[01]: 2 MHz
[10]: 1 MHz
[11]: 500 kHz

MODE: ADC measurement MODE.

[0]: Single MODE.
[1]: Continuous MODE.

MVS [2:0]: ADC average times .

[000]: No Average.
[001]: Average 2 times.
[010]: Average 4 times.
[011]: Average 8 times.
[100]: Average 16 times.
[101]: Average 32 times.
[110]: Average 64 times.
[111]: Average 128 times.

ADCE: ADC measurement enable.

[0]: Disable.
[1]: Enable

9.1.17 ADC Control Register II (Address: 0x50008004)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W								
R					MVADC11	MVADC10	MVADC9	MVADC8
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W								
R	MVADC7	MVADC6	MVADC5	MVADC4	MVADC3	MVADC2	MVADC1	MVADC0
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W								
R					ADC11	ADC10	ADC9	ADC8

Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W								
R	ADC7	ADC6	ADC5	ADC4	ADC3	ADC2	ADC1	ADC0
Reset	0	0	0	0	0	0	0	0

MVADC [11:0]: Moving average ADC output value

ADC [11:0]: ADC output value

9.1.18 ADC Channel Register (Address: 0x50008008)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	INS1	INS0	PGS2	PGS1	PGS0		ADCS_N1	ADCS_N0
R	INS1	INS0	PGS2	PGS1	PGS0		ADCS_N1	ADCS_N0
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W		ADCS_P1	ADCS_P0	ENCHS	ADCCH3	ADCCH2	ADCCH1	ADCCH0
R		ADCS_P1	ADCS_P0	ENCHS	ADCCH3	ADCCH2	ADCCH1	ADCCH0
Reset	0	0	0	0	0	0	0	0

INS[1:0] : PGA status

[00]: BUF, bypass PGA

[01]: Non inverter mode

[10]: Inverter mode

[11]: Differential mode

PGS[2:0] : PGA gain

[000]: 1

[001]: 2

[010]: 4

[011]: 8

[100]: 16

[101]: 32

[110]: 64

[111]: 128

ADCS_N[1:0] :

[0]: Select P0.25 as ADC N analog input.

[1]: Select P0.27 as ADC N analog input.

ADCS_P[1:0] :

[0]: Select P0.24 as ADC P analog input.

[1]: Select P0.26 as ADC P analog input.

ENCHS : enable ADC I/O for Differential mode.

ADCCH[3:1] : ADC I/O select

[000]: Select P0.18 as ADC analog input.

[001]: Select P0.19 as ADC analog input.

[010]: Select P0.8 as ADC analog input.
[011]: Select P0.9 as ADC analog input.
[100]: Select P0.12 as ADC analog input.
[101]: Select P0.13 as ADC analog input.
[110]: Select P0.14 as ADC analog input.
[111]: Select P0.15 as ADC analog input.

ADCCH0: ADC input enable

[0]: Disable.
[1]: Enable.

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10. A3117M0 RF

A3117M0 integrate 2.4 GHz GFSK transceiver and use Strobe control register (50001004h) to control RF state. There are 6 Strobe commands to control internal state machine for RF operations. These MODEs include Sleep MODE, Idle MODE, Standby MODE, PLL MODE, RX MODE and TX MODE. There are 256Bytes FIFO for data transmitting, receiving. Sleep timer is used for WOR (Wake On Rx) and time-slotted MODE operation.

10.1 Strobe Command Register 1 (Address:0x50001004)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	STRB[7:0]							
R	--							
Reset	1	0	1	0	0	0	0	0

Use strobe command control RF state.

STRB: Strobe command register.

0x80: Sleep MODE.

0x90: Idle MODE.

0xA0: Standby MODE.

0xB0: PLL MODE.

0xC0: RX MODE.

0xD0: TX MODE.

Status Register (Address:0x50001010)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--	--	--	--	--	--	--	--
R	WTR	FECF	CRCF	CER	XER	PLLER	TRSR	TRER
Reset	--	--	--	--	--	--	--	--

In A3117M0, user can read the RF state from MODE register

CER: RF chip enable status.

[0]: RF chip is disabled.

[1]: RF chip is enabled.

XER: Internal crystal oscillator enabled status.

[0]: Crystal oscillator is disabled.

[1]: Crystal oscillator is enabled.

PLLER: PLL enabled status.

[0]: PLL is disabled.

[1]: PLL is enabled.

TRSR: TRX Status Register.

[0]: RX state.

[1]: TX state.

TRER: TRX state enabled status.

[0]: TRX is disabled.

[1]: TRX is enabled.

10.1.1 Strobe Command - Sleep MODE

Refer to Strobe Control Register, user can write 0x80 to Strobe Control Register directly to set RF into Sleep MODE.

10.1.2 Strobe Command - Idle MODE

Refer to Strobe Control Register, user can write 0x90 to Strobe Control Register directly to set RF into Idle MODE.

10.1.3 Strobe Command - Standby MODE

Refer to Strobe Control Register, user can write 0xA0 to Strobe Control Register directly to set RF into Standby MODE.

10.1.4 Strobe Command - PLL MODE

Refer to Strobe Control Register, user can write 0xB0 to Strobe Control Register directly to set RF into PLL MODE.

10.1.5 Strobe Command - RX MODE

Refer to Strobe Control Register, user can write 0xC0 to Strobe Control Register directly to set RF into RX MODE.

10.1.6 Strobe Command - TX MODE

Refer to Strobe Control Register, user can write 0xD0 to Strobe Control Register directly to set RF into TX MODE.

10.2 RF Reset Command

In addition to power on reset (POR), A3117M0 could issue software reset (80h) to RF by setting Reset Register (0x50001000h). A3117M0 generates an internal signal "RESETN" to initial RF circuit. After reset command, RF state is in standby MODE and re-calibration is necessary.

Reset Register (Address: 0x50001000)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	RESETN	FWPRN	FRPRN	FDATARN	BFCRN	--	--	--
R	--	--	--	--	--	--	--	--
Reset	0	0	0	0	0	0	0	0

RESETN: Write to this register to issue reset command. (Write "1" to reset)

FWPRN: FIFO Write Point Software Reset. (Write "1" to reset)

FRPRN: FIFO Read Point Software Reset. (Write "1" to reset)

BFCRN: IF Filter Bank Calibration Software Reset. (Write "1" to reset)

10.3 FIFO Accessing Command

Before TX delivery, user only needs to write wanted data into TX FIFO (0x50001400 ~ 0x500014FF) in advance. Similarly, user can read RX FIFO (0x50001500 ~ 0x500015FF) once payload data is received. It is easy to delivery data to air. Below is the procedure of writing TX FIFO.

Step1: Send (n+1) bytes TX data in sequence by Data Byte 0, 1, 2 to n.

Step2: Send TX Strobe command for transmitting.

There are similar steps to read RX FIFO.

Step1: Send RX Strobe command for receiving data.

Step2: Read RX data from RX FIFO in sequence by Data Byte 0, 1, 2 to n.

A3117M0 supports separated 256-bytes TX and RX FIFO. To use A3117M0's FIFO MODE, user just needs to enable FMS =1 (01h). For FIFO accessing, TX FIFO (write-only) and RX FIFO (read-only). TX FIFO represents transmitted payload. On the other hand, RX circuitry synchronizes ID Code and stores received payload into RX FIFO.

Relative Control Register

FIFO Register (Address: 0x50001020)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W	FPM[1:0]		--					
R								
Reset	0	1	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W	--		PSA[5:0]					
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	--							
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	FEP[7:0]							
R								
Reset	0	0	1	1	1	1	1	1

FPM [1:0]: FIFO Pointer Margin

PSA [5:0]: Used for Segment FIFO.

FEP [7:0]: FIFO End Pointer for TX FIFO and Rx FIFO.

10.4 Packet Format of FIFO MODE

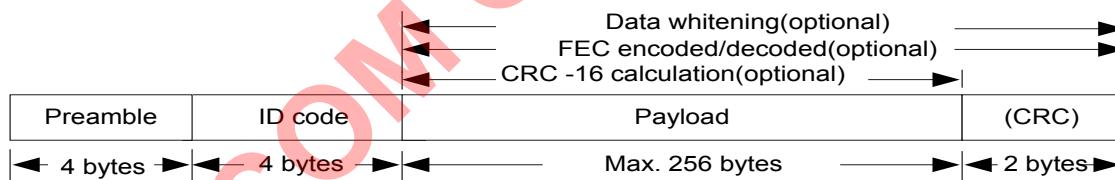


Figure 10.1 Packet Format of FIFO MODE

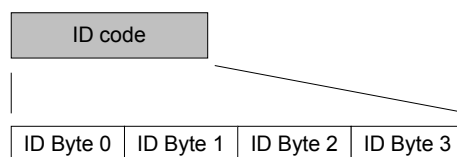


Figure 10.2 ID Code Format

Preamble:

The packet is led by preamble composed of alternate 0 and 1. If the first bit of ID code is 0, preamble shall be 0101...0101. In the contrast, if the first bit of ID code is 1, preamble shall be 1010...1010. Preamble length is recommended to set 4 bytes by PML [1:0].

ID code:

ID code is recommended to set 4 bytes by IDL=1. ID Code is sequenced by Byte 0, 1, 2 and 3. If RX circuitry checks the ID code correct, payload will be written into RX FIFO. In special case, ID code could be set error tolerance (0~ 3bit error) by ETH [1:0] for ID Synchronization check.

Payload:

Payload length is programmable by FEP [7:0]. The physical FIFO depth is 256 bytes.

CRC (option)

In FIFO MODE, if CRC is enabled (CRCS=1), 2-bytes of CRC value is transmitted automatically after payload. In the same way, RX circuitry will check CRC value and show the result to CRC Flag.

10.5 Transceiver Frequency

A3117M0 is a half-duplex transceiver with embedded PA and LNA.

The receiver is a low-IF architecture consisting of a LNA, down conversion mixers, poly-phase channel filters and IF limiting amplifiers with RSSI.

The transmitter is direct modulation architecture with 6 dBm maximum output power and 35 dB power control range. For TX or RX frequency setting, user just needs to set up one register, Channel register (0x500010C0), for frequency agility.

A3117M0's main PLL features are:

- Fractional-N to generate RX/TX frequencies for all ISM 2.4 GHz channels
- Autonomous calibration loops for stable operation within the operating range
- Fast PLL settling to support frequency hopping

During receive operation, the frequency synthesizer works as a local oscillator. During transmit operation, the voltage-controlled oscillator (VCO) is directly modulated to generate the RF transmit signal. The frequency synthesizer is implemented as a fractional-N PLL.

10.5.1 State machine

In chapter 10.1 user can learn both accessing A3117M0's control registers as well as issuing Strobe commands.

10.5.2 Key states

A3117M0 supports 6 key operation states. Those are,

- (1) Standby MODE
- (2) Sleep MODE
- (3) Idle MODE
- (4) PLL MODE
- (5) TX MODE
- (6) RX MODE

After power on reset or software reset or deep sleep MODE, user has to do calibration process because all control registers are in reset values. The calibration process of A3117M0 is very easy, user only needs to issue Strobe commands and enable calibration registers. After calibration, A3117M0 is ready to do TX and RX operation. User can start wireless transmission.

Strobe Command								Description
b7	b6	b5	b4	b3	b2	b1	b0	
1	0	0	0	x	x	x	x	Sleep MODE
1	0	0	1	x	x	x	x	Idle MODE
1	0	1	0	x	x	x	x	Standby MODE
1	0	1	1	x	x	x	x	PLL MODE
1	1	0	0	x	x	x	x	RX MODE
1	1	0	1	x	x	x	x	TX MODE

MODE	RF Register retention	RF Regulator	XTAL Osc.	VCO	PLL	RX	TX	Strobe Command
Sleep	Yes	ON	OFF	OFF	OFF	OFF	OFF	(1000-xxxx)b
Idle	Yes	ON	OFF	OFF	OFF	OFF	OFF	(1001-xxxx)b
Standby	Yes	ON	ON	OFF	OFF	OFF	OFF	(1010-xxxx)b
PLL	Yes	ON	ON	ON	ON	OFF	OFF	(1011-xxxx)b
TX	Yes	ON	ON	ON	ON	OFF	ON	(1101-xxxx)b
RX	Yes	ON	ON	ON	ON	ON	OFF	(1100-xxxx)b

Remark: x means "don't care"

Table 10.1 Operation MODE and strobe command.

10.5.3 FIFO MODE

This mod is suitable for the requirements of general purpose applications and can be chosen by setting FMS = 1. After calibration, user can issue Strobe command to enter standby mode where write TX FIFO or read RX FIFO. From standby mode to packet data transmission, only one Strobe command is needed. Once transmission is done, A3117M0 is auto back to standby mode. Figure 10.3 and Figure 10.4 are TX and RX timing diagram respectively. Figure 10.5 State diagram of FIFO mode.

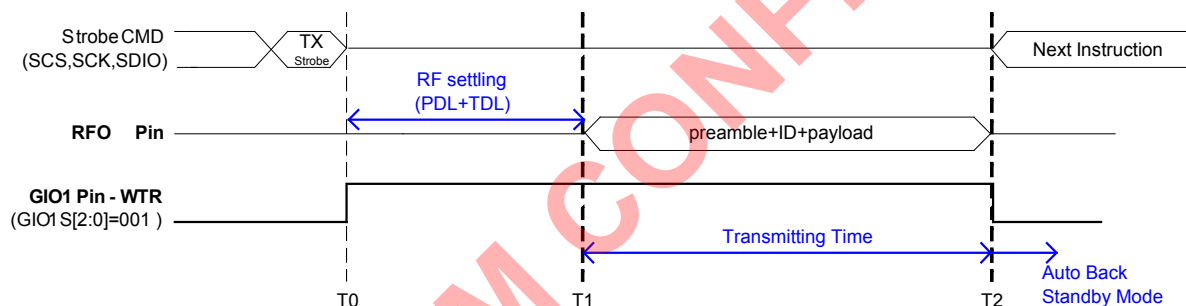


Figure 10.3 TX timing of FIFO MODE.

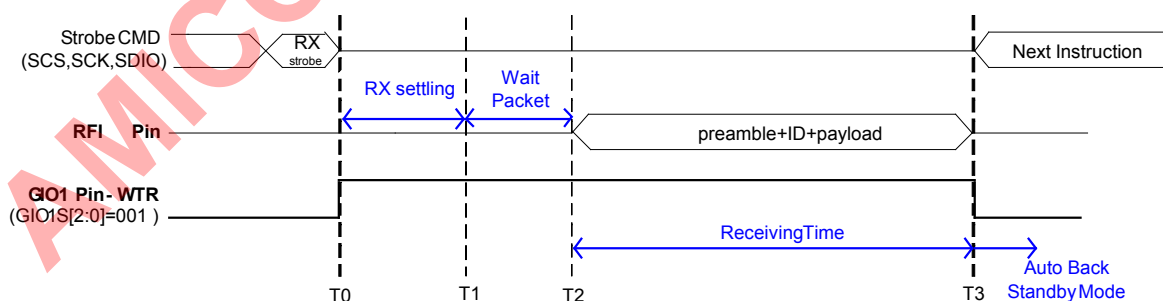


Figure 10.4 RX timing of FIFO MODE.

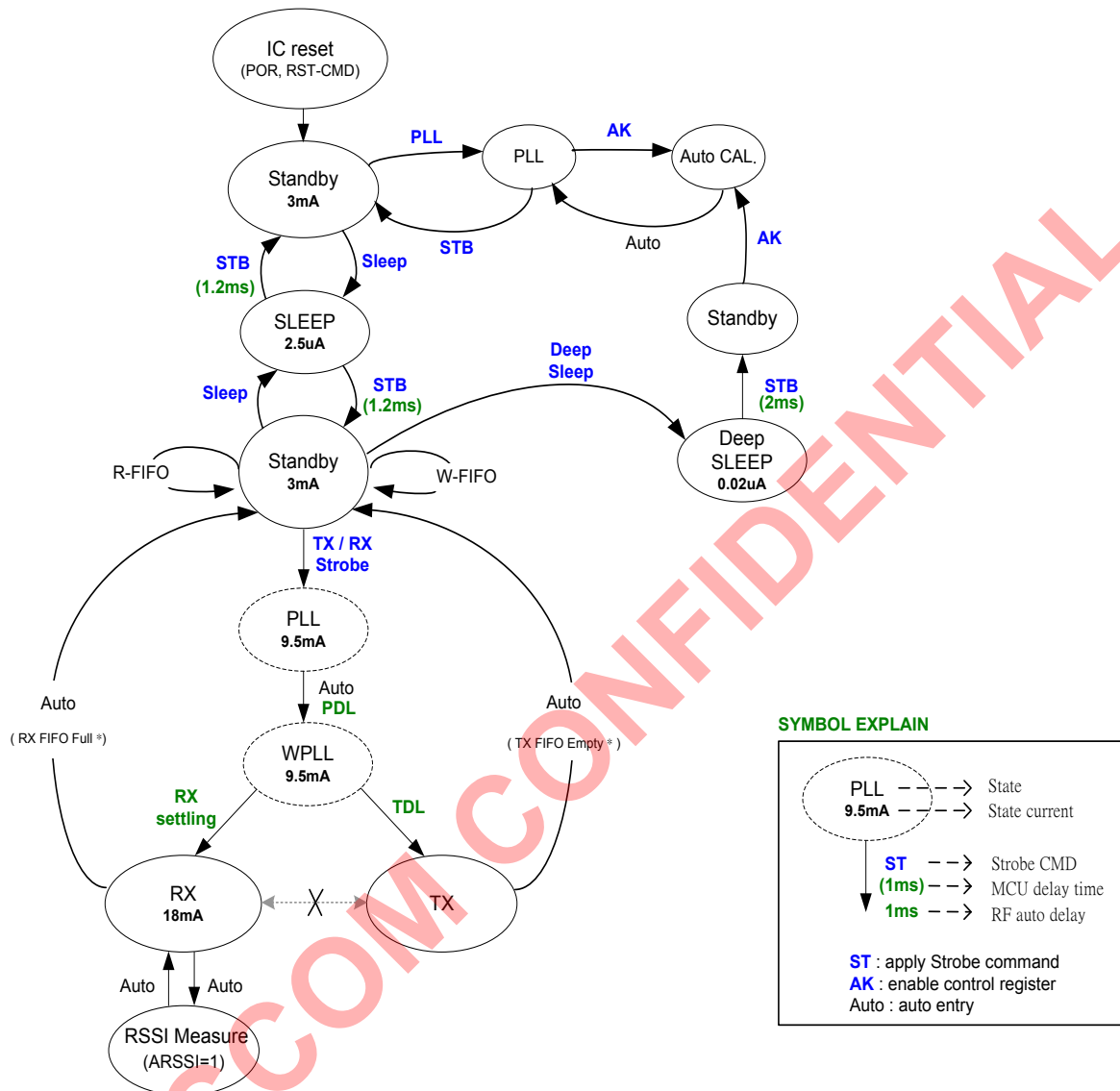


Figure 10.5 State diagram of FIFO MODE.

11. SoC Architectural Overview

A3117M0 microcontroller is instruction set compatible with Cortex™-M0 profile processors.

A3117M0 integrates many features, three 8/16bit counters/timers, watchdog timer, RTC, UART, SPI interface, I²C interface, 4 channels PWM, 8 channels ADC and battery detector, The interrupt controller is extended to support 6 interrupt sources; watchdog timer, RTC, SPI, I²C, ADC and RF.

A3117M0 includes SWD debug circuitry that provides full time, real-time, in-circuit debugging.

11.1 ARM Cortex-M0

The Cortex™-M0 processor is a configurable, multistage, 32-bit RISC processor which has an AMBA AHB-Lite interface and includes an NVIC component. It also has optional hardware debug functionality.

The processor can execute Thumb code and is compatible with other Cortex™-M0 profile processors. The profile supports two MODEs - Thread MODE and Handler MODE. Handler MODE is entered as a result of an exception. An exception return can only be issued in Handler MODE. Thread MODE is entered on Reset and can be entered as a result of an exception return. The following figure shows the functional controller of the processor.

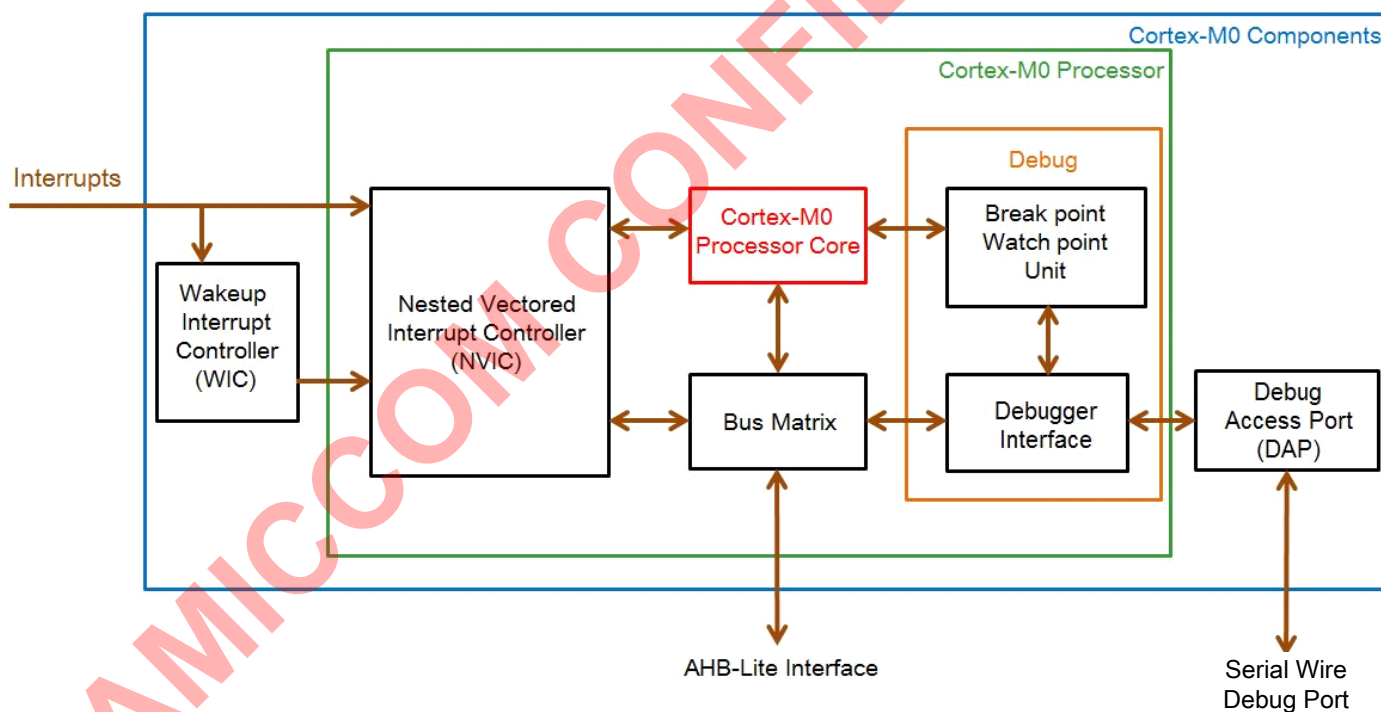


Figure 11.1 Core-M0 block diagram

11.1.1 Feature

- ◆ A low gate count processor
 - ARMv6-M Thumb® instruction set
 - Thumb-2 technology
 - ARMv6-M compliant 24-bit SysTick timer

- A 32-bit hardware multiplier
- System interface supported with little-endian data accesses
- Ability to have deterministic, fixed-latency, interrupt handling
- Load/store-multiples and multicycle-multiplies that can be abandoned and restarted to facilitate rapid interrupt handling
- C Application Binary Interface compliant exception MODEI:
This is the ARMv6-M, C Application Binary Interface (C-ABI) compliant exception MODEI that enables the use of pure C functions as interrupt handlers
- Low power Idle MODE entry using the Wait For Interrupt (WFI), Wait For Event (WFE) instructions, or return from interrupt sleep-on-exit feature
- ◆ NVIC
 - 32 external interrupt inputs, each with four levels of priority
 - Dedicated Non-maskable Interrupt (NMI) input
 - Supports for both level-sensitive and pulse-sensitive interrupt lines
 - Supports Wake-up Interrupt Controller (WIC) and, providing Ultra-low Power Idle MODE
- ◆ Debug support
 - Four hardware breakpoints
 - Two watch points
 - Program Counter Sampling Register (PCSR) for non-intrusive code profiling
 - Single step and vector catch capabilities
- ◆ Bus interfaces
 - Single 32-bit AMBA-3 AHB-Lite system interface that provides simple integration to all system peripherals and memory
 - Single 32-bit slave port that supports the DAP (Debug Access Port)

11.2 Memory Organization

The memory organization is shown as figure 11.2.

0xFFFF_FFFF	Reserved
0xE010_0000	Private Peripheral Bus
0xE000_0000	Reserved
0x5000_0000	AHB Peripherals
0x4008_0000	Reserved
0x4000_0000	APB Peripherals
	Reserved
0x2000_0000	RAM
	Reserved
0x1000_1000	UICR
	Reserved
0x1000_0000	FICR
	Reserved
0x0000_0000	Code

Figure 11.2 Memory Organization

11.3 Nested Vectored Interrupt Controller (NVIC)

The Cortex™-M0 CPU provides an interrupt controller as an integral part of the exception MODE, named as “Nested Vectored Interrupt Controller (NVIC)”, which is closely coupled to the processor core and provides following features.

11.3.1 Feature

- Flexible interrupt management

In the Cortex-M0 processor, each external interrupt can be enabled or disabled and can have its pending status set or clear by software. It can also accept exception requests at signal level (interrupt request from a peripheral remain asserted until the interrupt service routine clears the interrupt request), as well as an exception request pulse (minimum 1 clock cycle). This allows the interrupt controller to be used with any interrupt source.

- Nested interrupt support

In the Cortex-M0 processor, each exception has a priority level. The priority level can be fixed or programmable. When an exception occurs, such as an external interrupt, the NVIC will compare the priority of this exception to the current level. If the new exception has a higher priority, the current running task will be suspended. Some of the registers will be stored on to the

stack memory, and the processor will start executing the exception handler of the new exception. This process is called "preemption." When the higher priority exception handler is complete, it is terminated with an exception return operation and the processor automatically restores the registers from the stack and resumes the task that was running previously. This mechanism allows nesting of exception services without any software overhead.

- Vectored exception entry

When an exception occurs, the processor will need to locate the starting point of the corresponding exception handler. Traditionally, in ARM processors such as the ARM7TDMI, software usually handles this step. The Cortex-M0 automatically locates the starting point of the exception handler from a vector table in the memory.

As a result, the delay from the start of the exception to the execution of the exception handlers is reduced.

- Interrupt masking

The NVIC in the Cortex-M0 processor provides an interrupt masking feature via the PRIMASK special register. This can disable all exceptions except hard fault and NMI. This masking is useful for operations that should not be interrupted such as time critical control tasks or real-time multimedia codecs.

11.3.2 Exception Types and Interrupt Map

Each exception source in the Cortex-M0 processor has a unique exception number. The exception number for NMI is 2, and the exception numbers for the on-chip peripherals and external interrupt sources are from 16 to 47. The other exception numbers, from 1 to 15, are for system exceptions generated inside the processor, although some of the exception numbers in this range are not used. Each exception type also has an associated priority. The priority levels of some exceptions are fixed and some are programmable. Table 11.1 shows the exception types, exception numbers, and priority levels.

Exception Number	Exception Type	Priority	Interrupt Description
1	Reset	-3(Highest)	Reset
2	NMI	-2	Non maskable interrupt
3	Hard fault	-1	Fault handing exception
4-10	Reserved	--	--
11	SVC	Programmable	Supervisor call via SVC instruction
12-13	Reserved	--	--
14	PendSV	Programmable	Pendable request for system service
15	SysTick	Programmable	System tick timer
16-47	IRQ0~IRQ31	Programmable	IRQ

Table 11.1 Exception Types

Exception Number	Interrupt Number Bit	Interrupt Name	Interrupt Description
16	0	--	-
17	1	UART0_INT	UART0 Tx/Rx/Overflow interrupt
18	2	SLPTMR0_INT	Sleep timer0 interrupt
19	3	RADIO_INT	RADIO interrupt
20	4	--	--
21	5	UART2_INT	UART2 Tx/Rx/Overflow interrupt
22	6	GPIO0_INT	GPIO 0 combined interrupt for AHB GPIO and I/O port GPIO
23	7	--	--
24	8	TIMER0_INT	Timer0 interrupt
25	9	TIMER1_INT	Timer1 interrupt
26	10	Dual_Timer_INT	Dual Timer interrupt
27	11	MPU_LCD_INT	MPU_LCD interrupt
28	12	FSYNC	FSYNC interrupt
29	13	UART1_INT	UART1 Tx/Rx/Overflow interrupt
30	14	--	--
31	15	WUN_INT	WUN interrupt
32	16	SPI_INT	SPI interrupt
33	17	I ² C_INT	I ² CM/I ² CS interrupt
34	18	RTC_INT	Real Time Counter interrupt
35	19	--	--
36	20	AES_INT	AES/CCM interrupt
37	21	ADC_INT	12bits-ADC interrupt
38	22	--	--
39	23	--	--
40	24	SLPTMR1_INT	Sleep timer1 interrupt
41	25	--	--
42	26	--	--
43	27	--	--
44	28	--	--
45	29	--	--
46	30	--	--
47	31	EXT_INT	External signal interrupt from 0x50001300 bit[10] bit[9] bit[8] bit[5]

Table 11.2 Interrupt Map Vector Table

11.4 Reset source

Reset circuitry allows A3117M0 to be easily placed in a predefined default condition. LVD, Reset, POR, NVIC reset, and Watchdog signal will reset A3117M0 when they happen.

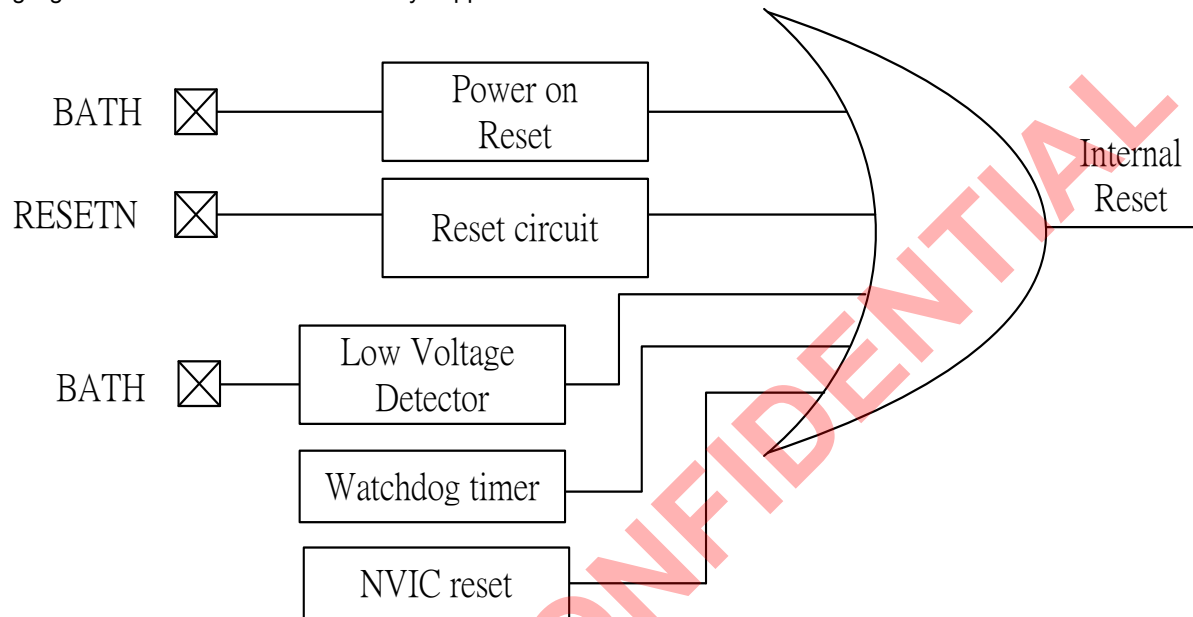


Figure 11.3 Reset source

11.5 Clock Source

A3117M0 has three clock source, crystal oscillator (XI, XO), RTC crystal (P0.22, P0.23/ RTC_I, RTC_O) and internal RC oscillator. In the MCU part (digital peripherals), user chooses the suitable clock source by power consumptions and performance. In the RF part, the clock source only comes from XTAL.

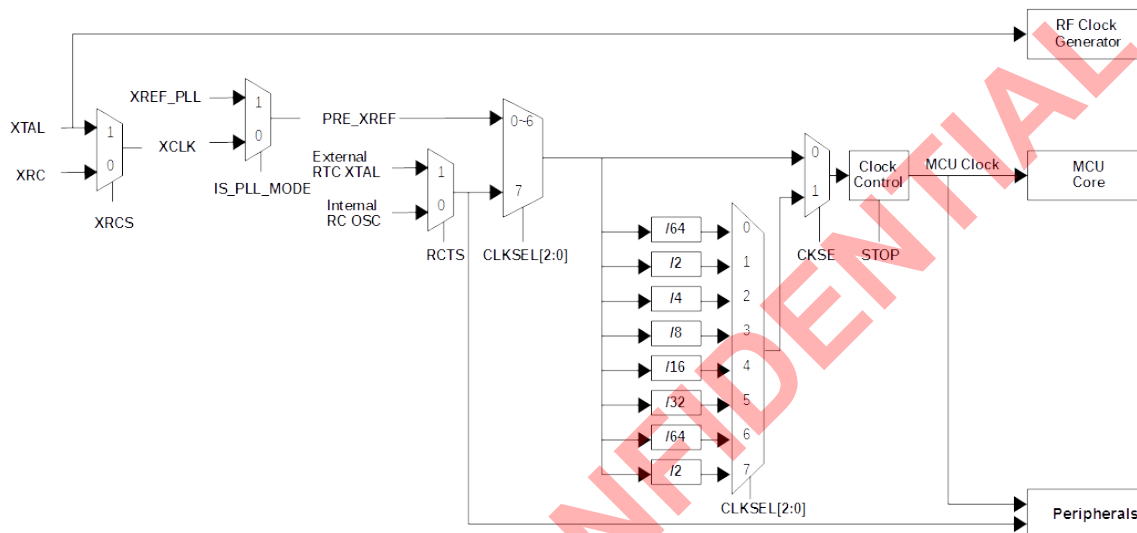


Figure 11.4 Whole chip clock

11.5.1 Turn on XREF_PLL

XREF_PLL control Register (0x4001F308)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	DBRS	DBBS	MCUSWS		IS_PLL_Mode	EN_PLL	WS_CFG1	WS_CFG0
R								
Reset	0	0	0	0	0	0	1	0

DBRS: Reserved.

DBBS: Reserved.

MCUSWS: Reserved.

IS_PLL_Mode: select CPU clock source.

[0]: XREF

[1]: XREF_PLL

EN_PLL: enable PLL.

WS_CFG[1:0]: Wait state configuration.

User can follow the step as blow to turn on XREF_PLL 48MHz:

1. Wait state configuration (0x4001F308) = (0<<0) | (1<<1)
2. Enable EN_PLL (0x4001F308) = (1<<2)
3. Select XREF_PLL for CPU clock (0x4001F308) = (1<<3)

User can follow the step as blow to turn off XREF_PLL 48MHz:

1. Select XREF for CPU clock (0x4001F308) = (0<<3)
2. Disable EN_PLL (0x4001F308) = (0<<2)
3. Wait state configuration (0x4001F308) = (0<<0) | (0<<1)

11.6 System Timer (SysTick)

The SysTick timer is a 24-bit down counter. It reloads automatically after reaching zero, and the reload value is programmable. When reaching zero, the timer can generate a SysTick exception (exception number 15). For the Cortex-M0 processor, a simple timer called the SysTick is included to generate this regular interrupt request.

11.6.1 SysTick Control and Status Register (Address:0xE000E010)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W	--							
R	--							
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W	--							
R	--							COUNTFLAG
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	--							
R	--							
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--					CLKSOURCE	TICKINT	ENABLE
R	--					CLKSOURCE	TICKINT	ENABLE
Reset	0	0	0	0	0	0	0	0

COUNTFLAG: Returns 1 if timer counted to 0 since the last read of this register.

CLKSOURCE : Selects the SysTick timer clock source

0 = external reference clock

1 = processor clock.

CLKSOURCE needs to be set 1 when uses SysTick.

TICKINT: Enables SysTick exception request

0 = counting down to zero does not assert the SysTick exception request

1 = counting down to zero to asserts the SysTick exception request.

ENABLE: Enables the counter

0 = counter disabled

1 = counter enabled.

11.6.2 SysTick Reload Value Register (Address:0xE000E014)

R/W	Bit 31	-----	Bit 24	Bit 23	-----	Bit 0
W	--			--		
R	--			RELOAD[23:0]		
Reset	0x0			0x000		

RELOAD[23:0]: Value to load into the SysTick when the counter is enabled and when it reaches 0.

11.6.3 SysTick Current Value Register (Address:0xE000E018)

R/W	Bit 31	-----	Bit 24	Bit 23	-----	Bit 0
W	--			--		
R	--			CURRENT[23:0]		
Reset	0x0			0x000		

CURRENT[23:0]: Reads return the current value of the SysTick counter.

11.7 Slow Clock Source

A3117M0 support two slow clock sources: internal RC oscillator and extern RTC crystal. User can set RCTS=0 or 1 to select internal RC-OSC or external RTC-XTAL. Slow clock source is the clock source for slow peripherals to keep work when MCU enter PM (power management) mode. For example: Sleep Timer, Real Time Counter.

11.7.1 Relate Register

RC Control Register 1 (Address: 0x50000040)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--	--	MCALS	RTCIOSEL	RCTS	TMRE	MAN	ENCAL
R	--	--	MCALS	RTCIOSEL	RCTS	TMRE	MAN	ENCAL
Reset	0	0	0	0	0	0	0	0

MCALS: Enable Continuous RC-OSC Calibration.

[0]: Continuous mode.

[1]: Single mode.

RTCIOSEL: RTC XTAL I/O select

[1]: RTC XTAL

[0]: Normal I/O

RCTS: Internal Oscillator / External Crystal selection.

[0]: Internal RC OSC

[1]: External RTC XTAL.

TMRE: Internal RC OSC / External RTC XTAL enable.

[0]: Disable.

[1]: Enable.

MAN: Internal RC OSC Calibration type.

[0]: Auto calibration

[1]: Manual calibration

ENCAL: Enable Internal RC OSC calibration.

[0]: Disable

[1]: Enable (Auto clear to 0 when calibration finish)

RC Control Register 2 (Address: 0x50000044)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W	--				RC_WSEL[1:0]		MVS[1:0]	
R	--				RC_WSEL[1:0]		MVS[1:0]	
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W	--					RCOT[2:0]		
R	--					RCOT[2:0]		
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8

W	--						MRCT[9:8]	
R	--						RCOC[9:8]	
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	MRCT[7:0]							
R	RCOC[7:0]							
Reset	0	0	0	0	0	0	0	0

RC_WSEL [1:0]: Clock select for internal RC oscillator Calibration

[00]: 16 MHz

[01]: 8 MHz

[10]: 4 MHz

[11]: 2MHz

MVS[1:0]: RCOSC Calibration sample clock select.

[00]: 1/2.

[01]: 1/4.

[10]: 1/8.

[11]: 1/16

RCOT[2:0]: RCOSC current select. Recommend set value is 4.

MRCT [9:0]: WOR/RCOSC manual setting value.

RCOC [9:0]: WOR Calibration value.

RC Target Register (Address: 0x50000048)

R/W	Bit 15	-----	Bit 12	Bit 11	-----	Bit 0
W	--			TGNUM[11:0]		
R	--			NUMLH[11:0]		
Reset	0x0			0x000		

TGNUM[11:0]: Target Number for RC OSC Calibration for RCOSC auto-calibration.

NUMLH[11:0]: WOR Calibration value.

11.7.2 Turn on External RTC XTAL

User can follow the step as blow to turn on external RTC XTAL:

4. POALTFUNCSET (0x40010018) = (1<<22) | (1<<23)
5. RCCTRL1 (0x50000040) = 0x00
6. RCCTRL1 (0x50000040) = 0x18 (Set RCTS=1, RTCIOSEL=1)
7. RCCTRL1 (0x50000040) = 0x1C (Set TMRE=1)
8. Delay sometime for External RTC XTAL stable (about 100ms, depend on RTC XTAL)

11.7.3 Turn on Internal RC OSC

User can follow the step as blow to turn on internal RC OSC:

1. RCCTRL1 (0x50000040) = 0x00
2. RCCTRL2 (0x50000044) = 0x03040012
3. RCTARGET (0x50000048) = 977 (for 32.768KHz) or 1000 (for 32KHz)
4. RCCTRL1 (0x50000040) = 0x04 (Set TMRE=1)
5. RCCTRL1 (0x50000040) = 0x05 (Set ENCAL=1)
6. Check RCCTRL1 until ENCAL auto clear to 0 (about 10ms)

12. I/O Ports

12.1 FEATURE

- Support High impedance
- Support Pull-up resistor
- Support Wakeup pin
- Support 4 types GPIO Interrupt
- Support High Driving Current Output

12.2 BLOCK DIAGRAM

Each GPIO has the same structure as below:

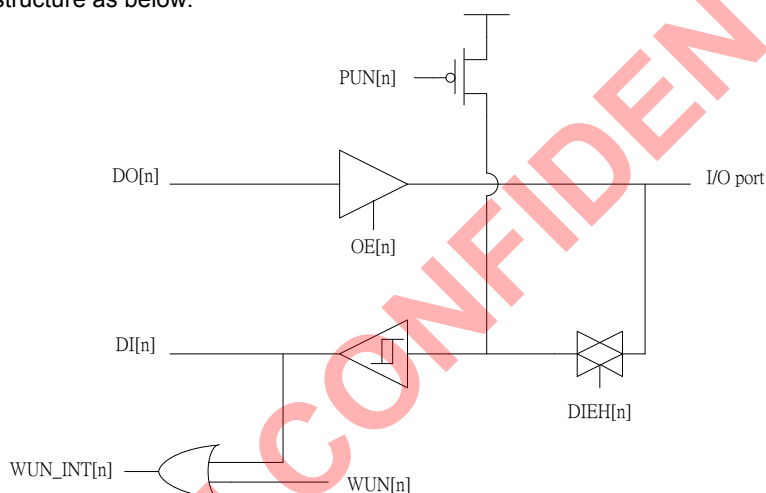


Figure 12.1 I/O Block Diagram

12.3 REGISTER

12.3.1 Register List

Address	Name	DESCRIPTION
0x40010000	P0DATA	Port 0 Data Register
0x40010004	P0DATAOUT	Port 0 Data Out Register
0x40010008	P0PUN	Port 0 Pull Up Not Register
0x4001000C	P0WUN	Port 0 Wakeup Enable Not Register
0x40010010	P0OUTENABLESET	Port 0 Output Enable Set Register
0x40010014	P0OUTENABLECLR	Port 0 Output Enable Clear Register
0x40010018	P0ALTFUNCSET	Port 0 Alternative Function Set Register
0x4001001C	P0ALTFUNCCLR	Port 0 Alternative Function Clear Register
0x40010020	P0INTENSET	Port 0 Interrupt Enable Set Register
0x40010024	P0INTENCLR	Port 0 Interrupt Enable Clear Register
0x40010028	P0INTTYPESET	Port 0 Interrupt Type Set Register
0x4001002C	P0INTTYPECLR	Port 0 Interrupt Type Clear Register
0x40010030	P0INTPOLSET	Port 0 Interrupt Polarity Set Register
0x40010034	P0INTPOLCLR	Port 0 Interrupt Polarity Clear Register
0x40010038	P0INTSTATUS	Port 0 Interrupt Request Status Register
0x5000004C	HDV	Port 0 High Driving Current Output Register
0x5000002C	P0DIEH	Port 0 High impedance Set Register(P0.7~P0.0)
0x50000030	P0DIEH	Port 0 High impedance Set Register(P0.15~P0.8)
0x50000034	P0DIEH	Port 0 High impedance Set Register(P0.23~P0.16)

0x50000038	P0DIEH	Port 0 High impedance Set Register(P0.31~P0.24)
0x5000003C	P0PLSH	P0.29~P0.26 PLSH Set Register

Table 12.1 GPIO0 Register list

12.3.2 Register Description

Port 0 Data Register (Address: 0x40010000)

R/W	Bit 31	-----	Bit 0
W		P0DATAOUT [31:0]	
R		P0DATA [31:0]	
Reset		0x00000000	

P0DATAOUT[31:0]: Port 0 data out (output data, DO)

P0DATA[31:0]: Port 0 data (input data, DI)

Port 0 Data Out Register (Address: 0x40010004)

R/W	Bit 31	-----	Bit 0
W		P0DATAOUT [31:0]	
R			
Reset		0x00000000	

P0DATAOUT[31:0]: Port 0 data out (output data, DO)

Port 0 Pull Up Not Register (Address: 0x40010008)

R/W	Bit 31	-----	Bit 0
W		P0PUN [31:0]	
R			
Reset		0x00000000	

P0PUN[31:0]: Port 0 Pull Up Not

[0]: Pull up resistor enable (input setting usually).

