



PMB182(B)
8bit OTP with Charge IC
Datasheet

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Revision History

Revision	Date	Description
0.03	2025/02/17	1. Add a comparison table for PMB182 and PMB182B 2. Update the official website link
0.04	2025/05/08	1. Add description for Code Option
0.05	2025/11/14	1. Modify the description of Bit6 and Bit3 in section 6.45.

Usage Warning

User must read all application notes of the IC by detail before using it.

Please visit the official website to download and view the latest APN information associated with it.

<https://www.padauk.com.tw/en/product/show.aspx?num=188&kw=PMB>

(The following picture are for reference only.)

PMB182(B)

- ◆ General purpose series
- ◆ Operating temperature : -40°C ~ 85°C

Feature
Documents
Software & Tools
Application Note

Content	Description	Download (CN)	Download (EN)
APN002	Over voltage protection		
APN003	Over voltage protection		
APN004	Semi-Automatic writing handler		
APN007	Setting up LVR level		
APN011	Semi-Automatic writing Handler improve writing stability		
APN013	Notification of crystal oscillator		
APN019	E-PAD PCB layout guideline		

Major Differences between PMB182 and PMB182B

Item	Function	PMB182	PMB182B
1	Charger	The VCC5 pin cannot be left floating, otherwise the VBAT pin voltage may leak to the VCC5 pin. (Solution refer to APN-021: a capacitor of 0.1uF or more and load resistor of 500Ω or less must be connected in parallel to VCC5 pin)	The VCC5 pin can be left floating, and the VBAT pin voltage will not leak to the VCC5 pin. (No solution required)
2	Program	The PDK file of PMB182 can be programmed into the chip. The PDK file of PMB182B cannot be programmed into the chip.	The PDK file of PMB182 can be programmed into the chip. The PDK file of PMB182B can be programmed into the chip.

1. Features

1.1. Special Features

- ◆ General purpose series
- ◆ Operating temperature range: -40°C ~ 85°C

1.2. System Features

- ◆ 1.25KW OTP program memory
- ◆ 80 Bytes data RAM
- ◆ One hardware 16-bit timer
- ◆ One hardware 8-bit timers with 6/7/8-bit PWM generation
- ◆ One set triple 11bit SuLED(Super LED) PWM generators
- ◆ One hardware comparator
- ◆ 17 IO pins with optional pull-high / pull-low resistor
- ◆ Every IO pin can be configured to enable wake-up function
- ◆ One Channel(PB7) has four current options
IoL = 130mA/100mA/60mA/25mA @V_{BAT}=5V, V_{OL}=0.5V
- ◆ Clock sources: IHRC & ILRC & EOSC
- ◆ For every wake-up enabled IO, two optional wake-up speed are supported: normal and fast
- ◆ LVR Range: 1.8V ~ 4.5V
- ◆ External interrupt pins: PA0 / PB5, PA4 / PB0
- ◆ Bandgap circuit to provide 1.20V reference voltage
- ◆ One low-power clock (NILRC) wake-up stopsys regularly.
- ◆ VCC input range: 4.3V~6.5V
- ◆ Programmable Charge Current Up to 500mA
- ◆ No MOSFET, Sense Resistor or Blocking Diode Required
- ◆ Constant-Current/Constant-Voltage Operation with Thermal Regulation to Maximize Charge Rate Without Risk of Overheating
- ◆ Preset 4.2V Charge Voltage with ±1% Accuracy
- ◆ Automatic Recharge
- ◆ C/10 Charge Termination
- ◆ 2.9V Trickle Charge Threshold
- ◆ Standby power dissipation 57uA (VCC) in charging mode

1.3. CPU Features

- ◆ One processing unit operating mode
- ◆ 86 powerful instructions
- ◆ Most instructions are 1T execution cycle
- ◆ Programmable stack pointer to provide adjustable stack level
- ◆ Direct and indirect addressing modes for data access. Data memories are available for use as an index pointer of Indirect addressing mode
- ◆ IO space and memory space are independent

1.4. Ordering/ Package Information

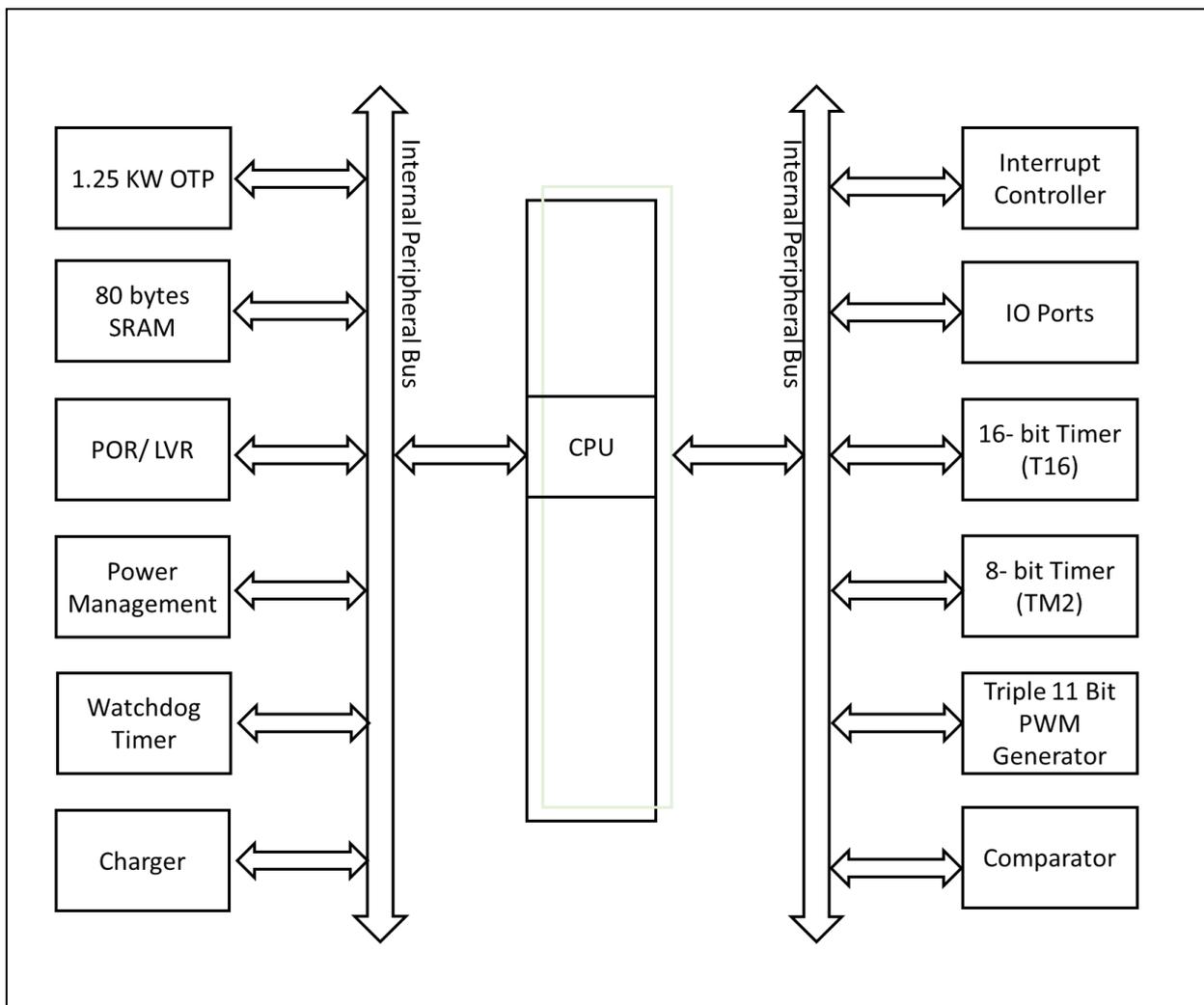
- ◆ PMB182(B)-ES08:ESOP8 (150mil with E-PAD)
- ◆ PMB182(B)-EY10: ESSOP10 (150mil with E-PAD)
- ◆ PMB182(B)-EM10 (EMSOP10 with E-PAD)
- ◆ PMB182(B)-ES16 (ESOP16-150mil with E-PAD)
- ◆ PMB182(B)-ET20 (ETSSOP20 with E-PAD)
- ◆ PMB182(B)-1J20 (QFN20L- 3*3*0.75mm with E-PAD)
- Please refer to the official website file for package size information : "Package information "

2. General Description and Block Diagram

The PMB182(B) family is an IO-Type, fully static, OTP-based CMOS 8-bit microcontroller. It employs RISC architecture and all the instructions are executed in one cycle except that some instructions are two cycles that handle indirect memory access.

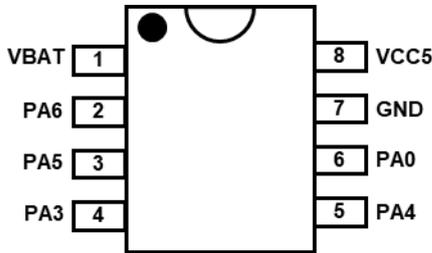
1.25KW bits OTP program memory and 80 bytes data SRAM are inside; one hardware comparator is built inside the chip to compare signal between two pin or with either internal reference voltage $V_{internalR}$ or internal bandgap reference voltage. PMB182(B) also provides three hardware timers: one 16-bit timer, one 8-bit timer with PWM generation, and one new triple 11-bit timer with PWM generation (LPWIMG0, LPWIMG1 & LPWIMG2) are included.