[1]: Pull up resistor disable (output setting usually)

Port 0 Wakeup Enable Not Register (Address: 0x4001000C)

R/W	Bit 31	-----	Bit 0
W		P0WUN [31:0]	
R			
Reset		0xFFFFFFFF	

P0WUN[31:0]: Port 0 Wake Up Enable Not

[0]: IO pin wakeup enable

[1]: IO pin wakeup disable

Port 0 Output Enable Set Register (Address: 0x40010010)

R/W	Bit 31	-----	Bit 0
W		P0OUTENABLESET [31:0]	
R		P0OUTENABLE [31:0]	
Reset		0x00000000	

P0OUTENABLESET [31:0]: Port 0 Output Enable Set

[0]: No effect

[1]: Output enable set. (Set IO pin to output)

P0OUTENABLE[31:0]: Port 0 Output Enable

[0]: IO pin is input

[1]: IO pin is output.

Port 0 Output Enable Clear Register (Address: 0x40010014)

R/W	Bit 31	-----	Bit 0
-----	--------	-------	-------

W	P0OUTENABLECLR [31:0]
R	P0OUTENABLE [31:0]
Reset	0x00000000

P0OUTENABLECLR [31:0]: Port 0 Output Enable Clear

[0]: No effect

[1]: Output enable clean (set IO pin to input).

P0OUTENABLE[31:0]: Port 0 Output Enable

[0]: IO pin is input

[1]: IO pin is output.

Port 0 Alternative Function Set Register (Address: 0x40010018)

R/W	Bit 31	-----	Bit 0
W		P0ALTFUNCSET [31:0]	
R		P0ALTFUNC [31:0]	
Reset		0x00000000	

P0ALTFUNCSET [31:0]: Alternative function set

[0]: No effect

[1]: Alternative function set (alternative function enable).

P0ALTFUNC[31:0]: Alternative function status

[0]: Alternative function disable (GPIO).

[1]: Alternative function enable (Multi-function IO)

Port 0 Alternative Function Clear Register (Address: 0x4001001C)

R/W	Bit 31	-----	Bit 0
W		P0ALTFUNCCLR [31:0]	
R		P0ALTFUNC [31:0]	
Reset		0x00000000	

P0ALTFUNCCLR [31:0]: Alternative function clear

[0]: No effect

[1]: Alternative function clean (alternative function disable)..

P0ALTFUNC[31:0]: Alternative function status

[0]: Alternative function disable (GPIO)

[1]: Alternative function enable (Multi-function IO)

Port 0 Interrupt Enable Set Register (Address: 0x40010020)

R/W	Bit 31	-----	Bit 0
W		POINTENSET [31:0]	
R		POINTEN [31:0]	
Reset		0x00000000	

POINTENSET[31:0]: Port 0 interrupt enable set

[0]: No effect

[1]: Interrupt enable set (interrupt enable)

POINTEN[31:0]: Port 0 interrupt enable status

[0]: Interrupt disable

[1]: Interrupt enable

Port 0 Interrupt Enable Clear Register (Address: 0x40010024)

R/W	Bit 31	-----	Bit 0
W		POINTENCLR [31:0]	
R		POINTEN [31:0]	
Reset		0x00000000	

POINTENCLR[31:0]: Port 0 interrupt enable clear

[0]: No effect
[1]: Interrupt enable clear (interrupt disable)

POINTEN[31:0]: Port 0 interrupt enable status

[0]: Interrupt disable
[1]: Interrupt enable

Port 0 Interrupt Type Set Register (Address: 0x40010028)

R/W	Bit 31	-----	Bit 0
W		POINTTYPESET [31:0]	
R		POINTTYPE [31:0]	
Reset		0x00000000	

POINTTYPESET[31:0]: Port 0 interrupt type set

[0]: No effect
[1]: Interrupt type set (interrupt by edge)

POINTTYPE[31:0]: Port 0 interrupt type status

[0]: Interrupt by level
[1]: Interrupt by edge

Port 0 Interrupt Type Clear Register (Address: 0x4001002C)

R/W	Bit 31	-----	Bit 0
W		POINTTYPECLR [31:0]	
R		POINTTYPE [31:0]	
Reset		0x00000000	

POINTTYPECLR[31:0]: Port 0 interrupt type clear

[0]: No effect
[1]: Interrupt type clean (interrupt by level).

POINTTYPE[31:0]: Port 0 interrupt type status

[0]: Interrupt by level
[1]: Interrupt by edge

Port 0 Interrupt Polarity Set Register (Address: 0x40010030)

R/W	Bit 31	-----	Bit 0
W		POINTPOLSET [31:0]	
R		POINTPOL [31:0]	
Reset		0x00000000	

POINTPOLSET[31:0]: Port 0 interrupt level set

[0]: No effect
[1]: Polarity-level set (high level or rising edge)

POINTPOL[31:0]: Port 0 interrupt level status

[0]: Low level or falling edge
[1]: High level or rising edge

Port 0 Interrupt Polarity Clear Register (Address: 0x40010034)

R/W	Bit 31	-----	Bit 0
W		POINTPOLCLR [31:0]	
R		POINTPOL [31:0]	
Reset		0x00000000	

POINTPOLCLR[31:0]: Port 0 interrupt level clear

[0]: No effect
[1]: Polarity-level clean (low level or falling edge)

POINTPOL[31:0]: Port 0 interrupt level status

[0]: Low level or falling edge

[1]: High level or rising edge

Port 0 Interrupt Request Status Register (Address: 0x40010038)

R/W	Bit 31	-----	Bit 0
W		POINTSTATUSCLR [31:0]	
R		POINTSTATUS [31:0]	
Reset		0x00000000	

POINTSTATUSCLR[31:0]: Port 0 interrupt request clear

[0]: No effect

[1]: Clear interrupt request status

POINTSTATUS[31:0]: Port 0 interrupt request status

[0]: No interrupt request

[1]: An interrupt request has occurred

Port 0 High Driving Current Output Register (Address: 0x5000004C)

R/W	Bit 31	-----	Bit 0
W		HDV [31:0]	
R		--	
Reset		0x00000000	

HDV[31:0]: Port0 High Driving Current Output Enable

[0]: Normal Driving Current Output

[1]: High Driving Current Output

Port 0 High Impedance Set Register (Address: 0x5000002C)

R/W	Bit 7	-----	Bit 0
W		DIEH [7:0]	
R		--	
Reset		0xFF	

DIEH[7:0]: P0[7:0] High impedance Set.

[1]: Non High impedance

[0]: High impedance

Note: must unlock protect PWR_TA before write.

Port 0 High Impedance Set Register (Address: 0x50000030)

R/W	Bit 7	-----	Bit 0
W		DIEH [15:8]	
R		--	
Reset		0xFF	

DIEH[15:8]: P0[15:8] High impedance Set.

[1]: Non High impedance

[0]: High impedance

Note: must unlock protect PWR_TA before write.

Port 0 High Impedance Set Register (Address: 0x50000034)

R/W	Bit 7	-----	Bit 0
W		DIEH [23:16]	
R		--	
Reset		0xFF	

DIEH[23:16]: P0[23:16] High impedance Set.

[1]: Non High impedance

[0]: High impedance

Note: must unlock protect PWR_TA before write.

Port 0 High Impedance Set Register (Address: 0x50000038)

R/W	Bit 7	-----	Bit 0
W	DIEH [31:24]		
R	--		
Reset	0xFF		

DIEH[31:24]: P0[31:24] High impedance Set.

[1]: Non High impedance

[0]: High impedance

Note: must unlock protect PWR_TA before write.

Port 0 PLSH Set Register (Address: 0x5000003C)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	PLSH [3:0]							
R	--							
Reset	0x00							

PLSH[3]: Reserved

PLSH[2]: Reserved

PLSH[1]: Reserved

PLSH[0]: Reserved

Note: must unlock protect PWR_TA before write.

12.4 FUNCTION DESCRIPTION

12.4.1 Output Enable (OE)

Each port has 32pins digital I/O Pins and each pin of port can be defined as general-purpose I/O (GPIO) or peripheral I/O signals connected to the timers, UART, I²C and SPI functions. Thus, each pin can also be used to wake up from PM mode.

User can select each pin function by setting register. Each port has itself port register like P0DATA (0x40010000). When reading, the logic levels of the Port's input pins are returned. As shown the below Table 12.2 and Table 12.3, each port has three registers to setting Pull-Up Not (PUN), Output-Enable (OE) and Wakeup enable Not (WUN). As shown the below block diagram, Figure 12.1 I/O Block Diagram. Unused I/O pins should have a defined level and not be left floating. One way to do this is to leave the pin unconnected and configure the pin as a general-purpose I/O input with pull-up resistor.

According the Table 12.2, all pins can be configured as Output, Input or Input with the pull-up resistor (around 100 Kohm). Please refer the Table 12.2 truth table to know every function setting. When OE=1, this pin is configured as Output. Otherwise OE=0, this pin is configured as Input. User can set PUN=1 or 0 depending on application. When OE=0, PUN=0 is recommended for saving power.

OE[n]	PUN[n]	I/O port status
0	0	input with pull high
0	1	input without pull high
1	1	output

Table 12.2 I/O Port setting

WUN[n]	Wakeup Interrupt (WUN_INT)
0	Enable*
1	Disable

* The I/O port must set to input(i.e. OE = 0).

Table 12.3 WUN_INT setting

12.4.2 WUN interrupt (WUN_INT)

The NVIC IRQn of WUN_INT is 15. Please refer Table 11.2. This interrupt can wake up MCU from PM1, PM2. Port 0.26~Port 0.29 can wakeup MCU and need to initial all needed peripherals.

All Port pins can wake MCU up when WUN=0 and configured GPIO. All Port pins' WUN signals connect one OR gate to WUN_INT. It means pin wake up function needs WUN_INT to take care this interrupt event.

User can use P0 port as key input and meanwhile these key are low to event a WUN_INT to wakeup MCU. It is a helpful use to design a remote controller and low power consumption with power saving mode setting.

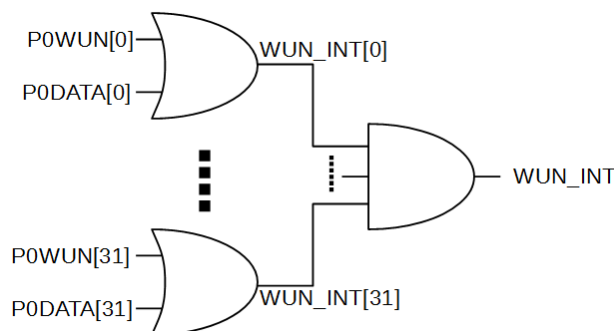


Figure 12.2 WUN_INT block diagram

12.4.3 GPIO0 interrupt (GPIO0_INT)

The NVIC IRQn of GPIO0_INT is 6. Please refer Table 11.2.. This interrupt can't wakeup MCU. GPIO0_INT supports 4 types IO interrupt. It needs work on normal mode. The setting of GPIO0_INT shows as Table 12.4.

P0INTTYPE	P0INTPOL	Interrupt by
0	0	Low level
0	1	High Level
1	0	Falling Edge
1	1	Rising Edge

Table 12.4 Port 0 interrupt setting table

12.4.4 High Driving Current Output

The HDV register (0x5000004C) can set Prots0 IO driving more current when output high and output low. Please refer chapter 8 Electrical Specification.

12.4.5 Debug Interface and Flash Mask

There are four IO pins need to notice: P0_06, P0_07, P0_10 and P0_12.

- P0_06, P0_07 will be set to SWDIO and SWCLK when P0_12 = 0 at reset.
- IC can't work normal and it is into debug status when P0_12 = 0 at reset.
- Flash will be mask (read out 0xFFFFFFFF) when P0_12=0 and P0_10=0 at reset.

GPIO pins	At Reset		After Rest		
	P0_12	P0_10	IO Pins	IO Status	Flash Status
P0_12	1	X	P0_12	Normal	Normal
P0_06			P0_06		
P0_07			P0_07		
P0_10			P0_10		
P0_12	0	1	P0_12	Debug	Normal
P0_06			SWDIO		
P0_07			SWCLK		
P0_10			P0_10		
P0_12	0	0	P0_12	Debug	MASKED (all ROM will read by 0xFFFFFFFF)
P0_06			SWDIO		
P0_07			SWCLK		
P0_10			P0_10		

X: don't care.

Table 12.5 The pins for debug interface and flash mask

Flash mask is a special measure when the MCU can't download code because of a program execution. User can use Flash Mask to mask flash ROM and erase flash ROM. Please pay attention to the use of restrictions when planning the circuit.

13. Timer

13.1 FEATURE

- Programmable 32-bits Timer
- Interrupt generator
- Support input-edge count or time-capture

13.2 PINS DESCRIPTION

PIN	GPIO	TYPE	DESCRIPTION
TIMER0EIN	P0_08	INPUT	EXTIN (external input) for Timer0
TIMER1EIN	P0_09	INPUT	EXTIN (external input) for Timer1

13.3 BLOCK DIAGRAM

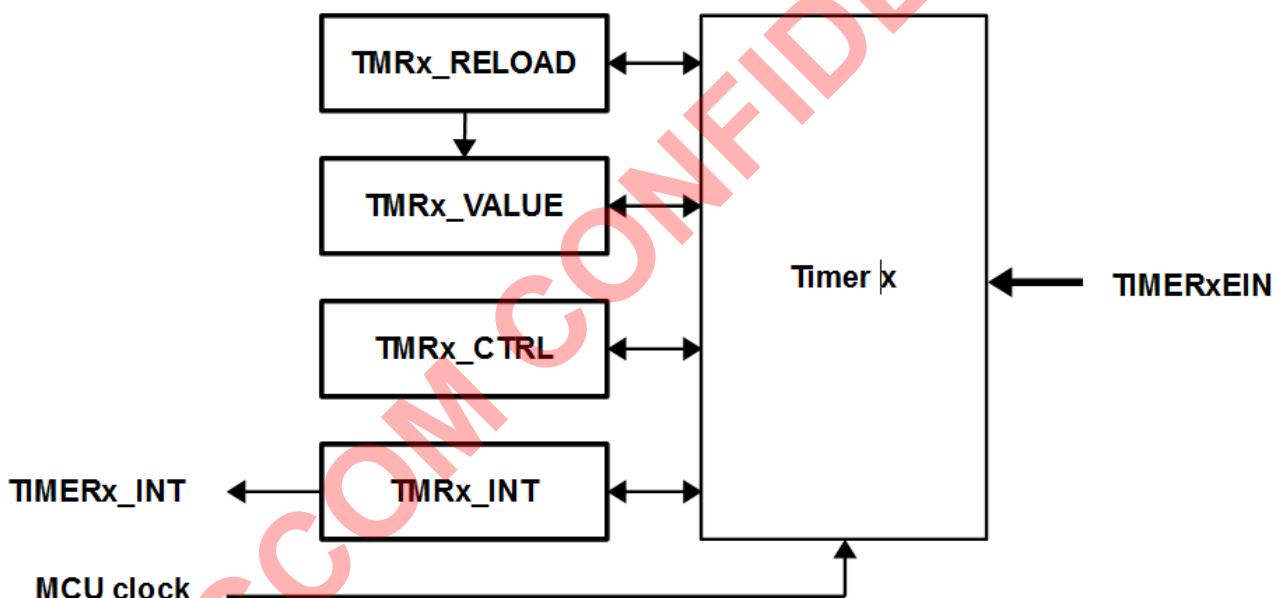


Figure 13.1 32-Bit Timer/Counter block diagram

13.4 REGISTER

13.4.1 Base Address List

Base Address	DESCRIPTION
0x40000000	TIMER0 Base address
0x40001000	TIMER1 Base address

Table 13.1 Base address list

13.4.2 Register List

offset	Name	DESCRIPTION
0x000	TMRx_CTRL	Timer x Control Register
0x004	TMRx_VALUE	Timer x Current Value Register
0x008	TMRx_RELOAD	Timer x Reload Register
0x00C	TMRx_INT	Timer x Interrupt Status Register

Table 13.2 Register list

13.4.3 Register Description

Timer x Control Register (Offset: 0x000)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--				CTRL [3:0]			
R								
Reset	0	0	0	0	0	0	0	0

CTRL[0]: Enable decrement control

[0]: Disable (Timer stop decrement)

[1]: Enable (Timer start decrement)

CTRL[1] : Select external input as enable

[0]: Disable

[1]: Enable (Timer stop when EXTIN=0)

CTRL[2] : Select external input as clock

[0]: Disable

[1]: Enable (Timer decrement when EXTIN rising edge)

CTRL[3] : Timer interrupt enable.

[0]: Disable

[1]: Enable

Timer x Current Value Register (Offset: 0x004)

R/W	Bit31	-----	Bit 0
W	VALUE [31:0]		
R			
Reset	0x00000000		

VALUE[31:0]: Current counter value.

Timer x Reload Register (Offset: 0x008)

R/W	Bit31	-----	Bit 0
W	RELOAD [31:0]		
R			
Reset	0x00000000		

RELOAD [31:0]: Reload value. VALUE[31:0] will be wrote when write RELOAD [31:0] immediately.

Timer x interrupt Status Register (Offset: 0x00C)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--							INTCLEAR
R								INTSTATUS
Reset	0	0	0	0	0	0	0	0

INTCLEAR:

[0]: No effect

[1]: Clear INTSTATUS

INTSTATUS: interrupt status (TIMERINT status)

[0]: Interrupt not occur

[1]: Interrupt occur

13.5 FUNCTION DESCRIPTION

13.5.1 VALUE and RELOAD

When any value write to RELOAD[31:0], the VALUE[31:0] will be write to the same value immediately. When timer CTRL[0]=1, the VALUE[31:0] start count-down with MCU clock or EXTIN rising edge. When VALUE[31:0] count-down to 0, the VALUE[31:0] will be write with RELOAD[31:0] in next clock or rising edge. Please refer Table 13.2.

13.5.2 Input-edge Counter

When CTRL[2]=1, Timer is in input-edge count mode. The value of Timer will count down when EXTIN rising edge. The interrupt will occur when VALUE[31:0] count down to 0 and VALUE[31:0] will set with RELOAD[31:0] in next EXTIN rising edge. Figure 13.2 and Figure 13.3 are examples for input-edge counter.

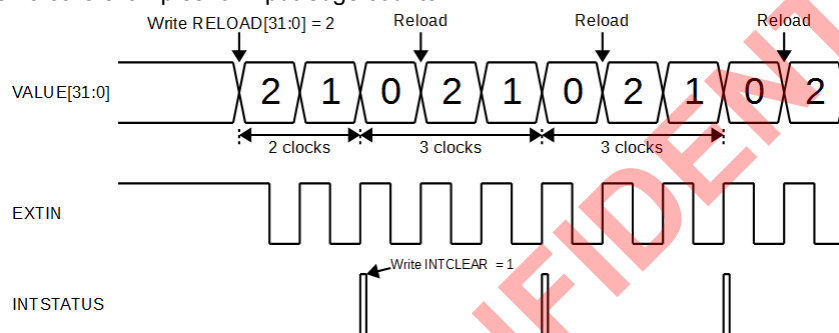


Figure 13.2 A example for input-edge count

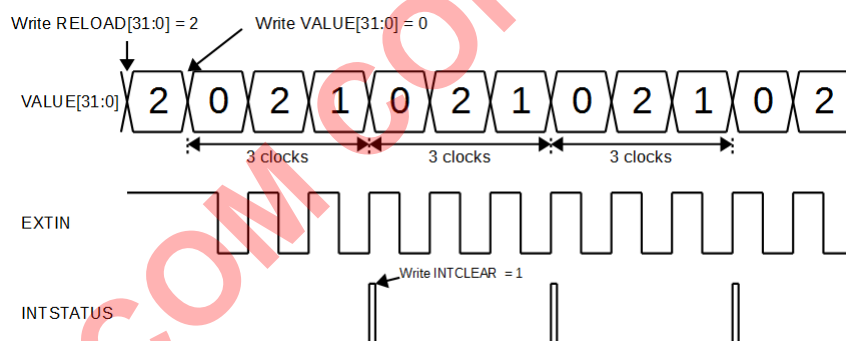


Figure 13.3 Another example for input-edge count

Note: EXTIN must be slower than half of the MCU clock.

13.5.3 Time Capture

When CTRL[1]=1, Timer is in time-capture mode. In this mode, timer will stop count-down when EXTIN=0. User can use this mode to capture time of EXTIN high.

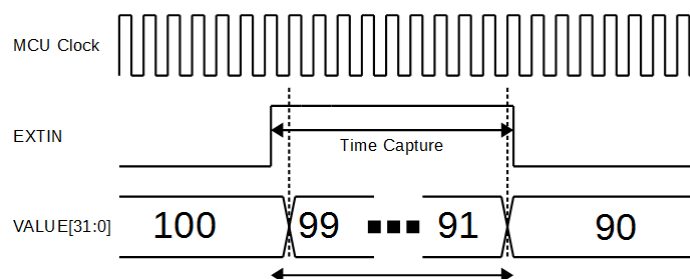


Figure 13.4 A example for time capture

13.5.4 Timer Interrupt

When VALUE[31:0] count-down to 0, the INTSTATUS will set to 1. The interrupt will occur if CTRL[3]=1. User need write INTCLEAR=1 to clear INTSTATUS. Please refer Figure 13.2

The NVIC IRQn of TIMER0 and TIMER1 is 8 and 9. Please refer Table 11.2 Interrupt Map Vector Table

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14. Dual Timer

Dual Timer is two programmable 32-bit down-counters with MCU clock. Interrupt will generate when any dual timer count-down to 0.

14.1 FEATURE

- Three clock pre-scale: 1, 16, 256
- Two counter sizes: 16-bits and 32-bits
- Three modes: free-running, one-shot and periodic
- One interrupt for two dual timers.
- Background Load

14.2 BLOCK DIAGRAM

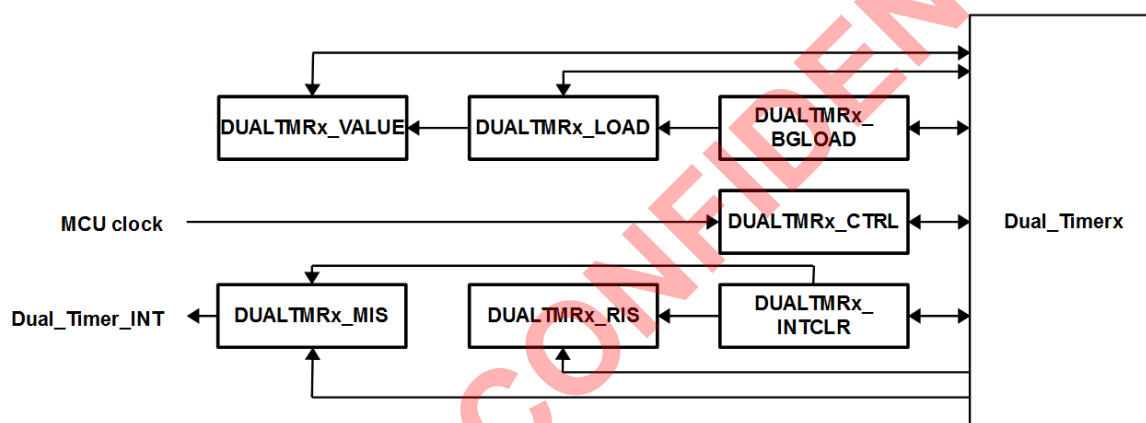


Figure 14.1 Dual Timer block diagram

14.3 REGISTER

14.3.1 Base Address List

Base Address	DESCRIPTION
0x40002000	Dual Timer 1 Base address
0x40002020	Dual Timer 2 Base address

Table 14.1 Base address list

14.3.2 Register List

Offset	Name	DESCRIPTION
0x00	DUALTMRx_LOAD	Dual Timer x Load register
0x04	DUALTMRx_VALUE	Dual Timer x current Value register
0x08	DUALTMRx_CTRL	Dual Timer x Control register
0x0C	DUALTMRx_INTCLR	Dual Timer x Interrupt Clear register
0x10	DUALTMRx_RIS	Dual Timer x Raw Interrupt register
0x14	DUALTMRx_MIS	Dual Timer x Mask Interrupt register
0x18	DUALTMRx_BGLOAD	Dual Timer x Back Ground Load register

Table 14.2 Register list

14.3.3 Register Description

Dual Timer x Load Register (Offset: 0x00)

R/W	Bit31	-----	Bit 0
W	LOAD[31:0]		
R			
Reset	0x00000000		

LOAD[31:0]: Dual timer x Load value. Write LOAD[31:0] will reset the VALUE[31:0] immediately.

Dual Timer x current Value Register (Offset: 0x04)

R/W	Bit31	-----	Bit 0
W	VALUE[31:0]		
R			
Reset	0x00000000		

VALUE[31:0]: Dual timer x current count value.

Dual Timer x Control Register (Offset: 0x08)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	EN	MD	INTEN	--	PRE[1:0]		SLT	OS
R								
Reset	0	0	1	0	0	0	0	0

EN: Dual timer x Enable

[0]: Disable

[1]: Enable (Dual timer start count down)

MD: Dual timer Mode

[0]: Free-running mode

[1]: Periodic mode

INTEN: Dual timer interrupt enable.

[0]: Dual Timer interrupt disable.

[1]: Dual Timer interrupt enable.

PRE[1:0]: Dual timer prescale.

[00]: Clock is divided by 1.

[01]: Clock is divided by 16

[10]: Clock is divided by 256

[11]: Undefined

SLT: Dual timer size selects 16-bit or 32-bit counter operation

[0]: 16-bit counter

[1]: 32-bit counter

OS: Dual timer one-shot count selects

[0]: Wrapping

[1]: One-shot

Dual Timer x Interrupt Clear Register (Offset: 0x0C)

R/W	Bit31	-----	Bit 0
W	INTCLR		
R			
Reset	0x00000000		

INTCLR: Timer interrupt clear. Write any value to this register to clean RIS and MIS.

Dual Timer x RIS Register (Offset: 0x10)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W								--
R								RIS
Reset	0	0	0	0	0	0	0	0

RIS: Dual timer Raw interrupt status.

[0]: VALUE[31:0] not counts down to 0.

[1]: VALUE[31:0] had counted down to 0.

Dual Timer x MIS Register (Offset: 0x14)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W								--
R								MIS
Reset	0	0	0	0	0	0	0	0

MIS: Dual timer interrupt enabled status from the counter.

[0]: INTEN=0 or RIS=0. Dual Timer interrupt not occur.

[1]: INTEN=1 and RIS=1. Dual Timer interrupt occur.

Dual Timer x Background Load Register (Offset: 0x18)

R/W	Bit31	-----	Bit 0
W	BGLOAD[31:0]		
R	BGLOAD[31:0]		
Reset	0x00000000		

BGLOAD[31:0]: Dual timer Background Load. Write BGLOAD[31:0] will set LOAD[31:0] to BGLOAD[31:0] immediately but not effect to VALUE[31:0].

14.4 FUNCTION DESCRIPTION

14.4.1 Operation Mode

The BIT0 of DUALTMRx_CTRL is OS and the BIT6 of DUALTMR_CTRL is MD. These control bits can set dual timer to three operation mode:

OS	MD	Operation	VALUE reload when counts down to 0
0	0	Free-running	0xFFFF or 0xFFFFFFFF
0	1	Period	LOAD
1	X	One-Shot	Dual Timer Halted. Write LOAD to re-start dual timer.

Table 14.3 Dual Timer operation modes

14.4.2 LOAD and BGLOAD

Dual timer has two reload register: LOAD[31:0] and BGLOAD[31:0]. VALUE[31:0] will be set to LOAD[31:0] when any value write to LOAD[31:0] immediately. LOAD[31:0] will be set to BGLOAD[31:0] when any value write to BGLOAD[31:0] and the same time, VALUE[31:0] will not any effect. Figure 14.2 is an example for write LOAD[31:0] and write BGLOAD[31:0].

Write LOAD[31:0] can modify period and current counting immediately. Write BGLOAD[31:0] can modify period at next time count-down to 0 but does not affect the current counting.

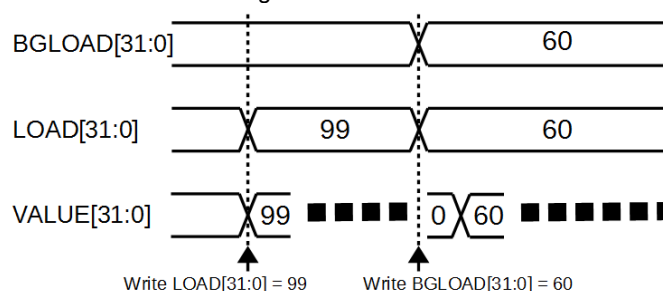


Figure 14.2 An example for write LOAD and BGLOAD

14.4.3 Interrupt

Dual timer 1 and Dual timer 2 have the same interrupt handler. Users can check MIS to distinguish interrupt source. The NVIC IRQn of Dual Timer is 10. Please refer Table 11.2 Interrupt Map Vector Table

Interrupt will occurred when VALUE[31:0] count-down to 0 and INTEN=1.

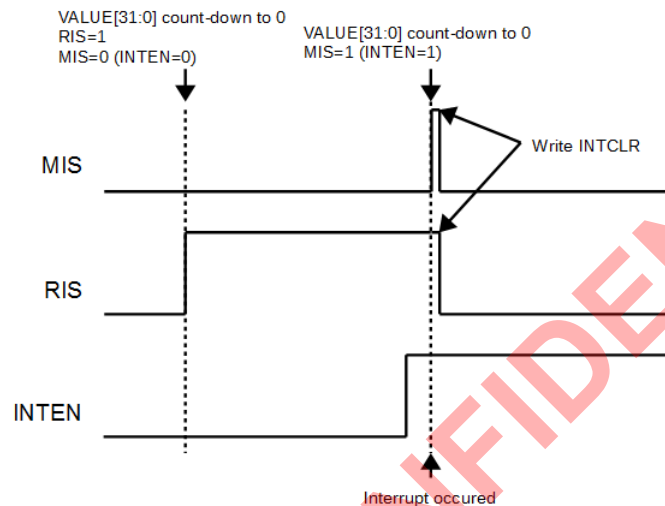


Figure 14.3 Dual Timer interrupt

There is a sample code for Dual timer handle show as below:

```
void DUALTIMER_Handler(void)
{
    if(DUALTIMER1->MIS & DUALTIMER_MASKINTSTAT_Msk)
    {
        DualTimer_ClearIRQ(DUALTIMER1);
        /* User code */
    }

    if(DUALTIMER2->MIS & DUALTIMER_MASKINTSTAT_Msk)
    {
        DualTimer_ClearIRQ(DUALTIMER2);
        /* User code */
    }
}
```

15. Sleep Timer

A3117M0 include two sleep timer: Sleep Timer0 and Sleep Timer1. Sleep timer 0 wakeup MCU from PM1, PM2, and PM3 mode. Sleep Timer 1 wakeup MCU from PM1 and PM2 mode.

15.1 FEATURES

- Two 16-bit timers and independent interrupts
- Programmable timer interval (ex. RTC clock=32.768KHz, 0.3125 ms~163.84 s)
- Programmable timer0 offset setting for entering Rx mode or Tx mode in advance

15.2 BLOCK DIAGRAM

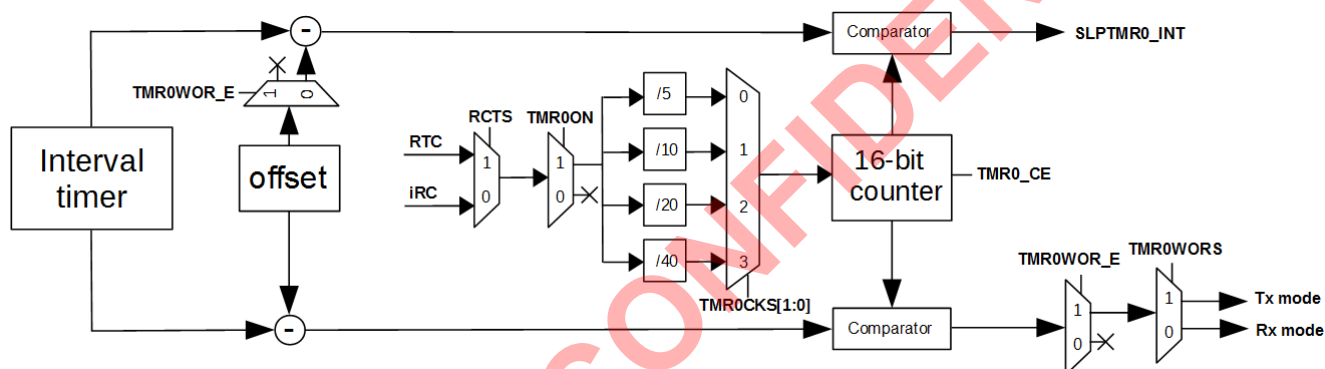


Figure 15.1 Sleep Timer0 Block Diagram

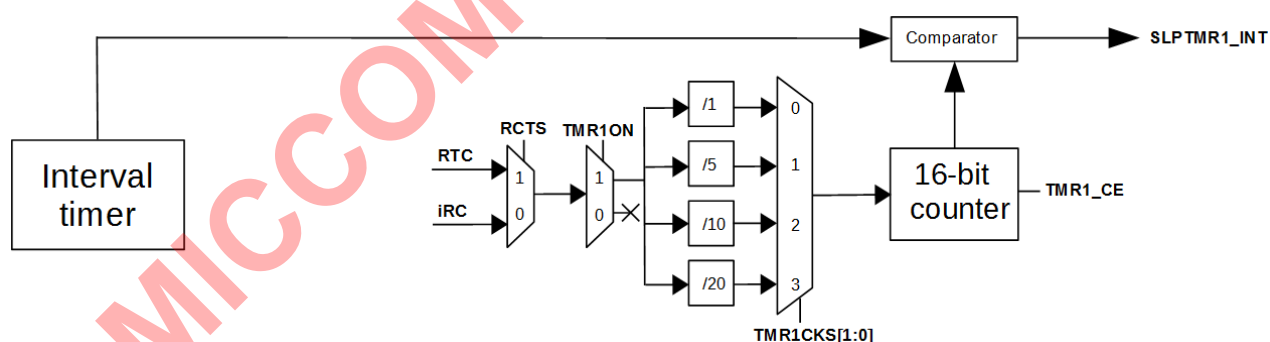


Figure 15.2 Sleep Timer1 Block Diagram

15.3 REGISTER

15.3.1 Register list

Address	Name	DESCRIPTION
0x50006000	STOIR	Sleep Timer0 Interval Register
0x50006004	ST0CR	Sleep Timer0 Control Register
0x50006010	ST1IR	Sleep Timer1 Interval Register
0x50006014	ST1CR	Sleep Timer1 Control Register

Table 15.1 Sleep Timer Register List

15.3.2 Register Description

Sleep Timer0 Interval Register (Address: 0x50006000)

R/W	Bit 15	-----	Bit 0
W	TMR0_ITV[15:0]		
R			
Reset	0x00000000		

TMR0_ITV [15:0]: Timer0 interval setting.

Timer0 interval time = 1/ (timer source clock frequency) * (TMR0_ITV[15:0] + 1)

Sleep Timer0 Control Register (Address: 0x50006004)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W	TMR0_RST	--						
R	--							
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W	--			TMR0_OFS[4:0]				
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	--		TMR0COR1	TMR0_PM3	TMR0WORS	TMR0SK	TMR0COR	TMR0WOR_E
R				--				
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	TMR0ON	TMR0IE	TMR0IF	--		TMR0CKS[1:0]		TMR0_CE
R								
Reset	0	0	0	0	0	0	0	0

TMR0_RST: Write to this bit to issue TMR0 reset command. (Write "1" to reset).

TMR0_OFS[4:0]: TMR0 interval offset for 16-bits Timer0.

TMR0COR1: Timer0 CLK re-correct when 2M mode SYNC.

[0]: Disable.

[1]: Enable.

TMR0_PM3: Reserved for internal usage. Should be set to [0]

TMR0WORS: Timer0 WOR / WOT selection.

[0]: Wakeup On Rx

[1]: Wakeup On Tx

TMR0SK: Must be set to [1] when TMR0COR set to [1].

[0]: Disable.

[1]: Enable.

TMR0COR: Timer0 CLK re-correct when SYNC.

[0]: Disable.

[1]: Enable.

TMR0WOR_E: Timer0 WOR / WOT enable.

[0]: Disable. Interrupt generates at (TMR0_ITV[15:0] + 1- TMR0_OFS[4:0])

[1]: Enable. Enter Rx / Tx mode at (TMR0_ITV[15:0] + 1- TMR0_OFS[4:0]) and interrupt generates at (TMR0_ITV[15:0]+1)

TMR0ON: Turn on TMR0CK.

[0]: Disable.

[1]: Enable.

TMR0IE: Timer0 Interrupt Enable. Must set to [1].

[0]: Disable.

[1]: Enable.

TMR0IF: Timer0 Interrupt Flag. (Must write "1" to clear if TMR0IF=1).

[0]: Interrupt not occur

[1]: Interrupt had occurred.

TMR0CKS [1:0]: Select Timer0 Source Clock.

[00]: RTC clock / 5

[01]: RTC clock / 10

[10]: RTC clock / 20

[11]: RTC clock / 40

TMR0_CE: Start Timer0 counter.

[0]: Stop.

[1]: Start.

Sleep Timer1 Interval Register (Address: 0x50006010)

R/W	Bit 15	-----	Bit 0
W	TMR1_ITV[15:0]		
R			
Reset	0x00000000		

TMR1_ITV [15:0]: Timer1 interval setting.

Timer1 interval = 1 / (timer source clock frequency) * (TMR1_ITV[15:0] + 1)

Sleep Timer1 Control Register (Address: 0x50006014)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W	TMR1_RST	--						
R	--							
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W	--							
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	--							
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	TMR1ON	TMR1IE	TMR1IF	--		TMR1CKS[1:0]		TMR1_CE
R								
Reset	0	0	0	0	0	0	0	0

TMR1_RST: Write to this bit to issue TMR1 reset command. (Write "1" to reset).

TMR1ON: Turn on TMR1CK.

[0]: Disable.

[1]: Enable.

TMR1IE: Timer1 Interrupt Enable. Must set to [1].

[0]: Disable.

[1]: Enable.

TMR1IF: Timer1 Interrupt Flag. (Must write "1" to clear if TMR1IF=1).

[0]: Interrupt not occur

[1]: Interrupt had occurred.

TMR1CKS [1:0]: Select Timer1 Source Clock

[00]: RTC clock

[01]: RTC clock / 5
[10]: RTC clock / 10
[11]: RTC clock / 20

TMR1_CE: Start Timer1 counter

[0]: Stop
[1]: Start

15.4 FUNCTION DESCRIPTION

A3117M0 has two 16-bit sleep timers. Each sleeper timer has a control register (STxCR), a time interval setting register (STxIR) and an independent interrupt. TMRxRST is setting for clear counter number. After writing target number into TMRx_ITV[15:0], user must enable TMRxIE select the clock source by setting TMRxCKS, turn on the clock source by setting TMRxON, and start timerx counter - up by setting TMRx_CE. When the counter target number is reached, counter number will turn into 0, then generate an interrupt signal. If MCU is in the PM mode, the interrupt signal will wake up MCU immediately. User need write TMRxIF =1 to clear INTSTATUS if TMRxIF =1. In addition, Sleeper timer0 has extra offset functions that can be used for entering Rx or Tx mode earlier by setting TMR0_OFS[4:0], TMR0WOR_E and TMR0WORS. List some example setting in table 15.2

RTC Clock = 32.768KHz					
Sleep timer	TMRxCKS	TMRx_ITV[15:0]	TMR0_OFS[4:0]	Timer0 interval offset	Timerx interval
Sleep Timer0	RTC clock / 5	655	0	0ms	100.098ms
Sleep Timer0	RTC clock / 5	655	31	4.73ms	100.098ms
Sleep Timer1	RTC clock	3276	0	0ms	100.006ms
Sleep Timer1	RTC clock / 5	655	0	0ms	100.098ms

Table 15.2 Some example setting

The NVIC IRQn of Sleep timer0 and Sleep timer1 is 2 and 24. Please refer Table 11.2

15.5 PROCEDURE

15.5.1 Sleep Timer0

Below is the procedure to set sleep timer0 (ex. Timer Interval 100.098ms, Tx mode offset 4.73ms)

- Step1: Set A3117M0 in STBY MODE.
- Step2: Set on RTC / IRC.
- Step3: Set on sleep timer0 NVIC IRQn.
- Step4: Set ST0CR (0x50006004), TMR0_RST=1.
- Step5: Set ST0CR (0x50006004), TMR0CKS [1:0]=0, TMR0IE=1, TMR0ON=1.
- Step6: Set ST0CR (0x50006004), TMR0_OFS [4:0]=31, TMR0WORS =1, TMR0WOR_E =1.
- Step7: Set ST0IR (0x50006000), TMR0_ITV[15:0]=655.
- Step8: Set ST0CR (0x50006004), TMR0_CE=1.
- Step9: Interrupt will occur if TMR0IF =1. User need write TMR0IF =1 to clear INTSTATUS.

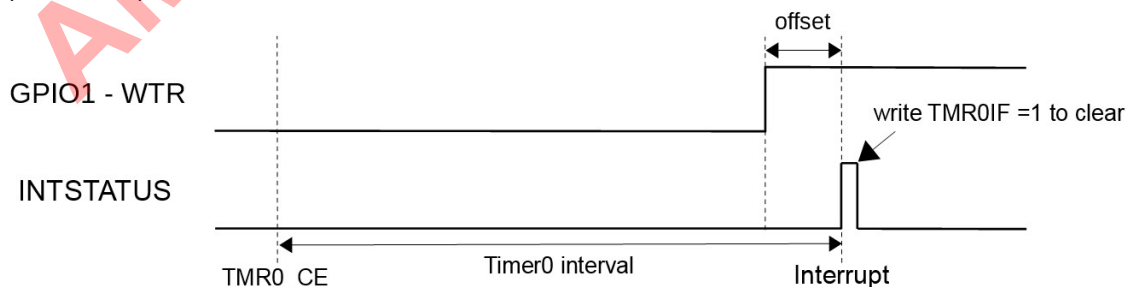


Figure 15.3 Sleep timer0 Function Diagram

15.5.2 Sleep Timer1

Below is the procedure to set sleep timer1. (ex. Timer Interval 100.098ms)

- Step1: Set A3117M0 in STBY MODE.
- Step2: Set on RTC / IRC.
- Step3: Set on sleep timer1 NVIC IRQn.
- Step4: Set ST1CR (0x50006014), TMR1_RST=1.
- Step5: Set ST1CR (0x50006014), TMR1CKS [1:0]=1, TMR1IE=1, TMR1ON=1.
- Step6: Set ST1IR (0x50006010), TMR1_ITV[15:0]=655.
- Step7: Set ST1CR (0x50006014), TMR1_CE=1.
- Step8: Interrupt will occur if TMR1IF =1. User need write TMR1IF =1 to clear INTSTATUS.

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16. Watchdog Timer

A3117M0 has a special timer, called Watchdog Timer. It is a useful programmable clock counter that serves as a time-base generator, an event timer or system supervisor. User can use be a very long timer with disabled reset function.

16.1 FEATURE

- The 32-bit free-running down-counter
- Lock register to prevent accidental write access
- Interrupt and Reset generation

16.2 BLOCK DIAGRAM

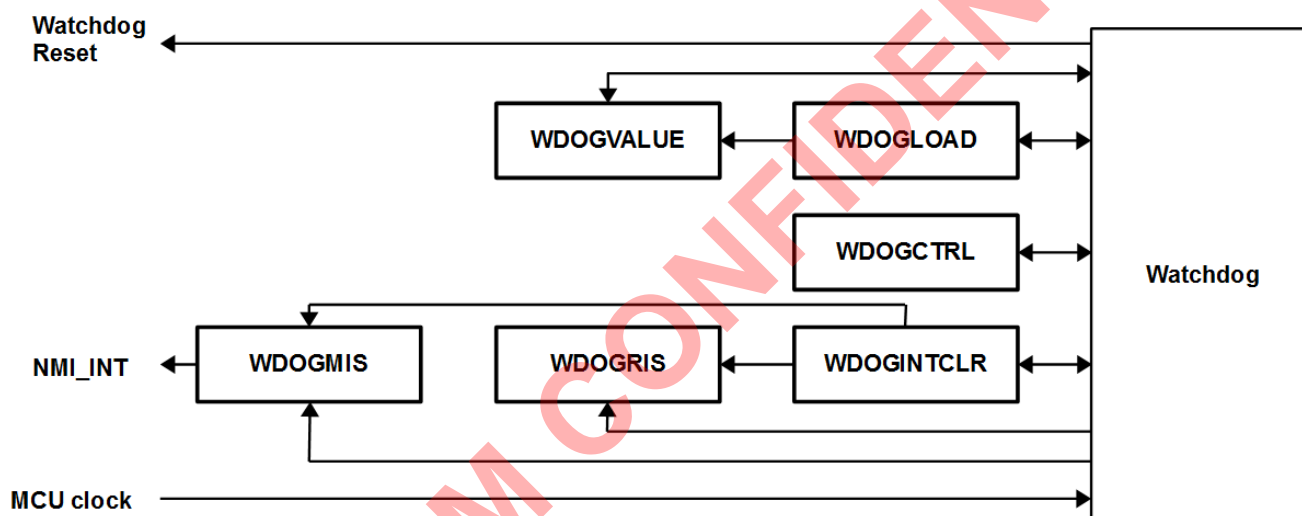


Figure 16.1 Watchdog block diagram

16.3 REGISTER

16.3.1 Register List

Address	Name	DESCRIPTION
0x40008000	WDOGLOAD	Watchdog Load Register
0x40008004	WDOGVAlUE	Watchdog Value Register
0x40008008	WDOGCTRL	Watchdog Control Register
0x4000800C	WDOGINTCLR	Watchdog Interrupt Clean Register
0x40008010	WDOGRIS	Watchdog Raw Interrupt Status Register
0x40008014	WDOGMIS	Watchdog Enabled Interrupt Status Register
0x40008C00	WDOGLOCK	Watchdog Lock Register

Table 16.1 Watchdog register list

16.3.2 Register Description

Watchdog Load Register (Address: 0x40008000)

R/W	Bit 31	-----	Bit 0
W		LOAD[31:0]	
R			
Reset		0xFFFFFFFF	

LOAD [31:0]: The minimum valid value for WDOGLOAD is 1.

WDOGVALUE (Watchdog Value Register)

Address: 0x40008004

R/W	Bit 31	-----	Bit 0
W	VALUE[31:0]		
R			
Reset	0xFFFFFFFF		

VALUE[31:0]: Current count value

Watchdog CTRL Register (Address: 0x40008008)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--						RESTEN	INTEN
R								
Reset	0	0	0	0	0	0	0	0

RESTEN: Enable watchdog reset.

[0]: Watchdog reset disable

[1]: Watchdog reset enable

INTEN: Watchdog counter and interrupt enable.

[0]: Disable counter and interrupt

[1]: Enable counter and interrupt

Watchdog Interrupt Clean Register (Address: 0x4000800C)

R/W	Bit 32	-----	Bit 0
W	INTCLR		
R			
Reset	0x00000000		

INTCLR: A write of any value to clear the watchdog interrupt, and reloads the counter from the value in LOAD.

Watchdog RAWINTSTAT Register (Address: 0x40008010)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--							--
R								RAWINTSTAT
Reset	0	0	0	0	0	0	0	0

RAWINTSTAT: Raw Watchdog Interrupt Raw interrupt status from the counter.

Watchdog MASKINTSTAT Register (Address: 0x40008014)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--							--
R								MASKINTSTAT
Reset	0	0	0	0	0	0	0	0

MASKINTSTAT: Watchdog Interrupt Enabled interrupt status from the counter.

Watchdog LOCK Register (Address: 0x40008C00)

R/W	Bit31	-----	Bit 0
W	LOCK[31:0]		
R			
Reset	0x0000 0000		

LOCK: Enable register writes Enable write access to all other registers by writing 0x1ACCE551. Disable write access by writing any other value.

LOCK[0]: Register write enable status

[0]: Write access to all other registers is enabled. (Default)

[1]: Write access to all other registers is disabled.

16.4 FUNCTION DESCRIPTION

16.4.1 Watchdog Interrupt

The interrupt of Watchdog is NMI (Non Maskable Interrupt). It's always working. Please refer Table 11.1 Exception Types

Watchdog uses two control bit INTEN and RESTEN. When INTEN=1, the watchdog counter start count-down and interrupt enable. When INTEN=0, the watchdog counter stop count-down and interrupt disable.

RAWINTSTAT=1 when VALUE[31:0] count-down to 0.

MASKINTSTAT=1 when VALUE[31:0] count-down to 0 and RESTEN=1.

16.4.2 Watchdog Reset

Watchdog reset will occurred when VALUE[31:0] count-down to 0 and MASKINTSTAT=1.

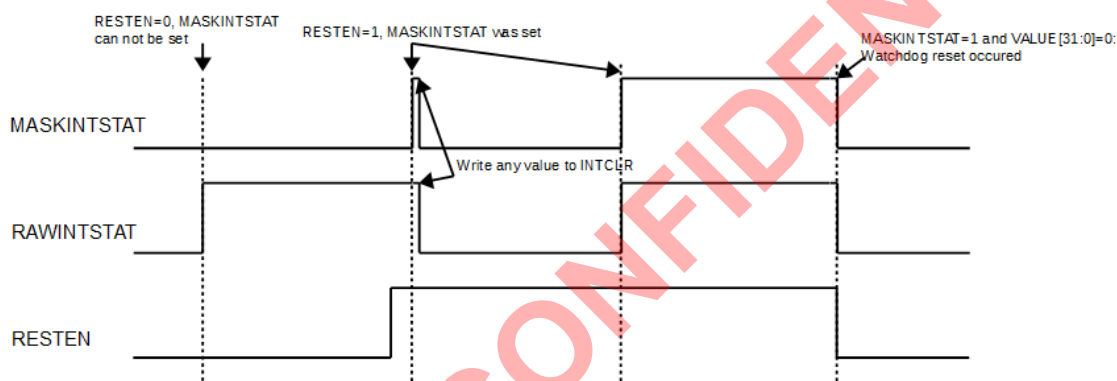


Figure 16.2 A example of watchdog reset

16.5 PROCEDURE

16.5.1 Watchdog Enable

1. Unlock watchdog access, Write 0x1ACCE551 to watchdog lock register
2. Set watchdog load value
3. Enable INTEN=1.
4. Lock watchdog access, Write 0 to watchdog lock register
5. Waiting for watchdog interrupt to occur.
6. Unlock watchdog access, Write 0x1ACCE551 to watchdog lock register.
7. Write 0 to the Watchdog INTCLR register clears the watchdog interrupt, and reloads the counter from the value in watchdog LOAD value.
8. Lock watchdog access, Write 0 to watchdog lock register
9. Repeat step 5~8

16.5.2 Watchdog Reset Enable

1. Unlock watchdog access, Write 0x1ACCE551 to watchdog lock register
2. Set watchdog load value
3. Enable INTEN=1 and RESTEN=1.
4. Lock watchdog access, Write 0 to watchdog lock register
5. Waiting for watchdog interrupt to occur.
6. Unlock watchdog access, Write 0x1ACCE551 to watchdog lock register.
7. Write 0 to the Watchdog INTCLR register clears the watchdog interrupt, and reloads the counter from the value in watchdog LOAD value.
8. Lock watchdog access, Write 0 to watchdog lock register
9. Repeat step 5~8

Watchdog timer that automatically generates a system reset if the main program neglects to periodically service it.

17. Watchdog Timer 1

A3117M0 has a special timer, called Watchdog Timer 1. It is a useful programmable clock counter that serves as a time-base generator, an event timer or system supervisor.

17.1 FEATURE

- The Time_Setting[2:0] bits select Watchdog timer 1 timeout period.
- Lock register to prevent accidental write access
- Interrupt and Reset generation

17.2 BLOCK DIAGRAM

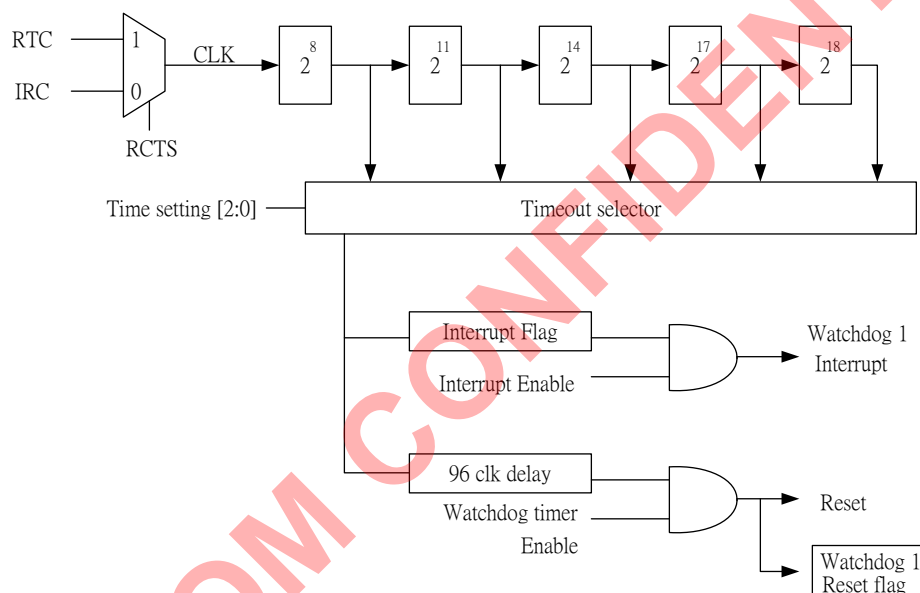


Figure 17.1 Watchdog 1 block diagram

17.3 REGISTER

17.3.1 Register List

Address	Name	DESCRIPTION
0x50000080	WDT1_CFG	Watchdog Configuration Register

Table 17.1 Watchdog 1 register list

17.3.2 Register Description

Watchdog Configuration Register (Address: 0x50000080)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W		WTRF_CLR	IE	WDIF_CLR		Time_setting[2:0]		Enable
R		WTRF	IE	WDIF		Time_setting[2:0]		Enable
Reset	0	0	0	0	0	0	0	0

Enable : Watchdog timer1 enable

[0]: Disable

[1]: Enable

Time_setting[2:0]: Watchdog Timer 1 Period Selection

WD[1:0]	Watchdog interval	Time period
---------	-------------------	-------------

000	2^{17}	4096ms
001	2^{14}	512ms
010	2^{11}	64ms
011	2^8	8ms
100	2^{18}	8192ms

IE: Watchdog interrupt enable

[0]: Disable

[1]: Enable

WDIF: Watchdog Interrupt Flag. (Write "1" to clear if WDIF=1)

WDIF in conjunction with the Enable Watchdog Interrupt bit (IE) , indicates if watchdog timer 1 event has occurred and what action should be taken. This bit must be cleared by software before exiting the interrupt service routine, or another interrupt is generated.

WTRF: Watchdog Timer1 Reset Flag. (Write "1" to clear if WTRF=1)

This bit must be cleared by software after power on reset. The watchdog timer 1 has no effect on this bit, when Enable = 0.

Note: must unlock protect PWR_TA before write.

17.4 FUNCTION DESCRIPTION

17.4.1 Watchdog1 Interrupt

The interrupt of Watchdog1 is NMI (Non Maskable Interrupt). It's always working. Please refer Table 11.1 Exception Types

The Watchdog Timer 1 is a free running timer. When used as a simple timer with both watch dog timer 1 enabled (Enable=1) and interrupt functions enabled (IE=1), the timer will continue to set the Watchdog Interrupt flag each time the timer completes the selected timer interval as programmed by Time_setting[2:0]. Restarting the timer using the Enable (0->1), allows software to use the timer in a polled timeout mode. The WDIF bit is cleared by software.

17.4.2 Watchdog1 Reset

If the Watchdog interrupt is reached without restarting the timer using the Enable (0->1), the Watchdog will reset the MCU.

A potential Watchdog Reset is executed 96 clks after setting of WDIF flag.

17.4.3 Watchdog1 Procedure

1. Unlock watchdog protect access,
Write 0x50000084 = AAAAAAAA
Write 0x50000084 = 55555555
2. Set watchdog Time_setting[2:0] value
3. Enable = 1 and IE = 1
4. Waiting for watchdog interrupt to occur.
5. Unlock watchdog protect access,
Write 0x50000084 = AAAAAAAA
Write 0x50000084 = 55555555
6. Clears the watchdog interrupt flag, and restart the watchdog timer1.
Enable = 0
Enable = 1
7. Repeat step 4~7

Watchdog timer that automatically generates a system reset if the main program neglects to periodically service it.

18. RTC (Real Time Counter)

RTC can use 32KHz or 32.768KHz to clock source. It is a simple and useful design to count year, month, date, week, hours, min, sec and manual count. It also has an alarm set by hour and min.

18.1 FEATURE

- Support 32KHz and 32.768KHz clock source
- Many interrupt: 10ms, 0.5sec, 1sec, alarm (by hour and min) and manual count (by 10ms).

18.2 BLOCK DIAGRAM

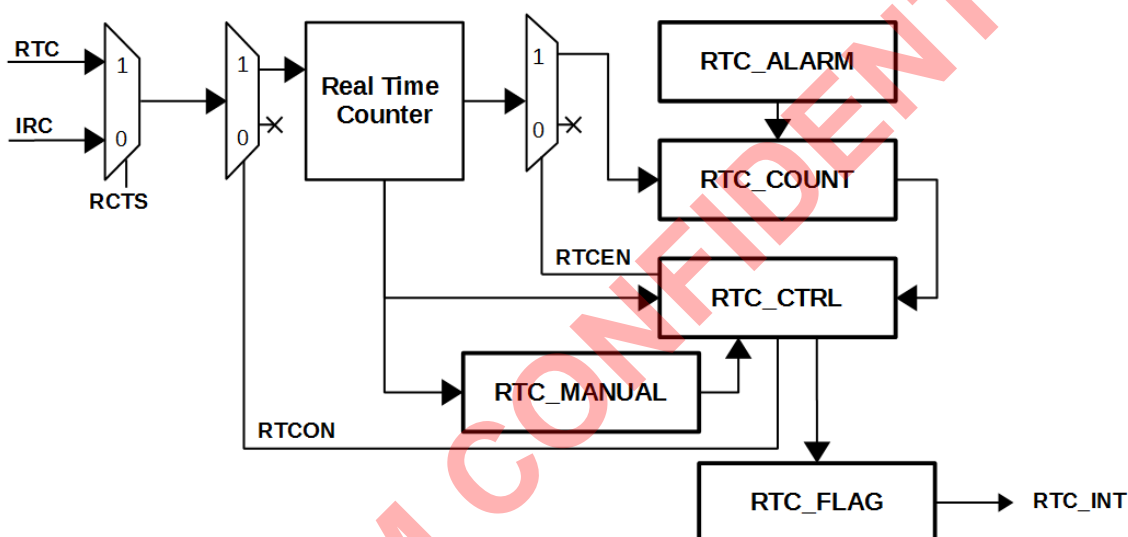


Figure 18.1 RTC Block Diagram

18.3 REGISTER

18.3.1 Register List

Address	Name	DESCRIPTION
0x50005000	RTC_COUNT1	RTC Count 1 Register
0x50005004	RTC_ALARM	RTC Alarm setting Register
0x50005008	RTC_CTRL	RTC Control Register
0x5000500C	RTC_FLAG	RTC Flag Register
0x50005010	RTC_MANUAL	RTC Manual count Register
0x50005014	RTC_COUNT2	RTC Count 2 Register
0x50005018	RTC_TA	RTC protect Register

Table 18.1 RTC register list

18.3.2 Register Description

RTC Count 1 Register (Address: 0x50005000)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W	WEEK[2:0]			HOUR[4:0]				
R	CWEEK[2:0]			CHOUR[4:0]				
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W	--		MIN[5:0]					
R	--		CMIN[5:0]					
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	--		SEC[5:0]					
R	--		CSEC[5:0]					
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--		--					
R	--		CTMS[6:0]					
Reset	0	0	0	0	0	0	0	0

WEEK[2:0]: Write WEEK[2:0] to set CWEEK[2:0]. The range of WEEK[2:0] is 0~6.

CWEEK[2:0]: The count value of week. When CWEEK[2:0] count up to 7, CWEEK[2:0] will reset to 0.

HOUR[4:0]: Write HOUR[5:0] to set CHOUR[5:0]. The range of HOUR[5:0] is 0~23.

CHOUR[4:0]: The count value of hour. When CHOUR[5:0] count up to 24, CHOUR[5:0] will reset to 0 and count up CWEEK[2:0] 1 times.

MIN[5:0]: Write MIN[5:0] to set CMIN[5:0]. The range of MIN[5:0] is 0~59.

CMIN[5:0]: The count value of min. When CMIN[5:0] count up to 60, CMIN[5:0] will reset to 0 and count up CHOUR[4:0] 1 times.

SEC[5:0]: Write SEC[5:0] to set CSEC[5:0]. The range of SEC[5:0] is 0~59.

CSEC[5:0]: The count value of sec. When CSEC[5:0] count up to 60, CSEC[5:0] will reset to 0 and count up CMIN[5:0] 1 times.

CTMS[6:0]: The count value of ten-ms. CTMS[6:0] will reset to 0 when write any value to RTC_COUNT. CMS[6:0] will count up 1 times when RTC count 10ms. CTMS[6:0] can't set by user.

RTC Alarm Register (Address: 0x50005004)

R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	--			ALARM_HOUR[4:0]				
R	--			ALARM_HOUR[4:0]				
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--		ALARM_MIN[5:0]					
R	--		ALARM_MIN[5:0]					
Reset	0	0	0	0	0	0	0	0

ALARM_HOUR[4:0]: Set alarm hour count

ALARM_MIN[5:0]: Set alarm min count

Alarm interrupt will occur when first time that CHOUR[4:0] equal ALARM_HOUR[4:0] and CMIN[5:0] equal ALARM_MIN[5:0].

RTC Control Register (Address: 0x50005008)

R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	--							MCNTEN
R	--							MCNTEN
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	CLKSEL	RTCON	INTMCNTIE	INT10MSIE	INT05SIE	INT1SIE	ALMIE	RTCEN
R	CLKSEL	RTCON	INTMCNTIE	INT10MSIE	INT05SIE	INT1SIE	ALMIE	RTCEN
Reset	0	0	0	0	0	0	0	0

MCNTEN: Manual Count Enable

[0]: Manual Count disable.

[1]: Manual Count enable.

CLKSEL: RTC clock select

[0]: RTC clock source is 32KHz

[1]: RTC clock source is 32.768KHz

RTCON: RTC clock on

[0]: RTC stop count.

[1]: RTC start count.

INTMCNTIE: Manual Count interrupt enable

[0]: Disable

[1]: Enable

INT10MSIE: 10ms count interrupt enable

[0]: Disable

[1]: Enable

INT05SIE: 0.5sec count interrupt enable

[0]: Disable

[1]: Enable

INT1SIE: 1sec count interrupt enable

[0]: Disable

[1]: Enable

ALMIE: Alarm interrupt enable

[0]: Disable

[1]: Enable

RTCEN: RTC_COUNT enable.

[0]: RTC Disable. RTC_COUNT, RTC_MANUAL count stop.

[1]: RTC Enable. RTC_COUNT, RTC_MANUAL count start.

RTC Flag Register (Address: 0x5000500C)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--	--	CLRMCNTIF	CLRTMSIF	CLRHSECIF	CLRSECIF	CLRALMIF	CLRINTIF
R	--	--	MCNTIF	TMSIF	HSECIF	SECIF	ALMIF	INTIF
Reset	0	0	0	0	0	0	0	0

CLRMCNTIF: Clear Manual Count interrupt Flag

[0]: No effect

[1]: Clear MCNTF

MCNTIF: Manual Count interrupt Flag

[0]: Manual Count interrupt not occur

[1]: Manual Count interrupt was occurred

CLRTMSIF: Clear 10-ms interrupt Flag

[0]: No effect

[1]: Clear TMSIF

TMSIF: 10ms interrupt Flag

[0]: RTC 10ms interrupt not occur

[1]: RTC 10ms interrupt was occurred

CLRHSECIF: Clear half-sec (0.5sec) interrupt Flag

[0]: No effect

[1]: Clear HSECIF

HSECIF: Half-sec (0.5sec) interrupt Flag

[0]: RTC half-sec interrupt not occur

[1]: RTC half-sec interrupt was occurred

CLRSECIF: Clear sec interrupt Flag

[0]: No effect

[1]: Clear SECIF

SECIF: 1 sec interrupt Flag

[0]: RTC 1 sec interrupt not occur

[1]: RTC 1 sec interrupt was occurred

CLRALMIF: Clear alarm interrupt Flag

[0]: No effect

[1]: Clear ALMIF

ALMIF: Alarm interrupt Flag

[0]: RTC alarm interrupt not occur

[1]: RTC alarm interrupt was occurred

CLRINTIF: Clear interrupt Flag

[0]: No effect

[1]: Clear INTIF

INTIF: Interrupt Flag

[0]: RTC any interrupt not occur

[1]: RTC any interrupt was occurred

NOTE: User need clear interrupt flag when interrupt occurred.

RTC Manual count Register (Address: 0x50005010)

R/W	Bit 15	-----	Bit 0
W	MANUAL_COMP[15:0]		
R	MANUAL_COUNT[15:0]		
Reset	0x00000000		

MANUAL_COMP[15:0]: MANUAL_COUNT[15:0] will reset to 0 when MANUAL_COUNT[15:0] equal MANUAL_COMP[15:0].

MANUAL_COUNT[15:0]: The current count of manual counter. MANUAL_COUNT[15:0] will count up 1 times when RTC count 10ms and MCNTEN=1. MANUAL_COUNT[15:0] will reset to 0 when MCNTEN=0. Write MANUAL_COMP[15:0] was not effect to MANUAL_COUNT[15:0].

RTC Count 2 Register (Address: 0x50005014)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16

W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W								
R								
Reset	0	0	0	0	0	0	0	0

YEAR[6:0]: Write YEAR[6:0] to set CYEAR[6:0]. The range of YEAR[6:0] is 0~99.

CYEAR[6:0]: The count value of year. When CYEAR[6:0] count up to 99, CYEAR[6:0] will reset to 0.

MONTH[3:0]: Write MONTH[3:0] to set CMONTH[3:0]. The range of MONTH[5:0] is 1~12.

CMONTH[3:0]: The count value of month. When CMONTH[3:0] count up to 12, CMONTH[3:0] will reset to 0 and count up CYEAR[6:0] 1 times.

DATE[4:0]: Write DATE[4:0] to set CDATE[4:0]. The range of DATE[5:0] is 1~28/29/30/31.

CDATE[4:0]: The count value of date. When CDATE[4:0] count up to 28/29/30/31, CDATE[4:0] will reset to 0 and count up CMONTH[4:0] 1 times.

RTC TA Register (Address: 0x50005018)

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

RTC_TA[31:0]: Unlock register write access,
Write 0x50005018 = AAAAAAAA
Write 0x50005018 = 55555555

Note: must unlock protect RTC_TA before write Real time clock register.

18.4 FUNCTION DESCRIPTION

18.4.1 Write RTC Register

When user writes any RTC register, the register needs RTC clock to update. Max. wait time is 1 / (RTC clock source frequency).

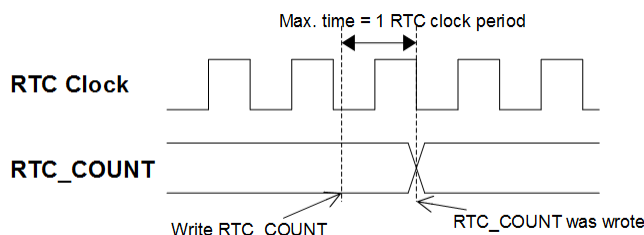


Figure 18.2 The timing for write RTC_COUNT

18.4.2 Bit RTCON

RTC start count after RTCON=1. The 10ms interrupt, 0.5sec interrupt, 1sec interrupt and manual count interrupt will occur if interrupt enable.

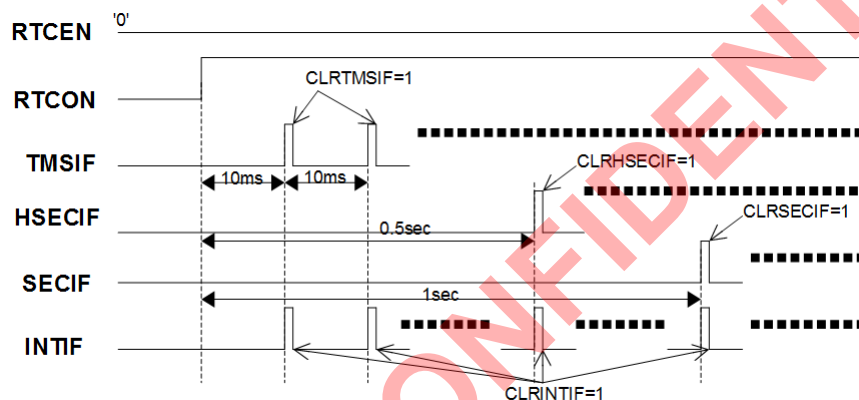


Figure 18.3 An example for RTCON=1, RTCEN=0 and all interrupt enable.

18.4.3 Bit RTCEN

RTC_COUNT will count sec, min, hour and week after RTCEN=1 and RTCON=1. CTMS[6:0] will set to 0 when RTCEN=0.

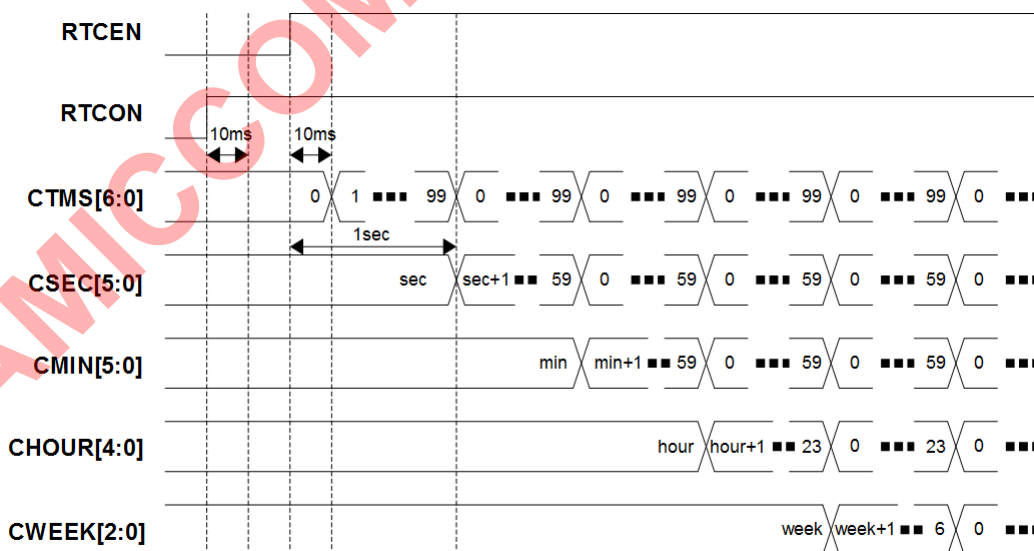


Figure 18.4 An example for RTCON=1, RTCEN=1, RTC_COUNT will count up

18.4.4 Alarm

Register RTC_ALARM can set hour and min. Alarm interrupt will occur when first time that hour and min of RTC_COUNT match hour and min of RTC_ALARM.

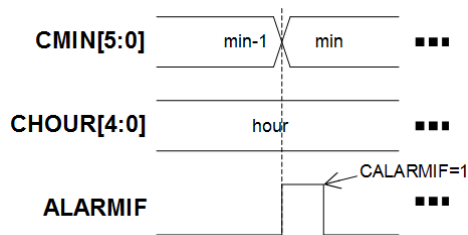


Figure 18.5 An example for alarm set "hour, min"

18.4.5 Manual Count

RTC build-in a 16bits manual count that clock source is RTC count 10ms. The interval of manual count is $RTC_MANUAL \times 10ms$. Min interval is 10ms ($RTC_MANUAL=0x0001$). Max. interval is 655.36sec ($RTC_MANUAL = 0x0000$). Manual count start count when bit MCNTEN = 1. RTCEN=0 or 1 is no effect to manual count action.

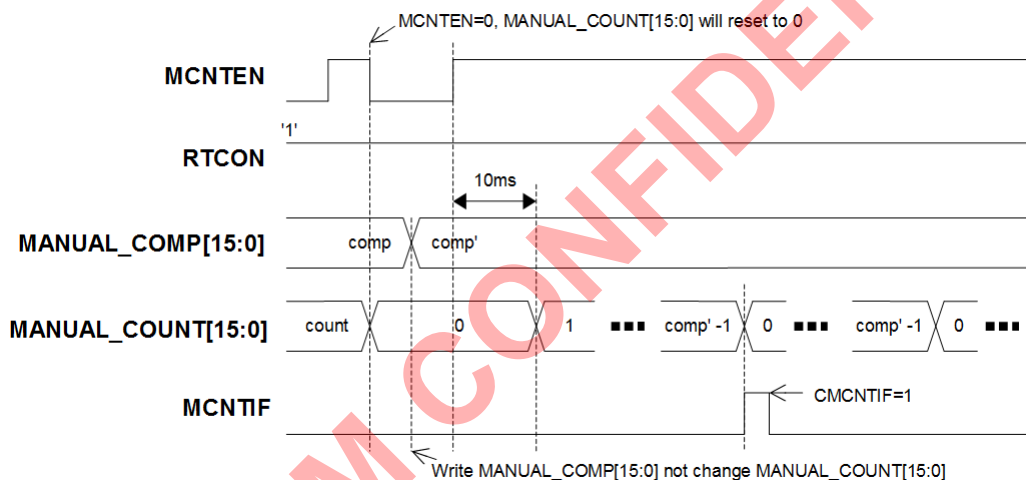


Figure 18.6 An example for manual count.

18.4.6 Interrupt

The NVIC IRQn of RTC is 18. Please refer Table 11.2 Interrupt Map Vector Table

There is a sample code for RTC handle show as below:

```
void RTC_Handler(void)
{
    uint32_t flag;
    flag = RTC->FLAG;           // store FLAG
    RTC->FLAG = flag;           // clean all FLAG
    if(flag & RTC_FLAG_MANUALCOUNT_Msk) // manual count interrupt
    {
    }
    if(flag & RTC_FLAG_TMS_Msk)    // 10ms interrupt
    {
    }
    if(flag & RTC_FLAG_HSEC_Msk)   // 0.5sec interrupt
    {
    }
    if(flag & RTC_FLAG_SEC_Msk)    // 1sec interrupt
    {
    }
    if(flag & RTC_FLAG_ALARM_Msk)  // Alarm interrupt
    {
    }
    if(flag & RTC_FLAG_RTC_Msk)    // When any RTC interrupt occurred
    {
    }
}
```

19. PWM

PWM (Pulse Width Modulation) is the method to control analog circuits with a processor's digital outputs. It generates variable pulse frequency and the duty cycle of the signal with digital means. Using PWM function, it can be used for a wide variety of control applications.

19.1 FEATURES

- 4 channels PWM output
- Programmable PWM frequency (1/2, 1/4, 1/8, 1/16, 1/32, 1/64 of MCU clock and that of RTC clock)
- Programmable PWM duty cycle

19.2 PINS DESCRIPTION

PIN	GPIO	TYPE	DESCRIPTION
PWM0	P0_20	OUTPUT	PWM channels 0
PWM1	P0_21	OUTPUT	PWM channels 1
PWM2	P0_10	OUTPUT	PWM channels 2
PWM3	P0_11	OUTPUT	PWM channels 3

Table 19.1 PWM pins description

19.3 BLOCK DIAGRAM

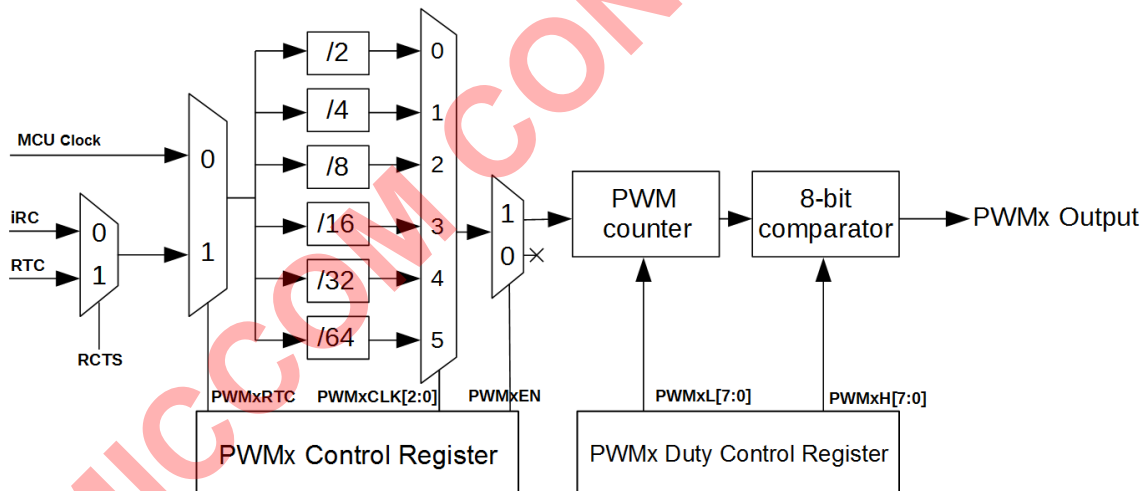


Figure 19.1 PWMx Block Diagram

19.4 REGISTER

19.4.1 Register list

Base Address	DESCRIPTION
0x50004000	PWM0 Base address
0x50004100	PWM1 Base address
0x50004200	PWM2 Base address
0x50004300	PWM3 Base address

Table 19.2 Base address of each PWM

offset	Name	DESCRIPTION
0x000	PWMxCR	PWMx Control Register
0x004	PWMxDCR	PWMx Duty Control Register

Table 19.3 PWM Register List

19.4.2 Register Description

PWMx Control Register (Offset: 0x000)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	PWMxEN	PWMxCK_EN			PWMxRTC		PWMxCLK[2:0]	
R								
Reset	0	1	0	0	0	0	0	0

PWMxCK_EN: PWM Channel x clock gating Enable

[0]: Enable.

[1]: Disable.

PWMxEN: PWM Channel x Enable,

[0]: Disable.

[1]: Enable.

PWxRTC: PWM Channel x Clock Source select,

[0]: MCU Clock.

[1]: RTC clock.

PWxCLK[2:0]: PWM Channel x Clock select

[000]: PWM Clock / 2

[001]: PWM Clock / 4

[010]: PWM Clock / 8

[011]: PWM Clock / 16

[100]: PWM Clock / 32

[101]: PWM Clock / 64

[110]: Not allowed to use.

[111]: Not allowed to use.

PWMx Duty Control Register (Offset: 0x004)

R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W								
R								
Reset	0	0	0	0	0	0	0	0

PWMxH[7:0]: PWMx output HIGH register

PWMxL[7:0]: PWMx frequency setting register

19.5 FUNCTION DESCRIPTION

A3117M0 has four channels PWM output. Each channel PWM has an 8-bit counter with comparator, a control register (PWMxCR) and two setting registers (PWMxH and PWMxL). User can select clock source by setting PWMxCR. It divide MCU clock and RTC clock to 2,4,8,16,32,64 by setting PWMxCLK. Enable PWM output and function by setting PWMxEN = 1; otherwise disable PWM output and function by setting PWMxEN = 0. When user sets PWMxEN=1, it outputs LOW single and loads the PWMxL to itself. When the up counter is enabled and matches the content of PWMxH, its output is asserted HIGH; when the counter is overflow, its output is asserted LOW and reload PWMxL to itself. The pulse frequency and the duty cycle for 8-bit PWM is given by the below equations

$$\text{Pulse frequency} = \text{Clock Source} / 2^{(\text{PWMxCLK}+1)} / (256-\text{PWMxL})$$

$$\text{Duty cycle} = (256-\text{PWMxH}) / (256-\text{PWMxL})$$

Noted: PWMxH must be larger than PWMxL. Otherwise, PWM output is always HIGH.
List some example setting in Table 19.4 Some example setting

MCU Clock = 16MHz RTC Clock = 32.768KHz				
Offset 0x000	Offset 0x004	Clock Source	PWM Frequency	Duty Cycle
0x80	0xFFFE	16MHz	4MHz	50%
0x80	0xFFFD	16MHz	2.667KHz	33.3%
0x85	0xFFFE	16MHz	125KHz	50%
0x80	0x8000	16MHz	31.25KHz	50%
0x88	0x8000	32.768KHz	64Hz	50%
0x88	0xFFFD	32.768KHz	5.461KHz	33.3%
0x8D	0xFFFE	32.768KHz	256Hz	50%

Table 19.4 Some example setting

19.6 PROCEDURE

Below is the procedure to set PWM0 output (ex. PWM Frequency 4MHz, Duty Cycle 50%)

- Step10: Set A3117M0 in STBY, PLL, TX or RX MODE.
- Step11: Set Port 0 Output Enable Set Register (0x40010010), P0_20=1.
- Step12: Set Port 0 ALTFUNCSET Register (0x40010018), P0_20=1.
- Step13: Set PWM0CR (0x50004000), PWM0CLK[2:0]=0, and PWM0RTC=0.
- Step14: Set PWM0DCR (0x50004004), PWM0L [7:0]=254, and PWM0H [7:0]=255.
- Step15: Set PWM0CR (0x50004000), PWM0EN=1

PWM0(P0_20) generates 4MHz Pulse frequency and 50% duty cycle of the signal.

Counter >= PWMxH : output high
Counter < PWMxH : output low

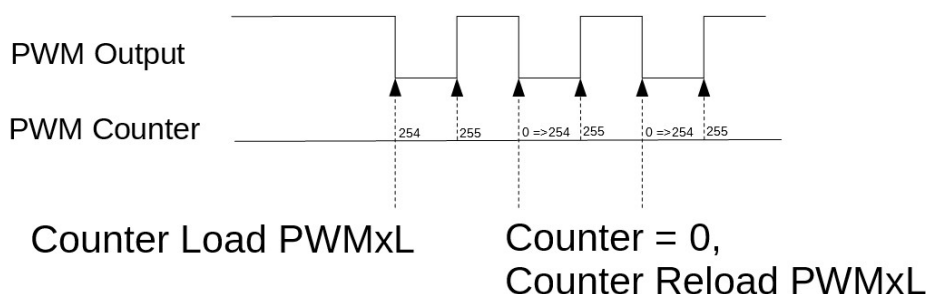
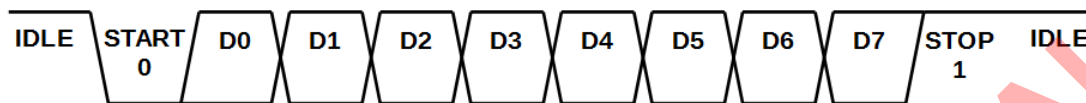


Figure 19.2 An example for PWM

20. UART

The UART implements a universal asynchronous receiver/transmitter function. It supports flexible baudrate generation. It's a simple design that only supports 8-bit communication without parity, and is fixed at one stop bit per configuration (N-8-1).



START: Start bit, always low
D0~D7: Data bit
STOP: Stop bit, always high

Figure 20.1 UART transmission format.

20.1 FEATURE

- Three UARTs (RX/TX)
- Support format: 8 bit data, 1 start, 1 stop bit and no parities (N-8-1).
- Baud rate derived from system clock.

20.2 PINS DESCRIPTION

PIN	GPIO	TYPE	DESCRIPTION
UART0_RX	P0_16	INPUT	UART0 Receiver Input pin
UART0_TX	P0_17	OUTPUT	UART0 Transmitter Output pin
UART1_RX	P0_18	INPUT	UART1 Receiver Input pin
UART1_TX	P0_19	OUTPUT	UART1 Transmitter Output pin
UART2_RX	P0_20	INPUT	UART2 Receiver Input pin
UART2_TX	P0_21	OUTPUT	UART2 Transmitter Output pin

20.3 BLOCK DIAGRAM

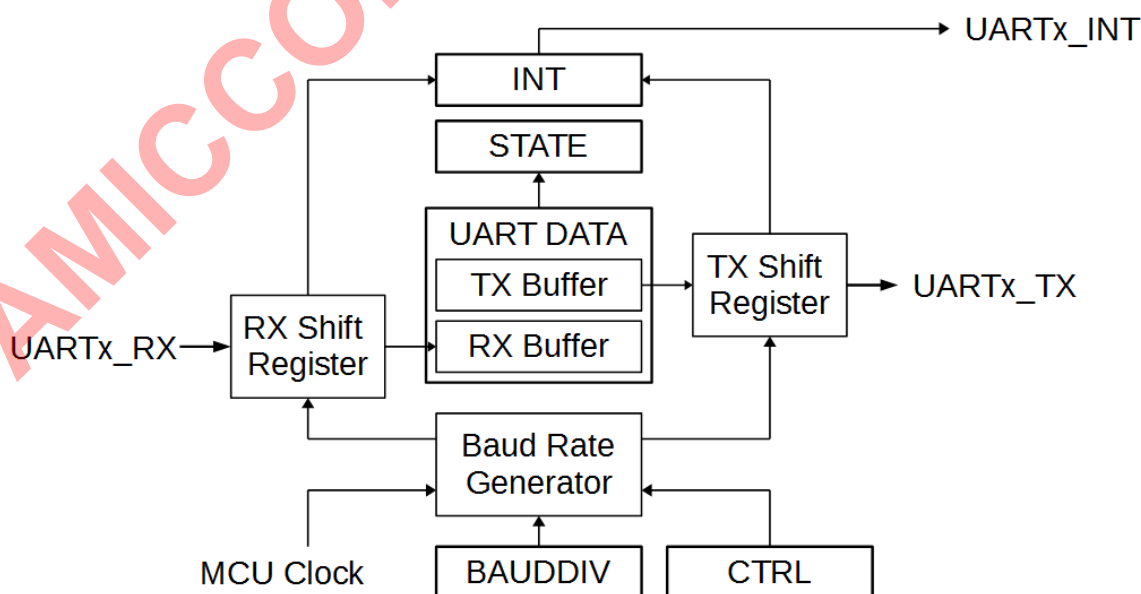


Figure 20.2 UART block diagram

20.4 REGISTER

20.4.1 Base Address List

Base Address	DESCRIPTION
0x40004000	UART0 Base Address
0x40005000	UART1 Base Address
0x40006000	UART2 Base Address

Table 20.1 Base address list

20.4.2 Register List

Offset	Name	DESCRIPTION
0x000	UART_DATA	UART Data Register
0x004	UART_STATE	UART Status Register
0x008	UART_CTRL	UART Control Register
0x00C	UART_INT	UART interrupt state and clear Register
0x010	UART_BAUDDIV	UART Baud rate divider register

Table 20.2 Register list

20.4.3 Register Description

UART Data Register (Offset: 0x000)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	DATA[7:0]							
R								
Reset	--	--	--	--	--	--	--	--

DATA[7:0]: UART Data. Write data to TX Buffer or read data from RX Buffer.