The charger in PMB182(B) is a constant current/constant voltage charger for single cell Li-Ion batteries and is designed to work within USB power specifications. An internal block regulates the current when the junction temperature increases, in order to protect the device when it operates in high power or high ambient temperature. The charge voltage is fixed at 4.2V, and the charge current limitation can be programmed by the registers without the external resistor and the current up to 500mA. The charge cycle is automatically terminated when the current flowing to the battery is lower than 1/10 of the programmed value. If the external adaptor is removed, the charger turned off and a less 2 μ A current can flow from the battery to the device.

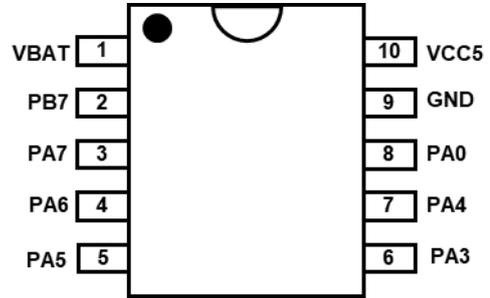


PMB182(B) 8bit OTP with Charge IC

3. Pin Definition and Functional Description

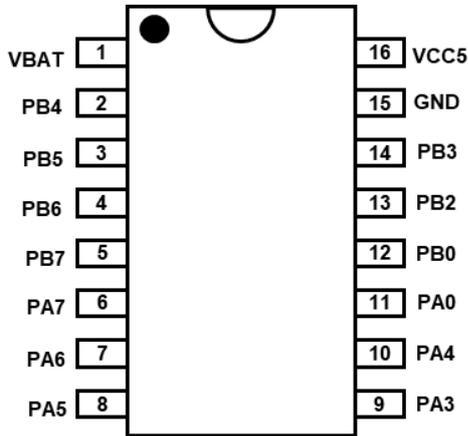


PMB182(B)-ES08: ESOP8 (150mil with E-PAD)

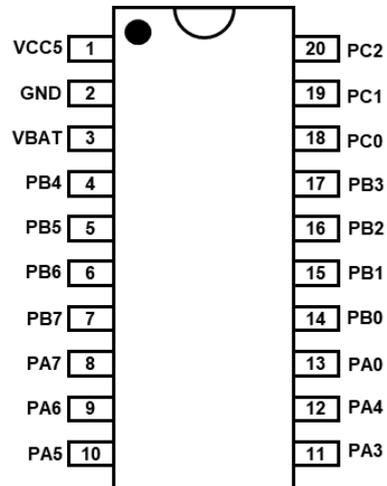


PMB182(B)-EY10: ESSOP10 (150mil with E-PAD)

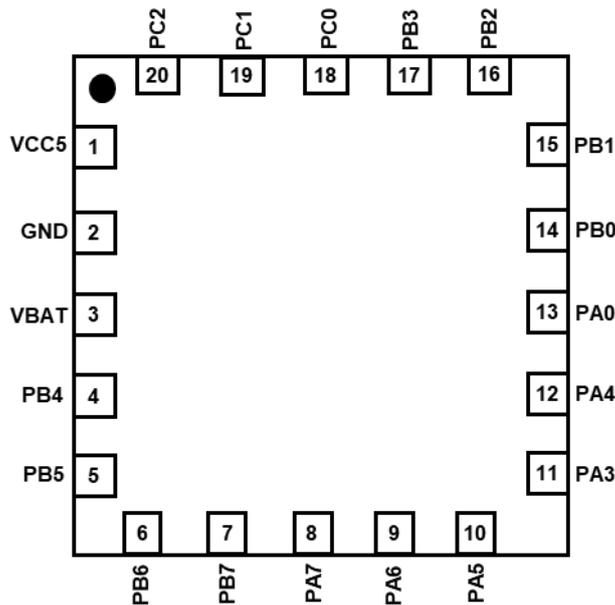
PMB182(B)-EM10 (EMSOP10 with E-PAD)



PMB182(B)-ES16 (ESOP16-150mil with E-PAD)



PMB182(B)-ET20 (ETSSOP20 with E-PAD)



PMB182(B)-1J20 (QFN20L- 3*3*0.75mm with E-PAD)

PMB182(B)

8bit OTP with Charge IC

Pin Name	Pin Type & Buffer Type	Description
PA7 / X1	IO ST / CMOS	<p>The functions of this pin can be:</p> <p>(1) Bit 7 of port A. It can be configured as digital input or two-state output, with pull-high resistor / pull-low resistor.</p> <p>(2) X1 is Crystal XIN when crystal oscillator is used.</p> <p>If this pin is used for crystal oscillator, bit 7 of padier register must be programmed “0” to avoid leakage current. This pin can be used to wake-up system during sleep mode; however, wake-up function is also disabled if bit 7 of padier register is “0”.</p>
PA6 / X2	IO ST / CMOS	<p>The functions of this pin can be:</p> <p>(1) Bit 6 of port A. It can be configured as digital input or two-state output, with pull-high resistor / pull-low resistor.</p> <p>(2) X2 is Crystal XOUT when crystal oscillator is used.</p> <p>If this pin is used for crystal oscillator, bit 6 of padier register must be programmed “0” to avoid leakage current. This pin can be used to wake-up system during sleep mode; however, wake-up function is also disabled if bit 6 of padier register is “0”.</p>
PA5 / PRSTB / LPG2PWM	IO ST / CMOS	<p>The functions of this pin can be:</p> <p>(1) Bit 5 of port A. It can be configured as digital input or output, with pull-high resistor / pull-low resistor.</p> <p>(2) Hardware reset.</p> <p>(3) Output of 11-bit PWM generator LPWMG2.</p> <p>This pin can be used to wake-up system during sleep mode; however, wake-up function is also disabled if bit 5 of padier register is “0”. Please put 33Ω resistor in series to have high noise immunity when this pin is in input mode.</p>
PA4 / CIN+ / CIN1- / LPG1PWM / INT1	IO ST / CMOS / Analog	<p>The functions of this pin can be:</p> <p>(1) Bit 4 of port A. It can be configured as digital input or two-state output, with pull-high resistor / pull-low resistor.</p> <p>(2) Plus input source of comparator.</p> <p>(3) Minus input source 1 of comparator.</p> <p>(4) Output of 11-bit PWM generator LPWMG1.</p> <p>(5) External interrupt line 1. Both rising edge and falling edge are accepted to request interrupt service and configurable by register setting</p> <p>When this pin is configured as analog input, please use bit 4 of register padier to disable the digital input to prevent current leakage. The bit 4 of padier register can be set to “0” to disable digital input; wake-up from power-down by toggling this pin is also disabled.</p>

PMB182(B)

8bit OTP with Charge IC

Pin Name	Pin Type & Buffer Type	Description
PA3 / CIN0- / TM2PWM / LPG2PWM	IO ST / CMOS / Analog	<p>The functions of this pin can be:</p> <ol style="list-style-type: none"> (1) Bit 3 of port A. It can be configured as digital input or two-state output, with pull-high resistor / pull-low resistor. (2) Minus input source 0 of comparator. (3) PWM output from Timer2 (4) Output of 11-bit PWM generator LPWGM2 <p>When this pin is configured as analog input, please use bit 3 of register padier to disable the digital input to prevent current leakage. The bit 3 of padier register can be set to "0" to disable digital input; wake-up from power-down by toggling this pin is also disabled.</p>
PA0 / CO / LPG0PWM / INT0	IO ST / CMOS	<p>The functions of this pin can be:</p> <ol style="list-style-type: none"> (1) Bit 0 of port A. It can be configured as digital input or two-state output, with pull-high resistor / pull-low resistor. (2) Output of comparator. (3) Output of 11-bit PWM generator LPWGM0. (4) External interrupt line 0. Both rising edge and falling edge are accepted to request interrupt service and configurable by register setting <p>The bit 0 of padier register can be set to "0" to disable wake-up from power-down by toggling this pin.</p>
PB7 / CIN5- / LPG1PWM	IO ST / CMOS / Analog	<p>The functions of this pin can be:</p> <ol style="list-style-type: none"> (1) Bit 7 of port B. It can be configured as digital input or two-state output, with pull-high and pull-low resistor. (2) Minus input source 5 of comparator. (3) Output of 11-bit PWM generator LPWGM1. <p>When this pin is configured as analog input, please use bit 7 of register pbdier to disable the digital input to prevent current leakage. The bit 7 of pbdier register can be set to "0" to disable digital input; wake-up from power-down by toggling this pin is also disabled.</p>
PB6 / CIN4- / LPG1PWM	IO ST / CMOS / Analog	<p>The functions of this pin can be:</p> <ol style="list-style-type: none"> (1) Bit 6 of port B. It can be configured digital input or two-state output, with pull-high and pull-low resistor. (2) Minus input source 4 of comparator. (3) Output of 11-bit PWM generator LPWGM1. <p>When this pin is configured as analog input, please use bit 6 of register pbdier to</p>

PMB182(B)