UART Status Register (Offset: 0x004)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--				STATE[3]	STATE[2]	--	--
R							STATE[1]	STATE[0]
Reset	0	0	0	0	0	0	0	0

STATE[3]: RX buffer overrun.

[0]: RX Buffer does not overrun.

[1]: RX Buffer has overrun. Write 1 to clean this bit.

STATE[2]: TX buffer overrun.

[0]: TX Buffer does not overrun.

[1]: TX Buffer has overrun. Write 1 to clean this bit.

STATE[1]: RX buffer full.

[0]: RX buffer not full.

[1]: RX buffer full.

STATE[0]: TX buffer full.

[0]: TX buffer not full.

[1]: TX buffer full.

UART Control Register (Offset: 0x008)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--		CTRL[5]	CTRL[4]	CTRL[3]	CTRL[2]	CTRL[1]	CTRL[0]
R	--		CTRL[5]	CTRL[4]	CTRL[3]	CTRL[2]	CTRL[1]	CTRL[0]
Reset	0	0	0	0	0	0	0	0

CTRL[5] : RX overrun interrupt enable.
[0]: Disable UART RX overrun interrupt.
[1]: Enable UART RX overrun interrupt.

CTRL[4] : TX overrun interrupt enable.
[0]: Disable UART TX overrun interrupt.
[1]: Enable UART TX overrun interrupt.

CTRL[3] : RX interrupt enable.
[0]: Disable UART RX interrupt.
[1]: Enable UART RX interrupt.

CTRL[2] : TX interrupt enable.
[0]: Disable UART TX interrupt.
[1]: Enable UART TX interrupt.

CTRL[1] : RX enable.
[0]: Disable UART RX.
[1]: Enable UART RX.

CTRL[0] : TX enable.
[0]: Disable UART TX.
[1]: Enable UART TX.

UART Interrupt Register (Offset: 0x00C)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--				INT[3]	INT[2]	INT[1]	INT[0]
R	--				INT[3]	INT[2]	INT[1]	INT[0]
Reset	0	0	0	0	0	0	0	0

INT[3] : RX overrun interrupt.
[0]: RX overrun interrupt does not occur.
[1]: RX overrun interrupt has occurred. Write 1 to clear this bit.

INT[2] : TX overrun interrupt.
[0]: TX overrun interrupt does not occur.
[1]: TX overrun interrupt has occurred. Write 1 to clear this bit.

INT[1] : RX interrupt.
[0]: RX interrupt does not occur.
[1]: RX interrupt has occurred. Write 1 to clear this bit.

INT[0] : TX interrupt.
[0]: TX interrupt does not occur.
[1]: TX interrupt has occurred. Write 1 to clear this bit.

UART Baud rate Divider Register (Offset: 0x010)

R/W	Bit 31	-----	Bit 20	Bit 19	-----	Bit 0
W	--			BAUDDIV[19:0]		
R	--			BAUDDIV[19:0]		
Reset	0x000			0x00000		

BAUDDIV[19:0] : Baud rate divider. The minimum number is 16.

20.5 FUNCTION DESCRIPTION

20.5.1 I/O pin setting

To communicate with an external serial interface, the internal UARTx has two external pins known as UARTx_TX and UARTx_RX. The UARTx_TX and UARTx_RX pins are the UARTx transmitter and receiver pins respectively. The UARTx_TX and UARTx_RX pin function should first be selected by the corresponding pin-shared function selection register (ALTFUNCSET Register) before the UARTx function is used. If set, will automatically setup the UARTx_TX and UARTx_RX pins to their respective TX output and RX input conditions.

20.5.2 UART Baud Rate

The baud rate is depended on MCU clock frequency (F_{mcu}), the equation is

$$\text{Baud Rate} = F_{mcu} / \text{BAUDDIV}[19:0]$$

Usually, we choice the baud rate to find the BAUDDIV[19:0]. The equation is

$$\text{BAUDDIV}[19:0] = F_{mcu} / (\text{Baud rate})$$

For example, if the system clock frequency is 16MHz and the required baud rate is 9600bps, then the BAUDDIV[19:0] = $16,000,000 / 9,600 = 1666$ or 1667. And the actual baud rate is $16,000,000 / 1666 = 9603.84\text{bps}$ (+0.04% with 9600bps) or 9598.08bps (-0.02% with 9600bps).

20.5.3 UART TX state and interrupt

The data of TX Buffer will send to TX Shift Register automatic if TX Shift Register empty. There has 1 data in TX Shift Register to transmit when STATE[0]=0. The STATE[2]=1 when user write data to TX Buffer and STATE[0]=1. INT[0]=1 when TX Shift Register transmit complete.

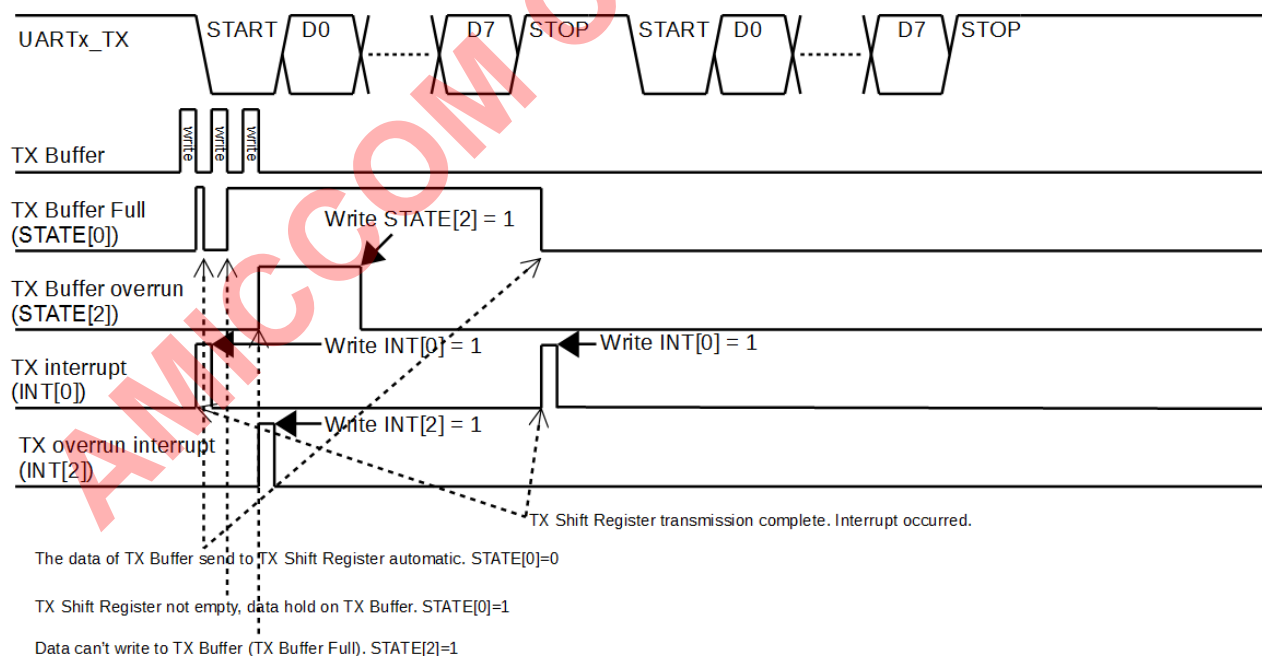


Figure 20.3 A example for UART TX write 3 bytes data

20.5.4 UART RX state and interrupt

When data send to UARTx_RX, data will store in RX Shift Register. This data will send to RX Buffer automatic when RX Shift Register has received one data. And RX interrupt will occur. User need read data from RX Buffer when STATE[1]=1. If RX Shift Register has received one data and STATE[1]=1 then STATE[3]=1 and data will not send to RX Buffer.

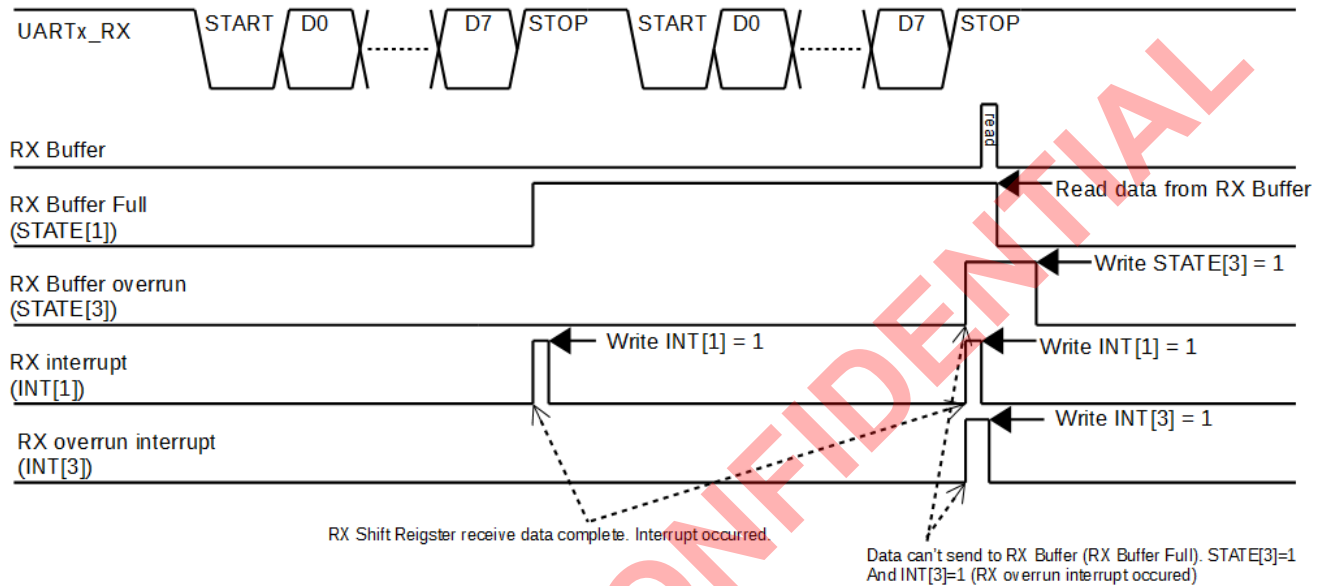


Figure 20.4 A example for UART RX receive data

20.6 PROCEDURE

UARTx TX :

1. Set wanted UART I/O port.
2. Set Baud Rate.
3. Enable UART TX and enable TX interrupt.
4. Fill in data to UART DATA Register to transmit data.
5. Waiting for TX interrupt to occur and interrupt clear.
6. Repeat step 4~5.

UARTx RX :

1. Set wanted UART I/O port.
2. Set Baud Rate.
3. Enable UART RX and enable RX interrupt.
4. Waiting for RX interrupt to occur and interrupt clear.
5. Read out data from UART DATA Register.
6. Repeat step 4~5.

21. I²C Interface

The I²C bus provides bidirectional data transfer through a 2-wire design, a serial data line (I²C_SDA) and a serial clock line (I²C_SCL).

21.1 FEATURE

- Conforms to v2.1 of the I²C specification (published by Philips Semiconductor)
- Master transmit / receive
- Slave transmit / receive
- Flexible transmission speed: Standard (up to 100 Kb/s), Fast (up to 400Kb/s) and Fast plus(1MHz)
- Multi-master systems supported
- Supports 7-bits and 10-bits addressing on the I²C bus
- Interrupt generation
- Allows operation from a wide range of input clock frequencies

21.2 PINS DESCRIPTION

I²C bus uses two signals: I²C_SCL and I²C_SDA. The alternate function is Port 0.4 and Port 0.5 or Port0.10 and Port0.11 for I²CBSSEL. User need set ALTFUNCSET (0x40010018) for GPIO0 to setup the PIN function.

PIN	GPIO	TYPE	DESCRIPTION
I ² C_SCL	P0_04	INPUT / OUTPUT	I ² C clock input/output (I ² CBSEL=0)
I ² C_SDA	P0_05	INPUT / OUTPUT	I ² C data input/output (I ² CBSEL=0)
I ² C_SCL	P0_10	INPUT / OUTPUT	I ² C clock input/output (I ² CBSEL=1)
I ² C_SDA	P0_11	INPUT / OUTPUT	I ² C data input/output (I ² CBSEL=1)

Table 21.1 I²C interface pins description

21.3 BLOCK DIAGRAM

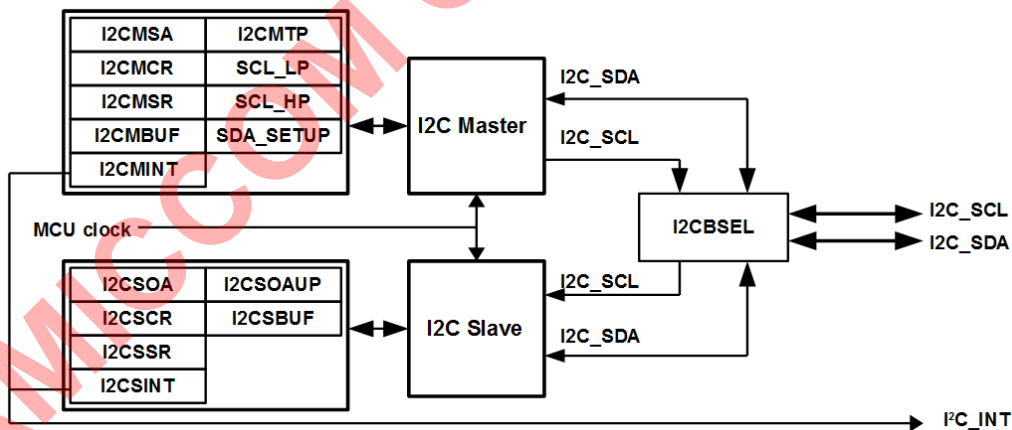


Figure 21.1 I²C Interface Block Diagram

21.4 REGISTER

21.4.1 Register List

Address	Name	DESCRIPTION
0x50003000	I ² CMSA	I ² C Master Slave address
0x50003004	I ² CMSR / I ² CMSR	I ² C Master Control Register / I ² C Master Status Register
0x50003008	I ² CMBUF	I ² C Master transmitted/Received data Buffer Register
0x5000300C	I ² CMTP	I ² C Master Timer Period Register
0x50003010	SCL LP	I ² C SCL Low Period Register

0x50003014	SCL_HP	I ² C_SCL High Period Register
0x50003018	SDA_SETUP	I ² C_DAT Setup Period Register
0x5000301C	I ² CMINT	I ² C Master Interrupt Register
0x50003020	I ² CBSEL	I ² C Bus Select Register
0x50003800	I ² CSOA	I ² C Slave Own Address Register
0x50003804	I ² CSCR / I ² CSSR	I ² C Slave Control Register / I ² C Slave Status Register
0x50003808	I ² CSBUF	I ² C Slave Transmitted/Received data Buffer Register
0x5000380C	I ² CSOAUP	I ² C Slave Own Address UP Register
0x50003810	I ² CSINT	I ² C Slave Interrupt register

Table 21.2 I²C interface Register List

21.4.2 I²C Master Register Description

I²C Master Slave address (Address: 0x50003000)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	SA[6:0]							RS
R								
Reset	0	0	0	0	0	0	0	0

SA[6:0]: Slave Address.

RS: Receive or Send in START condition. This bit work with START, RUN or HS, RUN.

[0]: Transmitter

[1]: Receiver

I²C Master Control Register (Address: 0x50003004)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	RSTB	SLRST	--	HS	ACK	STOP	START	RUN
R	--	--	--	--	--	--	--	--
Reset	0	0	0	0	0	0	0	0

RSTB: Reset Bit for I²C Master.

[0]: No effect.

[1]: Reset I²C controller.

SLRST: Slave Reset.

[0]: No effect.

[1]: Reset slaves connected to I²C bus by generating 9 I²C_SCK clocks followed by STOP. This bit need with RUN to work.

HS: Transmission speed switch to High-speed.

[0]: No effect.

[1]: Send START follow by Slave Address and Switching to High-speed.

ACK: Master in Receive mode need to set this bit. This bit must work with RUN bit.

[0]: Read data follow by NAK.

[1]: Read data follow by ACK.

STOP: Send STOP and return to Idle mode, and transmission speed switch to Standard.

[0]: No effect.

[1]: Send STOP.

START: Send START follow by Slave Address and SEND or RECEIVE. This bit need with RUN and RS to work.

[0]: No effect.

[1]: Send START follow by Slave Address and SEND or RECEIVE.

RUN: This bit work with START, STOP, ACK and HS.

[0]: No effect.

[1]: Run a transmission.

I²C Master Slave Register (Address: 0x50003004)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--	--	--	--	--	--	--	--
R	--	BUS_BUSY	IDLE	ARB_LOST	DATA_ACK	--	ERROR	BUSY
Reset	0	0	1	0	0	0	0	0

BUS_BUSY: This bit is set by START conditions and reset by STOP conditions.

[0]: Bus not busy.

[1]: Bus is busy.

IDLE: I²C Bus controller is in the idle state.

[0]: I²C Bus controller is not in idle state.

[1]: I²C Bus controller is in idle state.

ARB_LOST: Due the last operation I²C Bus controller lost the arbitration.

[0]: not arbitration lost.

[1]: has arbitration lost.

DATA_ACK: The acknowledged of DATA.

[0]: DATA with NAK.

[1]: DATA with ACK.

ERROR: Due the last operation an error occurred, that include slave address wasn't acknowledged, transmitted data wasn't acknowledged, or I²C Bus controller lost the arbitration.

[0]: Normal.

[1]: Some error occurred.

BUSY: I²C Master is receiving, or transmitting data on the bus and other bits of I²CMSR are no valid.

[0]: I²C Master controller not busy.

[1]: I²C Master controller is busy.

I²C Master transmitted data Buffer (Address: 0x50003008)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	D[7:0]							
R								
Reset	0	0	0	0	0	0	0	0

D[7:0]: I²C Master write SEND data or read RECEIVE data.

I²C Master Timer Period (Address: 0x5000300C)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	MTP[6:0]							
R								
Reset	0	0	0	0	0	0	0	1

MTP[6:0]: I²C master timer period register. The range of MTP[6:0] is 1~63.

I²C_SCL Low Period (Address: 0x50003010)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--				SCL_LP[3:0]			
R								
Reset	0	0	0	0	0	1	0	0

SCL_LP[3:0]: I²C master SCL low time period register. The range of SCL_LP[3:0] is 1~14.

I²C_SCL High Period (Address: 0x50003014)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--				SCL_HP[3:0]			
R								
Reset	0	0	0	0	0	0	1	0

SCL_HP[3:0]: I²C master SCL high time period register. The range of SCL_HP[3:0] is 2~15.

I²C_DAT Setup Period (Address: 0x50003018)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--				SDA_SETUP[3:0]			
R	--				SDA_SETUP[3:0]			
Reset	0	0	0	0	0	0	1	0

SDA_SETUP[3:0]: I²C Master SDA setup time register. The range of SDA_SETUP[3:0] is 2~15.

I²C Master Interrupt (Address: 0x5000301C)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	I2CMCK_EN	--					I ² CMIF	I ² CMIE
R	I2CMCK_EN	--					I ² CMIF	I ² CMIE
Reset	1	0	0	0	0	0	0	0

I2CMCK_EN: I²C MASTER clock gating.

[0]: Enable.

[1]: Disable.

I²CMIF: I²C MASTER MODULE interrupt flag.

[0]: No effect.

[1]: I²C Master Interrupt occurred. Write 1 to clean this bit.

I²CMIE: I²C Master interrupt enable.

[0]: Disable.

[1]: Enable.

I²C Bus Select (Address: 0x50003020)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--							I2CBSEL
R	--							I2CBSEL
Reset	0	0	0	0	0	0	0	0

I²CBSEL: I²C Bus select.

[0]: I²C_SCL connect to P0_04 and I²C_SDA connect to P0_05.

[1]: I²C_SCL connect to P0_10 and I²C_SDA connect to P0_11.

21.4.3 I²C Slave Register Description

I²C Slave Own Address (Address: 0x50003800)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--	ADDR[6:0]						
R	--	ADDR[6:0]						
Reset	0	0	0	0	0	0	0	0

ADDR[6:0]: Slave device 7bits own address.

I²C Slave Control Register (Address: 0x50003804)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	RSTB	DA	--	--	RECFINCLR	SENDFINCLR	--	--
R	--	--	--	--	--	--	--	--
Reset	0	0	0	0	0	0	0	0

RSTB: I²C Slave controller reset.

[0]: No effect.

[1]: Reset I²C Slave controller.

DA: I²C module Device Active.

[0]: I²C Slave device inactive.

[1]: I²C Slave device active.

RECFINCLR: RECFIN clear.

[0]: No effect.

[1]: Clear RECFIN flag.

SENDFINCLR:

[0]: No effect.

[1]: Clear SENDFIN flag.

I²C Slave Status Register (Address: 0x50003804)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--	--	--	--	--	--	--	--
R	--	DA	--	BUSACTIVE	RECFIN	SENDFIN	TREQ	RREQ
Reset	0	0	0	0	0	0	0	0

DA: I²C slave Device Active.

[0]: I²C slave device inactive.

[1]: I²C slave device active.

BUSACTIVE: BUS ACTIVE.

[0]: Bus no any transmission.

[1]: Bus has any transmission.

RECFIN: Receive Finish.

[0]: No effect.

[1]: I²C Slave device receive finish. User need write 1 to RECFINCLR to clear this bit.

SENDFIN: Send Finish.

[0]: No effect.

[1]: I²C Slave device send finish. User need write 1 to SENDFINCLR to clear this bit.

TREQ: Transmit Request.

[0]: No transmit request.

[1]: I²C Slave device is addressed as transmitter and requires data from host. User need write data to I2CBUF to clear this bit.

RREQ: Receive Request.

[0]: No receive request.

[1]: Receive request occurred. User need read data from I²CSBUF to clear this bit.

I²C Slave Transmitted data Buffer (Address: 0x50003808)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	D[7:0]							
R	D[7:0]							
Reset	0	0	0	0	0	0	0	0

D[7:0]: I²C Slave read data from D[7:0] when RREQ occurred, and write data to D[7:0] when TREQ occurred.

I²C Slave Own Address UP (Address: 0x5000380C)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--				TEN_ADDR_EN	ADDR[9:7]		
R	--				TEN_ADDR_EN	ADDR[9:7]		
Reset	0	0	0	0	0	0	0	0

TEN_ADDR_EN: Ten bits address enable.

[0]: I²C Slave device using 7bits address.

[1]: I²C Slave device using 10bits address.

ADDR[9:7]: The higher 3 bits for I²C Slave device 10bits own address.

I²C Slave Interrupt register (Address: 0x50003810)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
-----	-------	-------	-------	-------	-------	-------	-------	-------

W	I2CSCK_EN						I ² CSIF	I ² CSIE
R								
Reset	1	0	0	0	0	0	0	0

I2CSCK_EN: I²C Slave clock gating.

[0]: Enable.

[1]: Disable.

I²CSIF: I²C Slave device interrupt flag.

[0]: No effect.

[1]: I²C Slave device interrupt occurred. Write 1 to clear this bit.

I²CSIE: I²C Slave device interrupt enable.

[0]: Disable.

[1]: Enable.

21.5 FUNCTION DESCRIPTION

21.5.1 I²C Transmission Format

I²C transmission uses 2 signals: I²C_SCL and I²C_SDA. The transmission format consists of START, STOP, DATA and Acknowledge. These 2 signals are the open-drain signal, therefore, they need to use resistor to pull high. The resistor value is determined by transmission speed and circuit design. In general, 4.7Kohm can be used when transmission speed is 400Kbps.

When I²C_SCL is high, I²C_SDA is changed from high to low, it is called START.

When I²C_SCL is high, I²C_SDA is changed from low to high, it is called STOP.

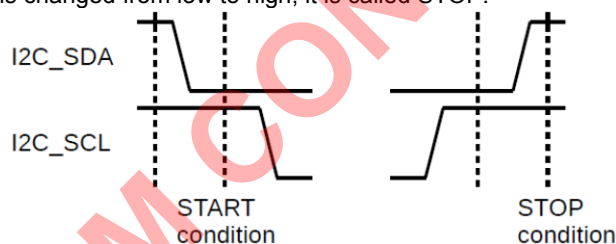


Figure 21.2 START condition and STOP condition

DATA is fixed to 8 bits. When data is sent, I²C_SDA can be changed state only I²C_SCL is low. After each 8 bits DATA is sent, 1 bit Acknowledge should be followed. It is called ACK when Acknowledge=0. It is called NAK when Acknowledge=1:

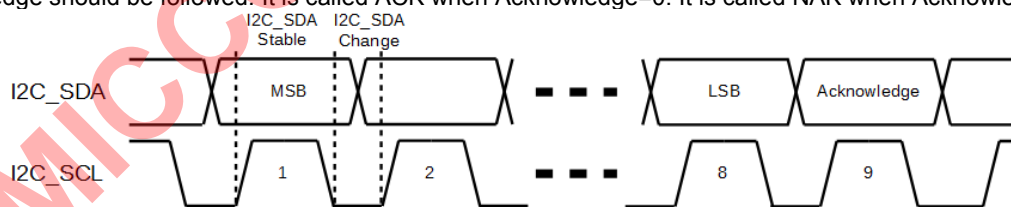


Figure 21.3 Data Validity

I²C Bus must be checked and it is idle before sending. When I²C bus is idle, START can be sent by I²C Master. I²C bus will be occupied after sending START and the other I²C host will be not transmitted. I²C Bus will be released and changed to idle until STOP is sent. The simplest data and successful data of an I²C transmission will contain START, SA [7: 0], RS, Acknowledge (0), DATA [7: 0], Acknowledge, STOP at least. Please refer following figure:

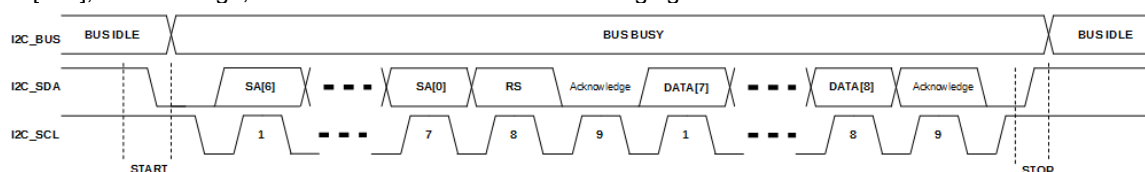


Figure 21.4 A simple I²C Transmission

For easy to describe, these symbols will be used later.

- | |
|---|
| S |
|---|

 represents START.
- | |
|----|
| Sr |
|----|

 represents Repeat START.
- | |
|---|
| a |
|---|

 represents Acknowledge to send by device.
- | |
|---|
| A |
|---|

 represents Acknowledge to send by I²C Master.
- | |
|---|
| P |
|---|

 represents STOP.

After sending START, then slave address and RS will be transmitted. If address of I²C Bus matched with device, I²C_SDA will be pulled low and generated ACK by device, transmission will be continued.

S	7 bits Slave Address	RS	0
---	----------------------	----	---

If I²C bus does not match with device, I²C_SDA keeps high and generated NAK. STOP will be transmitted by I²C Master and transmission will be ended.

S	7 bits Slave Address	RS	1	P
---	----------------------	----	---	---

It represents I²C Master to send data to device when RS is 0.

S	7 bits Slave Address	0	0	8 bits data SEND	a
---	----------------------	---	---	------------------	---

ACK will be returned when Device received data normally. STOP will be sent by I²C Master to release I²C Bus when transmission was ended.

8 bits data SEND	0	---	8 bits data SEND	0	P
------------------	---	-----	------------------	---	---

NAK will be returned when Device cannot receive data or error happened. In general, STOP will be sent by I²C Master to release I²C Bus.

8 bits data SEND	1	P
------------------	---	---

It represents device sends data to I²C Master when RS is 1.

S	7 bits Slave Address	1	0	8 bits data RECEIVE	A
---	----------------------	---	---	---------------------	---

In general, ACK will be set when I²C Master keeps receiving data. NAK will be set and STOP will be sent for transmission ending when I²C Master does not receive data.

8 bits data RECEIVE	0	---	8 bits data RECEIVE	1	P
---------------------	---	-----	---------------------	---	---

During transmission, if the I²C Master wants to change the transmission direction or with other Device to communicate, and does not want to release I²C BUS. START is sent again when STOP does not send. The START is called Repeat START. Transmission will be continued after Repeat START.

To use Repeat START read data from Device after I²C Master sending data.

---	8 bits data SEND	a	Sr	7 bits Slave Address	1	a	8 bits data RECEIVE	A	---
-----	------------------	---	----	----------------------	---	---	---------------------	---	-----

To use Repeat START send data to Device after I²C Master reading data.

---	8 bits data RECEIVE	0	Sr	7 bits Slave Address	0	a	8 bits data SEND	a	---
-----	---------------------	---	----	----------------------	---	---	------------------	---	-----

Via combine these formats, I²C transmission can be completed.

21.5.2 I²C Transmission Speed

A lot of transmission speed is defined by I²C protocol, including

- Standard Mode (<= 100K bps)
- Fast Mode (<= 400 Kbps)
- Fast Mode Plus (<= 1M bps)
- High Speed Mode (<= 3.4 Mbps)

Standard mode, fast mode and fast mode plus do not require extra control. The high speed mode requires a specific Master Code to control.

21.5.2.1 Normal Speed

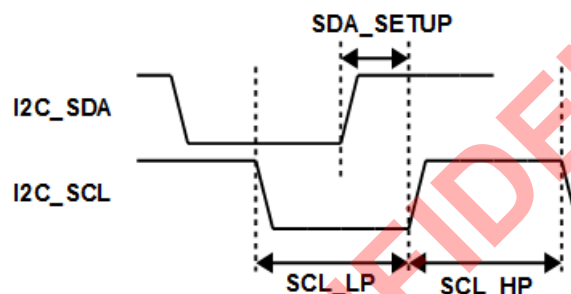
In Normal Speed, I²C Master supports these transmission speed : Standard Mode (<= 100K bps), Fast Mode (<= 400 Kbps) and Faster Mode Plus (<= 1M bps) of I²C. MTP[6:0] (0x5000300C), SCL_LP[3:0] (0x50003010) and SCL_HP[3:0] (0x50003014) can be combined transmission speed wanted by user. The formula is as follows:

$$\text{SCL_PERIOD} = 2 \times (1 + \text{MTP}[6:0]) \times (\text{SCL_LP}[3:0] + \text{SCL_HP}[3:0]) \times \text{CLK_PRD}$$

$$\text{SCL_FREQUENCY} = 1 / \text{SCL_PERIOD}$$

For example, if CLK_FRQ = 16MHz, CLK_PRD = 62.5ns. MTP[6:0] = 3, SCL_LP[3:0] = 6, SCL_HP[3:0] = 4.
Then SCL_PERIOD = 2 x (1 + 3) x (6 + 4) x 62.5ns = 5000ns = 5us
And SCL_FREQUENY = 1 / 5us = 200 KHz

SCL_LP [3:0] is used to determine the duration of I²C_SCL at low.
SCL_HP[3:0] is used to determine the duration of I²C_SCL at high.
SDA_SETUP [3: 0] is used to determine the time point of I²C_SDA conversion.



NOTE: SCL_LP > SDA_SETUP

Figure 21.5 SCL_LP, SCL_HP and SDA_SETUP

21.5.2.2 High Speed

When Device supports High Speed Mode, Master Code (0x00001XXX) can be sent after START, followed a forced NAK Acknowledge. And then, Speed will be changed to High Speed. High Speed will be back to Normal Speed until transmission end.

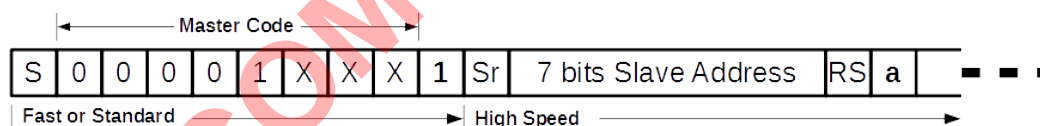


Figure 21.6 Switching High Speed Mode

Please be noted, the Master Code is provided by the Device that supports High Speed Mode.

In I²C Master, bit HS controls whether to enter the High Speed Mode or not. Transmission speed of High Speed Mode is fixed as follows:

$$\text{SCL_PERIOD} = 12 \times \text{CLK_PRD}$$

$$\text{SCL_FREQUENCY} = \text{MCU Clock} / 12$$

21.5.3 I²C Master

I²C Master will be switched at Idle State, Master Transmitter and Master Receiver.

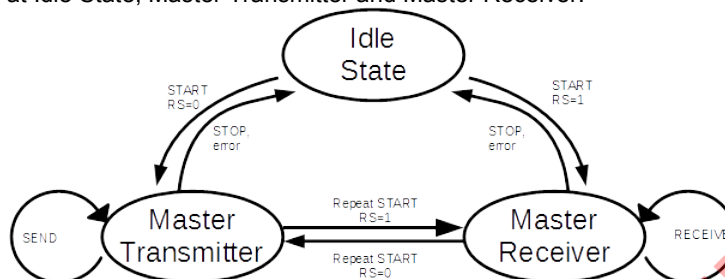


Figure 21.7 State of I²C Master

21.5.3.1 I²C Master Control

I²C Master can control by the main use of I²CMSA (0x50003000) and I²CMCR (0x50003004). Bit RS is included in I²CMSA. These bits RSTB, SLRST, HS, ACK, STOP, START and RUN are included in I²CMCR. These control bits can be combined the following transmission formats:



R S	R S T B	S L R S T	H S	A C K	S T O P	S T A R T	R U N	OPERATION	Next I ² C Master State	Next Speed Mode
X	1	0	X	X	X	X	X	I ² CM module software reset	Idle	Normal
0	0	1	0	0	0	0	1	9 SCK clocks followed by STOP: I2C_SCL  I2C_SDA 	Idle	Normal
0	0	0	0	X	0	1	1	S 7 bits Slave Address 0 a 8 bits data SEND a	Transmitter	Continue
0	0	0	0	X	1	1	1	S 7 bits Slave Address 0 a 8 bits data SEND a P	Idle	Normal
1	0	0	0	0	0	1	1	Sr 7 bits Slave Address 1 a 8 bits data RECEIVE 1	Receiver	Continue
1	0	0	0	0	1	1	1	Sr 7 bits Slave Address 1 a 8 bits data RECEIVE 1 P	Idle	Normal
1	0	0	0	1	0	1	1	Sr 7 bits Slave Address 1 a 8 bits data RECEIVE 0	Receiver	Continue
0	0	0	1	0	0	0	1	S Master Code 0 a	Transmitter	High Speed

Table 21.3 Control bits combinations permitted in Idle state

R S	R S T B	S L R S T	H S	A C K	S T O P	S T A R T	R U N	OPERATION	Next I ² C Master State	Next Speed Mode
X	1	0	X	X	X	X	X	I ² CM module software reset	Idle	Normal
X	0	0	0	X	1	0	0	P	Idle	Normal
X	0	0	0	X	0	0	1	8 bits data SEND a	Transmitter	Continue
X	0	0	0	X	1	0	1	8 bits data SEND a P	Idle	Normal
0	0	0	0	X	0	1	1	Sr 7 bits Slave Address 0 a 8 bits data SEND a	Transmitter	Continue
0	0	0	0	X	1	1	1	Sr 7 bits Slave Address 0 a 8 bits data SEND a P	Idle	Normal
1	0	0	0	0	0	1	1	Sr 7 bits Slave Address 1 a 8 bits data RECEIVE 1	Receiver	Continue
1	0	0	0	0	1	1	1	Sr 7 bits Slave Address 1 a 8 bits data RECEIVE 1 P	Idle	Normal
1	0	0	0	1	0	1	1	Sr 7 bits Slave Address 1 a 8 bits data RECEIVE 0	Receiver	Continue

Table 21.4 Control bits combinations permitted in Master Transmitter

R	S	R	S	S	H	A	S	S	R	OPERATION	Next I ² C Master State	Next Speed Mode
S	T	T	R	S	C	T	T	A	U			
B	B	S	S	T	K	O	P	R	N			
X	1	0	X	X	X	X	X	X	X	I ² C module software reset	Idle	Normal
X	0	0	0	X	1	0	0		P		Idle	Normal
X	0	0	0	0	0	0	1			8 bits data RECEIVE 1	Receiver	Continue
X	0	0	0	0	1	0	1			8 bits data RECEIVE 1 P	Idle	Normal
X	0	0	0	1	0	0	1			8 bits data RECEIVE 0	Receiver	Continue
1	0	0	0	0	0	1	1	S		7 bits Slave Address 1 a 8 bits data RECEIVE 1	Receiver	Continue
1	0	0	0	0	1	1	1	S		7 bits Slave Address 1 a 8 bits data RECEIVE 1 P	Idle	Normal
1	0	0	0	1	0	1	1	S		7 bits Slave Address 1 0 8 bits data RECEIVE 0	Receiver	Continue
0	0	0	0	X	0	1	1	Sr		7 bits Slave Address 0 a 8 bits data SEND a	Transmitter	Continue
0	0	0	0	X	1	1	1	Sr		7 bits Slave Address 0 a 8 bits data SEND a P	Idle	Normal

Table 21.5 Control bits combinations permitted in Master Receiver

21.5.3.2 BUSY bit

When Control bit write to I²CMCR, the BUSY bit will not change to high immediately. There are about delay 2us.

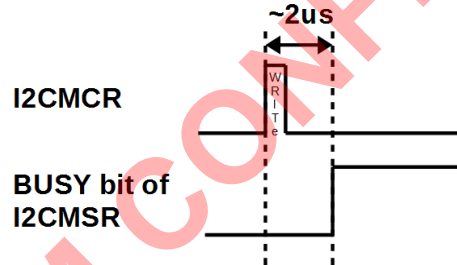


Figure 21.8 Timing for BUSY bit

21.5.3.3 I²C Master Interrupt

To use the I²C Master interrupt, in addition to set I²CMIE = 1 in I²CMINT (0x5000301C), I²C_INT=1 should be set in NVIC. Please refer Table 11.2 Interrupt Map Vector Table

When any transmission is completed by I²C Master, I²C Master Interrupt will be generated. I²CMIF can be determined whether interrupt is generated by I²C Master.

User need write I²CMIF=1 to clean I²CMIF.