8bit OTP with Charge IC

Pin Name	Pin Type & Buffer Type	Description
		disable the digital input to prevent current leakage. The bit 6 of <i>pbdierr</i> register can be set to “0” to disable digital input; wake-up from power-down by toggling this pin is also disabled.
PB5 / LPG0PWM / INT0	IO ST / CMOS	<p>The functions of this pin can be:</p> <ol style="list-style-type: none"> (1) Bit 5 of port B. It can be configured as digital input or two-state output, with pull-high and pull-low resistor. (2) Output of 11-bit PWM generator LPWGM0. (3) External interrupt line 0A. It can be used as an external interrupt line 0. <u>Both rising edge and falling edge are accepted to request interrupt service and configurable by register setting.</u> <p>The bit 5 of <i>pbdierr</i> register can be set to “0” to disable digital input; wake-up from power-down by toggling this pin is also disabled.</p>
PB4 / TM2PWM / LPG0PWM	IO ST / CMOS	<p>The functions of this pin can be:</p> <ol style="list-style-type: none"> (1) Bit 4 of port B. It can be configured as digital input or two-state output, with pull-high and pull-low resistor. (2) PWM output from Timer2 (3) Output of 11-bit PWM generator LPWGM0. <p>The bit 4 of <i>pbdierr</i> register can be set to “0” to disable digital input; wake-up from power-down by toggling this pin is also disabled.</p>
PB3 / LPG2PWM	IO ST / CMOS	<p>The functions of this pin can be:</p> <ol style="list-style-type: none"> (1) Bit 3 of port B. It can be configured as digital input or two-state output, with pull-high and pull-low resistor. (2) Output of 11-bit PWM generator LPWGM2. <p>The bit 3 of <i>pbdierr</i> register can be set to “0” to disable digital input; wake-up from power-down by toggling this pin is also disabled.</p>
PB2 / TM2PWM / LPG2PWM	IO ST / CMOS	<p>The functions of this pin can be:</p> <ol style="list-style-type: none"> (1) Bit 2 of port B. It can be configured as digital input or two-state output, with pull-high and pull-low resistor. (2) PWM output from Timer2. (3) Output of 11-bit PWM generator LPWGM2. <p>The bit 2 of <i>pbdierr</i> register can be set to “0” to disable digital input; wake-up from power-down by toggling this pin is also disabled.</p>
PB1	IO ST / CMOS	<p>The functions of this pin can be:</p> <p>Bit 1 of port B. It can be configured as digital input or two-state output, with pull-high and pull-low resistor.</p>

PMB182(B)

8bit OTP with Charge IC

Pin Name	Pin Type & Buffer Type	Description
		The bit 1 of <i>pbdier</i> register can be set to “0” to disable digital input; wake-up from power-down by toggling this pin is also disabled.
PB0 / INT1	IO ST / CMOS	<p>The functions of this pin can be:</p> <p>(1) Bit 0 of port B. It can be configured as digital input or two-state output, with pull-high and pull-low resistor.</p> <p>(2) External interrupt line 1. It can be used as an external interrupt line 1. Both rising edge and falling edge are accepted to request interrupt service and configurable by register setting.</p> <p>If bit 0 of <i>pbdier</i> register is set to “0” to disable digital input, wake-up from power-down by toggling this pin is also disabled.</p>
PC2	IO ST / CMOS	<p>The functions of this pin can be:</p> <p>Bit 2 of port C. It can be configured as digital input or two-state output, with pull-high and pull-low resistor.</p> <p>The bit 2 of <i>pcdier</i> register can be set to “0” to disable digital input; wake-up from power-down by toggling this pin is also disabled.</p>
PC1	IO ST / CMOS	<p>The functions of this pin can be:</p> <p>Bit 1 of port C. It can be configured as digital input or two-state output, with pull-high and pull-low resistor.</p> <p>The bit 1 of <i>pcdier</i> register can be set to “0” to disable digital input; wake-up from power-down by toggling this pin is also disabled.</p>
PC0	IO ST / CMOS	<p>The functions of this pin can be:</p> <p>Bit 0 of port C. It can be configured as digital input or two-state output, with pull-high and pull-low resistor.</p> <p>The bit 0 of <i>pcdier</i> register can be set to “0” to disable digital input; wake-up from power-down by toggling this pin is also disabled.</p>
VBAT	VBAT	Positive power for Charger. Positive power for MCU.
VCC5	VCC	When VCC is connected, can charge Battery.
GND	GND	Ground
<p>Notes: IO: Input/Output; ST: Schmitt Trigger input; OD: Open Drain; Analog: Analog input pin CMOS: CMOS voltage level</p>		

4. Device Characteristics

4.1. AC/DC Device Characteristics

All data are acquired under the conditions of $T_a = -40^\circ\text{C} \sim 85^\circ\text{C}$, $V_{\text{BAT}} = 5.0\text{V}$, $f_{\text{SYS}} = 2\text{MHz}$ unless noted.

Symbol	Description	Min	Typ	Max	Unit	Conditions ($T_a=25^\circ\text{C}$)
V_{BAT}	Operating Voltage	1.8 [#]	5.0	5.5	V	# Subject to LVR tolerance
LVR%	Low Voltage Reset Tolerance	-5		5	%	
f_{SYS}	System clock (CLK)* =					$V_{\text{BAT}} \geq 2.7\text{V}$ $V_{\text{BAT}} \geq 2.2\text{V}$ $V_{\text{BAT}} \geq 1.8\text{V}$ $V_{\text{BAT}} = 3.0\text{V}$
	IHRC/2	0		8M	Hz	
	IHRC/4	0		4M		
	IHRC/8 ILRC	0	100K	2M		
V_{POR}	Power On Reset Voltage		1.8*			V
I_{OP}	Operating Current		0.55		mA	$f_{\text{SYS}} = \text{IHRC}/16 = 1\text{MIPS}@5.0\text{V}$ $f_{\text{SYS}} = \text{ILRC} = 100\text{KHz}@5.0\text{V}$
			81		uA	
I_{PD}	Power Down Current (by stopsys command)		0.6		uA	$f_{\text{SYS}} = 0\text{Hz}$, $V_{\text{BAT}} = 5.0\text{V}$ $f_{\text{SYS}} = 0\text{Hz}$, $V_{\text{BAT}} = 3.3\text{V}$
			0.3		uA	
I_{PS}	Power Save Current (by stopexe command)		3.5		uA	$V_{\text{BAT}} = 5.0\text{V}$; $f_{\text{SYS}} = \text{ILRC}$ Only ILRC module is enabled.
V_{IL}	Input low voltage for IO lines	0		$0.2 V_{\text{BAT}}$	V	
V_{IH}	Input high voltage for IO lines	$0.7 V_{\text{BAT}}$		V_{BAT}	V	
I_{OL}	IO lines sink current					
	PB7 (Strong)		136		mA	$V_{\text{BAT}} = 5.0\text{V}$, $V_{\text{OL}} = 0.5\text{V}$
	PB7 (High)		102			
	PB7 (Normal)		64			
	PB7 (Low)		26			
	Others		18			
I_{OH}	IO lines drive current					
	All IO		-16		mA	$V_{\text{BAT}} = 5.0\text{V}$, $V_{\text{OH}} = 4.5\text{V}$
V_{IN}	Input voltage	-0.3		$V_{\text{BAT}} + 0.3$	V	
$I_{\text{INJ}}(\text{PIN})$	Injected current on pin			1	mA	$V_{\text{BAT}} + 0.3 \geq V_{\text{IN}} \geq -0.3$
R_{PH}	Pull-high Resistance		95		K Ω	$V_{\text{BAT}} = 5.0\text{V}$
R_{PL}	Pull-low Resistance		95		K Ω	$V_{\text{BAT}} = 5.0\text{V}$
V_{BG}	Bandgap Reference Voltage	1.145*	1.20*	1.255*	V	$V_{\text{BAT}} = 2.2\text{V} \sim 5.5\text{V}$ $-40^\circ\text{C} < T_a < 85^\circ\text{C}$ *
f_{IHRC}	Frequency of IHRC after calibration *	15.76*	16*	16.24*	MHZ	25°C , $V_{\text{BAT}} = 2.2\text{V} \sim 5.5\text{V}$
		15.20*	16*	16.80*		$V_{\text{BAT}} = 2.2\text{V} \sim 5.5\text{V}$, $-40^\circ\text{C} < T_a < 85^\circ\text{C}$ *
		13.60*	16*	18.40*		$V_{\text{BAT}} = 1.8\text{V} \sim 5.5\text{V}$, $-40^\circ\text{C} < T_a < 85^\circ\text{C}$
f_{ILRC}	Frequency of ILRC *		100		KHz	$V_{\text{BAT}} = 5.0\text{V}$
f_{NILRC}	Frequency of NILRC *		18		KHz	$V_{\text{BAT}} = 5.0\text{V}$
t_{INT}	Interrupt pulse width	30			ns	$V_{\text{BAT}} = 5.0\text{V}$
V_{DR}	RAM data retention voltage*	1.5			V	in stop mode

PMB182(B)

8bit OTP with Charge IC

Symbol	Description	Min	Typ	Max	Unit	Conditions (Ta=25°C)	
t _{WDT}	Watchdog timeout period		8k			T _{ILRC} misc[1:0]=00 (default)	
			16k				misc[1:0]=01
			64k				misc[1:0]=10
			256k				misc[1:0]=11
t _{WUP}	Wake-up time period for fast wake-up		45		T _{ILRC}	Where T _{ILRC} is the time period of ILRC	
	Wake-up time period for slow wake-up		2800				
t _{SBP}	System boot-up period from power-on for Slow boot-up		30		ms	V _{BAT} =5V	
t _{RST}	External reset pulse width	120			us	@ V _{BAT} =5V	
CP _{os}	Comparator offset*		±10	±20	mV		
CP _{cm}	Comparator input common mode*	0		V _{BAT} -1.5	V		
CP _{spt}	Comparator response time**		100	500	ns	Both Rising and Falling	
CP _{mc}	Stable time to change comparator mode		2.5	7.5	us		
CP _{cs}	Comparator current consumption		20		uA	V _{BAT} = 3.3V	
V _{CC}	Charger Input Supply Voltage	4.3	5	6.5	V		
I _{VCC}	Charger Input Supply Current		200	500	μA	Charge mode	
			57		μA	Standby mode	
			38		μA	Shutdown mode	
			0		μA	Sleep mode	
I _{CCM}	Constant Current Mode Charge Current	-15%	50	+15%	mA	@V _{CC} =5V	
			100		mA		
			200		mA		
			250		mA		
			300		mA		
			350		mA		
			400		mA		
			500		mA		
I _{TRKL}	Trickle Charge Current		1/10		I _{CCI}	V _{BAT} <V _{TRKL}	
V _{FLOAT}	Float Voltage	-1%	4.2	+1%	V	@V _{CC} =5V	

PMB182(B)

8bit OTP with Charge IC

Symbol	Description	Min	Typ	Max	Unit	Conditions (Ta=25oC)
V _{TRKL}	Trickle-Charge Threshold Voltage		2.9		V	V _{BAT} rising
V _{TRHYS}	Trickle Voltage Hysteresis Voltage		100		mV	
V _{UV}	UnderVoltage Lockout threshold		3.7		V	VCC rising
V _{UVHYS}	UnderVoltage Lockout Hysteresis		200		mV	
V _{ASD}	VCC-V _{BAT} lockout threshold voltage		100		mV	VCC rising
			30		mV	VCC falling
t _{RECHA}	Recharge Comparator Filter Time		2		mS	V _{BAT} High to Low
t _{TERM}	Termination Comparator Filter Time		1		mS	I _{CCM} is less than 1/10
I _{TERM}	C/10 termination current threshold		0.1		mA	
ΔV _{RECHA}	Recharge Battery Threshold Voltage		150		mV	
T _{LIM}	Junction Temperature in Constant Temperature Mode		90		°C	

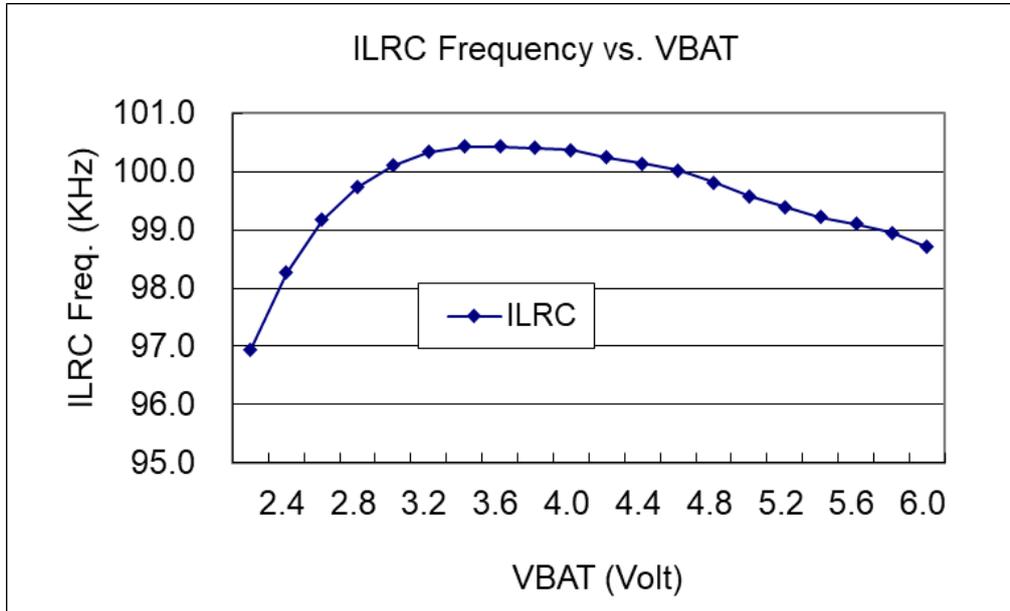
*These parameters are for design reference, not tested for each chip.

**The characteristic diagrams are the actual measured values. Considering the influence of production drift and other factors, the data in the table are within the safety range of the actual measured values.

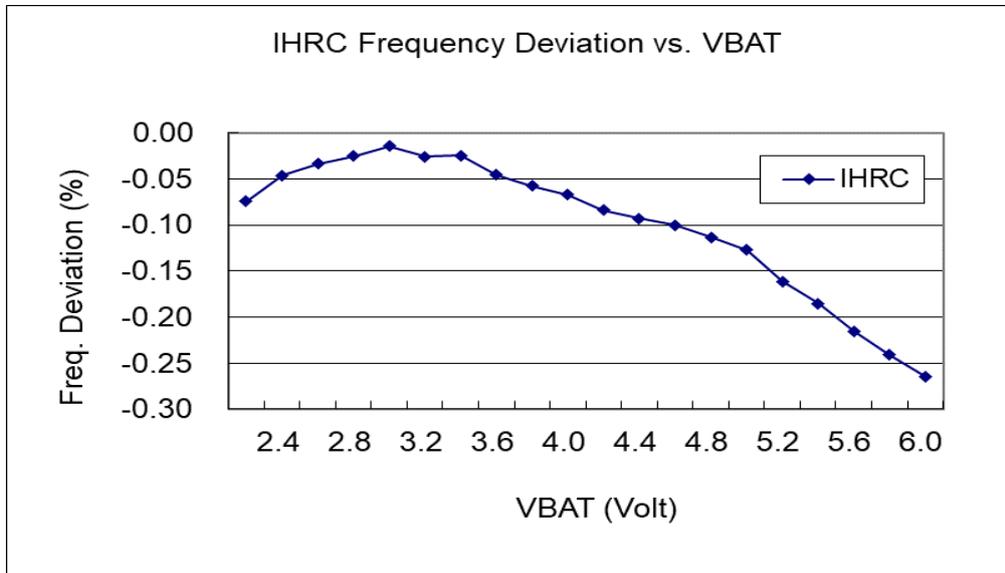
4.2. Absolute Maximum Ratings

Parameter	Maximum Rating	Notes
Supply Voltage	1.8V ~ 5.5V (Maximum Rating: 5.5V)	*If V _{BAT} is over the maximum rating, it may lead to a permanent damage of IC.
Input Voltage	-0.3V ~ V _{BAT} + 0.3V	
Operating Temperature	-40°C ~ 85°C	
Storage Temperature	-50°C ~ 125°C	
Junction Temperature	150°C	

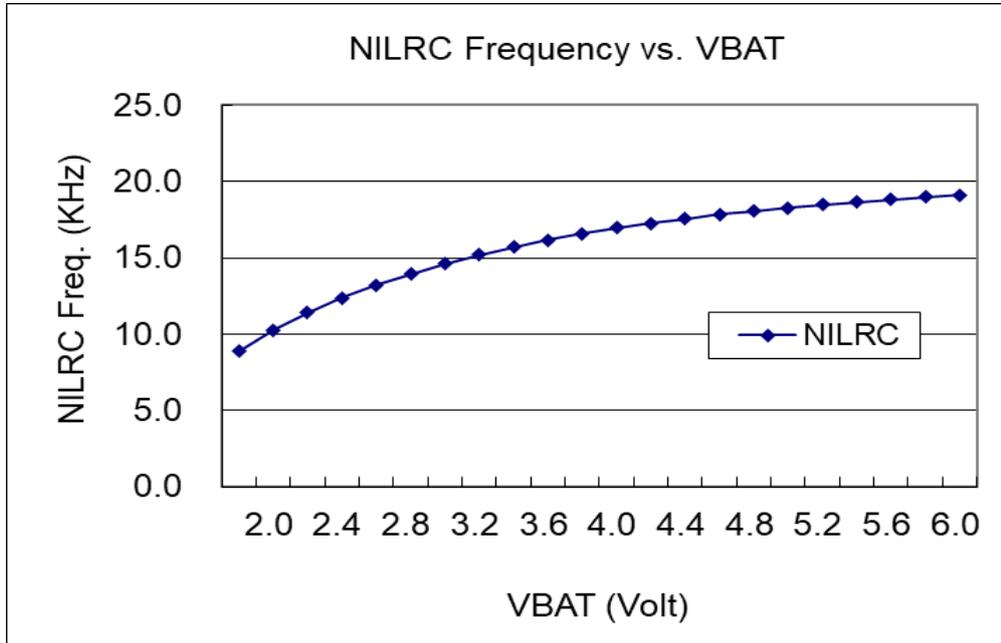
4.3. Typical ILRC frequency vs. V_{BAT}



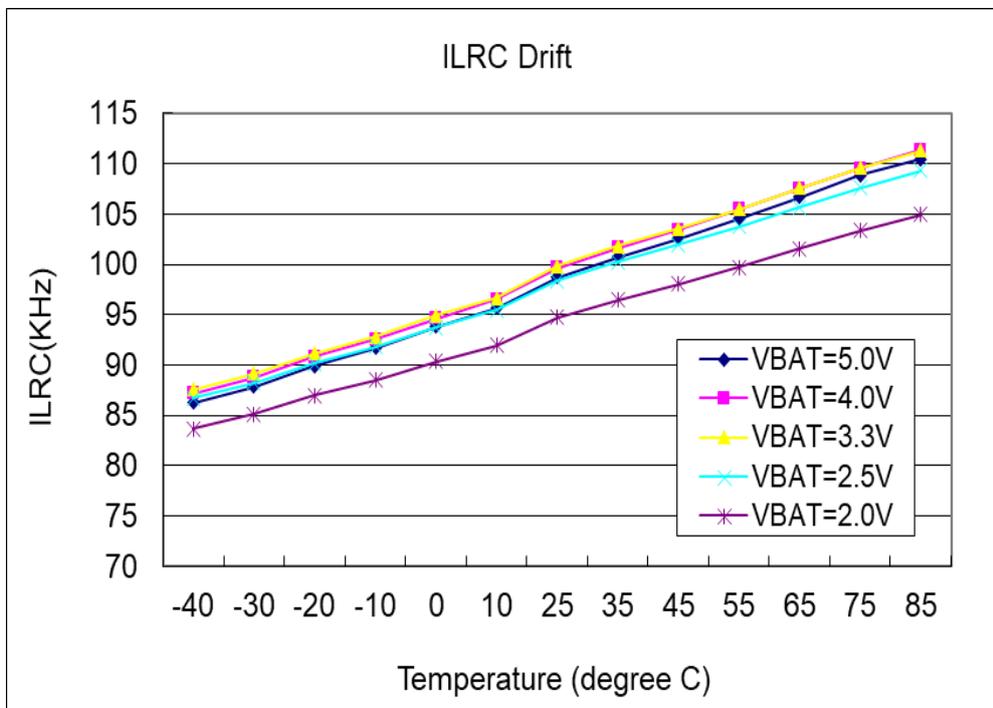
4.4. Typical IHRC frequency deviation vs. V_{BAT} (calibrated to 16MHz)