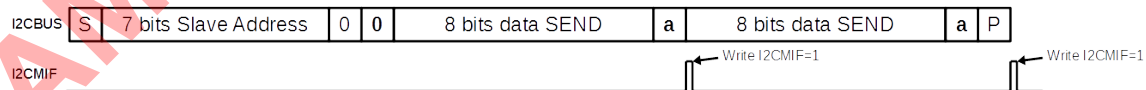


Figure 21.9 I²CMIF=1 when transmit finish

21.5.3.4 I²C Master Transmit

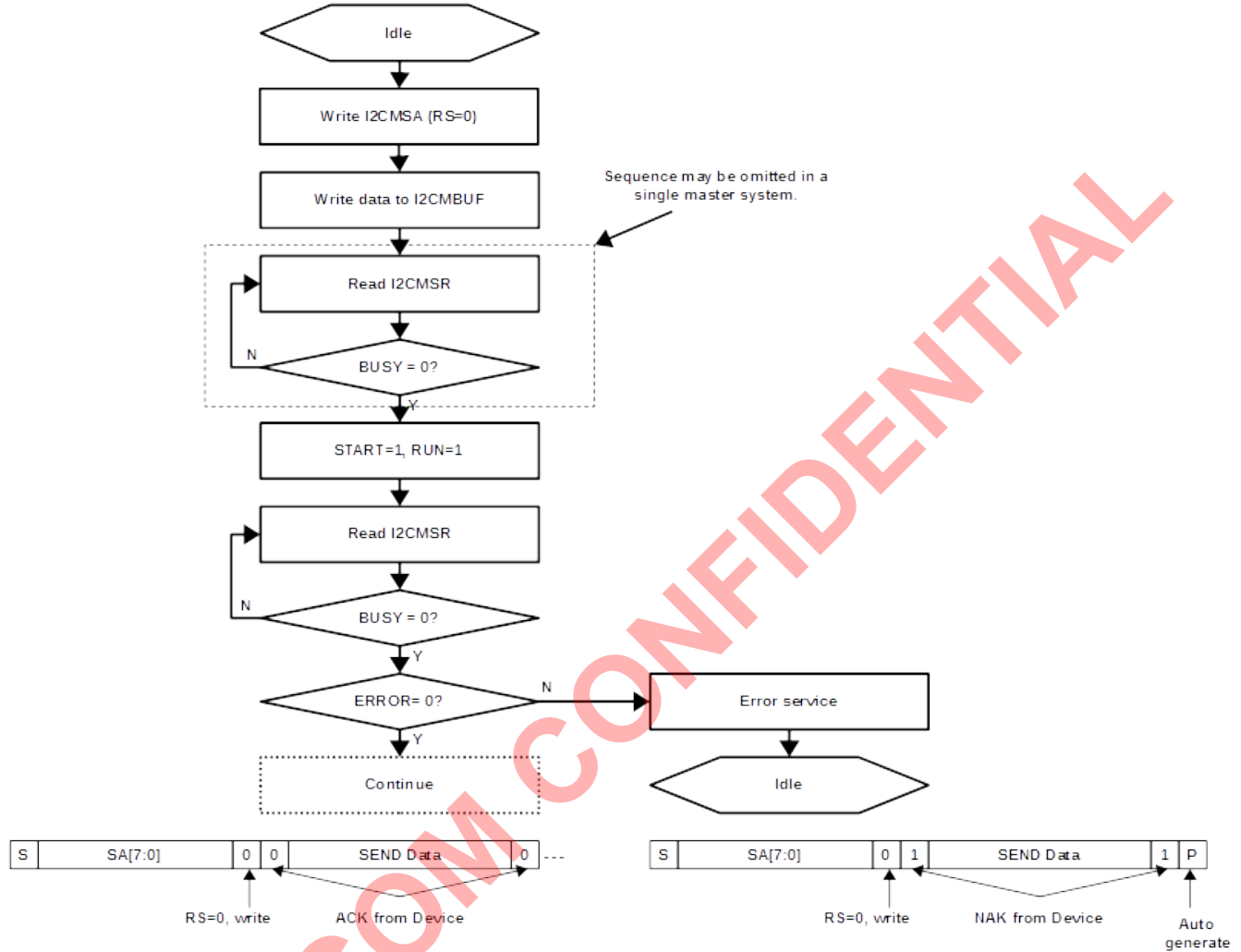


Figure 21.10 The flow chart of I²C Master Transmit

21.5.3.5 I²C Master Receive

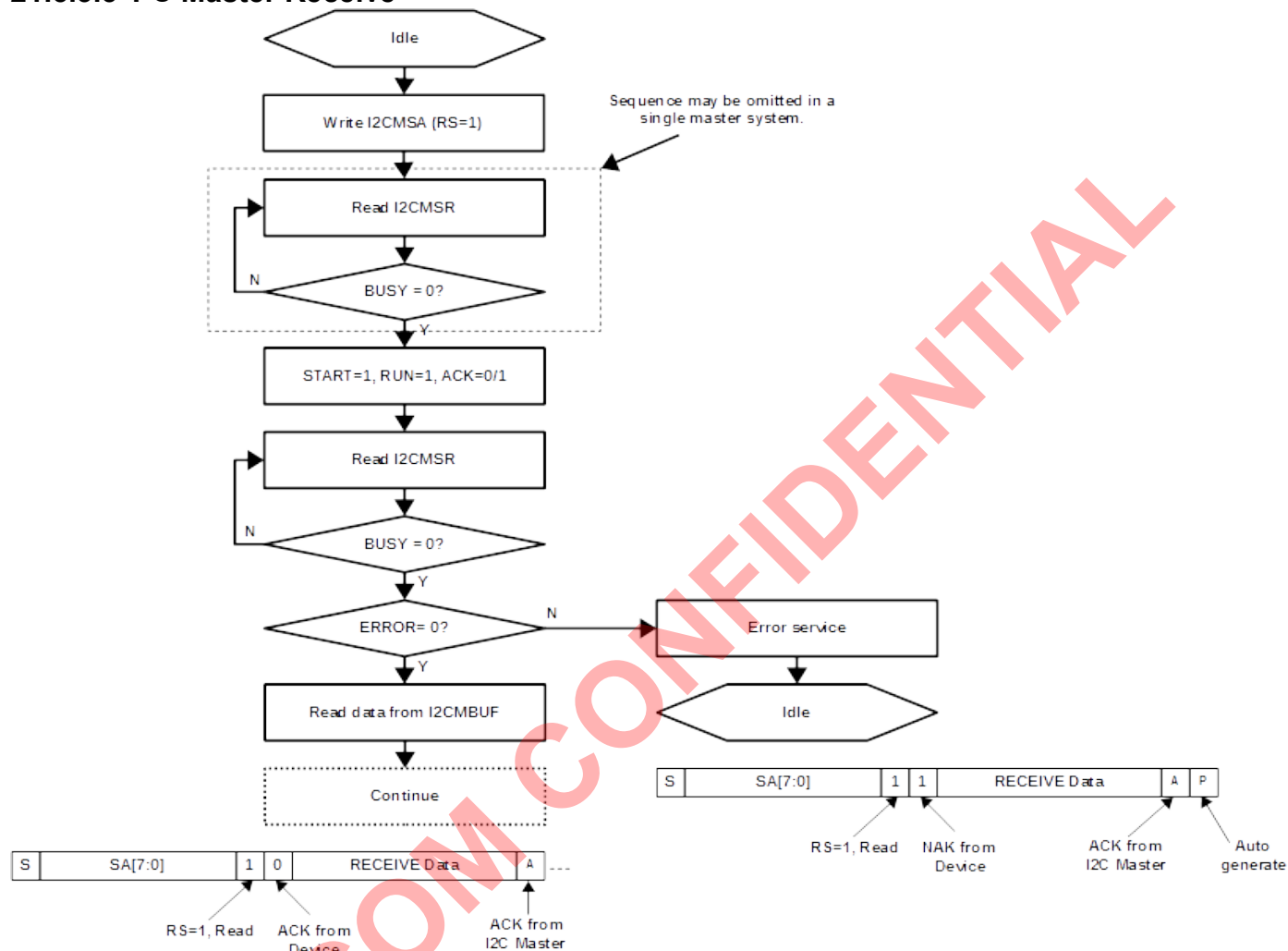


Figure 21.11 The flow chart of I²C Master Receive

21.5.3.6 I²C Master Transmit with Repeat START

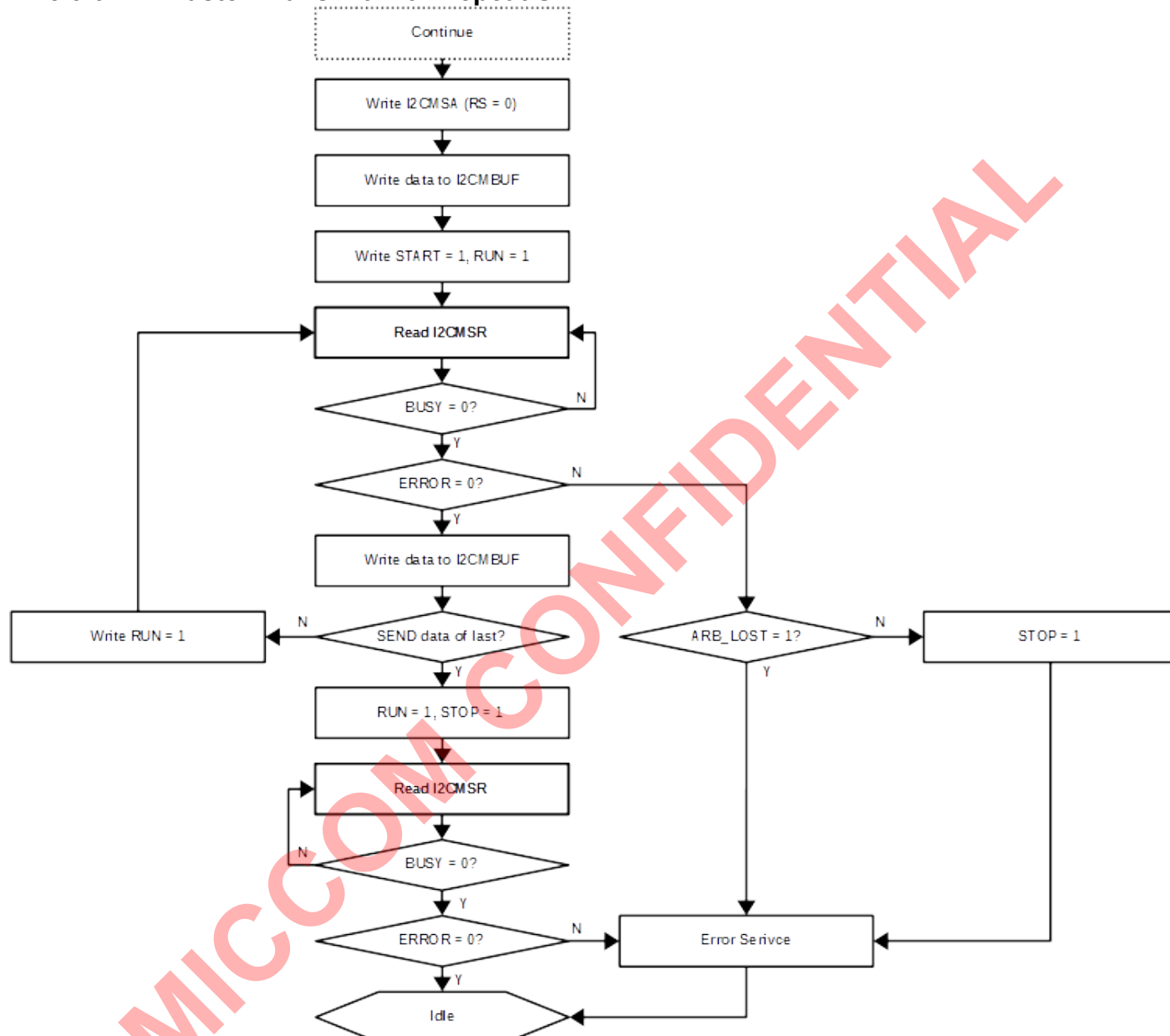


Figure 21.12 The flow chart of I²C Master Transmit with Repeat START

21.5.3.7 I²C Master Receive with Repeat START

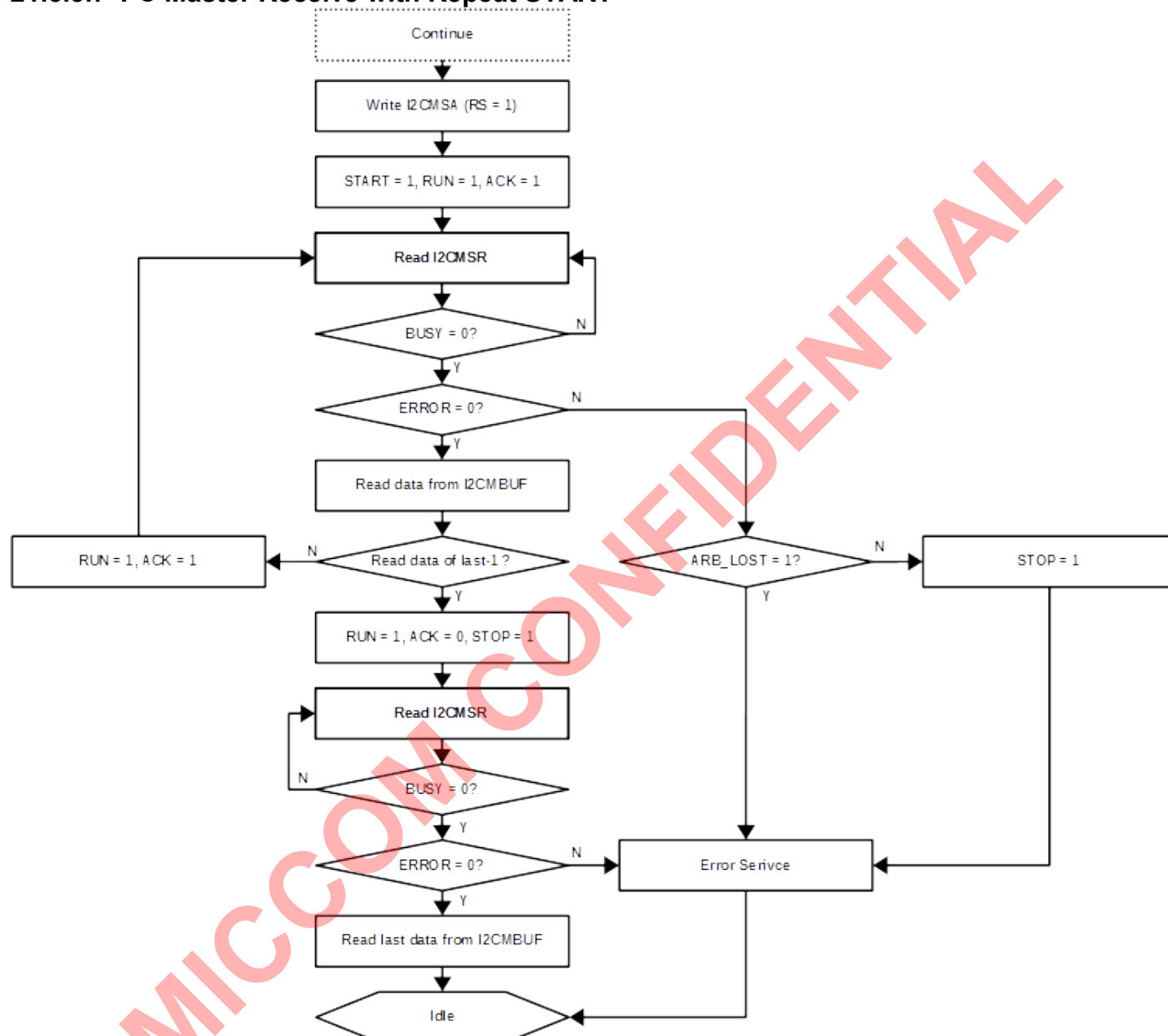


Figure 21.13 The flow chart of I²C Master Receive with Repeat START

21.5.4 I²C Slave

I²C Slave will be switched at Idle State, Slave Receiver and Slave Transmitter.

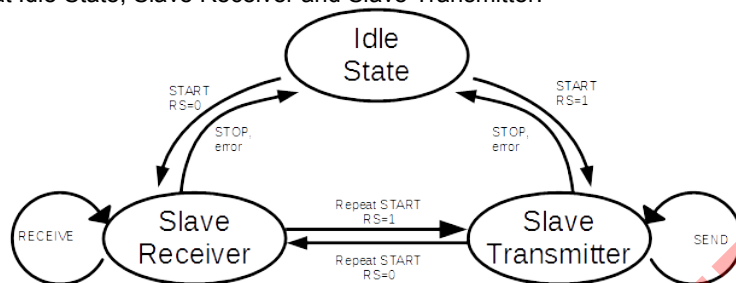


Figure 21.14 State of I²C Slave

21.5.4.1 I²C Slave Control

Due to I²C Slave can only be received state passively, therefore, bits need to be controlled are less actually. I²C Slave will be ready when after set DA=1. And then, read the state of the I²CSSR to determine the action.

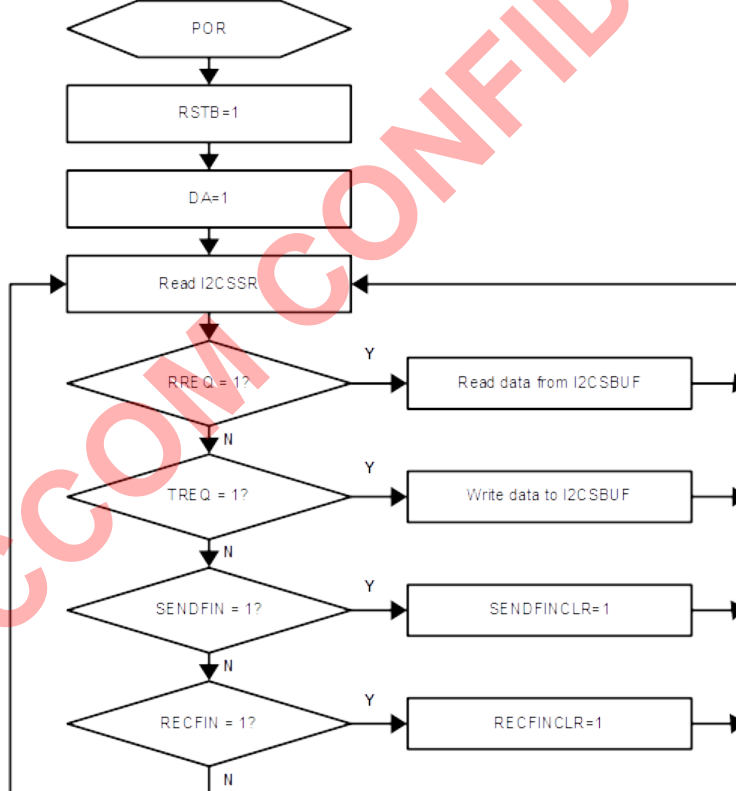


Figure 21.15 The flow chart of I²C Slave

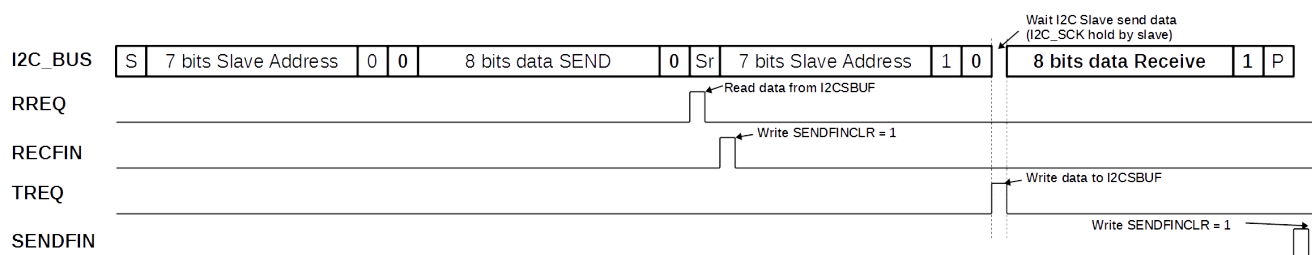


Figure 21.16 Timing for RREQ, TREQ, RECFIN, SENDFIN

21.5.4.2 I²C Slave Interrupt

To use the I²C Slave interrupt, in addition to set I²CSIF=1 in I²CSINT (0x50003810), I²C_INT=1 should be set in NVIC. Please Refer Table 11.2 Interrupt Map Vector Table

When any signal of RREQ or TREQ or SENDFIN or RECFIN is generated by I²C Slave, I²C Slave interrupt will be generated. I²CSIF can be determined whether interrupt is generated by I²C Slave. After interrupt generation, I²CSIF should be written to 1 to clear I²CSIF.

21.5.5 10 Bit Address

I²C protocol uses 10 Bit Address to solve address 7 Bit Address caused by the lack of address space, and it can be compatible with the original 7 Bit Address protocol. Preamble “11110” is used to determine 10 Bit Address and 7 Bit Address by 10 Bit Address. Followed by 2 Bits Slave Address (SA [9: 8]), and then the next packet can be written to the remaining 8 Bits Slave Address (SA [7: 0]).

The following format is used to write and read 10 Bit Address Device generally:

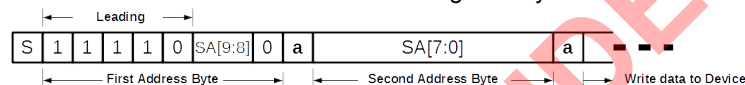


Figure 21.17 Write data to 10 Bit Address Device

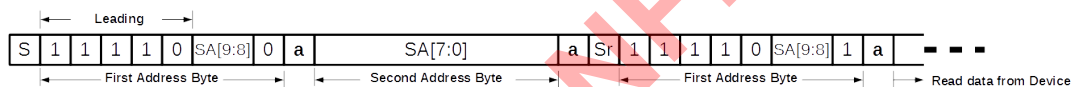


Figure 21.18 Read data from 10 Bit Address Device (It needs to use Repeat Start to direction conversion).

21.5.5.1 10 Bit Address for I²C Master

Due to 10 Bit Address is compatible with 7 Bit Address, I²C Master does not need to set specially. Only according to transmission format of the 10 Bit Address to send the corresponding data.

21.5.5.2 10 Bit Address for I²C Slave

TEN_ADDR_EN=1 of I²CSOAUP (0x5000380C), set ADDR[9:7] and ADDR[6:0]. And then, set DA=1, followed by the same as the original Slave program.

22. SPI Interface

22.1 FEATURES

- Full duplex Synchronous serial data transfer
- Configurable as a master or a slave on the interface
- Programmable clock bit rate (1/2 (master only), 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, 1/256 of MCU clock)
- Programmable data size from 4 bits to 16 bits
- Separate TXFIFO (8x16bits) and RXFIFO (8x16bits).
- Interrupts for TXFIFO and RXFIFO

22.2 PINS DESCRIPTION

PIN	GPIO	TYPE	DESCRIPTION
SPI1_SCK	P0_03	INPUT / OUTPUT	SPI clock pin
SPI1_MOSI	P0_02	INPUT / OUTPUT	Slave serial data input / Master serial data output
SPI1_MISO	P0_01	INPUT / OUTPUT	Master serial data input / Slave serial data output
SPI1_CS	P0_00	INPUT / OUTPUT	Slave select pin
SPI2_SCK	P0_09	INPUT / OUTPUT	SPI clock pin
SPI2_MOSI	P0_05	INPUT / OUTPUT	Slave serial data input / Master serial data output
SPI2_MISO	P0_04	INPUT / OUTPUT	Master serial data input / Slave serial data output
SPI2_CS	P0_12	INPUT / OUTPUT	Slave select pin

Table 22.1 SPI pins description

22.3 BLOCK DIAGRAM

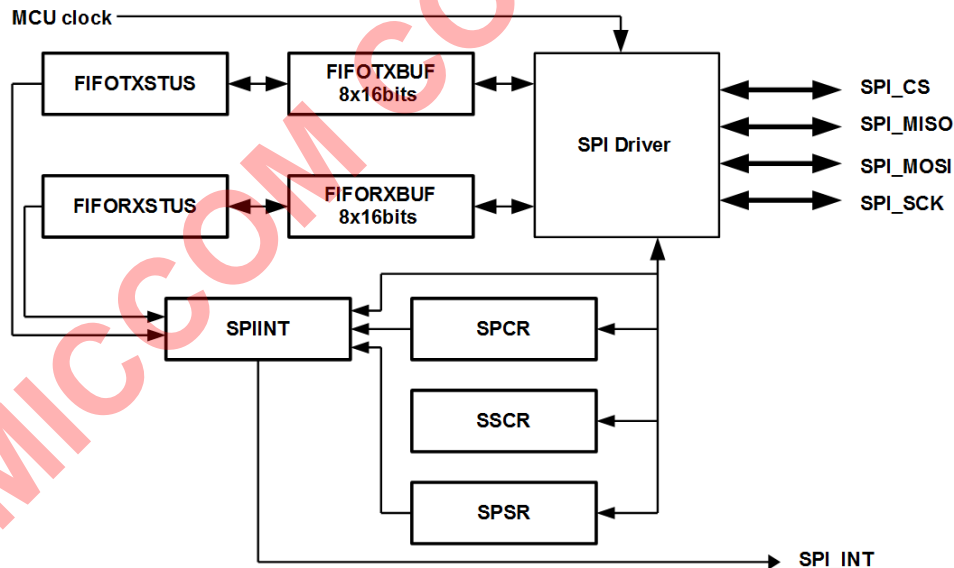


Figure 22.1 SPI Block Diagram

22.4 REGISTER

22.4.1 Base Address List

Base Address	DESCRIPTION
0x50002000	SPI1 Base address
0x50002100	SPI2 Base address

Table 22.2 Base address list

22.4.2 Register List

Offset	Name	DESCRIPTION
0x000	SPCR	SPI Control Register
0x004	SPSR	SPI Status Register
0x008	SPIINT	SPI Interrupt Register
0x00C	SSCR	Slave Select Control Register
0x010	FIFOTXSTUS	SPI TX FIFO Status
0x014	FIFORXSTUS	SPI RX FIFO Status
0x018	FIFOTXBUF	SPI TX FIFO Buffer
0x01C	FIFORXBUF	SPI RX FIFO Buffer

Table 22.3 SPI register list

22.4.3 Register Description

SPI Control Register (Offset: 0x000)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W								
R	--	RXFIFO_IL[2:0]			--	TXFIFO_IL[2:0]		
Reset	0	0	1	1	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	SLAVE_RST			FIFOEN				
R	--	--	--					
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W								
R	--	SPE	SPR[2]	MSTR	CPOL	CPHA	SPR[1]	SPR[0]
Reset	0	0	0	0	0	1	0	0

RXFIFO_IL[2:0]: Set SPI RX FIFO interrupt level. If RXFIFO_IL[2:0] < RXFIFO_REM[2:0], generate interrupt.

TXFIFO_IL[2:0]: Set SPI TX FIFO interrupt level. If TXFIFO_IL[2:0] > TXFIFO_REM[2:0], generate interrupt.

SLAVE_RST: In SPI Slave, write 1 to reset SPI TX FIFO point.

[0]: No effect

[1]: Reset SPI TX FIFO WP (only for SPI Slave)

FIFOEN: SPI FIFO mode enable

[0]: NOT SUPPORT

[1]: FIFO mode

BIT_LEN[3:0]: Set number of bits in a shift sequence.

[0~3]: 4 bits data

[4~15]: (BIT_LEN[3:0] + 1) bits data

SPE: SPI Enable

[0]: SPI disable

[1]: SPI enable

MSTR: SPI Master/ SPI Slave select

[0]: SPI Slave

[1]: SPI Master

CPOL: Clock polarity select

[0]: SPI_SCK idle low

[1]: SPI_SCK idle high

CPHA: Clock phase select

[0]: Latch data in first SPI_SCK edge change

[1]: Latch data in second SPI_SCK edge change

SPR[2:0]: SPI clock rate select bits:

SPR2	SPR1	SPR0	MCU clock divided by
0	0	0	4
0	0	1	8
0	1	0	16
0	1	1	32
1	0	0	64
1	0	1	128
1	1	0	256
1	1	1	2 (only for SPI Master)

SPI Status Register (Offset: 0x004)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--		--	--				SSCEN
R			SS_S					
Reset	0	0	0	0	0	1	0	0

SS_S: In SPI Salve, this bit connected with SPI_CS.

SSCEN: SPI_CS automatic select setting. This bit work with SS0.

SSCEN	SS0	SPI_CS
0	0	0
0	1	1
1	0	0 when transfer. 1 when idle.
1	1	1

SPI Interrupt Register (AddreOffset: 0x008)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	SPICK_EN		RXFIFO_INT_FLAG	TXFIFO_INT_FLAG	--		RXFIFO_INTEN	TXFIFO_INTEN
R								
Reset	1	0	0	0	0	0	0	0

SPICK_EN: SPI clock gating.

[0]: enable gating

[1]: disable gating

RXFIFO_INT_FLAG: RXFIFO interrupt flag

[0]: Interrupt not occurs.

[1]: Interrupt occurred, write 1 to clear.

TXFIFO_INT_FLAG: TXFIFO interrupt flag

[0]: Interrupt not occurs.

[1]: Interrupt occurred, write 1 to clear.

RXFIFO_INTEN: SPI RXFIFO interrupt enable

[0]: Disable

[1]: Enable

TXFIFO_INTEN: SPI TXFIFO interrupt enable

[0]: Disable

[1]: Enable

NOTE: User need clear RXFIFO_INT_FLAG and TXFIFO_INT_FLAG before write FIFOTXBUF when SPI interrupt occur.

SPI Select Control Register (Offset: 0x00C)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--							SS0
R								
Reset	1	1	1	1	1	1	1	1

SS0: SPI_CS automatic select setting

SSCEN	SS0	SPI_CS
0	0	0
0	1	1
1	0	0 when transfer. 1 when idle.
1	1	1

FIFO TX Status (Offset: 0x010)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--			--	--	--		
R	--			TX_FULL	TX_EMPTY	TXFIFO_REM[2:0]		
Reset	0	0	0	0	1	0	0	0

TX_FULL: FIFOTXBUF Full

[0]: FIFOTXBUF not full, user can write data to FIFOTXBUF.

[1]: FIFOTXBUF full, user can't write data to FIFOTXBUF.

TX_EMPTY: FIFOTXBUF Empty

[0]: FIFOTXBUF not empty.

[1]: FIFOTXBUF empty.

TXFIFO_REM [2:0]: FIFOTXBUF remnant. The number of data in the FIFOTXBUF

TX_FULL	TX_EMPTY	TXFIFO_REM[2:0]	Number of data in FIFOTXBUF
0	1	0	0
0	0	0	1
0	0	1	2
0	0	2	3
0	0	3	4
0	0	4	5
0	0	5	6
0	0	6	7
1	0	7	8

FIFO RX Status (Offset: 0x014)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--			--	--	--		
R	--			RX_FULL	RX_EMPTY	RXFIFO_REM[2:0]		
Reset	0	0	0	0	1	0	0	0

RX_FULL: FIFORXBUF Full

[0]: FIFORXBUF not full.

[1]: FIFORXBUF full.

RX_EMPTY: FIFORXBUF Empty

[0]: FIFORXBUF not empty.

[1]: FIFORXBUF empty. Read FIFORXBUF will read as 0.

RXFIFO_REM [2:0]: The numbers of data in the FIFORXBUF

RX_FULL	RX_EMPTY	RXFIFO_REM[2:0]	Numbers of data in FIFORXBUF
0	1	0	0
0	0	1	1
0	0	2	2
0	0	3	3
0	0	4	4
0	0	5	5
0	0	6	6
0	0	7	7
1	0	0	8

FIFO TX Buffer (Offset: 0x018)

R/W	Bit 15	-----	Bit 0
W	TXBUF[15:0]		
R	--		
Reset	0x0000		

TXBUF[15:0]: FIFOTXBUF is a FIFO register with a width of 16 bits and depth of 8. User can write data to this FIFO and send out via SPI. Refer to SPI FIFO for details.

FIFO RX Buffer (Offset: 0x01C)

R/W	Bit 15	-----	Bit 0
W	--		
R	RXBUF[15:0]		
Reset	0x0000		

RXBUF[15:0]: FIFORXBUF is a FIFO register with a width of 16 bits and depth of 8. Data will be saved to FIFORXBUF when SPI received data. User can read out data from FIFORXBUF. Refer to for details.

22.5 FUNCTION DESCRIPTION

22.5.1 SPI Master and SPI Slave

SPI Driver can be set to SPI Master (MSTR=1) or SPI Slave (MSTR=0) via MSTR. When SPI Driver is set to SPI Master, SPI_CS and SPI_SCK will be controlled by SPI Driver, and send data via SPI_MOSI, receive data via SPI_MISO. When SPI Driver is set to SPI Slave, SPI_CS and SPI_SCK will be controlled by other SPI, and receive data via SPI_MOSI, send data via SPI_MISO.

22.5.2 SPI_SCK speed

Speed of SPI is decides by speed of SPI_CLK. Speed of SPI_CLK is related to MCU Clock. Speed can be adjusted by SPR2, SPR1 and SPR0:

SPR2	SPR1	SPR0	MCU clock divided by
0	0	0	4
0	0	1	8
0	1	0	16
0	1	1	32
1	0	0	64
1	0	1	128
1	1	0	256
1	1	1	2 (only for SPI Master)

Table 22.4 SPI pins description

For example:

System Clock is 16MHz and SPR2=0, SPR1=0, SPR0=0, speed of SPI_CLK is 4MHz (16MHz / 4). Therefore, speed of SPI is 4M bps.

It needs to be noted, the set SPR2=1, SPR1=1, SPR0=1 is only for SPI Master, SPI Slave does not use this set.

22.5.3 SPI Transmission Format

22.5.3.1 SPI Transmission Data Length

SPI can set every transmission data length via BIT_LEN[3:0] of SPCR. Data length can be set during 4~16 Bits.

For example:

Each data of SPI will transmit 4 bits when BIT_LEN[3:0]=3.

Each data of SPI will transmit 16 bits when BIT_LEN[3:0]=15.

22.5.3.2 SPI_CS Setting

In SPI Master, SPI_CS can be set auto selection mode or manual selection mode. Description is as follows:

Auto selection mode: When SSCEN=1, SS0=0, SPI_CS will be pulled low automatically at data is transmitting and SPI_CS will be pulled high automatically at data transmitting is complete. Shown is as following figure:

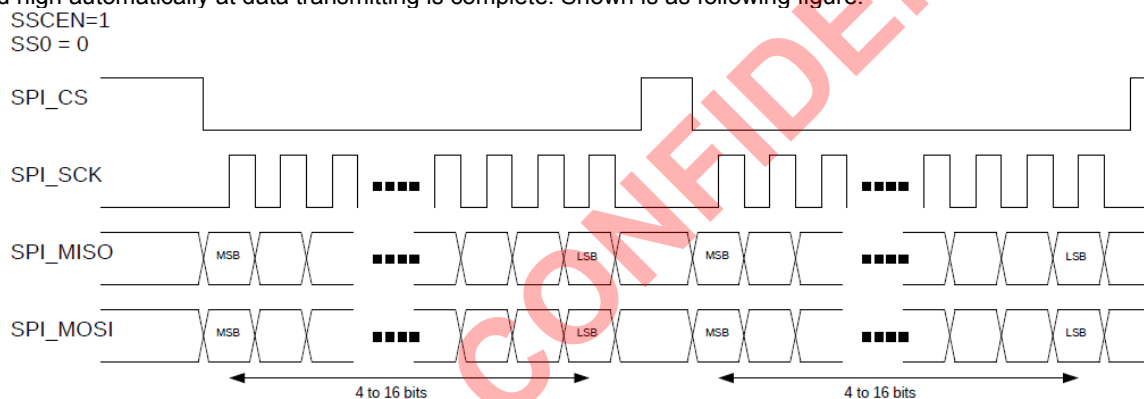


Figure 22.2 SPI_CS auto selection mode

Manual selection mode: When SSCEN=0, SPI_CS is controlled by SS0, SPI_CS will be pulled low when SS0=0; SPI_CS will be pulled high when SS0=1. Shown is as following figure:

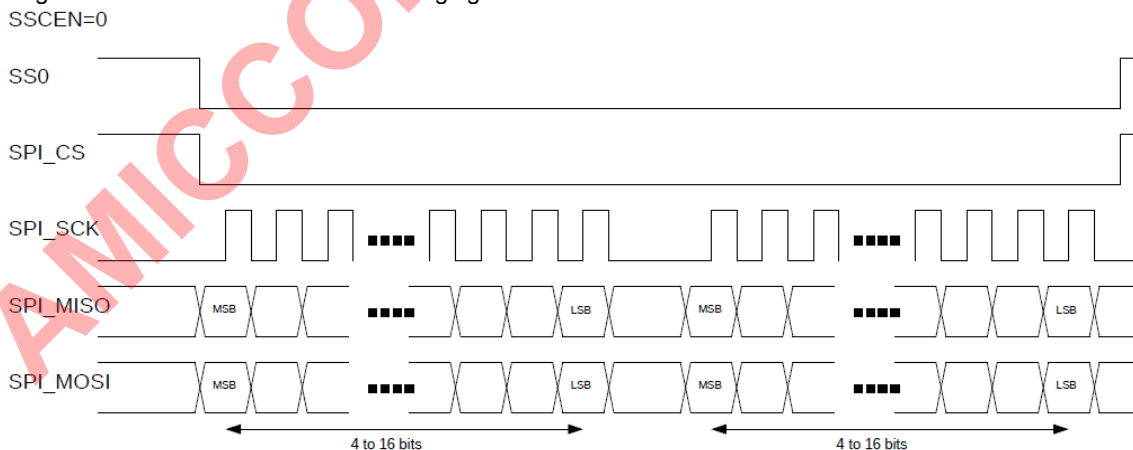


Figure 22.3 SPI_CS manual selection mode

22.5.3.3 SPI_SCK Setting

SPI can support four kinds of transmission format via CPOL and CPHA of SPCR. SPI_SCK is set by CPOL at idle state. When CPOL=0, SPI_SCK is low at idle state. When CPOL=1, SPI_SCK is high at idle state. CPHA is used to set which number of SPI_SCK to occur changed and start to latch data. When CPHA=0, start to latch data at SPI_SCK occurs changed first time. When CPHA=1, start to latch data at SPI_SCK occurs changed second time.

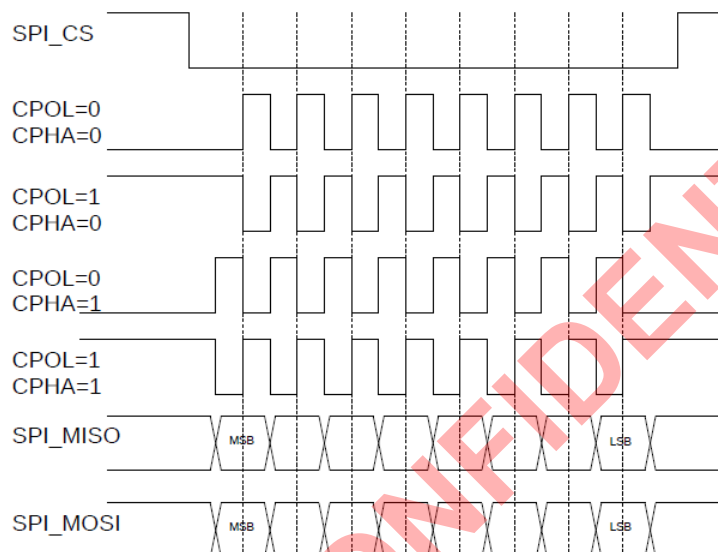


Figure 22.4 The dotted line represents timing to latch data.

22.5.4 SPI FIFO

The SPI has two separate FIFO, one is SPI TX FIFO, and the other is SPI RX FIFO. These two FIFO are with a width of 16 bits and depth of 8. They can be used to send/receive data continuously.

WP (write point) will move up when data is written to FIFOTXBUF.

WP (write point) will move down when data of SPI Master's MOSI or data of SPI Slave's MISO is sent out.

RP (read point) will move up when data of SPI Master's MISO or data of SPI Slave's MOSI is received.

RP (read point) will move down when data is read.

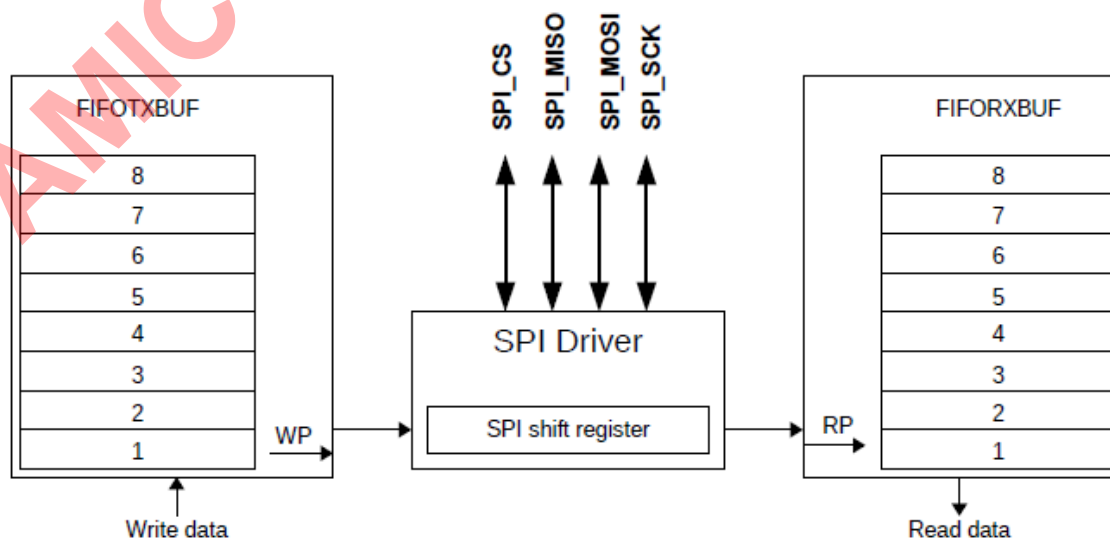


Figure 22.5 SPI FIFO Architecture descriptions

22.5.5 SPI FIFO interrupt

SPI FIFO interrupt, it must be $RXFIFO_INTEN=1$ of SPIINT or $TXFIFO_INTEN=1$ of SPIINT, and $SPI_INT=1$ of NVIC. Please refer Table 11.2 Interrupt Map Vector Table.

And then, when data number of SPI TX FIFO or data number of SPI RX FIFO reaches to set value of $TXFIFO_IL[2:0]$ or $RXFIFO_IL[2:0]$. SPI interrupt will be started. User can read $TXFIFO_INT_FLAG$ and $RXFIFO_INT_FLAG$ to determine the interruption is generated by SPI TX FIFO or SPI RX FIFO.

Please be noted, $TXFIFO_INT_FLAG$ and $RXFIFO_INT_FLAG$ should be cleared to zero by user. And then, $FIFOTXBUF$ can be written data or read data from $FIFORXBUF$.

SPI TX FIFO interrupt condition: $TXFIFO_IL[2:0] > TXFIFO_REM[2:0]$

SPI RX FIFO interrupt condition: $RXFIFO_IL[2:0] < RXFIFO_REM[2:0]$

Please refer to 22.5.6.1 SPI Master Transmit data and 22.5.6.2 SPI Master Receive data

22.5.6 SPI Master Transmit

When SPI Driver is set to SPI Master, data can be written from $FIFOTXBUF$ to SPI TX FIFO and data can be read from SPI RX FIFO via $FIFORXBUF$. At the same time, state of SPI TX FIFO and SPI RX FIFO can be checked by $FIFOTXSTUS$ and $FIFORXSTUS$, and write/read data at the right time to keep write/read data continuously.

22.5.6.1 SPI Master Transmit data

When $TX_FULL=0$, data can be written to $FIFOTXBUF$ by user. When $TX_FULL=1$, data can't be written to SPI TX FIFO if user keeps writing data continuously. When there is data in SPI TX FIFO, data will be sent by SPI_MOSI at SPI Master. At the same time, data will be read by SPI_MISO and will be saved to SPI RX FIFO.

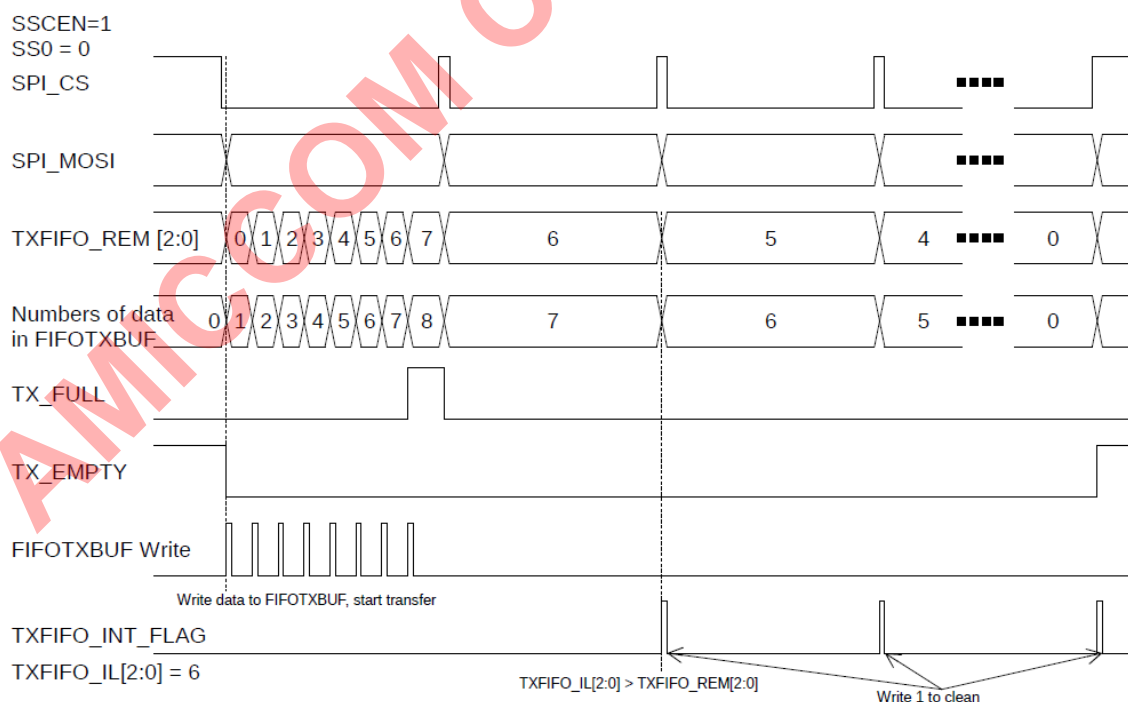


Figure 22.6 An example for SPI Master sent data 8 times and set $TXFIFO_IL[2:0]=6$

22.5.6.2 SPI Master Receive data

When SPI Master sent data, SPI will receive data and save to SPI RX FIFO at the same time. When RX_FULL=1, data will be not written to SPI RX FIFO.

SSCEN=1

SS0 = 0

SPI_CS

SPI_MISO

RXFIFO_REM [2:0]

Numbers of data
in FIFORXBUF

RX_FULL

RX_EMPTY

FIFORXBUF Read

RXFIFO_INT_FLAG

RXFIFO_IL[2:0] = 1

RXFIFO_IL[2:0] = RXFIFO_REM[2:0]

Write 1 to clean

Figure 22.7 An example SPI Master received data 8 times and set RXFIFO_IL[2:0]=1

22.5.7 SPI Slave Transmit

22.5.7.1 SPI Slave Transmit data

In SPI Slave mode, data can be written to FIFOTXBUF at SPI idle (there is no send/receive data). Or, data will be error. When TX_FULL=1, data cannot be written to SPI TX FIFO if user keeps writing data continuously. SLAVE_RST=1 can be set by SPI Slave, and SPI TX FIFO WP can be reset to first data position.