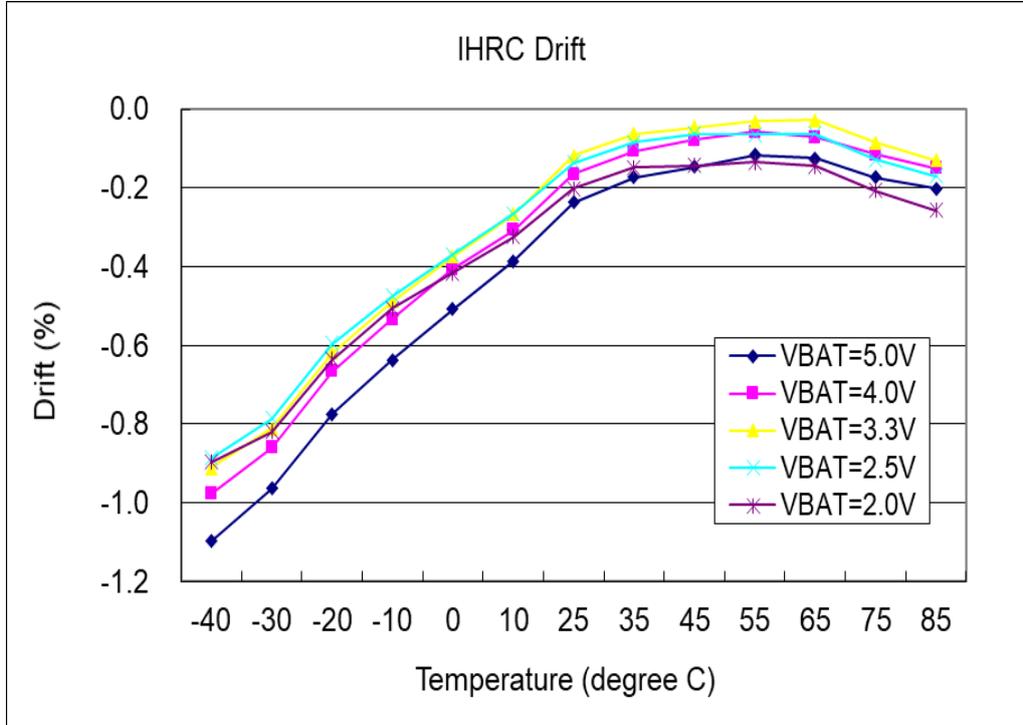
4.5. Typical NILRC Frequency vs. V_{BAT}



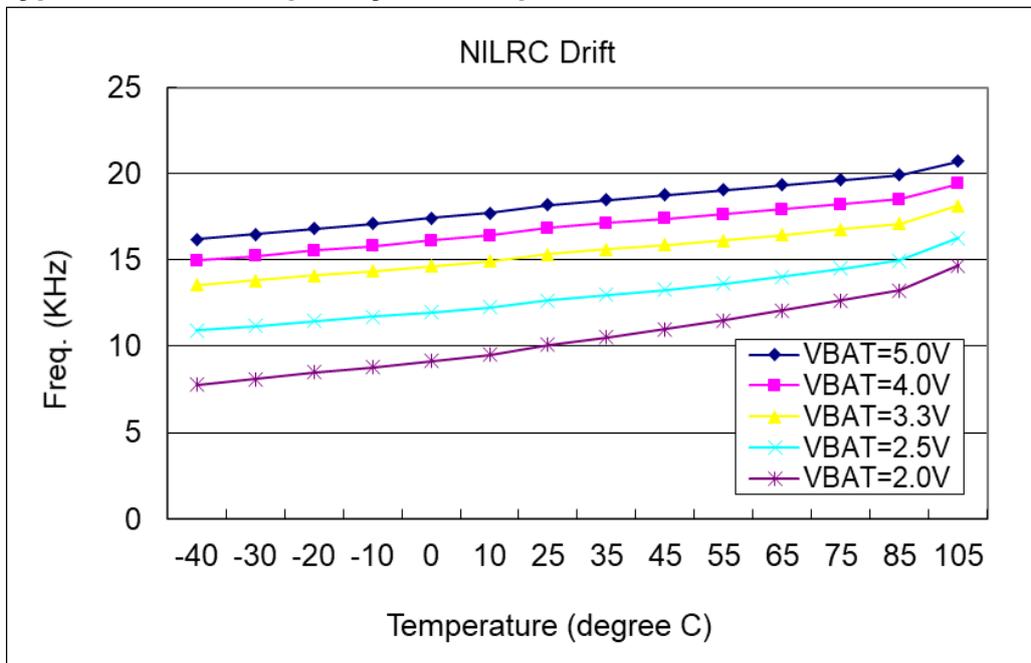
4.6. Typical ILRC Frequency vs. Temperature



4.7. Typical IHRC Frequency vs. Temperature (calibrated to 16MHz)

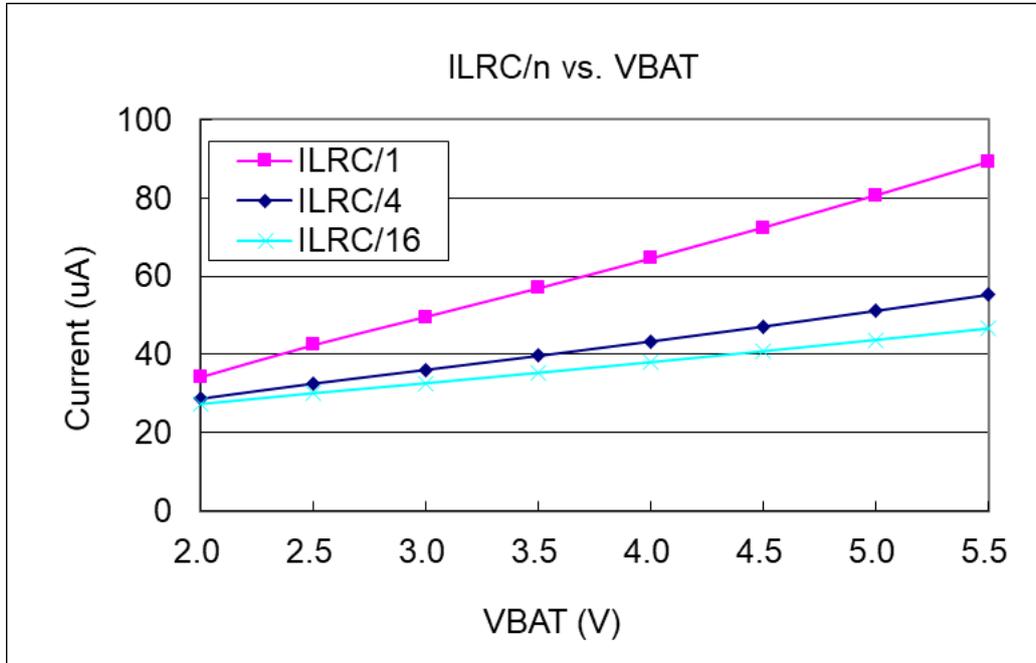


4.8. Typical NILRC Frequency vs. Temperature



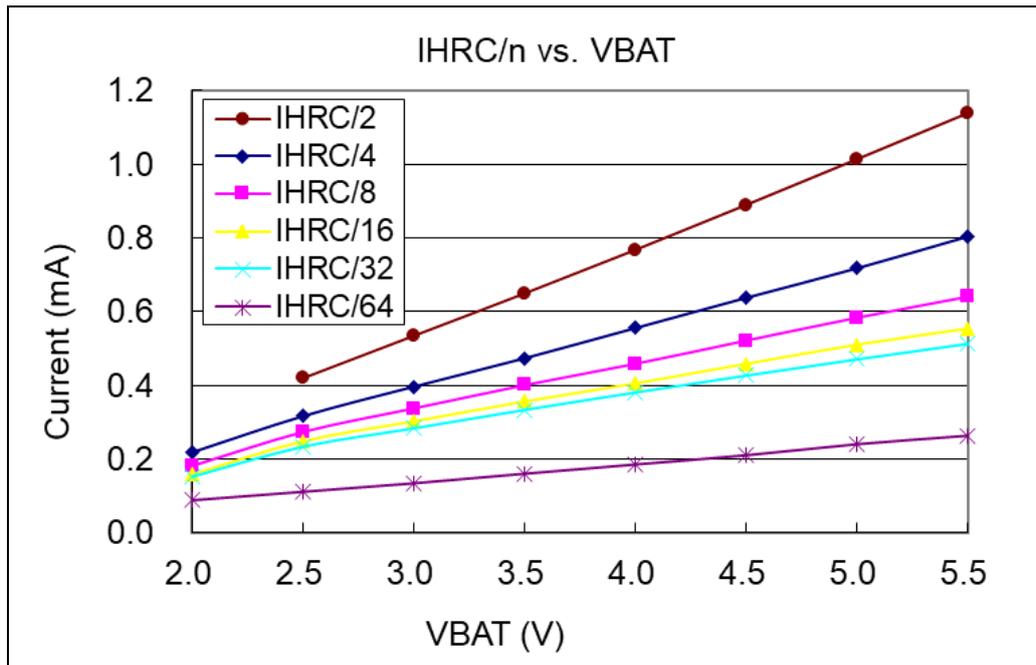
4.9. Typical operating current vs. V_{BAT} @ system clock = ILRC/n

Conditions: **ON**: Bandgap, LVR, ILRC; **OFF**: IHRC, EOSC, T16, TM2, LPWM, GPC;
IO: PA0:0.5Hz output toggle and no loading, **others**: input and no floating.