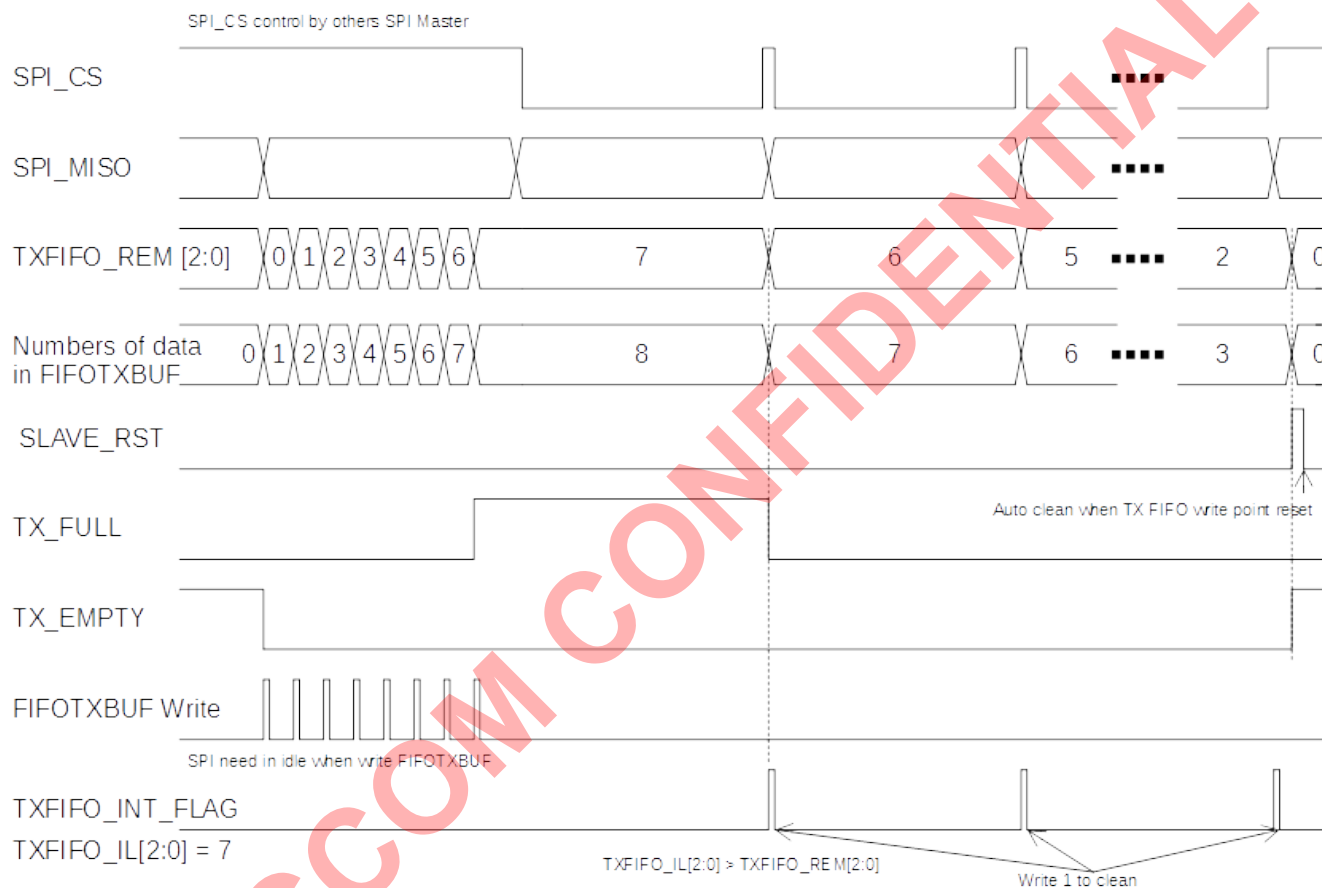


Figure 22.8 An example for SPI Slave wrote data 8 times in advance, and sent out data when received data.

22.5.7.2 SPI Slave Receive data

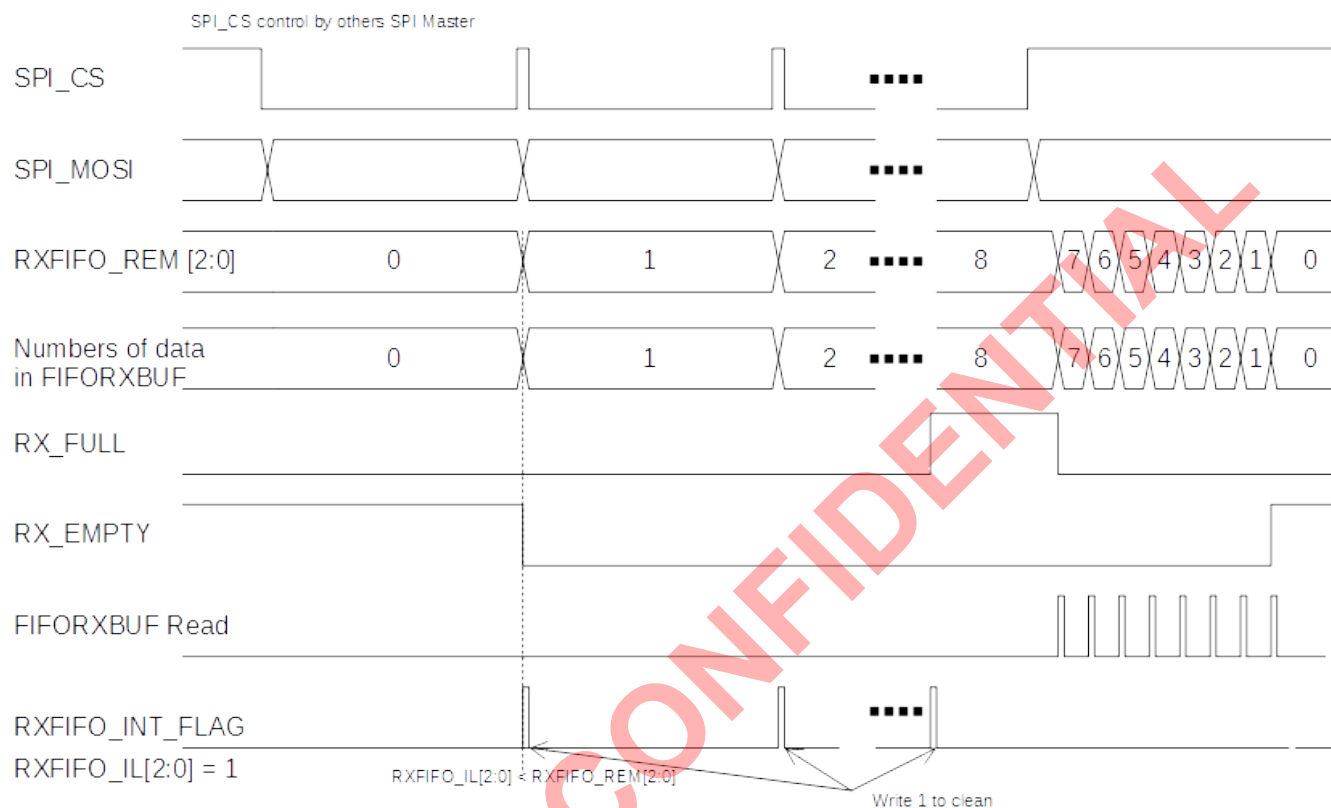


Figure 22.9 An example for SPI Slave received data 8 times

23. 8-bits ADC

A3117M0 has built-in 8-bits ADC (Analog to Digital Converter). The 8-bits ADC can be used to measure the carrier detect and RSSI.

23.1 FEATURES

- For carrier detect, RSSI measurement

23.2 BLOCK DIAGRAM

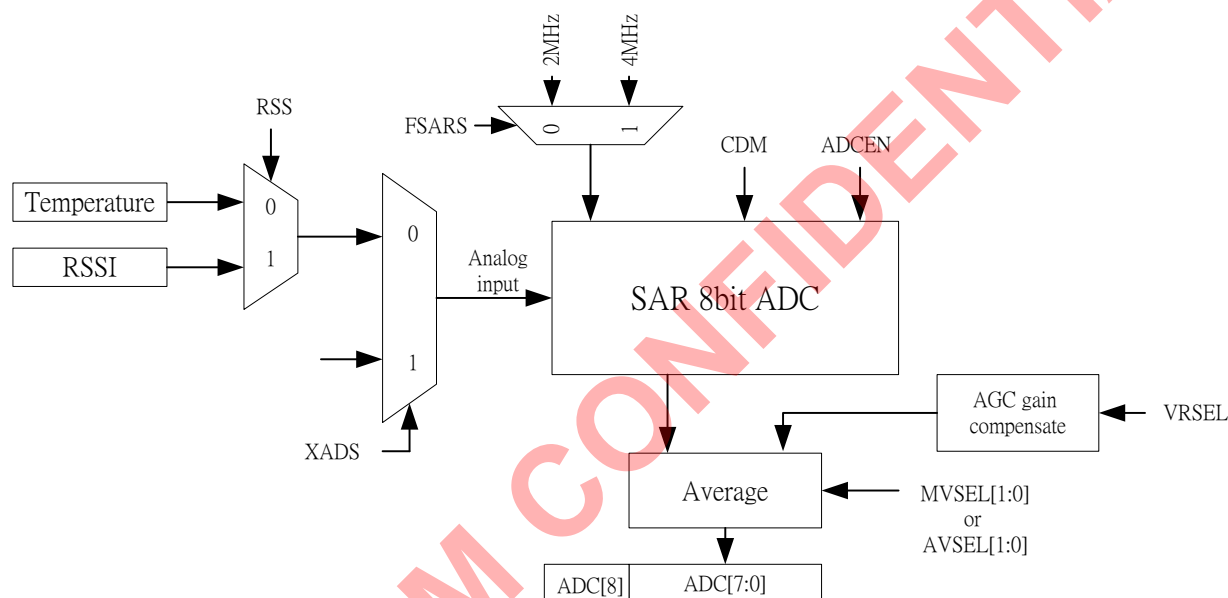


Figure 23.1 8-bits ADC block diagram

23.3 REGISTER

23.3.1 Register List

Address	Name	DESCRIPTION
0x50001240	ADC_CTRL	8-bits ADC Control Register
0x50001244	ADC	8-bits ADC Value / Threshold Register

Table 23.1 PWM Register List

23.3.2 Register Description

8-bits ADC Control Register (Address: 0x50001240)

R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	RADC	AVSEL[1:0]		MVSEL[1:0]		--	RSM[1:0]	
R								
Reset	0	1	0	1	0	0	0	1
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	ERSS	--	FSARS	XADS	RSS	ARSSI	CDM	ADCM
R								
Reset	0	0	1	0	1	0	1	0

RADC: ADC read out average mode.

[0]: 1, 2, 4, 8 average mode. The average number is according to the setting of AVSEL.

[1]: 8, 16, 32, 64 average mode. The average number is according to the setting of MVSEL.

AVSEL[1:0]: ADC average times

[00]: No average.

[01]: Average 2 times.

[10]: Average 4 times.

[11]: Average 8 times.

MVSEL[1:0]: ADC average times

[00]: Average 8 times.

[01]: Average 16 times.

[10]: Average 32 times.

[11]: Average 64 times.

RSM[1:0]: RSSI margin = RTH – RTL.

[00]: 5.

[01]: 10.

[10]: 15.

[11]: 20.

ERSS: End enable for RSSI measurement

[0]: RSSI measurement continues until leave off RX mode.

[1]: RSSI measurement will end when carrier detected and ID code word received.

FSARS: ADC clock select.

[0]: 2MHz.

[1]: 4MHz.

XADS: ADC mode input signal select.

[0]: Convert RSSI.

[1]: Not support

RSS: Temperature/RSSI measurement select.

[0]: Temperature measurement.

[1]: RSSI or carrier-detect measurement.

ARSSI: Auto RSSI measurement while entering RX mode.

[0]: Disable.

[1]: Enable.

CDM: RSSI measurement mode.

[0]: Single mode.

[1]: Continuous mode.

ADCM: ADC measurement enable (Auto clear when done for single mode).

[0]: Disable measurement or measurement finished.

[1]: Enable measurement.

8-bits ADC Value / Threshold Register (Address: 0x50001244)

R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	--							--
R	--							ADC[8]
Reset								0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	RTH[7:0]							
R	ADC[7:0]							
Reset	0	0	0	0	0	0	0	0

RTH[7:0]: Carrier detect threshold.

ADC[7:0]: ADC output value of temperature, RSSI

ADC[8]: ADC output value for RSSI with AGC on.

23.4 FUNCTION DESCRIPTION

23.4.1 8-bits ADC function:

The 8-bits ADC provides RSSI and carrier detect measurement.

Bit		MODE	
XADS	RSS	Standby	RX
0	1	None	RSSI / Carrier detect

Table 23.2 8-bits ADC setting

23.4.2 RSSI measurement

A3117M0 supports 8-bits digital RSSI to detect RF signal strength. RSSI value is stored in ADC [7:0] (0x50001244). Figure 23.2 and Figure 23.3 shows a typical plot of RSSI reading as a function of input power. This curve is based on the current gain setting of A3117M0 reference code. A3117M0 automatically averages 8-times ADC conversion a RSSI measurement until A3117M0 exits RX MODE. Therefore, each RSSI measuring time is $(8 \times 20 \times F_{ADC})$. Be aware RSSI accuracy is about $\pm 6\text{dBm}$.

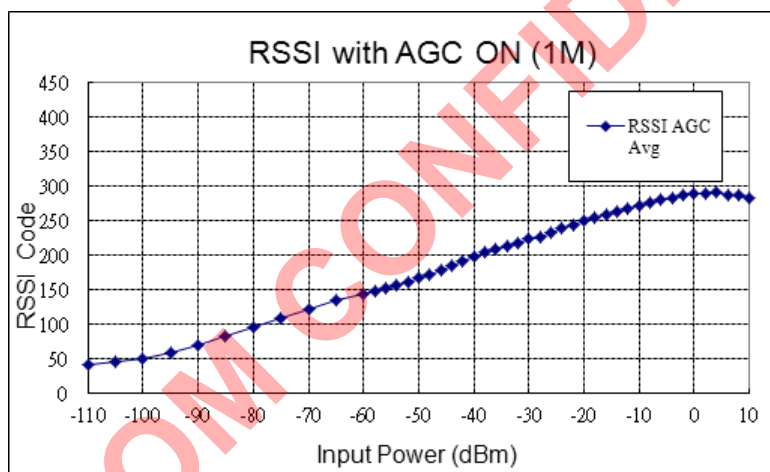


Figure 23.2 RSSI vs RF input Power (AGC On)

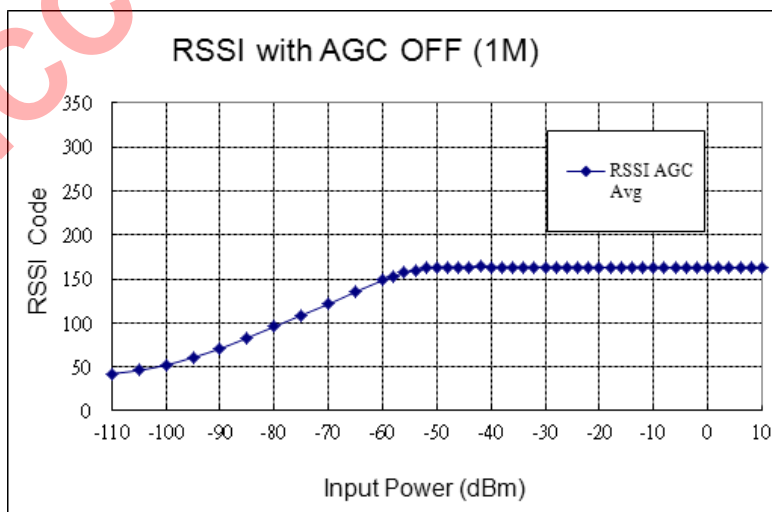


Figure 23.3 RSSI vs RF input Power (AGC Off)

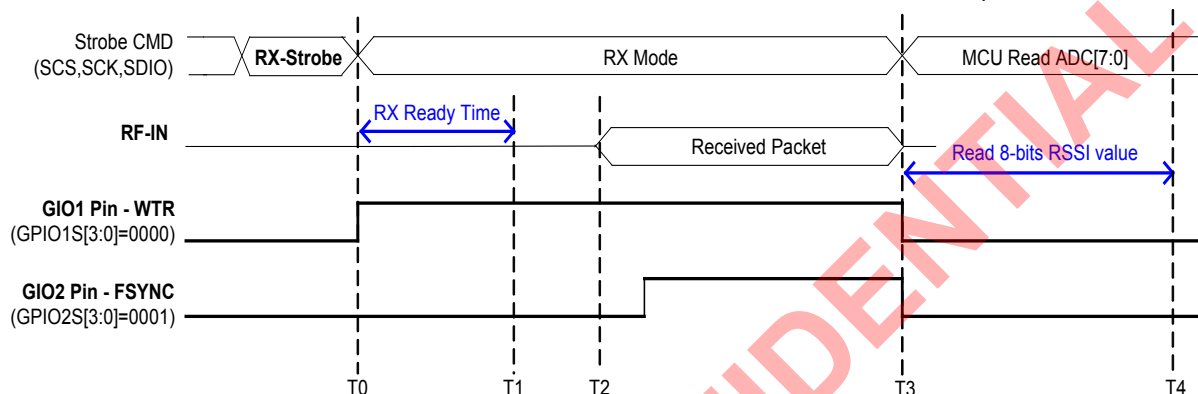
Auto RSSI measurement for TX Power:

1. Set wanted Channel (0x500010C0)

2. Set RSS = 1, FSARS= 0 (2MHz ADC clock).
3. Enable ARSSI = 1.
4. Enter RX state.
5. In RX mode, 8-times average a RSSI measurement periodically.
6. Exit RX mode, user can read digital RSSI value from ADC[7:0] (0x50001244) for TX power.

Note: If AGCE=1 and VRESL=1, RSSI value from ADC[8:0](0x50001244)

In step 6, if A3117M0 is set in direct MODE, MCU shall let A3117M0 exit RX MODE within 40us to prevent RSSI inaccuracy.

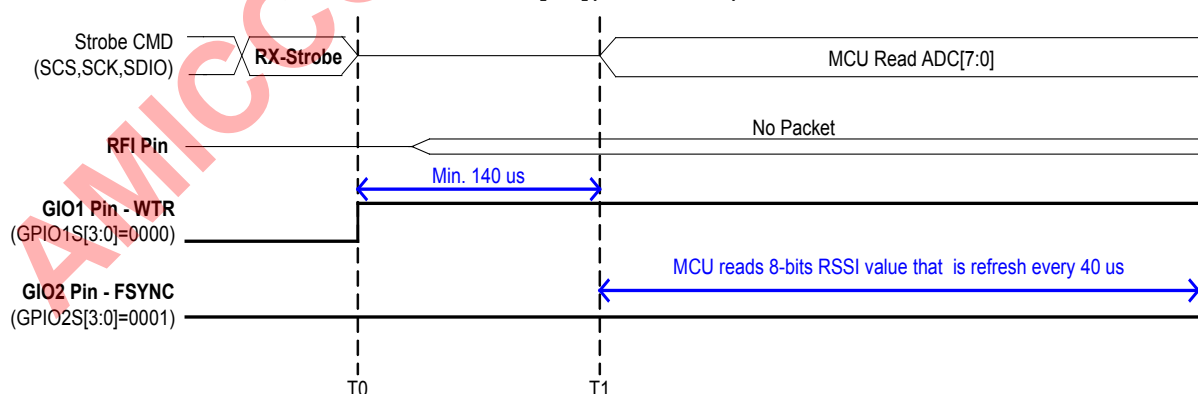


T0-T1: Settling Time
T2-T3: Receiving Packet
T3 : Exit RX mode automatically in FIFO mode
T3-T4: MCU read RSSI value @ ADC [7:0]
Figure 23.4 RSSI Measurement of TX Power

Auto RSSI measurement for Background Power:

1. Set wanted Channel (0x500010C0)
2. Set RSS = 1, FSARS= 1 (4MHz ADC clock).
3. Enable ARSSI = 1.
4. Enter RX state.
5. MCU delays min. 140us.
6. Read digital RSSI value from ADC[7:0] (0x50001244) to get background power.
7. Send other Strobe command to let A3117M0 exit RX mode.

Note: If AGCE=1 and VRESL=1, RSSI value from ADC[8:0](0x50001244)



T0-T1: MCU Delay Loop from PLL to RX mode for RSSI measurement
T1 : Auto RSSI Measurement is done by 8-times average.
MCU can read RSSI value from ADC [7:0]
Figure 23.5 RSSI Measurement of Background Power

23.4.3 Carrier Detect

Base on RSSI measurement, user can extend its application to do carrier detect (CD). In Carrier Detect MODE, RSSI is re-fresh every 5us without 8-times average. If RSSI level is below threshold level (RTH), CD is output high to GIO1 or GIO2 pin to inform MCU that current channel is busy.

Below is a reference procedure:

1. Set CDTH for absolute RSSI threshold level (ex. RTH = 80d).
2. Set GIO2S = [0010] for Carrier Detect to GIO2 pin.
 - (2-1) Set wanted F_{RXLO}
 - (2-2) Set RSM= [11], CDM =1.
 - (2-3) Enable ARSSI=1.
 - (2-4) Enter RX mode
 - (2-5) MCU enables a timer delay (min. 100 us).
3. MCU checks GIO2 pin.
 - (3-1) If $ADC \geq CDTH$, GIO2 = 1.
 - (3-2) If $ADC \leq CDTH-CDM$, GIO2=0
 - (3-3) If ADC locates in hysteresis zone, GIO2 = previous state.
4. Exit RX MODE.

A3117M0 has two built-in ADCs. One is 8-bits ADC do RSSI measurement as well as carrier detection function. The 8-bit ADC converting time is 20 x ADC clock periods. The other is 8-channel 12-bits SAR ADC.

24. 12-bits SAR ADC

A3117M0 includes a 12-bits successive approximation A/D converter which enables channel selection from 8 channels. The A/D converter has two operating modes: single mode and continuous mode. The 12-bits A/D converter can be used to perform the analog input of the specified channel or internal temperature sensor.

****Note:** Under the A3117M0 with DC to DC device, 12-bits ADC function must be used in ByPass mode.

24.1 FEATURES

- External Voltage measure from 8 channels
- Internal Temperature measure
- Programmable internal reference voltage: 1.8V, 2.0V, or external reference voltage
- Application measuring for internal temperature, sensor interface, battery operated system, data acquisition

24.2 PINS DESCRIPTION

PIN	GPIO	TYPE	DESCRIPTION
ADCCH0	P0_18	INPUT	12-bits ADC analog input channel 0
ADCCH1	P0_19	INPUT	12-bits ADC analog input channel 1
ADCCH2	P0_08	INPUT	12-bits ADC analog input channel 2
ADCCH3	P0_09	INPUT	12-bits ADC analog input channel 3
ADCCH4	P0_12	INPUT	12-bits ADC analog input channel 4
ADCCH5	P0_13	INPUT	12-bits ADC analog input channel 5
ADCCH6	P0_14	INPUT	12-bits ADC analog input channel 6
ADCCH7	P0_15	INPUT	12-bits ADC analog input channel 7

Table 24.1 12-bits ADC pins description

24.3 BLOCK DIAGRAM

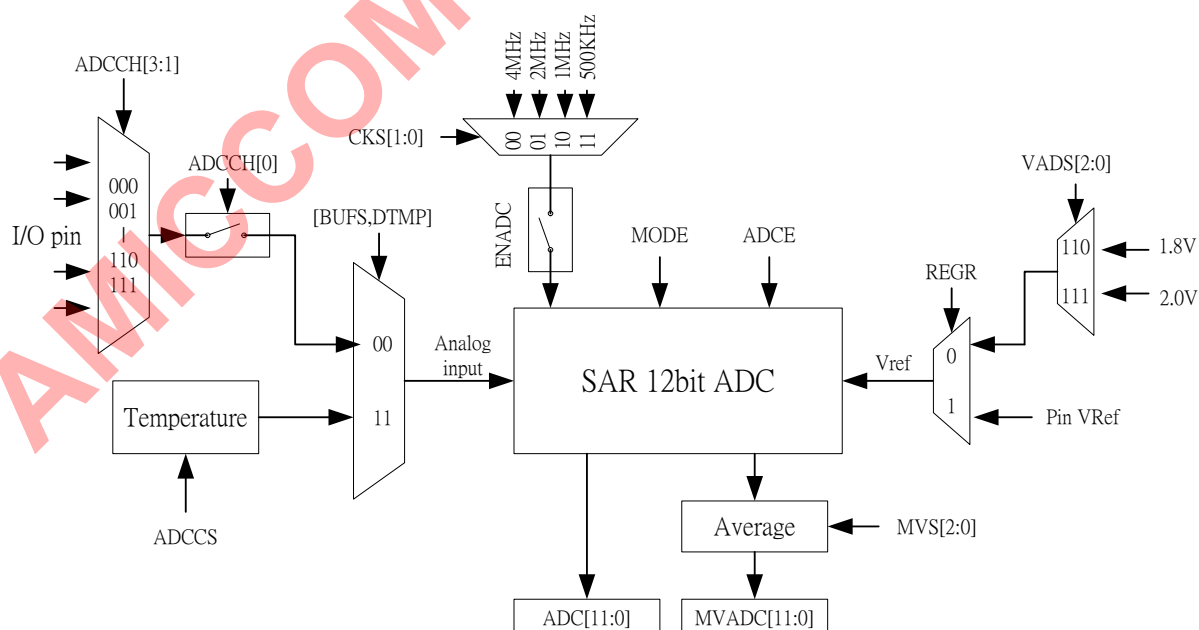


Figure 24.1 12-bits ADC block diagram

24.4 REGISTER

24.4.1 Register List

Address	Name	DESCRIPTION
0x50008000	ADC_CTRL_1	12-bit ADC Control Register
0x50008004	ADC_CTRL_2	12-bit ADC Value Register
0x50008008	ADC_CH	12-bit ADC external voltage channel select
0x50000010	PWR_CTRL_3	12-bit ADC reference voltage setting

Table 24.2 PWM Register List

24.4.2 Register Description

12-bits ADC Control Register 1 (Address: 0x50008000)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W	ADC12RN	--						
R	--							
Reset	0	0						
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W								ADCINT_clr
R								ADCINT_Flag
Reset	0							
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	ADCIE	VADS[2:0]			ADIVL	ADCYC	ENADC	DTMP
R	--	--			--	--	--	--
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	BUFS	CKS[1:0]		MODE	MVS[2:0]			ADCE
R	--	--						
Reset	0	1	0	0	0	0	0	0

ADC12RN: 12-bits ADC Reset. (Write "1" to reset).

[0]: Disable

[1]: Enable

ADCINT_Flag: 12-bits ADC interrupt flag. (Write "1" to reset)

ADCIE: 12-bits interrupt enable (only for single mode).

[0]: Disable

[1]: Enable

VADS[2:0]: ADC Reference Voltage.

[110]: 1.8V

[111]: 2.0V

[Others]: Reserved for internal usage only.

ADIVL: 12-bits ADC sargen initial value select.

[0]: 2048 (recommend)

[1]: 0

ADCYC: 12-bits ADC sargen clock counter select.

[0]: 31 (recommend)

[1]: 32

ENADC: Enable ADC clock source.

[0]: Disable

[1]: Enable

DTMP: 12-bits temperature select.

[0]: Disable
[1]: Enable

BUFS: input buffer select for 12 bit ADC.

[0]: Disable
[1]: Enable

CKS[1:0]: ADC clock selected.

[00]: MCU clock / 4
[01]: MCU clock / 8
[10]: MCU clock / 16
[11]: MCU clock / 32

MODE: ADC measurement mode.

[0]: Single mode
[1]: Continuous mode

MVS[2:0]: ADC average times.

[000]: No average
[001]: Average 2 times
[010]: Average 4 times
[011]: Average 8 times
[100]: Average 16 times
[101]: Average 32 times
[110]: Average 64 times
[111]: Average 128 times

ADCE: ADC measurement enable.

[0]: Disable
[1]: Enable

12-bits ADC Control Register II (Address: 0x50008004)

R/W	Bit 31	-----	Bit 28	Bit 27	-----	Bit 16
W	--	--	--	--	--	--
R	--	--	--	--	MVADC[11:0]	--
Reset	0x0	0x0	0x0	0x0	0x000	0x000
R/W	Bit 15	-----	Bit 12	Bit 11	-----	Bit 0
W	--	--	--	--	--	--
R	--	--	--	--	ADC[11:0]	--
Reset	0x0	0x0	0x0	0x0	0x000	0x000

MVADC [11:0]: Moving average ADC output value.

ADC [11:0]: ADC output value. ADC input voltage= VDD_ADC * MVADC [11:0] / 4095 V

12-bits ADC Channel Register (Address: 0x50008008)

R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W								
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	INS1	INS0	PGS2	PGS1	PGS0		ADCS_N1	ADCS_N0
R	INS1	INS0	PGS2	PGS1	PGS0		ADCS_N1	ADCS_N0
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W		ADCS_P1	ADCS_P0	ENCHS	ADCCH3	ADCCH2	ADCCH1	ADCCH0
R		ADCS_P1	ADCS_P0	ENCHS	ADCCH3	ADCCH2	ADCCH1	ADCCH0
Reset	0	0	0	0	0	0	0	0

INS[1:0] : PGA status
[00]: BUF, bypass PGA
[01]: Non inverter mode
[10]: Inverter mode
[11]: Differential mode

PGS[2:0] : PGA gain
[000]: 1
[001]: 2
[010]: 4
[011]: 8
[100]: 16
[101]: 32
[110]: 64
[111]: 128

ADCS_N[1:0] :
[0]: Select P0.25 as ADC N analog input.
[1]: Select P0.27 as ADC N analog input.

ADCS_P[1:0] :
[0]: Select P0.24 as ADC P analog input.
[1]: Select P0.26 as ADC P analog input.

ENCHS : enable ADC I/O for Differential mode.

ADCCH[3:1] : ADC I/O select.
[000]: Select P0.18 as ADC analog input.
[001]: Select P0.19 as ADC analog input.
[010]: Select P0.8 as ADC analog input.
[011]: Select P0.9 as ADC analog input.
[100]: Select P0.12 as ADC analog input.
[101]: Select P0.13 as ADC analog input.
[110]: Select P0.14 as ADC analog input.
[111]: Select P0.15 as ADC analog input.

ADCCH[0]: ADC input enable.
[0]: Disable.
[1]: Enable.

Power Control Register 3 (Address: 0x500000010)

R/W	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
W								
R	--							
Reset	--							
R/W	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
W								
R	ENVAD	--	--	ECH	LIBM	ADCCS	ECHA	REGR
Reset	0	0	0	1	0	0	1	0
R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	VTRB[3:0]				VMRB[3:0]			
R	--				--			
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--	IFAS	CGC	IWA	IWC	LBG	VCS	VCSW
R	--	--	--	--	--	--	--	--
Reset	0	0	0	0	0	0	0	0

ADCCS: Internal temperature measure enable.

[0]: Disable

[1]: Enable

REGR: 12-bit ADC external reference voltage (Vref) input.

[0]: Disable

[1]: Enable

24.5 FUNCTION DESCRIPTION

12-bit ADC provides two functions: one for analog input measurement and the other for internal temperature sensor measurement. The user can setting bit DTMP, bit BUFS to switch test mode.

Bit		MODE
DTMP	BUFS	
0	0	Analog Input
1	1	Internal temperature Sensor

Figure 24.2 12-bit ADC function

24.5.1 A/D Reference Voltage (Vref):

The reference voltage supply to the A/D Converter can be supplied from the positive power supply pin, VDD_ADC, an internal reference source derived from the Bandgap circuit. The desired selection is made using the VADS[2:0] bits in the ADC Control Register I and relevant pin function control bits.

REGR	VADS[2:0]	Vref	Description
0	110	VDD_ADC	ADC Reference Voltage comes from VDD_ADC=1.8V
0	111	VDD_ADC	ADC Reference Voltage comes from VDD_ADC=2.0V
1	x	Vref	External reference voltage from IC-Pin: RSSI (Max Vref ≤ BATH voltage)

Table 24.3 Reference Voltage

24.5.2 ADC Value Calculation:

12 Bit ADC can be used to measure the external input. The input voltage range is from 0V ~ VDD_ADC. Please care the input voltage if set the input source from external input. Refer to the following formula, input voltage can be calculated from MVADC[11:0] or ADC[11:0].

$$\text{ADC input voltage} = \text{Vref} * \text{MVADC} [11:0] / 4095$$

24.5.3 A/D Conversion Time:

The time of A/D conversion 1 times is:

$$t_{conv} = \frac{4 \times 2^{CKS[1:0]}}{\text{Crystal Frequency}} \times 32 \mu s$$

24.5.4 Analog Input (Voltage) Measurement

Measurement for Analog Input:

1. Set ADCCH (0x50008008) for selecting ADC channel.
2. Set MODE=1, ENADC=1, VADS=6, DTMP=0, BUFS=0 (0x50008000) to enable the SAR ADC with continue mode.
3. Set DCDC Control 2 register (0x50000018) =0 to switch to DCDC bypass mode (with DC to DC device function).
4. Set ADCE=1 (0x50008000) to enable ADC.
5. Delay two MVADC conversion time.
6. Read MVADC or ADC value.
7. Set ADCE=0 (0x50008000) to disable ADC.
8. Set DCDC Control 2 register (0x50000018) =241 to switch to DCDC mode (with DC to DC device function).

24.5.5 Internal Temperature Measurement

Measurement for Temperature:

1. Set RSS=0 (0x50001240) to select temperature sensor.
2. Set ADCCS=1 (0x50000010) to connect temperature sensor. Usually set PWR_CTRL_3 (0x50000010) = 0x0094000C.
3. Set MODE=1, ENADC=1, VADS=6, DTMP=1, BUFS=1 (0x50008000) to enable the SAR ADC with continue mode.
4. Set DCDC Control 2 register (0x50000018) =0 to switch to DCDC bypass mode.
5. Set ADCE=1 (0x50008000) to enable ADC.
6. Delay time that over two MVADC conversion time. For example, the delay time need over $2*((4*1/16\text{MHz})*32)*8 = 128\mu\text{s}$ if CKS=0, MVS=3.
7. Read MVADC or ADC (0x50008004) value.
8. Set ADCE=0 (0x50008000) to disable ADC.
9. Set DCDC Control 2 register (0x50000018) =241 to switch to DCDC mode.
10. Set ADCCS=0 (0x50000010) to disconnect temperature sensor.

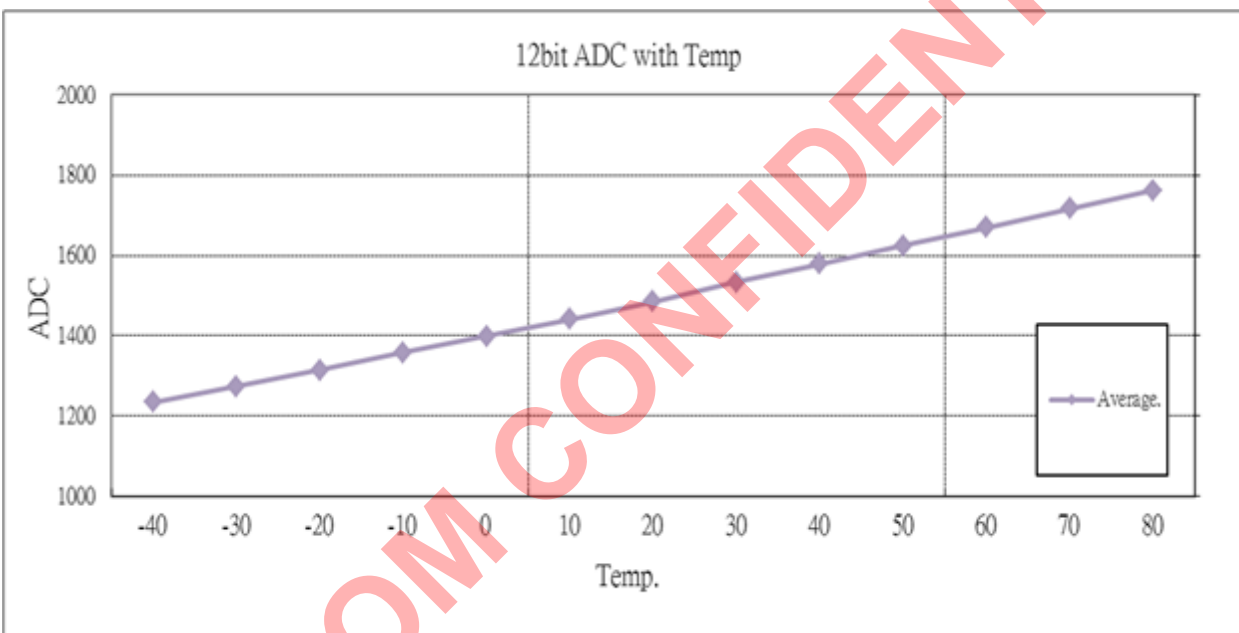


Figure 24.3 Typical 12-bit ADC temperature sensor characteristic curve

25. Battery Detect

The Battery detect function can be used to detect a low battery condition with setting voltage threshold. This is useful for warning that regulation voltages could no longer be maintained. Then MCU has the time to provide hardware protection of data stored in the program memory.

25.1 FEATURES

- Programmable voltage detection threshold in 8 levels

25.2 PINS DESCRIPTION

PIN	GPIO	TYPE	DESCRIPTION
BATH		INPUT	Regulator input

Table 25.1 Battery detect pin description

25.3 BLOCK DIAGRAM

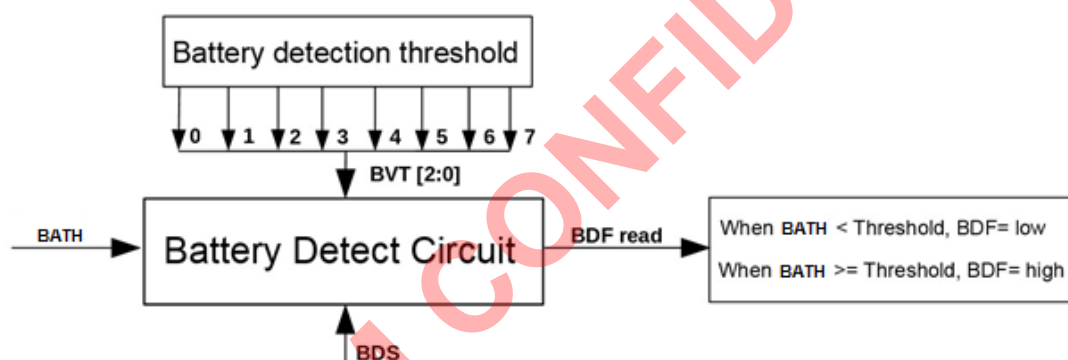


Figure 25.1 Battery detect Block Diagram

25.4 REGISTER

25.4.1 Register list

Address	Name	DESCRIPTION
0x50000000	BDR	Battery Detect Register
0x50007180	USB_CFG0	USB configure 0 Register

Table 25.2 Battery detect Register List

25.4.2 Register Description

Battery Detect Register (Address: 0x50000000)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--			--	BVT[2:0]			BDS
R	--			BDF	BVT[2:0]			BDS
Reset	0	0	0	0	0	1	1	0

BDF: Battery detection flag.

[0]: Battery voltage less than threshold.

[1]: Battery voltage greater than threshold.

BVT[2:0]: Battery detection threshold.

[000]: 1.875V.

[001]: 1.95V.

[010]: 2.025V.
 [011]: 2.1V.
 [100]: 2.175V.
 [101]: 2.25V.
 [110]: 2.325V.
 [111]: 2.4V.

BDS[0]: Battery detect enable.

[0]: Disable.

[1]: Enable. It will be clear after battery detection done.

USB Configure 0 Register (Address: 0x50007180)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--		SB_PHY_ENR1	USB_REGCS	USB_LCPWR	USB_CBGU[4:0]		
R	--		--	--	--	--		
Reset	0	0	0	0	0	1	1	0

USB_REGCS: BOD detector select

[0]: REGIH

[1]: USB

25.5 FUNCTION DESCRIPTION

A3117M0 has a built-in battery detector to check supply voltage (BATH pin). Battery detect function has a control register (BDR). User can select Battery detection threshold by setting BVT[2:0], and the detecting range is 1.875V ~ 2.4V in 8 levels. Enable Battery detect function by setting BDS = 1, and MCU read bit BDF (Battery detection flag) to detect voltage condition. If Battery voltage less than threshold, BDF will output low; otherwise BDF will output high.

25.6 PROCEDURE

Below is the procedure to detect low voltage input (ex. Battery detection threshold 2.1V).

1. Set USB_REGCS (0x50007180, BIT6) = 0
2. Set A3117M0 in STBY, PLL, TX or RX MODE.
3. Set BDR(0x50000000), BVT[2:0] = [011] and enable BDS = 1.
4. After 5 us, BDS is auto clear.
5. MCU reads BDF.
6. If BATH pin voltage >= 2.1V, BDF = 1 (battery high); otherwise BDF = 0 (battery low). Then back to step (2).

26. Power Management

A3117M0 has four power management mode: Normal mode and PM mode. In normal mode, user selects different clock be MCU core clock.in CLKSEL[2:0] then enable CKSE. User adjusts MCU clocks depends on the required power consumption.

PM mode includes PM1, PM2 and PM3. User can set STOP=1 into PMx mode, so that the clock to the core is stopped and all digital peripherals also stop. MCU can be waked up by hardware reset, wakeup key, sleep timer and RTC.

	MCU speed	16MHz XTAL	72KB RAM	LVR	RF	Back to Normal (Wakeup)
Normal CKSE=0	XRC, 16MHz	ON	ON	X	X	X
Normal CKSE=1 (Low speed)	8/4/2/1 MHz, IRC/RTC	ON	ON	X	X	X
PM1	STOP	OFF	Retention	X	OFF	HW reset/ WUN/ Sleep Timer 0, 1/ RTC
PM2	STOP	OFF	Retention	X	OFF	HW reset/ WUN/ Sleep Timer 0, 1/ RTC
PM3	STOP	OFF	Retention	OFF	OFF	HW reset/ WUNIE/ Sleep Timer 0

X: don't care, it can turn on or off by user setting

LVR: Low Voltage Regulator

WUN: Wakeup pin, setting by WUN

WUNIE: Only P0_26~P0_29 (Default enable PM3 wakeup function)

XRC : 48MHz/32MHz

Table 26.1 A3117M0 supports Power Management Modes

26.1 BLOCK DIAGRAM

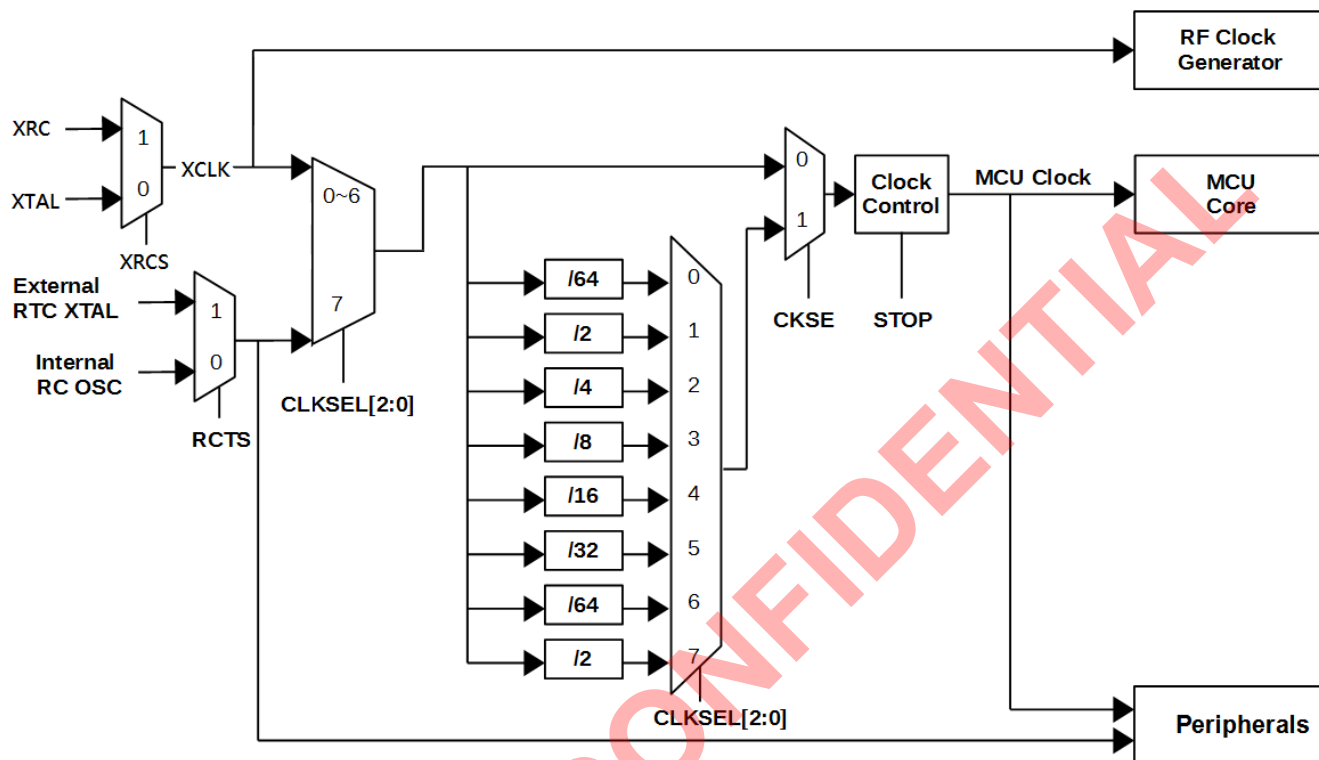


Figure 26.1 Whole chip clock sources

26.2 REGISTER

26.2.1 Register List

Address	Name	DESCRIPTION
0x5000000C	PWR_CTRL_2	Power Control Register 2
0x50000020	MCU_PWR_CTRL	MCU Power Control Register

Table 26.2 Power Management Register List

26.2.2 Register Description

Power Control Register 2 (Address: 0x5000000C)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	1	ENAV	QDSA	ENDV	QDSD	--	--	--
R	--	--	--	--	--	--	--	--
Reset	1	1	0	1	0	0	0	0

ENAV: REGOA and REGOS connection.

QDSA: Quick discharge select for REGOA.

ENDV: REGOA is connected to REGOD.

QDSD: Quick discharge select for REGOD.

MCU Power Control Register (Address: 0x50000020)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--		CLKSEL[2:0]			--	STOP	CKSE
R	--		CLKSEL[2:0]			--	STOP	CKSE
Reset	0	0	0	0	0	0	0	0

CLKSEL[2:0]: Clock Select, Select clock source when CKSE=1.

[000]: Clock source div 64 as MCU clock

[001]: Clock source div 2 as MCU clock

[010]: Clock source div 4 as MCU clock

[011]: Clock source div 8 as MCU clock

[100]: Clock source div 16 as MCU clock

[101]: Clock source div 32 as MCU clock

[110]: Clock source div 64 as MCU clock

[111]: Select RTC as MCU clock when CKSE=0; RTC div 2 as CPU clock when CKSE=1

STOP: Stop MCU clock

[0]: Disable

[1]: Enable

CKSE: Clock select enable

[0]: Disable clock select

[1]: Enable clock select

26.3 FUNCTION DESCRIPTION

26.3.1 Normal Mode

In normal mode, user selects different clock be MCU core clock.in CLKSEL[2:0] then enable CKSE .User adjusts MCU clocks depends on the required power consumption. CLKSEL[2:0] = 001b ~ 110b, the MCU core clock is the clock sources divide 2 ~ 64. User could adjust the MCU speed to trade-off between the performance and the power consumption. **BEWARE, please choice CLKSEL firstly then enable CKSE to avoid glitch.**

To perform Normal mode, follow these steps:

1. CKSE = 0
2. Set CLKSEL[2:0] to select clock source
3. CKSE = 1

26.3.2 PM Mode

User can STOP MCU clock and some circuit, peripherals to saving consume current:

PM Mode	PWR_CTRL_2 0x5000000C	Digital Power	Analog Power
PM1	0xD0	ON	ON
PM2	0xF0	ON	OFF
PM3	0xF8	OFF	OFF

Table 26.3 Power control register 2 setting for PM Mode

To perform PMx, follow these steps:

1. If CKSE = 1, set it to 0
2. Set PWR_CTRL_2 (0x5000000c) value by PMx mode. Please refer
3. Set FALSHCTRL (0x50000004) = 0x0000A495
4. Set ADC_CTRL_1 (0x50008000) = 0x000001FE to set VADS = 0
5. STOP = 1 to enter PMx mode

When wakeup MCU, please follow these steps:

1. Set ADC_CTRL_1 (0x50008000) = 0x000061FE to set VADS = 6
2. Set FALSHCTRL (0x50000004) = 0x00006495

27. MPULCD

The MPULCD controller driver pixels data to LCD panel directly and automatically. The MPULCD has 72KB SRAM, MPULCD_SRAM, for DMA function that address base 0x20000000 and offset 0x00000 to 0x10000. MPULCD_SRAM also are general SRAM when DMA function not active.

SRAM address Base : 0x20000000		
DMA memory	Offset	Size
MPULCD_SRAM_0	0x00000	2KB
MPULCD_SRAM_1	0x00800	6KB
MPULCD_SRAM_2	0x02000	8KB
MPULCD_SRAM_3	0x04000	16KB
MPULCD_SRAM_4	0x08000	8KB
MPULCD_SRAM_5	0x0A000	8KB
MPULCD_SRAM_6	0x0C000	8KB
MPULCD_SRAM_7	0x0E000	8KB
MPULCD_SRAM_8	0x10000	8KB

Table 27.1 SRAM for MPULCD DMA function

27.1 FEATURE

- Support 8-bits 8080 parallel interface, 16-bits 8080 parallel interface and serial interface
- Build-in two 8KB DMA SRAM

27.2 PINS DESCRIPTION

PIN	GPIO	TYPE	DESCRIPTION
LCD_TE	P0_11	INPUT	Tearing effect input pin to synchronies frame rate.
LCD_CSX	P0_16	OUTPUT	Chip Selection Pin
LCD_D/CX	P0_17	OUTPUT	Display Data / Command selection Pin
LCD_RDX	P0_12	OUTPUT	Read Enable pin
LCD_WRX = s_LCD_SCL	P0_20	OUTPUT	Write Enable in parallel interface Serial clock pin in serial Interface
LCD_D[0] = s_LCD_SDA	P0_15	INPUT / OUTPUT	D[15:0] are 16-bits 8080 parallel interface data bus D[7:0] are 8-bits 8080 parallel interface data bus D[0] is the serial input/output signal in serial interface
LCD_D[1]	P0_14		
LCD_D[2]	P0_13		
LCD_D[3]	P0_27		
LCD_D[4]	P0_26		
LCD_D[5]	P0_25		
LCD_D[6]	P0_24		
LCD_D[7]	P0_21		
LCD_D[8]	P0_31		
LCD_D[9]	P0_30		
LCD_D[10]	P0_29		
LCD_D[11]	P0_28		
LCD_D[12]	P0_05		
LCD_D[13]	P0_04		
LCD_D[14]	P0_19		
LCD_D[15]	P0_18		

Table 27.2 MPULCD pin description

27.3 BLOCK DIAGRAM

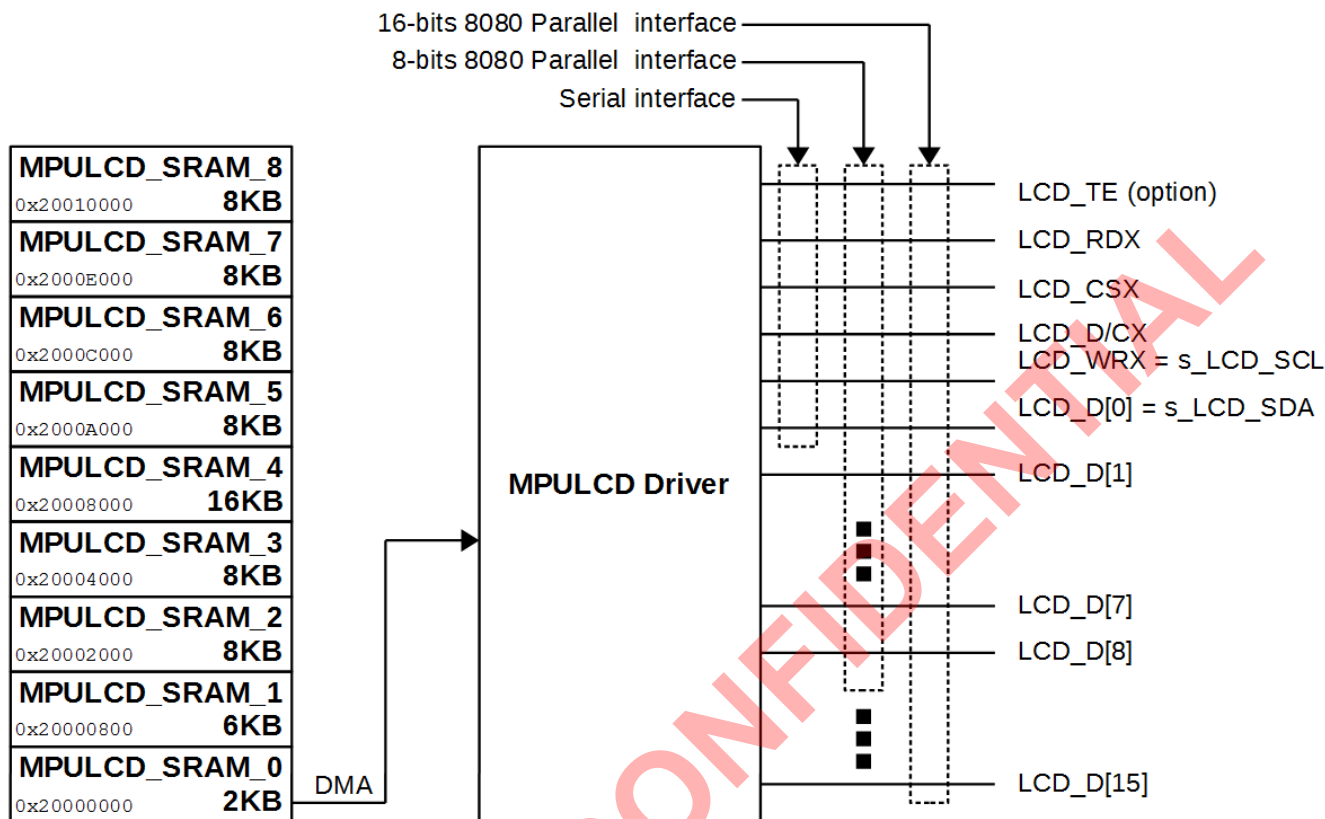


Figure 27.1 MPULCD Block Diagram

27.4 REGISTER

27.4.1 Register List

Address	Name	DESCRIPTION
0x5000A000	MPULCD_CTRL	MPULCD Control Register
0x5000A004	MPULCD_WIDTH	MPULCD SRAM Width Register
0x5000A008	MPULCD_HEIGHT	MPULCD SRAM Height Register
0x5000A010	MPULCD_CYCLE	MPULCD Stretch Cycle Register
0x5000A014	MPULCD_DATA	MPULCD Command Data Register
0x5000A018	MPULCD_OFFSET	MPULCD DMA Start Offset Register

Table 27.3 MPULCD Register List

27.4.2 Register Description

MPULCD Control Register (Address: 0x5000A000)

R/W	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
W	Data_Format[1:0]		INT	nCS_IO	Data_Interface[2:0]			--
R								
Reset	0	0	0	0	0	0	0	0
R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--	TE_Pol	TE_En	CMD	Enable	--	RDnWR	A0_Pol
R						Busy		
Reset	0	0	0	0	0	0	0	0

Data_Format[1:0]: The data transfer format when interface is 8-bits 8080 Parallel Interface.

[00]: RGB565.

[01]: RGB666 format 1.

[10]: RGB666 format 2.

INT: MPULCD interrupt enable.

[0]: Interrupt Disable.

[1]: Interrupt Enable.

nCS_IO: Control MPU LCD control pin LCD_CSX.

[0]: Disable.

[1]: Enable. This bit enables need before then MPULCD Enable.

Data_Interface[2:0]: MPULCD transfer interface:

[001]: 8-bits 8080 Parallel Interface.

[010]: 16-bits 8080 Parallel Interface.

[100]: 8-bits serial interface.

Others: Not support.

TE_Pol: TE Trigger Level.

[0]: Trigger when LCD_TE is low.

[1]: Trigger when LCD_TE is high.

TE_En: TE Trigger Enable.

[0]: Disable TE Trigger.

[1]: Enable TE Trigger. The trigger source from LCD control pin LCD_TE.

CMD: MPULCD transfer data select.

[0]: DMA mode. MPULCD will transfer data from MPULCD_SRAM (0x20004000).

[1]: Command mode. Only transfer one data from MPULCD_DATA (0x5000A014).

Enable: MPULCD enable.

[0]: Disable. MPULCD stop transfer data.

[1]: Enable. MPULCD start transfer data.

This bit is not auto-clean when transfer finish. User need clean Enable = 0 before next time set Enable=1.

Busy: MPULCD busy flag.

[0]: MPULCD is idle, not transfer data.

[1]: MPULCD is busy, still transfer data.

RDnWR: Control MPULCD control pin LCD_RD~~X~~ and LCD_WRX.

[0]: Write mode. LCD_RD~~X~~ is high and LCD_WRX is low when MPU_LCD transfer.

[1]: Read mode. LCD_RD~~X~~ is low and LCD_WRX is high when MPU_LCD transfer.

A0_Pol: Control MPULCD control pin LCD_D/CX.

[0]: LCD_D/CX is low when MPU_LCD transfer.

[1]: LCD_D/CX is high when MPU_LCD transfer.

MPULCD SRAM Width Register (Address: 0x5000A004)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	Width[7:0]							
R								
Reset	0	0	0	0	0	0	0	0

Width[7:0]: Set width by pixel.

MPULCD SRAM Height Register (Address: 0x5000A008)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	Height[7:0]							
R								
Reset	0	0	0	0	0	0	0	0

Height[7:0]: Set height by pixel.

The MPULCD DMA will transfer Width[7:0] * Height[7:0] pixel = Width[7:0] * Height[7:0] * 2 bytes.

MPULCD_CYCLE (MPULCD Stretch Cycle Register)

Address: 0x5000A010

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	--	Cycle[6:0]						
R	--	Cycle[6:0]						
Reset	0	0	0	0	0	1	0	1

Cycle[6:0]: Set to adjust the read / write pulse timing width = $2 * (\text{Cycle}[6:0] + 1) / (\text{MCU clock frequency})$.

MPULCD Command Data Register (Address: 0x5000A014)

R/W	Bit 15	-----	Bit 0
W	Data[15:0]		
R	Data[15:0]		
Reset	0x0000		

Data[15:0]: MPULCD data for command mode (CMD=1). MPULCD only transfer 8-bits data in 8-bits 8080 parallel interface and serial interface.

MPULCD DMA Start Offset Register (Address: 0x5000A018)

R/W	Bit 16	-----	Bit 0
W	Offset[15:0]		
R	Offset[15:0]		
Reset	0x0000		

Offset[16:0]: DMA access memory address offset. DMA will transfer data start from address $0x20000000 + \text{Offset}[16:0]$. Offset[16:0] need aligned by 4bytes. This means Offset[1:0] = 00 always.

27.5 FUNCTION DESCRIPTION

27.5.1 MPULCD DMA data Format

MPULCD_SRAM only support RGB565 format for DMA function. Each 32-bits data include 2 pixels data.

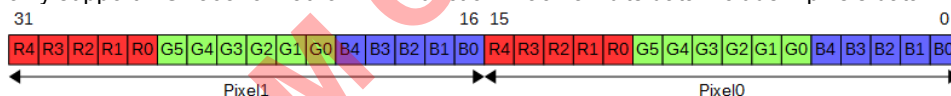


Figure 27.2 RGB565 format

27.5.2 MPULCD output interface

MPU LCD support 8-bits 8080 parallel, 16-bits 8080 parallel and serial Interface.

27.5.2.1 8-bits 8080 Parallel Interface

This interface support data out format is RGB565 and RGB666:

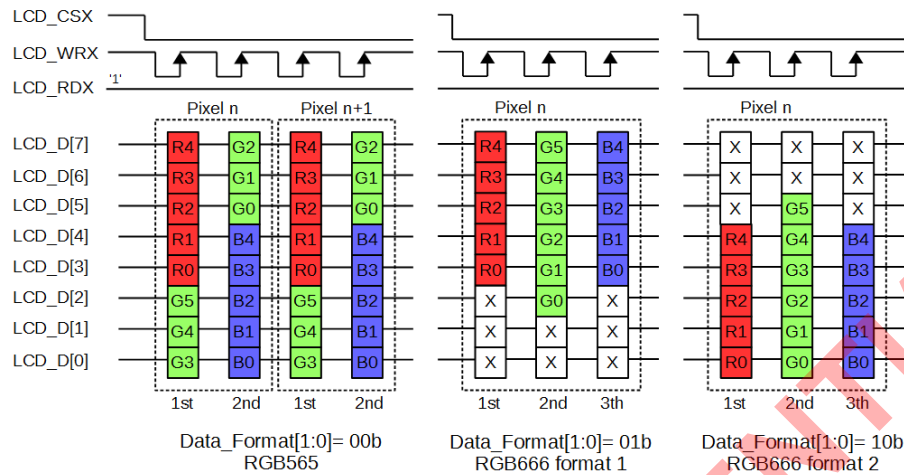


Figure 27.3 8-bits 8080 parallel interface data out

27.5.2.2 16-bits 8080 Parallel Interface

This interface only support data out format RGB565, finish a pixel with one LCD_WRX cycle.

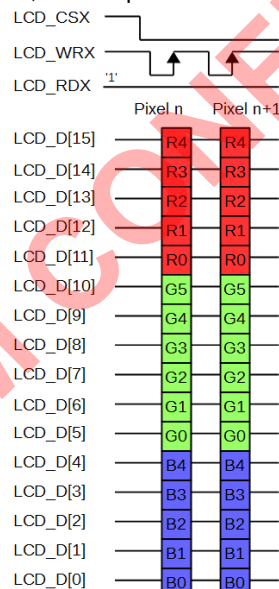


Figure 27.4 16-bits 8080 parallel interface data out

27.5.2.3 Serial interface (SPI)

This interface only support data out format RGB565, finish a pixel data with 16 s_LCD_SCL cycle.

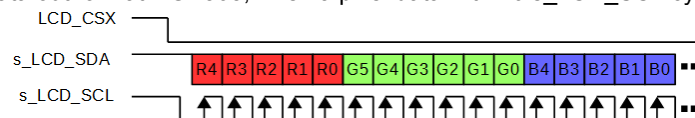


Figure 27.5 Serial Interface data out

27.6 PROCEDURE

27.6.1 MPULCD initial

- Step1: Set MPULCD_CYCLE (0 is fastest)
- Step2: Set MPULCD_CTRL. GPIO will change to MPULCD IO when nCS_IO=1.

27.6.2 MPULCD write data with command mode

- Step1: Set CMD=1 (BIT4 of MPULCD_CTRL)
- Step2: Set RDnWR=0 (BIT1 of MPULCD_CTRL) and A0 (BIT0 of MPULCD_CTRL)
- Step3: Write data to MPULCD_DATA
- Step4: Set Enable=1 (BIT3 of MPULCD_CTRL)
- Step5: Wait Busy (BIT2 of MPULCD_CTRL) from 1 to 0
- Step6: Set Enable=0

27.6.3 MPULCD read data with command mode

- Step1: Set CMD=1 (BIT4 of MPULCD_CTRL)
- Step2: Set RDnWR=1 (BIT1 of MPULCD_CTRL) and A0 (BIT0 of MPULCD_CTRL)
- Step3: Set Enable=1 (BIT3 of MPULCD_CTRL)
- Step4: Wait Busy (BIT2 of MPULCD_CTRL) from 1 to 0
- Step5: Read data from MPULCD_DATA
- Step6: Set Enable=0

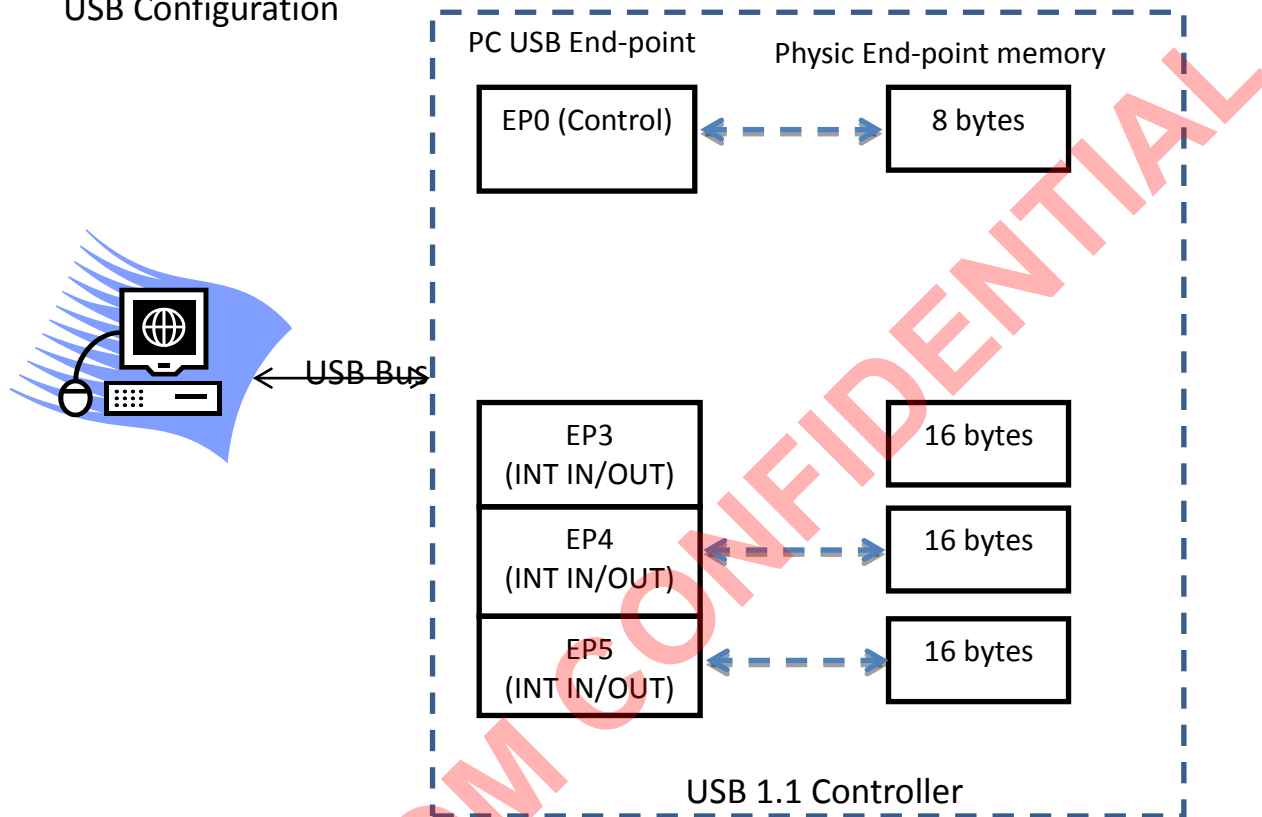
27.6.4 MPULCD write data with DMA mode

- Step1: Write data to MPULCD_SRAM
- Step2: Set MPULCD_WIDTH and MPULCD_HEIGHT
- Step3: Set CMD=0 (BIT4 of MPULCD_CTRL)
- Step4: Set RDnWR=0 (BIT1 of MPULCD_CTRL) and A0 (BIT0 of MPULCD_CTRL)
- Step5: Set Enable=1 (BIT3 of MPULCD_CTRL)
- Step6: Wait Busy (BIT2 of MPULCD_CTRL) from 1 to 0
- Step7: Set Enable=0

28.USB

A3117M0 USB controller has 4 end-points, one EP for basic control, and three EPs for configurable interrupt input or interrupt out. The end-point memory buffers allocations are as the following diagram.

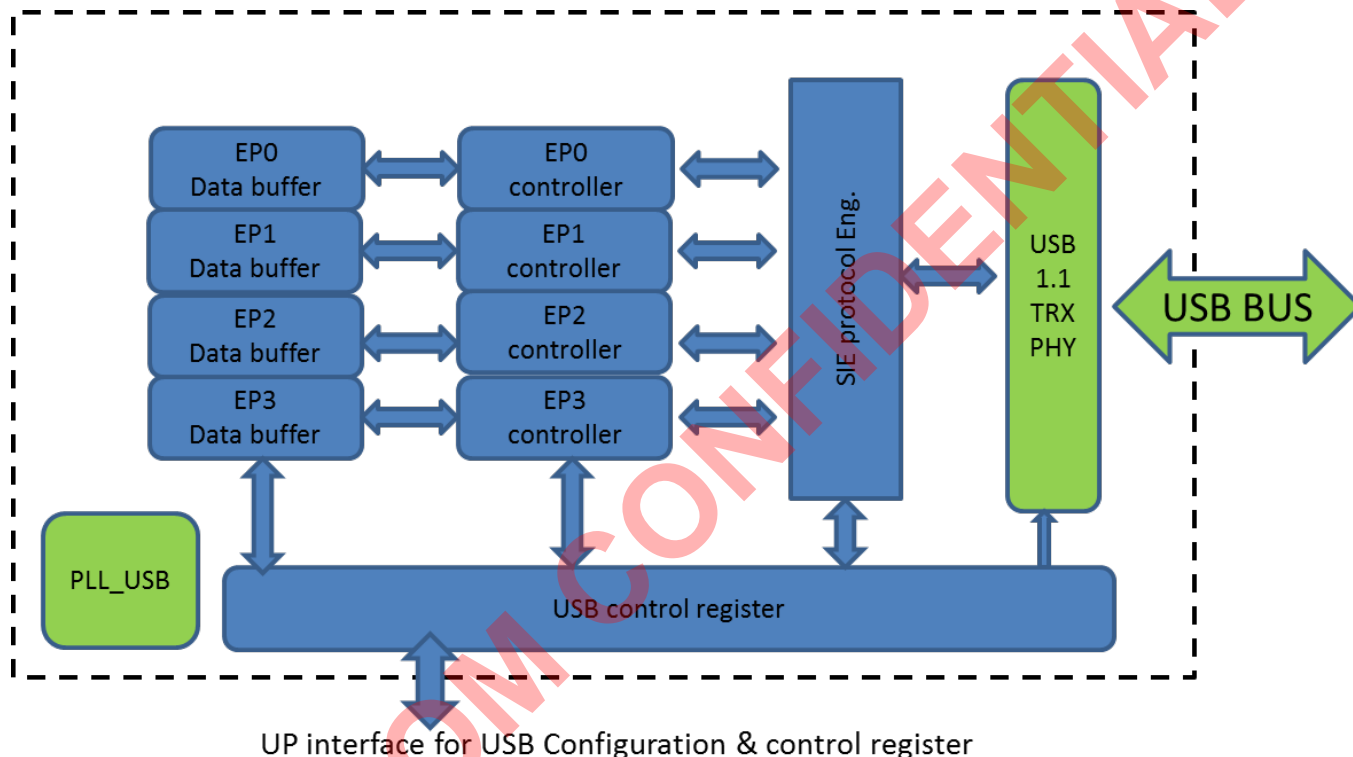
USB Configuration



For A3117M0 USB controller, user could configure this USB device as: HID interface, and keyboard/mouse application. The detail functions are described in the next section.

28.1 USB Configuration

In usual, A3117M0 USB controller configure EP0 to be control type for basic USB control, EP3 for interrupt type for HID control. EP4 and EP5 are also configured to be interrupt type and reserved for wireless keyboard and mouse application. After USB controller configuration, A3117M0 could receive SIE command and automatically response ACK/NAK to USB host. At the same time, USB controller will generate interrupt int3 to A3117M0 MCU for firmware application. A3117M0 MCU could read SIE command from USB EP data buffer and response properly data to USB host. The MCU only need to handle SIE command and HID control interface. The function block diagram is as the following:



28.2 USB Control Registers

The A3117M0 USB control registers are summary as the following:

Register Name	Address	Function
usb_basic_ctrl	0x50007000	Control PHY mode , USB Interrupt
usb_read	0x50007004~0x50007008	Read Current Address,End-Point
EPINFO_Buf0	0x5000700C~0x5000701C	EP0 Info Setting
EPINFO_Buf3	0x50007020~0x50007030	EP3 Info Setting
EPINFO_Buf4	0x50007034~0x50007044	EP4 Info Setting
EPINFO_Buf5	0x50007048~0x5000705C	EP5 Info Setting
usb_buf0_ctrl	0x50007060~0x50007068	EP0 for CONTROL
EP0 Buffer	0x5000706C~0x50007088	EP0 Buffer
usb_buf3_ctrl	0x5000708C~0x50007094	EP3 for CONTROL
EP3 Buffer	0x50007098~0x500070D4	EP3 Buffer
usb_buf4_ctrl	0x500070D8~0x500070E0	EP4 for CONTROL
EP4 Buffer	0x500070E4~0x50007120	EP4 Buffer
usb_buf5_ctrl	0x50007124~0x5000712C	EP5 for CONTROL
EP5 Buffer	0x50007130~0x5000716C	EP5 Buffer
usb_system_int	0x50007170~0x50007174	USB interrupt Flag
usb_PHY_Setting	0x50007178	For USB_PHY Setting
usb_event	0x5000717C	USB plug in plug out event
usb_cfg0	0x50007180	USB configuration0
usb_cfg1	0x50007184	USB configuration1
usb_cfg2	0x50007188	USB configuration2

The EPINFO_Buf0, EPINFO_Buf3~ EPINFO_Buf5 are the basic configuration for EP0, EP3~ EP5. In general, we configure the EP0 as USB basic control, and EP3~EP5 to be Int_IN/OUT for HID application, ..etc. After end-points are properly configured, the USB controller would generate interrupt when it receive USB bus reset, suspend, SIE command, or Int_IN/OUT command. User could check usb_system_int register and reset the usb interrupt by usb_basic_ctrl register. User also could use usb_PHY_Setting to generate J-state/K-state or SE0 signal for some control flow.

For usb_buf0_ctrl, it controls the end-point EP0. User could use this registers and EP0_Buffer, to get SIE command or respond SIE data base on USB command flow. In the same way, usb_buf3_ctrl ~ usb_buf5_ctrl and EP3_Buffer~ EP5_Buffer control the Int_IN/OUT command or data. The detail registers are described as following:

USB basic control Register (Address: 0x50007000)

Bit	R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Basic_Ctrl	R/W	Reserved				INT_Ctrl	PHY_Status_Setting[2:0]		
Reset	X1h	Reserved				0	3'b001		

INT_Ctrl: To clear USB interrupt.

[0]: Re-Enable Interrupt.

[1]: clear interrupt.

PHY_Status_Setting [2:0]: To set USB PHY.

PHY_Status_Setting[2:0]	Description
000	SE0 status
010	J status
100	K status
110	eye-diagram test
XX1	normal mode

USB Interrupt Register (Address: 0x50007170)

Bit	R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
-----	-----	-------	-------	-------	-------	-------	-------	-------	-------

USB_INT	R	EP0 interrupt	Reserved	Reserved	EP4 interrupt	EP5 interrupt	EP3 interrupt	Suspend interrupt	BUS Reset interrupt
Reset	00h	0	0	0	0	0	0	0	0

EP0 interrupt: To indicate USB EP0 interrupt occurred or not.

[0]: normal

[1]: EP0 interrupt occurred.

EP4 interrupt: To indicate USB EP4 interrupt occurred or not.

[0]: normal

[1]: EP4 interrupt occurred.

EP5 interrupt: To indicate USB EP5 interrupt occurred or not.

[0]: normal

[1]: EP5 interrupt occurred.

EP3 interrupt: To indicate USB EP3 interrupt occurred or not.

[0]: normal

[1]: EP3 interrupt occurred.

Suspend interrupt: To indicate USB suspend interrupt occurred or not.

[0]: normal

[1]: suspend interrupt occurred.

Bus Reset interrupt: To indicate USB Bus Reset interrupt occurred or not.

[0]: normal

[1]: Bus Reset interrupt occurred.

USB Interrupt mask Register (Address: 0x50007174)

Bit	R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
INT_Mask	R/W	EP0 interrupt mask	Reserved	Reserved	EP4 interrupt mask	EP5 interrupt mask	EP3 interrupt mask	Suspend interrupt mask	BUS Reset interrupt mask
Reset	9Fh	1	0	0	1	1	1	1	1

EP0 interrupt mask: To mask USB EP0 interrupt.

[0]: To disable EP0 interrupt

[1]: EP0 interrupt enable.

EP4 interrupt mask: To mask USB EP4 interrupt.

[0]: To disable EP4 interrupt

[1]: EP4 interrupt enable.

EP5 interrupt mask: To mask USB EP5 interrupt.

[0]: To disable EP5 interrupt

[1]: EP5 interrupt enable.

EP3 interrupt mask: To mask USB EP3 interrupt.

[0]: To disable EP3 interrupt

[1]: EP3 interrupt enable.

Suspend interrupt mask: To mask USB suspend interrupt.

[0]: To disable suspend interrupt

[1]: suspend interrupt enable.

Bus Reset interrupt: To indicate USB Bus Reset interrupt occurred or not.

[0]: normal

[1]: Bus Reset interrupt occurred.

USB PHY Setting Register (Address: 0x50007178)

Bit	R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
PHY_Set	R/W	Reserved	USB PHY suspend	USB PHY Speed	USB PHY mode	USB_PHY_ENR0	USB_PHY_SR[2:0]		
Reset	37h	0	0	1	1	0	3'b111		

USB PHY suspend:

[0]: normal.

[1]: suspend

USB PHY Speed:

[0]: LS driver*2

[1]: FS driver*8

USB PHY mode:

[0]: single.

[1]: differential

USB_PHY_ENR[0]: work with USB_ENR[1]

[00]: RS = 45 ohm.

[01]: RS = 36 ohm;

[10]: RS = 24 ohm

[11]: N/A

USB_PHY_SR[2:0]: DP pull-high Rup control.

USB_PHY_SR [2:0]	Rup
000	1.279K
001	1.393K
010	1.504K
011	1.613K
100	1.718K
101	1.929K
110	2.099K
111	open

USB Event Register (Address: 0x5000717C)

Bit	R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
EVENT	W	Resume_clr	RDY_clr	MVL_clr	DTL_clr		RDY_IE	MVL_IE	DTL_IE
	R	Resume_flag	RDY_flag	MVL_flag	DTL_flag	VRX	RDY_IE	MVL_IE	DTL_IE
Reset	80h	1	0	0	0	0	0	0	0

Resume_flag: Resume flag. (Write "1" to clear)

RDY_flag: USB 3.3 V supply ready flag. (Write "1" to clear)

MVL_flag: Voltage supply removed from Vbus flag. (Write "1" to clear)

DTL_flag: Voltage supply detected on Vbus flag. (Write "1" to clear)

VRX: USB 3.3 V supply ready flag. (read only)

RDY_IE: USB 3.3 V supply ready interrupt enable.

MVL_IE: Voltage supply removed from Vbus interrupt enable.

DTL_IE: Voltage supply detected on Vbus interrupt enable.

USB Configuration 0 Register (Address: 0x50007180)

Bit	R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
CFG0	W	USB_PHY_ENR1	USB_REGCS	USB_LCPWR	USB_CBGU[4:0]				
Reset	00h	0	0	0	0	0	0	0	0

USB_PHY_ENR[1]: Please see USB_ENR[0]

USB_REGCS: BOD detector select

[0]: REGIH

[1]: USB

USB_LCPWR: Reserved for internal usage only

USB_CBGU[4:0]: Reserved for internal usage only

USB Configuration 1 Register (Address: 0x50007184)

Bit	R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
CFG1	W		USB_DNS[1:0]		USB_WPREF	USB_USBR[3:0]			
Reset	08h	0	0	0	0	1	0	0	0

USB_DNS[1:0]: Setting divider for 48MHz

[00]: 24

[01]: 18

[10]: 36

[11]: 27

USB_WPREF: Select VCO or reference clock to CKOUT.

[0]: CKOUT = VCO Output *

[1]: CKOUT = reference clock

USB_USBR[3:0]: Change divided number of R.

R=USBR[3:0]+1

USB Configuration 2 Register (Address: 0x50007188)

Bit	R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
CFG2	W					Resume_ie	EN_USB_resume	PDN_USB	USB_TM
Reset	00h	0	0	0	0	1	1	0	0

USB_TM: USB test mode. Reserved.

PDN_USB: USB PLL enable

[0]: disable

[1]: enable

EN_USB_resume: enable resume state.

Resume_ie : resume interrupt enable.

29. Flash and IAP

A3117M0 build-in 256KB flash ROM. There have two flash chips, F1M and F2M. Each flash chip has total 32 sectors. Each sector has total 32 pages. Each page has total 32 words (32-bits, 4Bytes). Each word has 32 bits. See Table 29.1 Flash organization as below:

Item	Unit			
	Sectors	Pages	Words	Bytes
Flash Chip	32	1K	32K	128K
Flash Sector	1	32	1K	4K
Flash Page		1	32	128
Word			1	4

Table 29.1 Flash organization

Flash ROM support IAP (in application program). User can erase/write flash in application to store data, update code ...etc.

29.1 REGISTER

29.1.1 Register List

Address	Name	DESCRIPTION
0x4001F104	FLASH_CTRL	Flash Control Register
0x4001F108	FLASH_PWE	Flash Write Enable Register
0x4001F10C	FLASH_ADDR	Flash Address Register
0x4001F110	FLASH_PWD0	Flash Password0 Register
0x4001F114	FLASH_PWD1	Flash Password1 Register
0x4001F118	FLASH_KEY0	Flash Key0 Register
0x4001F11C	FLASH_KEY1	Flash Key1 Register
0x4001F200	FLASH_BUFFER	Flash Write Buffer Register
0x4001F300	FLASH_LOCK	Flash Lock Register

Table 29.2 Flash register list

29.1.2 Register Description

Flash Control Register (Address: 0x4001F104)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	CE	F2M	F1M	--	SERASE	PERASE	--	WRITE
R								
Reset	1	0	0	0	0	0	0	0

CE: Flash Chip Enable.

[0]: Disable (Not Support)

[1]: Enable

F2M: Second Flash ROM (address 0x00020000 ~ 0x0003FFFF) select.

[0]: Second Flash ROM not selected.

[1]: Second Flash ROM selected.

F1M: First Flash ROM (address 0x00000000 ~ 0x0001FFFF) select.

[0]: First Flash ROM not selected.

[1]: First Flash ROM selected.

SERASE: Flash Sector Erase.

[0]: No effect.

[1]: Flash sector erase active.

PERASE: Flash Page Erase.

[0]: No effect.

[1]: Flash page erase active.

WRITE: Flash Page write.
[0]: No effect.
[1]: Flash page write active.

Flash Enable Register (Address: 0x4001F108)

R/W	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
W	PWE	--	LENGTH[5:0]					
R								
Reset	0	0	0	0	0	0	0	0

PWE: Flash erase, write enable.
[0]: Flash only can read.
[1]: Flash can erase, write.

LENGTH[5:0]: Write LENGTH[5:0] words to flash from FLASH_BUFFER. The range of LENGTH[5:0] is 1~32.

Flash Address Register (Address: 0x4001F10C)

R/W	Bit 31	-----	Bit 0
W	ADDR		
R			
Reset	0x00000000		

ADDR: Flash IAP controller will erase or write flash by ADDR. The **BIT0** and **BIT1** need to keep to '0' of ADDR.

Flash Password0 Register (Address: 0x4001F110)

R/W	Bit 31	-----	Bit 0
W	PWD0		
R			
Reset	0x00000000		

PWD0: Flash IAP will skip if PWD0 is not equal KEY0.

Flash Password1 Register (Address: 0x4001F114)

R/W	Bit 31	-----	Bit 0
W	PWD1		
R			
Reset	0x00000000		

PWD1: Flash IAP will skip if PWD1 is not equal KEY1. PWD1 will set to reset value when Flash IAP finish or not match KEY1.

Flash Key0 Register (Address: 0x4001F118)

R/W	Bit 31	-----	Bit 0
W	KEY0		
R			
Reset	0xAAAA5555		

KEY0: User can set KEY0 before Flash IAP.

Flash Key1 Register (Address: 0x4001F11C)

R/W	Bit 31	-----	Bit 0
W	KEY1		
R			
Reset	0xAA55AA55		

KEY1: User can set KEY1 before Flash IAP.

Flash Write Buffer (Address: 0x4001F200 ~ 0x4001F27F)

R/W	Word 31	-----	Word 0
W	BUFFER[31:0]		

R	
Reset	--

BUFFER[31:0]: 32 words (128 Bytes) buffer to buffering data for page write.

Flash Lock Register (Address: 0x4001F300 ~ 0x4001F307)

R/W	Bit 63	-----	Bit 32
W	LOCK[1]		
R	LOCK[1]		
Reset	0xFFFFFFFF		
R/W	Bit 31	-----	Bit 0
W	LOCK[0]		
R	LOCK[0]		
Reset	0xFFFFFFFF		

LOCK[1]: Each bit can lock 4KB (1 sector) flash. Protect flash can't write / erase between address 0x20000~0x3FFFF.

LOCK[0]: Each bit can lock 4KB (1 sector) flash. Protect flash can't write / erase between address 0x00000~0x1FFFF.

User needs clean lock bit to 0 before flash erase / write. LOCK[1] and LOCK[0] will reset to reset value when IAP finish.

29.2 FUNCTION DESCRIPTION

29.2.1 Page Write

User can write data to flash with Page Write. A page will be wrote when page write finish, even only write 1 word to flash. This function can't over page.

29.2.2 Page Erase

User can erase 1 page flash with Page Erase. The flash need erase before Page Write. After Page Erase, all words will erase to 0xFFFFFFFF.

29.2.3 Sector Erase

This function is same as Page Erase but erase 1 sector.

29.3 PROCEDURE

User needs to set FLASH_KEY0 and FLASH_KEY1 before Flash IAP.

User needs to unlock flash protect when do flash IAP. User can refer the way as below that show unlock 1 sector of address:

```
unlock = (1 << ((address & 0x1FFFF) / 4096)) ^ 0xFFFFFFFF;
if (address < 0x20000)
    LOCK[0] = unlock;
else
    LOCK[1] = unlock;
```

The general Flash IAP show as below:

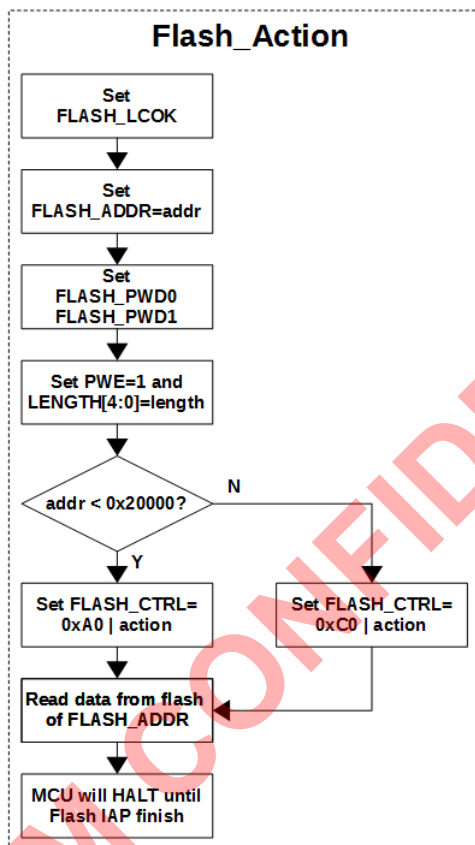


Figure 29.1 Flash_Action flow chart

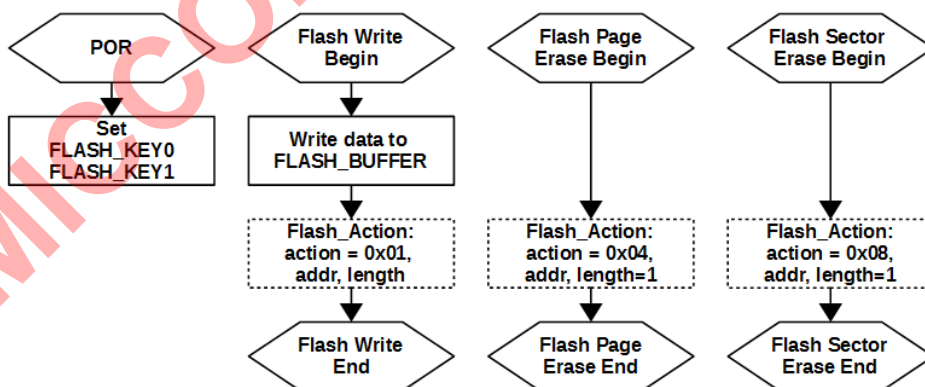


Figure 29.2 Flash IAP flow chart

30. Encryption and Authentication

For Bluetooth Low Energy application, it uses AES-128 link layer encryption block with Counter MODE CBC MAC defined in IETF RFC 3610. A3117M0 integrates AES-128 encryption core for user to encrypt data using AES algorithm with 128-bits key. The AES core also supports CBC-MAC for authentication.