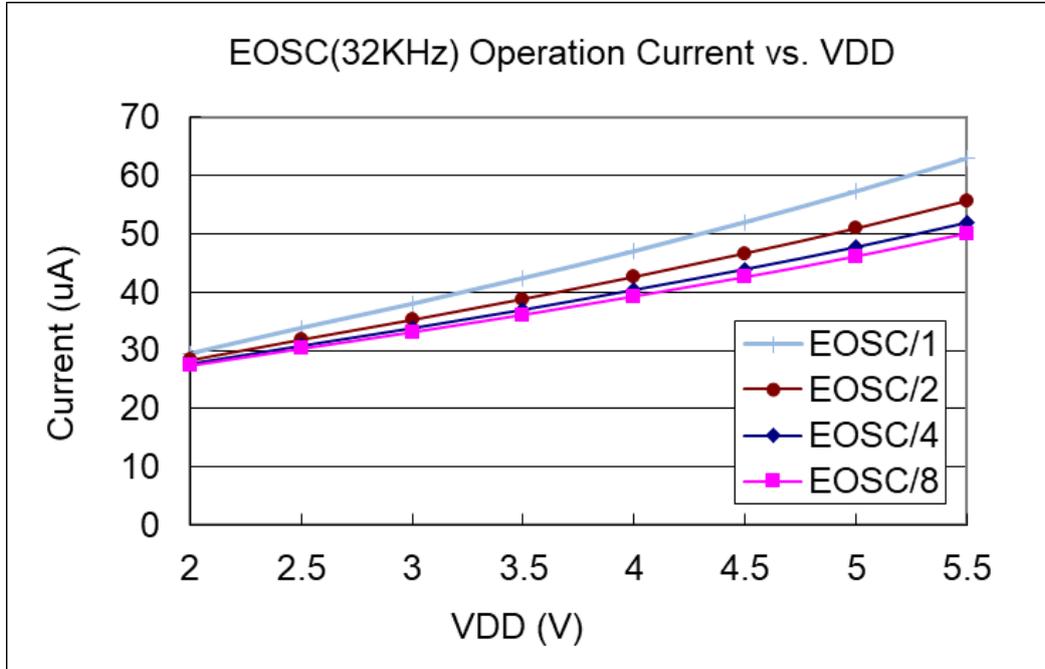
4.10. Typical operating current vs. V_{BAT} @ system clock = IHRC/n

Conditions: **ON**: Bandgap, LVR, IHRC; **OFF**: ILRC, EOSC, T16, TM2, LPWM, GPC;
IO: PA0:0.5Hz output toggle and no loading, **others**: input and no floating.



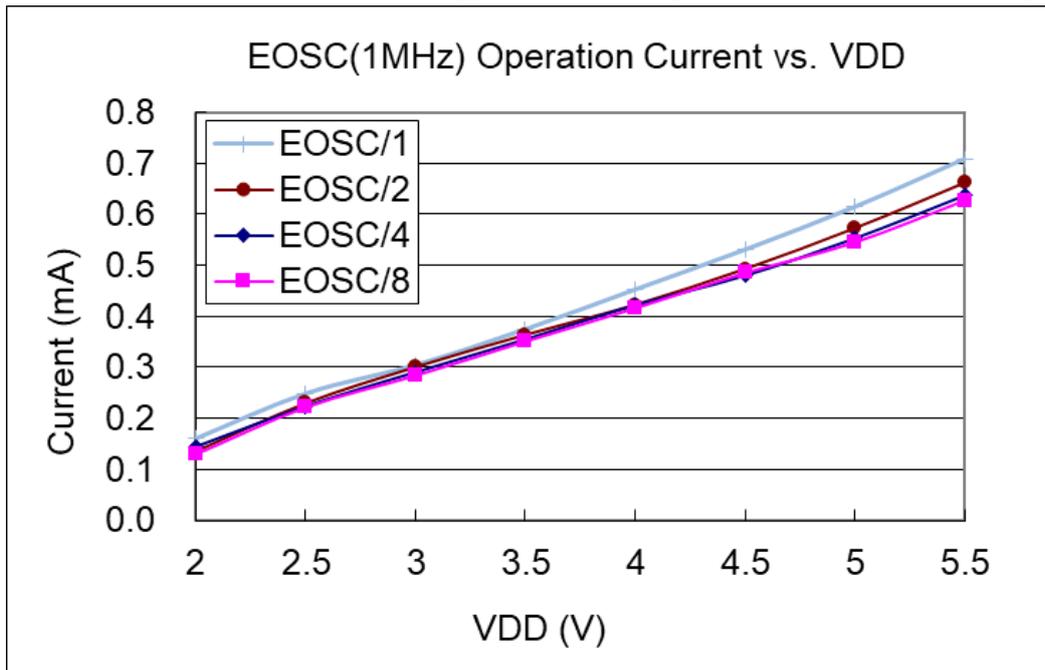
4.11. Typical operating current vs. V_{BAT} @ system clock = 32KHz EOSC/n

Conditions: **ON:** Bandgap, LVR, EOSC; **OFF:** IHRC, ILRC, T16, TM2, LPWM, GPC;
IO: PA0:0.5Hz output toggle and no loading, **others:** input and no floating.



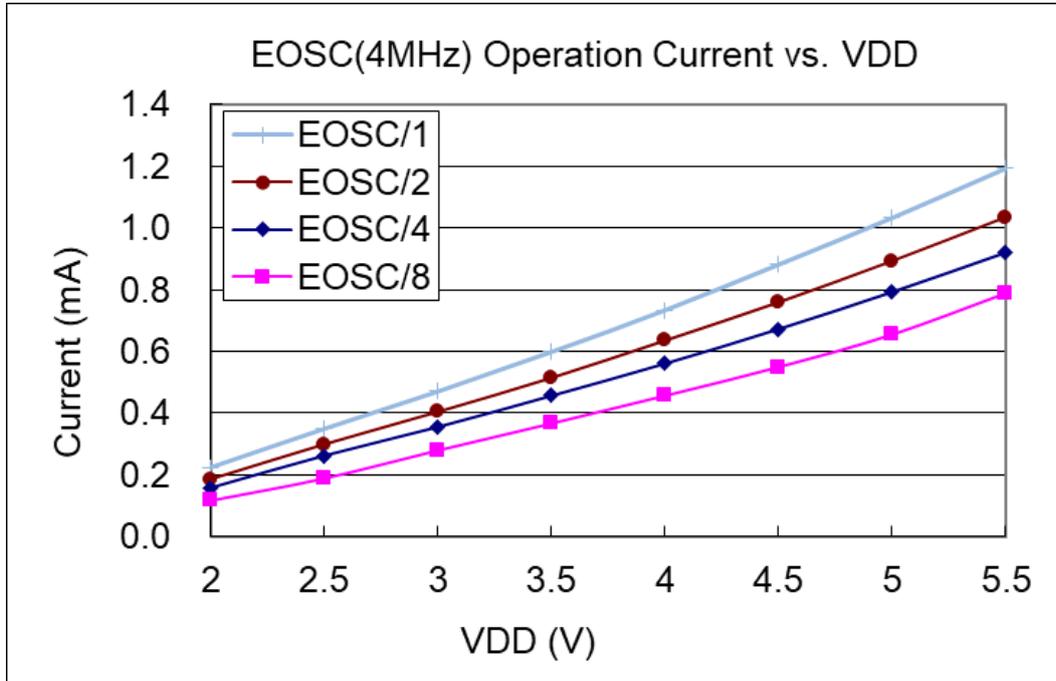
4.12. Typical operating current vs. V_{BAT} @ system clock = 1MHz EOSC/n

Conditions: **ON:** Bandgap, LVR, EOSC; **OFF:** IHRC, ILRC, T16, TM2, LPWM, GPC;
IO: PA0:0.5Hz output toggle and no loading, **others:** input and no floating.