30.1 AES

AES (Advanced Encryption Standard) is a symmetric block cipher on 128-bits data blocks, it consists 10 encryption rounds during encryption process. Figure 30.1 shows the structure of the AES encryption. AES can be divided into four basic operation block where data are treated at either byte or bit level. The array of bytes organized as a 4x4 matrix is also called "state" and those four basic steps, AddRoundKey, SubBytes, ShiftRows, and MixColumns. These four steps describe one round of the AES operation. The block diagram of the AES with 128 bit data is shown below in Figure 30.1.

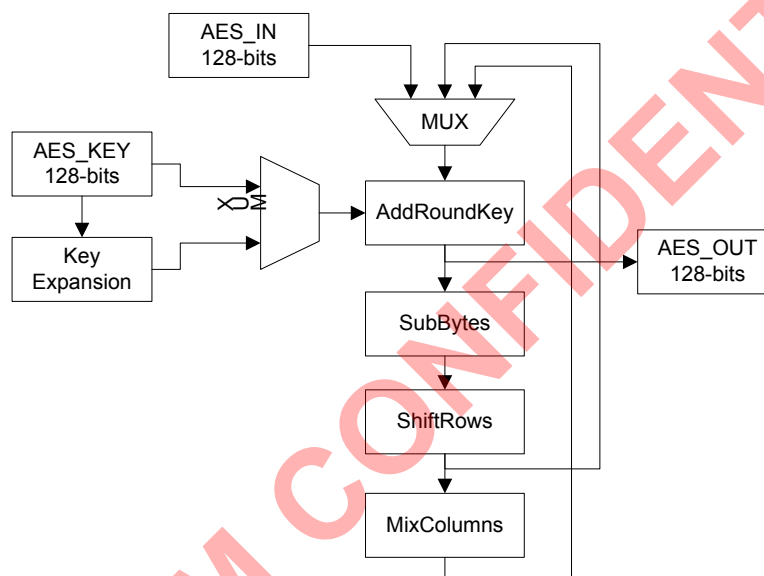


Figure 30.1 Structure of the AES-128 Core

30.1.1 AddRoundKey

Each byte of the array is added to a byte of the corresponding array of round subkeys. Excluding the first and the last round, the AES with 128-bits round key proceeds for 9 iterations. Round keys are generated by a procedure called round key expansion or key scheduling. Those sub-keys are derived from the original key by XOR the two previous columns. For columns that are in multiples of four, the process involves round constants addition, S-Box and shift operations.

30.1.2 SubBytes

This operation is a non-linear byte substitution. It composes of two sub-transformations; multiplicative inverse and affine transformation. In most implementations, these two sub-steps are combined into a single table lookup called S-Box.

30.1.3 ShiftRows

This step is a simple permutation process, operates on individual rows, i.e. each row of the array is rotated by a CERTAIN number of byte positions.

30.1.4 MixColumns

The MixColumns transformation is a substitution step that makes of arithmetic over $GF(2^8)$. Column vector is multiplied by a fixed matrix where bytes are treated as a polynomial of degree less than 4.

30.1.5 CCM

CCM is an authenticated encryption algorithm designed to provide both authentication and confidentiality. It is only defined for block ciphers with a block length of 128 bits. It uses encryption algorithm to generate encrypted and authenticated data at the same time. The AES-CCM process is shown in Figure 30.2

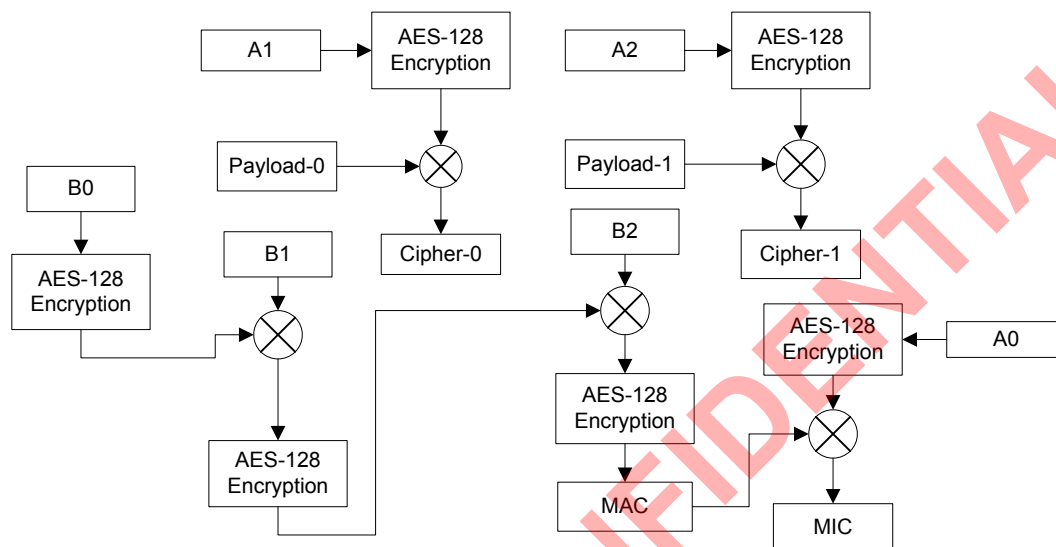


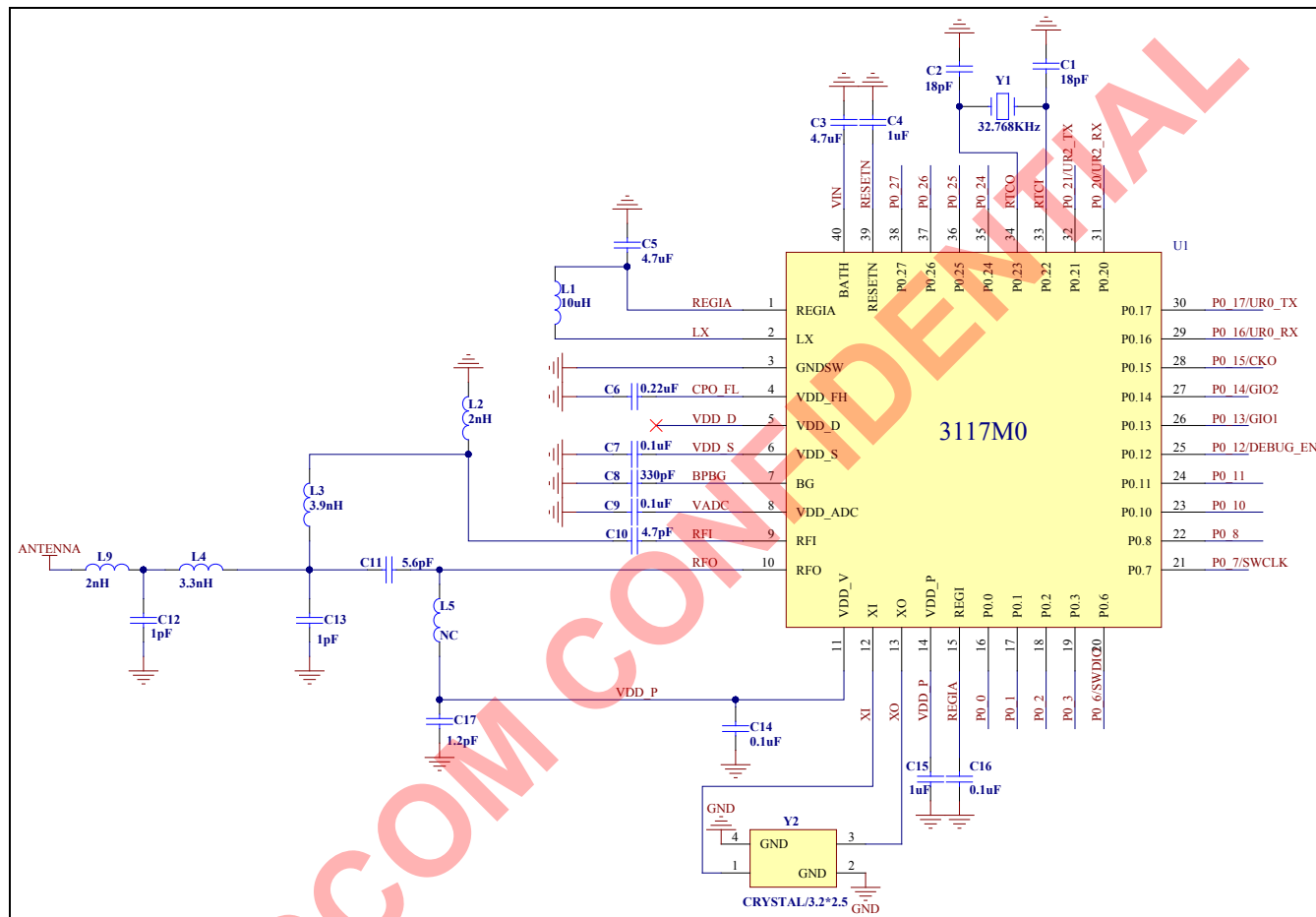
Figure 30.2 CCM Encryption Procedure

CCM authentication starts by defining a sequence of blocks B_0 , B_1 , and B_2 and thereafter CBC-MAC is applied to those blocks so that the authentication field MIC can be obtained. CCM uses the A_0 , A_1 , and A_2 blocks to generate key-stream that is used to encrypt the MIC and the payload. Block A_0 is always used to encrypt and decrypt the MIC. A_1 and A_2 blocks are generated as needed for encryption or decryption of the payload.

31. Application circuit

Below are AMICCOM's ref. design circuits. For more details, please contact AMICCOM's FAE for more details.

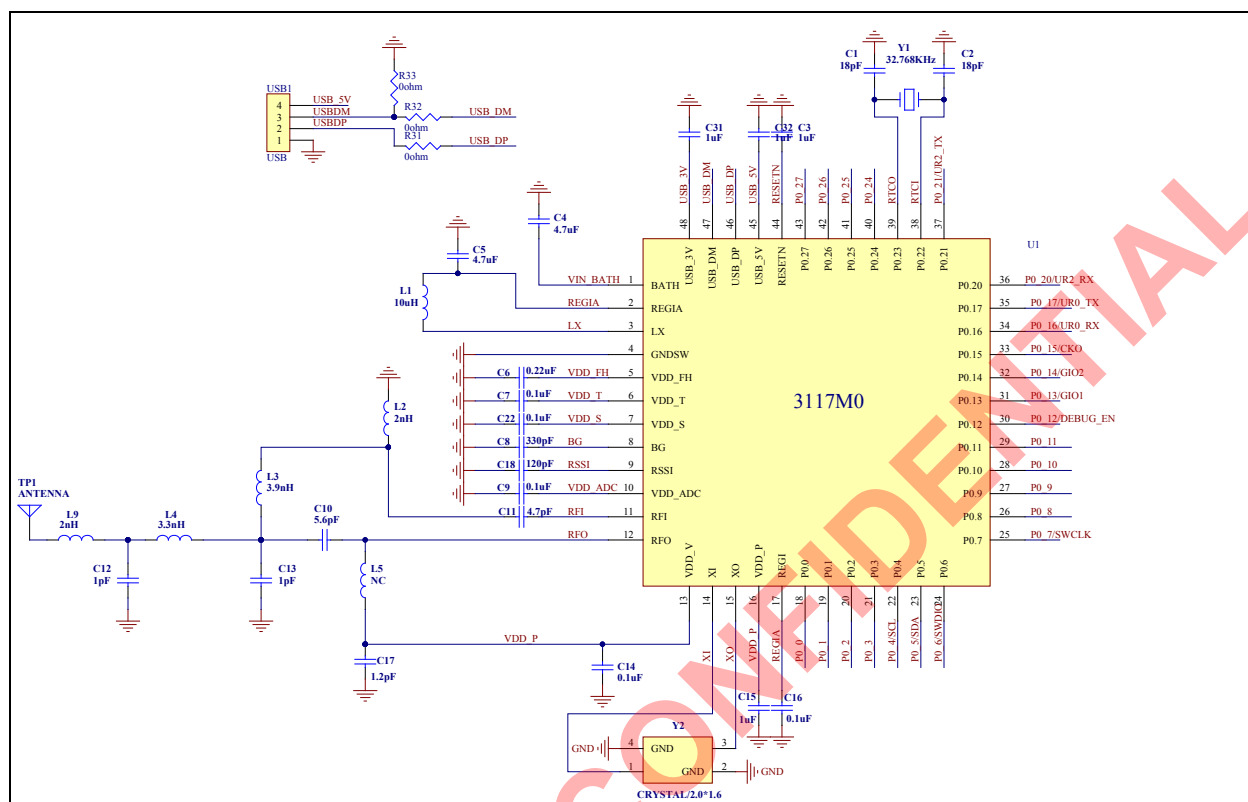
31.1 A3117M0 QFN40 5x5 Package



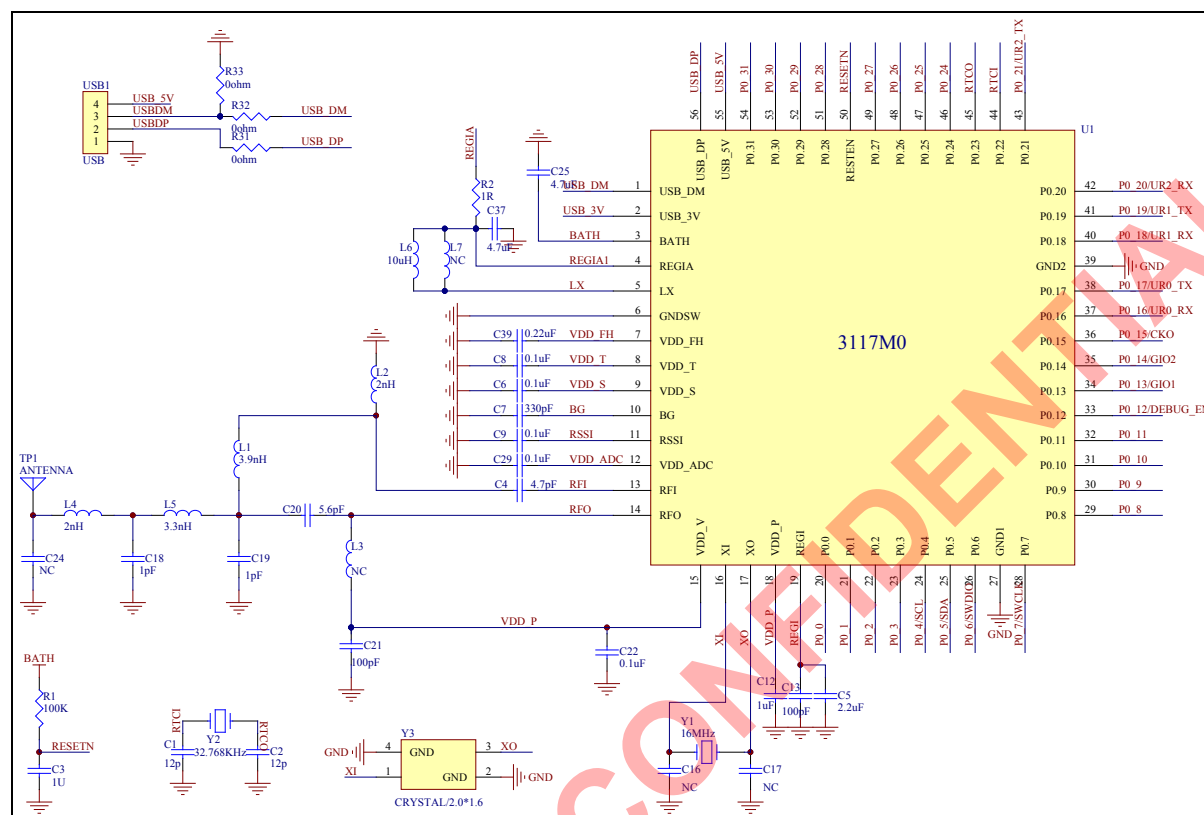


Bluetooth Low Energy SoC

31.3 A3117M0 QFN48 6x6 Package (with USB2.0)



31.4 A3117M0 QFN56 7x7 Package (with USB2.0)



32. Abbreviations

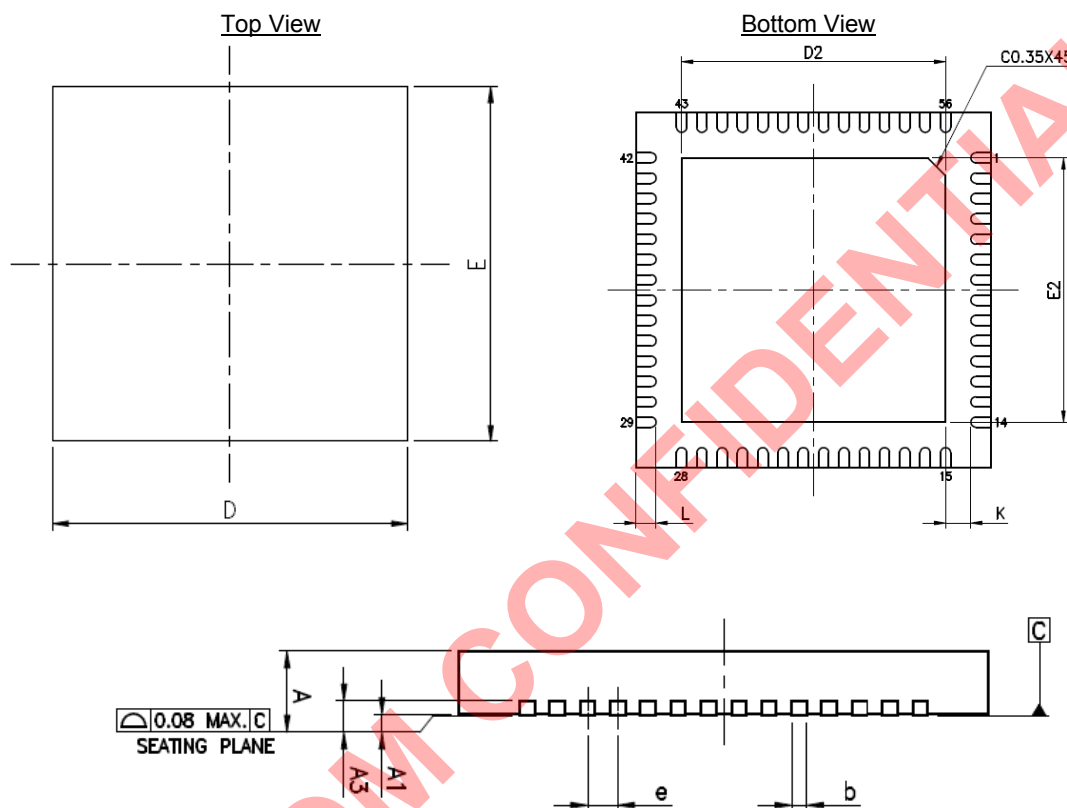
ADC	Analog to Digital Converter
AES	Advanced Encryption Standard
AGC	Automatic Gain Control
AIF	Auto IF
BER	Bit Error Rate
BLE	Bluetooth Low Energy
BW	Bandwidth
CD	Carrier Detect
CPU	Central processing unit
CRC	Cyclic Redundancy Check
DC	Direct Current
DC-DC	Direct Current- Direct Current Regulator
FC	Frequency Compensation
FEC	Forward Error Correction
FIFO	First in First out
FSK	Frequency Shift Keying
GPIO	General-purpose input/output
I ² C	Inter-Integrated Circuit
ICE	In Circuit Emulator
ID	Identifier
IF	Intermediate Frequency
I/O	Input/output
IRQ	Interrupt request
ISM	Industrial, Scientific and Medical
KB	1024 bytes
Kbps	Kilobits per second
LDO	Low Drop Out Regulator
LNA	Low Noise Amplifier
LO	Local Oscillator
LSB	Least-significant bit/byte
MCU	Micro Controller Unit
MISO	Master in, slave out
MOSI	Master out, slave in
PA	Power Amplifier
PFD	Phase Frequency Detector for PLL
PLL	Phase Lock Loop
PM1	Power Mode1
PM2	Power Mode2
PM3	Power Mode3
POR	Power on Reset
PWM	Pulse width modulation
RF	Radio frequency
RSSI	Received Signal Strength Indicator
RTC	Real-time clock
RX	Receiver
RXLO	Receiver Local Oscillator
SCK	Serial clock
SPI	Serial to Parallel Interface
SRAM	Static random-access memory
SYCK	System Clock for digital circuit
TX	Transmitter
TXRF	Transmitter Radio Frequency
UART	Universal ASynchronous Receiver/Transmitter
VCO	Voltage Controlled Oscillator
XOSC	Crystal Oscillator
XREF	Crystal Reference frequency
XTAL	Crystal

33. Ordering Information

Part No.	Package	Units Per Reel / Tray
A31U17F8106AQ7E/Q	QFN56L with 32 I/O, USB Pb Free, Tape & Reel, -40°C ~ 85°C	3K
A31U17F8106AQ7E	QFN56L with 32 I/O, USB Pb Free, Tray, -40°C ~ 85°C	490EA
A31U17F8105AQ6C/Q	QFN48L with 26 I/O, USB Pb Free, Tape & Reel, -40°C ~ 85°C	3K
A31U17F8105AQ6C	QFN48L with 26 I/O, USB Pb Free, Tray, -40°C ~ 85°C	490EA
A31U17F8102AQ6C/Q	QFN48L with 31 I/O, Pb Free, Tape & Reel, -40°C ~ 85°C	3K
A31U17F8102AQ6C	QFN48L with 31 I/O, Pb Free, Tray, -40°C ~ 85°C	490EA
A31U17F8101AQ5A/Q	QFN40L with 23 I/O, Pb Free, Tape & Reel, -40°C ~ 85°C	3K
A31U17F8101AQ5A	QFN40L with 23 I/O, Pb Free, Tray, -40°C ~ 85°C	490EA

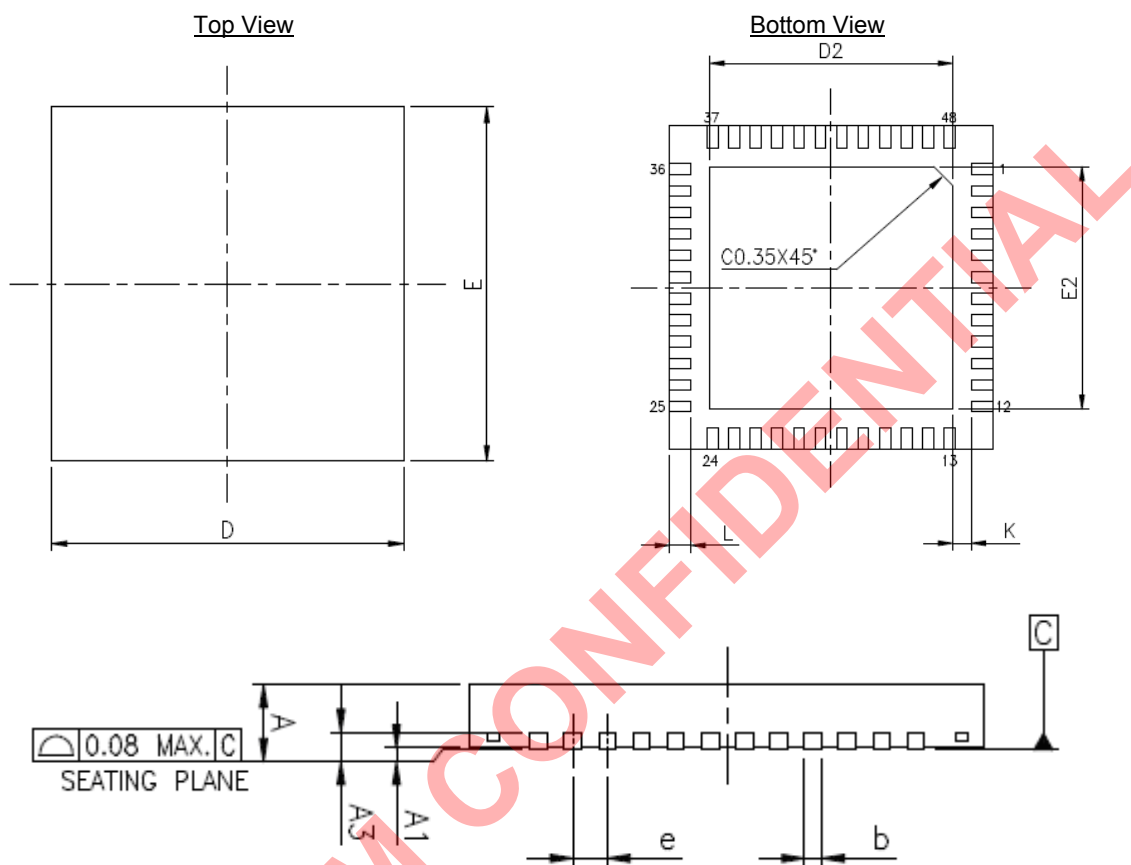
34. Package Information

QFN7*7 56L Outline Dimensions



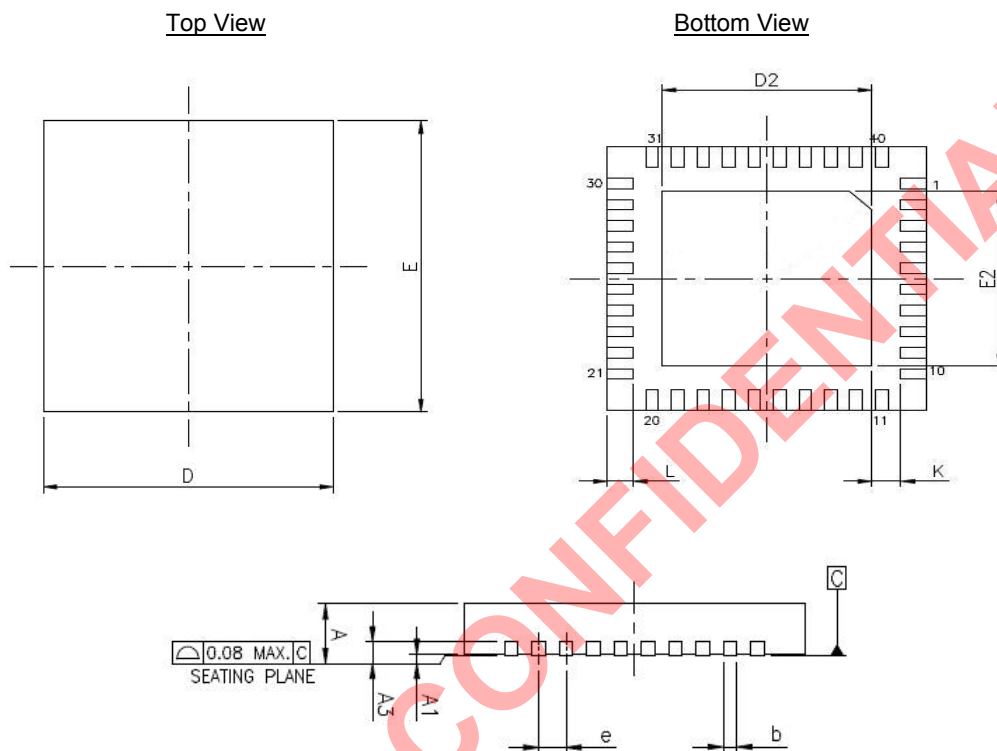
Symbol	Dimensions in mm			Dimensions in inches		
	Min	Nom	Max	Min	Nom	Max
A	0.70	0.75	0.80	0.028	0.030	0.031
A ₁	0.00	0.02	0.05	0	0.001	0.002
A ₃	0.203			0.008		
b	0.15	0.20	0.25	0.006	0.008	0.010
D	6.924	7	7.076	0.273	0.276	0.279
D ₂	4.5	5.2	5.9	0.177	0.205	0.232
E	6.924	7	7.076	0.273	0.276	0.279
E ₂	4.5	5.2	5.9	0.177	0.205	0.232
e	0.40BSE			0.016 BSE		
L	0.27	0.36	0.45	0.011	0.014	0.018
K	0.2	-	-	0.008	-	-

QFN6*6 48L Outline Dimensions



Symbol	Dimensions in inches			Dimensions in mm		
	Min	Nom	Max	Min	Nom	Max
A	0.028	0.030	0.031	0.7	0.75	0.8
A ₁	0	0.001	0.002	0.00	0.02	0.05
A ₃	0.009 REF.			0.23REF.		
b	0.006	0.008	0.010	0.15	0.2	0.25
D	0.240			6.1 BSC		
D ₂	0.146	0.177	0.179	3.70	4.50	4.55
E	0.240			6.1BSC		
E ₂	0.146	0.177	0.179	3.70	4.50	4.55
e	0.016BSC			0.4BSC		
L	0.013	0.016	0.020	0.32	0.4	0.48
k	0.008			0.2		

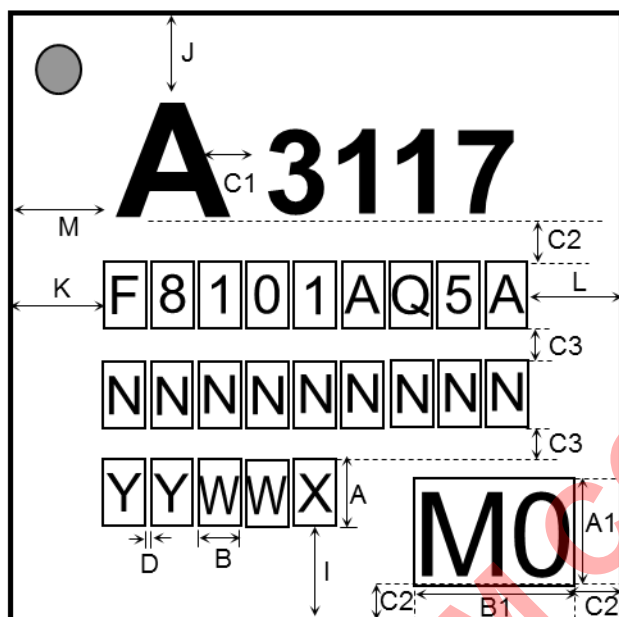
QFN5*5 40L Outline Dimensions



Symbol	Dimensions in inches			Dimensions in mm		
	Min	Nom	Max	Min	Nom	Max
A	0.028	0.030	0.031	0.70	0.75	0.80
A ₁	0.000	0.001	0.002	0.00	0.02	0.05
A ₃	0.008 REF			0.20 REF		
b	0.006	0.008	0.010	0.15	0.20	0.25
D	0.194	-	0.200	4.924	-	5.1
D ₂	0.126	-	0.138	3.20	-	3.50
E	0.194	-	0.200	4.924	-	5.1
E ₂	0.126	-	0.138	3.20	-	3.50
e	0.016			0.40		
L	0.013	0.016	0.019	0.324	0.40	0.5
k	0.008			0.2		

35. Top Marking Information

- Part No. : A31U17F8101AQ5A
- Pin Count : 40
- Package Type : QFN
- Dimension : 5*5 mm
- Mark Method : Laser Mark
- Character Type : Arial



❖ CHARACTER SIZE : (Unit in mm)

A : 0.55 **A1 : 0.75**
B : 0.36 **B1 : 1.10**
C1 : 0.25 **C2 : 0.3** **C3 : 0.2**
D : 0.03
M : 1.5

YYWW

: DATECODE

X

: PKG HOUSE ID

NNNNNNNNNN

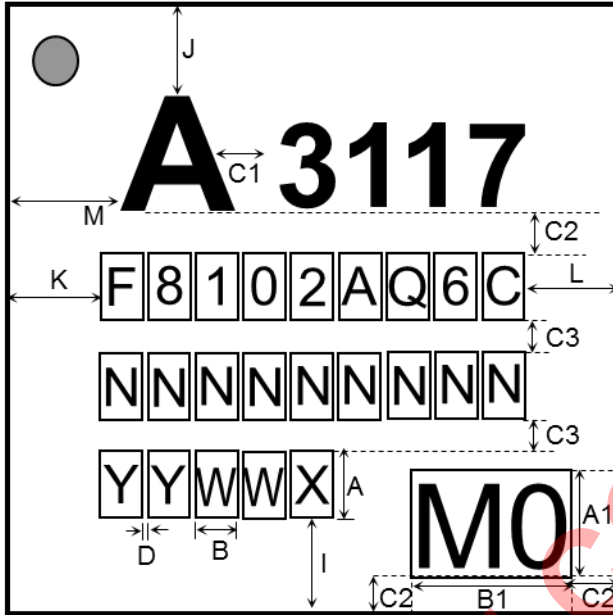
: LOT NO.
(max. 9 characters)

I=J
K=L

0.80
A
 0.68

0.65
3117
 1.6

- Part No. : A31U17F8102AQ6C
- Pin Count : 48
- Package Type : QFN
- Dimension : 6*6 mm
- Mark Method : Laser Mark
- Character Type : Arial



❖ CHARACTER SIZE : (Unit in mm)

A : 0.65 A1 : 0.75
 B : 0.45 B1 : 1.10
 C1 : 0.3 C2 : 0.4 C3 : 0.3
 D : 0.03
 M : 1.5

YYWW

: DATECODE

X

: PKG HOUSE ID

NNNNNNNNNN

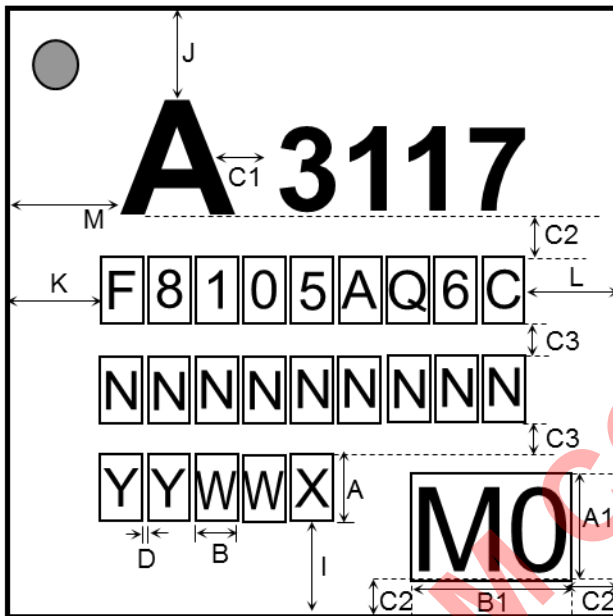
: LOT NO.
(max. 9 characters)

I=J
 K=L

0.90
A
 0.78

0.75
3117
 1.70

- Part No. : A31U17F8105AQ6C
- Pin Count : 48
- Package Type : QFN
- Dimension : 6*6 mm
- Mark Method : Laser Mark
- Character Type : Arial



❖ CHARACTER SIZE : (Unit in mm)

A : 0.65 **A1 : 0.75**
B : 0.45 **B1 : 1.10**
C1 : 0.3 **C2 : 0.4** **C3 : 0.3**
D : 0.03
M : 1.5

YYWW

: DATECODE

X

: PKG HOUSE ID

NNNNNNNNNN

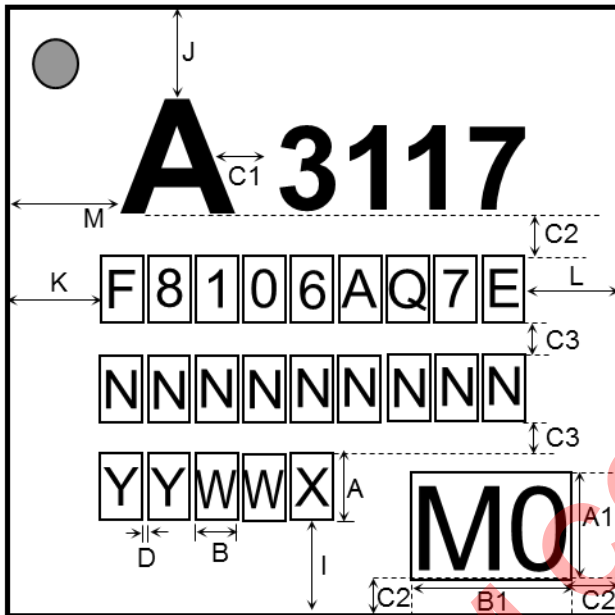
: LOT NO.
(max. 9 characters)

I=J
K=L

0.90
A
 0.78

0.75
3117
 1.70

- Part No. : A31U17F8106AQ7E
- Pin Count : 48
- Package Type : QFN
- Dimension : 6*6 mm
- Mark Method : Laser Mark
- Character Type : Arial



❖ CHARACTER SIZE : (Unit in mm)

A : 0.84 A1 : 0.75
 B : 0.63 B1 : 1.10
 C1 : 0.3 C2 : 0.5 C3 : 0.4
 D : 0.03
 M : 1.91

YYWW

: DATECODE

X

: PKG HOUSE ID

NNNNNNNNNN

: LOT NO.
 (max. 9 characters)

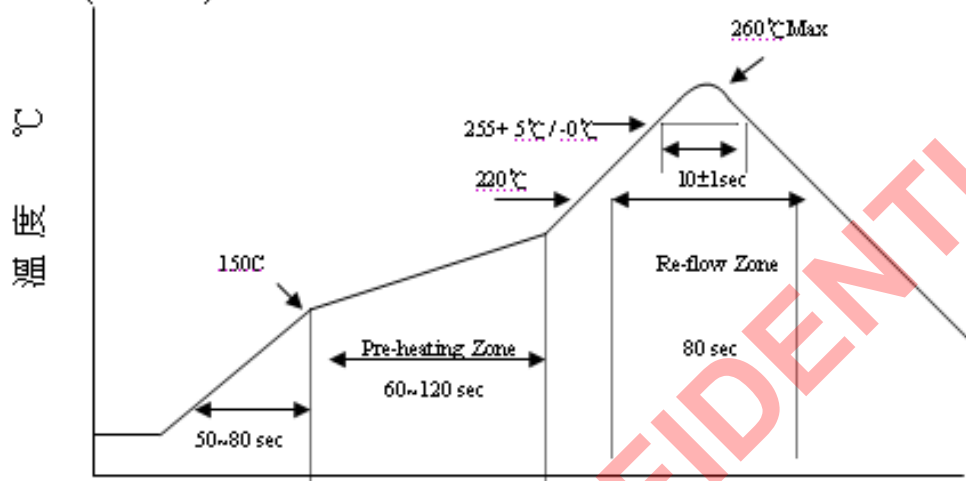
I=J
 K=L

1.10
 0.98
A

0.95
 2.55
3117

36. Reflow Profile

LEAD FREE (GREEN) PROFILE :

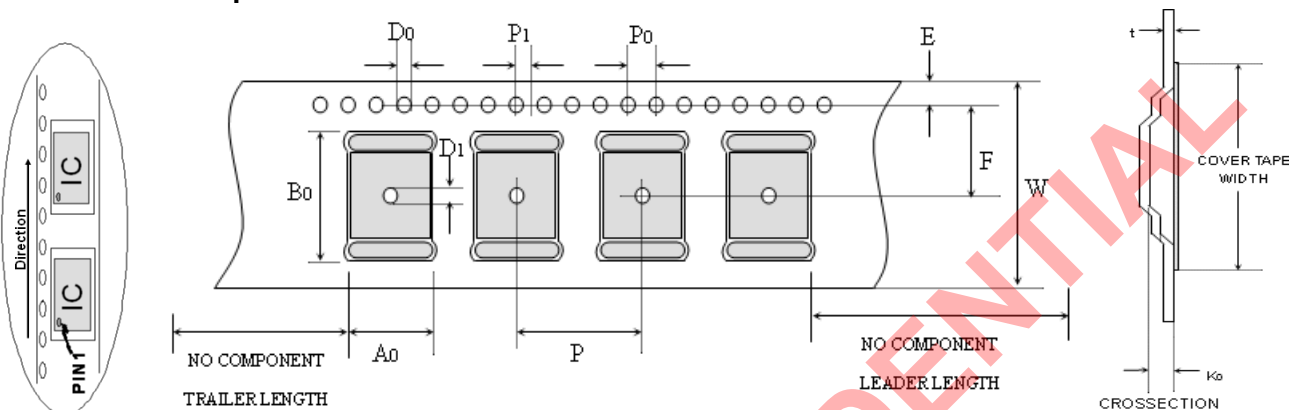


Actual Measurement Graph



37. Tape Reel Information

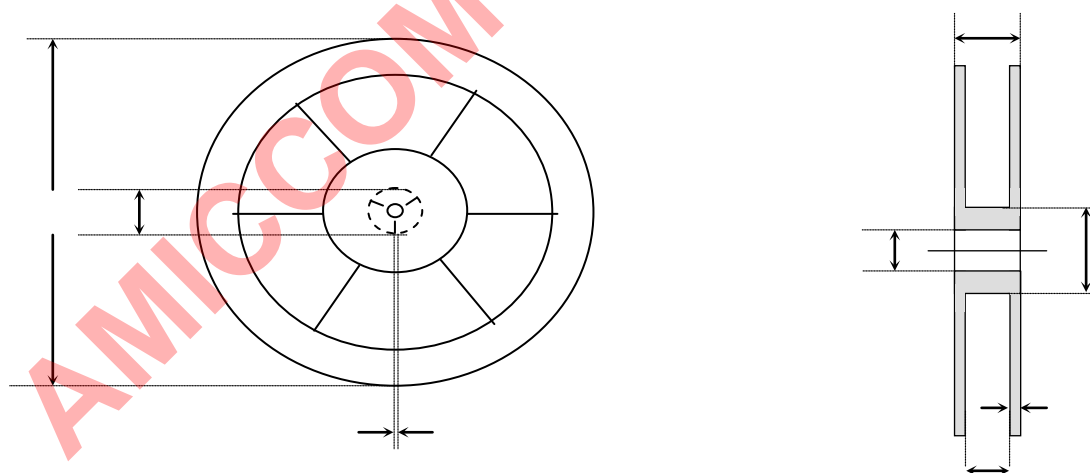
Cover / Carrier Tape Dimension



Unit: mm

TYPE	P	A0	B0	P0	P1	D0	D1	E	F	W	K0	t	Cover tape width
QFN 5*5	8±0.1	5.25±0.1	5.25±0.1	4±0.2	2±0.1	1.5±0.1	1.5	1.75±0.1	5.5±0.05	12±0.3	1.25±0.1	0.3±0.05	9.3±0.1
QFN 6*6	12±0.1	6.3±0.1	6.3±0.1	4±0.2	2±0.1	1.5±0.1	1.5±0.5	1.75±0.1	7.5±0.1	16±0.3	1.15±0.2	0.3±0.05	13.3±0.1
QFN 7*7	12±0.1	7.35±0.1	7.35±0.1	4±0.2	2±0.1	1.5±0.1	1.5±0.5	1.75±0.1	7.5±0.1	16±0.3	1.15±0.2	0.3±0.05	13.3±0.1

REEL DIMENSIONS



Unit: mm

TYPE	G	N	M	D	K	L	R
QFN5*5	12.9±0.5	102 REF±2.0	2.3±0.2	13.15±0.35	2.0±0.5	330±3.0	19.6±2.9
QFN6*6	17±0.5	102 REF±2.0	2.3±0.2	13.15±0.35	2.0±0.5	330±3.0	19.6±2.9
QFN7*7	17±0.5	102 REF±2.0	2.3±0.2	13.15±0.35	2.0±0.5	330±3.0	19.6±2.9

38. Product Status

Data Sheet Identification	Product Status	Definition
Objective	Planned or Under Development	This data sheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	Engineering Samples and First Production	This data sheet contains preliminary data, and supplementary data will be published at a later date. AMICCOM reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
No Identification	Noted Full Production	This data sheet contains the final specifications. AMICCOM reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
Obsolete	Not In Production	This data sheet contains specifications on a product that has been discontinued by AMICCOM. The data sheet is printed for reference information only.

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