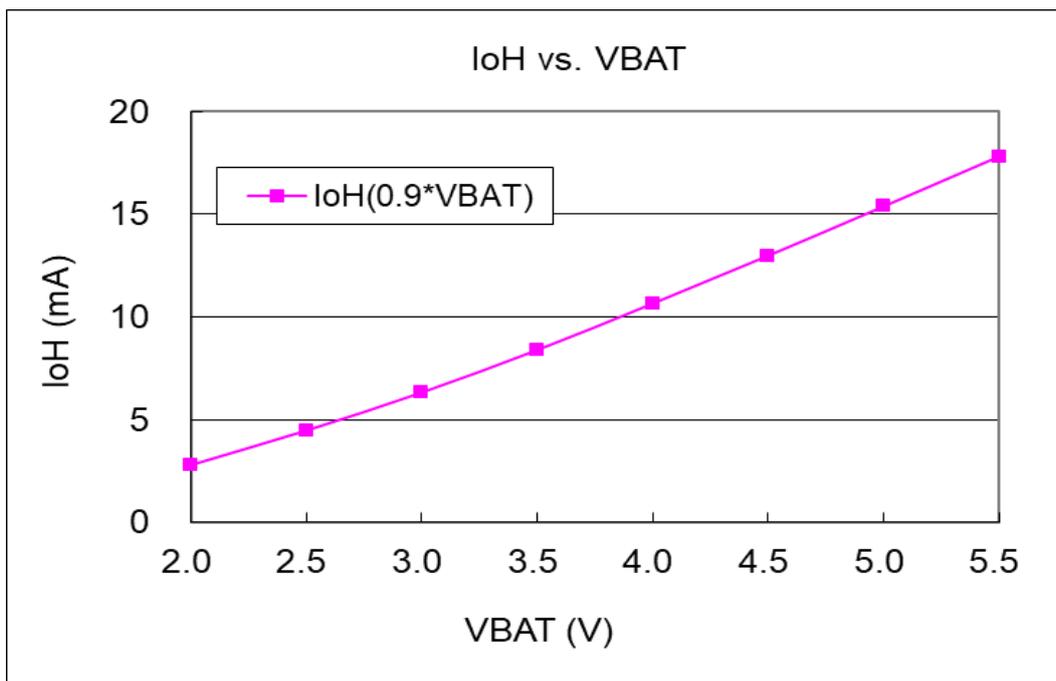
4.13. Typical operating current vs. V_{BAT} @ system clock = 4MHz EOSC/n

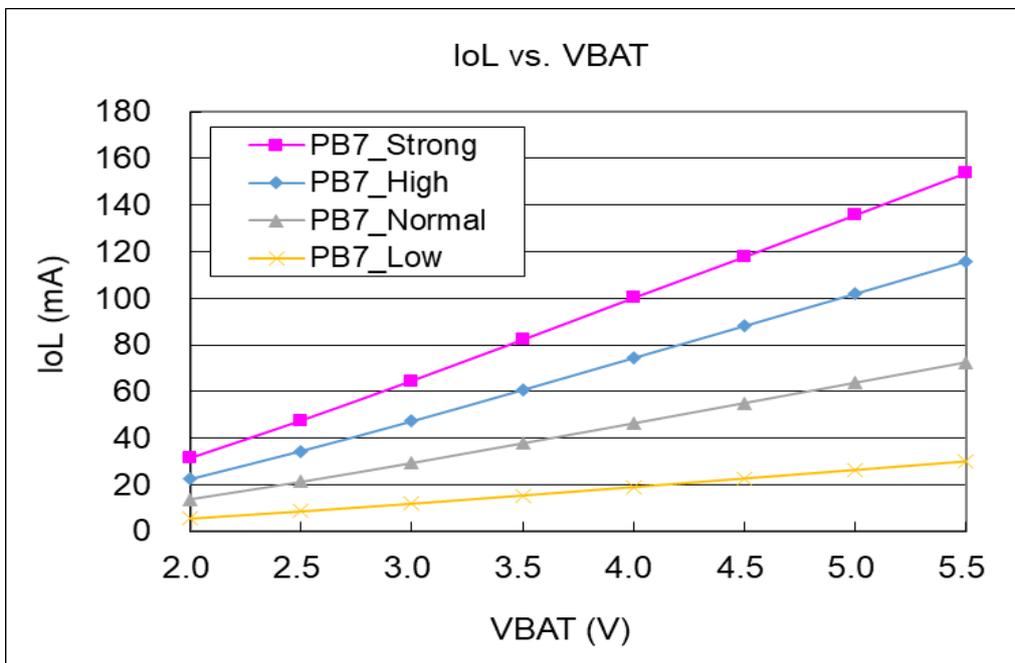
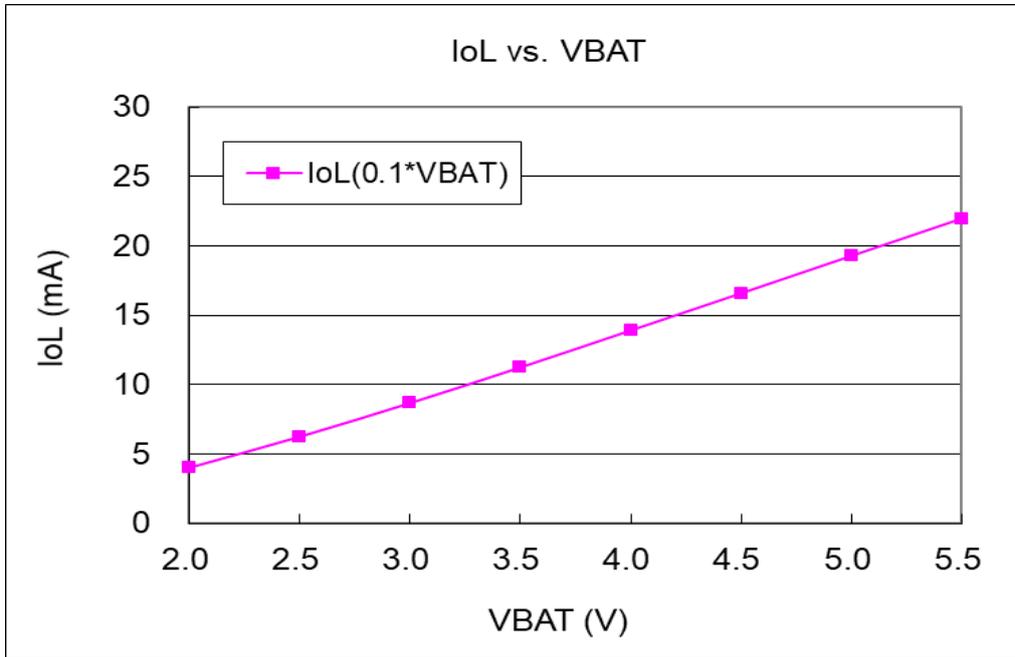
Conditions: **ON**: Bandgap, LVR, EOSC; **OFF**: IHRC, ILRC, T16, TM2, LPWM, GPC;
IO: PA0:0.5Hz output toggle and no loading, **others**: input and no floating.



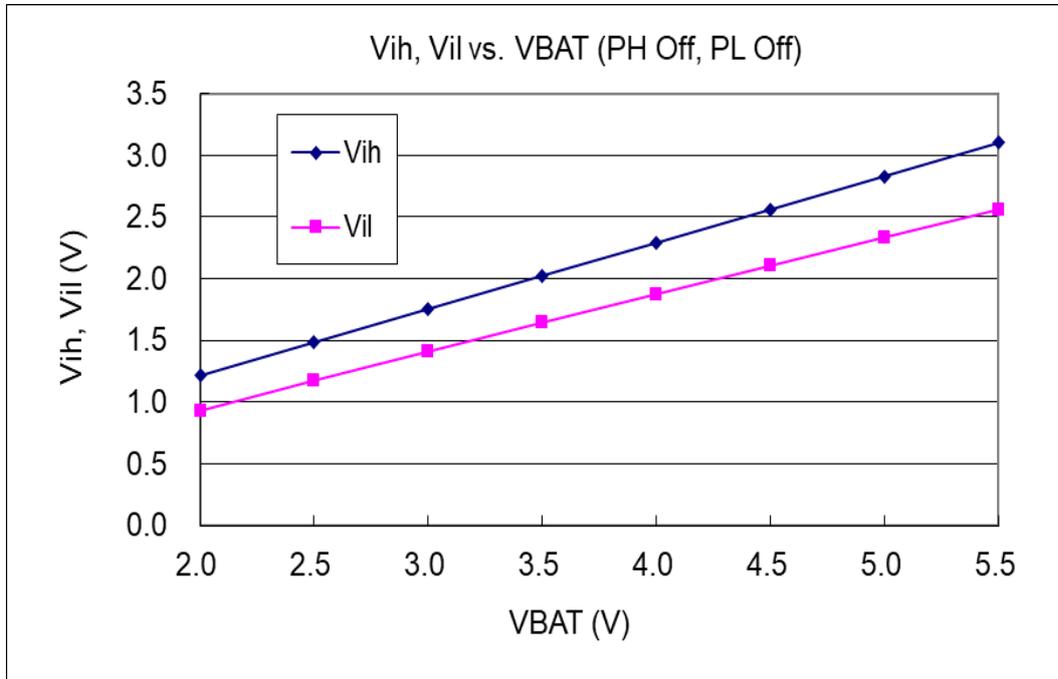
4.14. Typical IO driving current (I_{OH}) and sink current (I_{OL})

($V_{OH}=0.9 \cdot V_{BAT}$, $V_{OL}=0.1 \cdot V_{BAT}$)

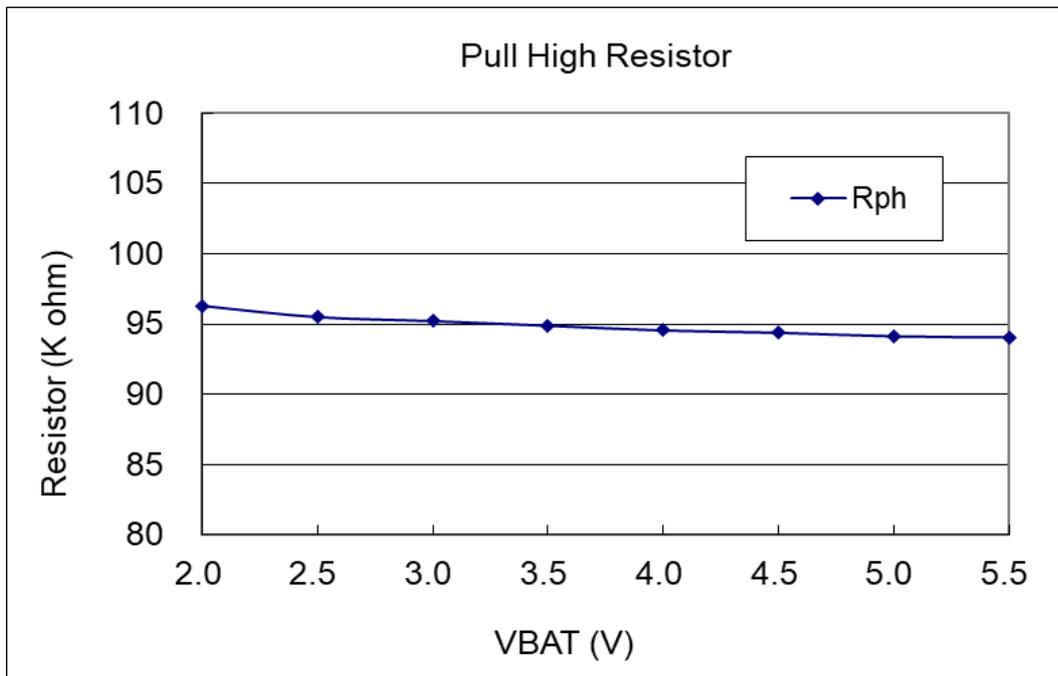


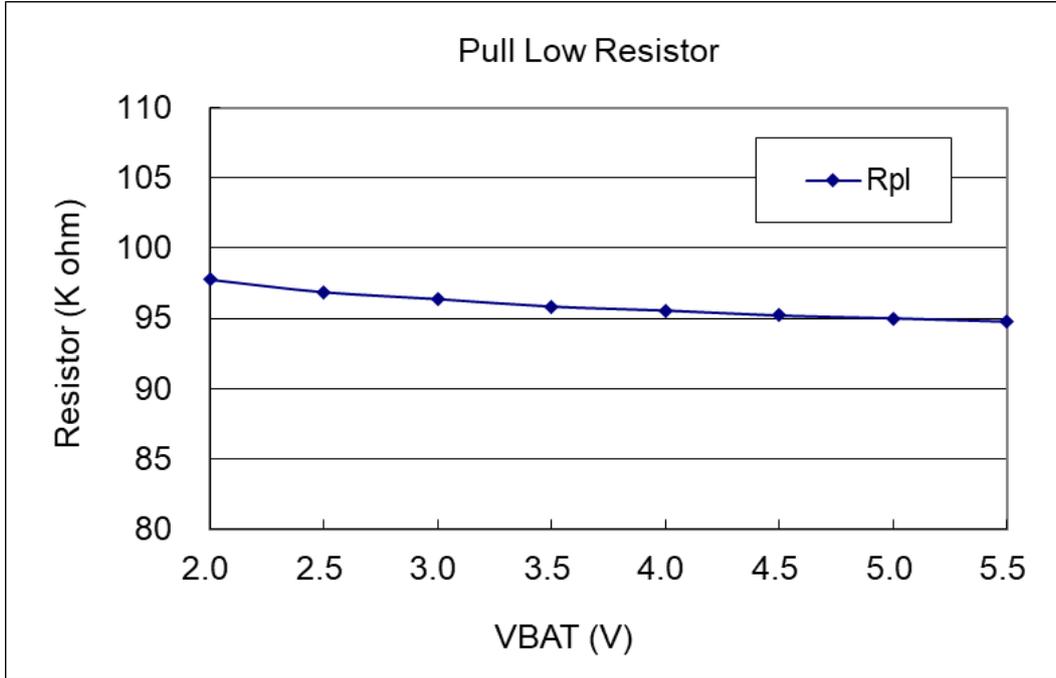


4.15. Typical IO input high/low threshold voltage (V_{IH}/V_{IL})

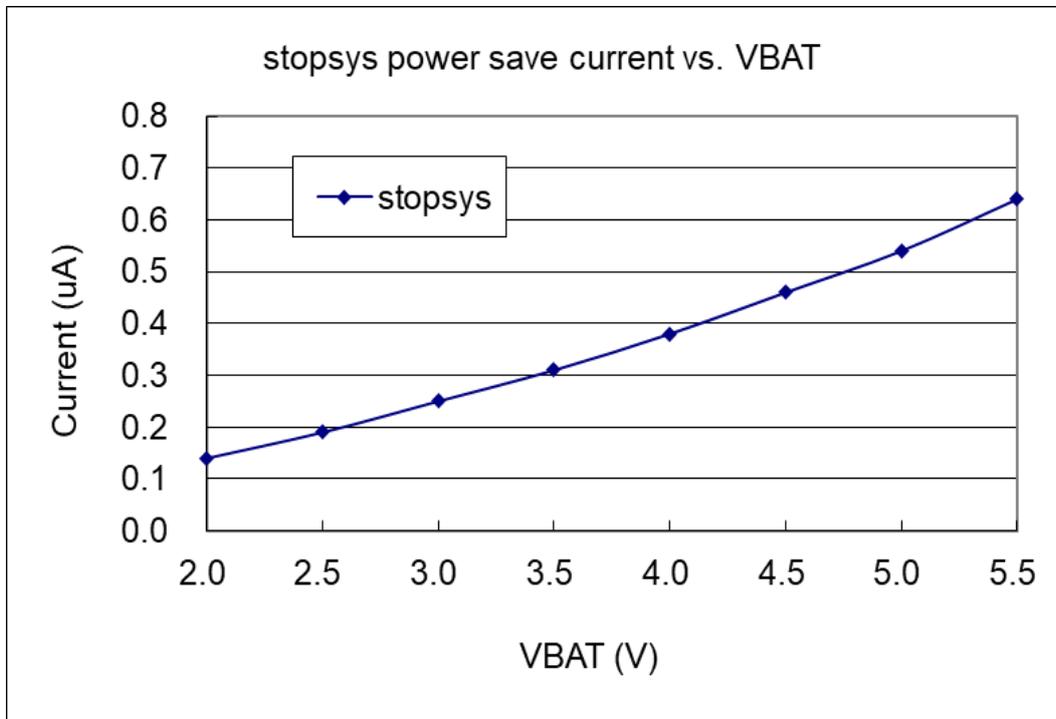


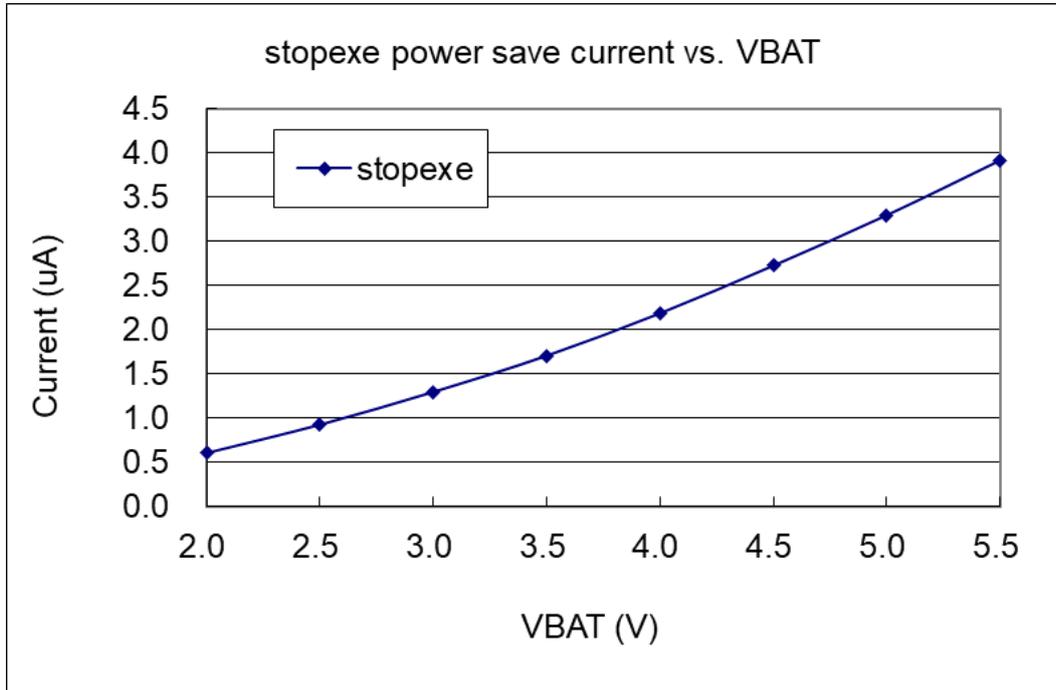
4.16. Typical resistance of IO pull high/low device





4.17. Typical power down current (I_{PD}) and power save current (I_{PS})





5. Functional Description

5.1. Program Memory - OTP

The OTP (One Time Programmable) program memory is used to store the program instructions to be executed. The OTP program memory may contain the data, tables and interrupt entry. After reset, the program will start from 0x000 which is GOTO FPPA0 instruction usually. The interrupt entry is 0x010 if used, the last 16 addresses are reserved for system using, like checksum, serial number, etc. The OTP program memory for PMB182(B) is 1.25KW that is partitioned as Table 1. The OTP memory from address '0x4F0 to 0x4FF is for system using, address space from 0x001 to 0x00F and from 0x011 to 0x4EF are user program spaces.

Address	Function
0x000	GOTO FPPA0 instruction
0x001	User program
•	•
0x00F	User program
0x010	Interrupt entry address
0x011	User program
•	•
0x4EF	User program
0x4F0	System Using
•	•
0x4FF	System Using

Table 1: Program Memory Organization

5.2. Boot Procedure

POR (Power-On-Reset) is used to reset PMB182(B) when power up. The boot up time is 3000 ILRC clock cycles Customer must ensure the stability of supply voltage after power up no matter which option is chosen, the power up sequence is shown in the Fig. 1 and t_{SBP} is the boot up time.

Please noted, during Power-On-Reset, the V_{BAT} must go higher than V_{POR} to boot-up the MCU.

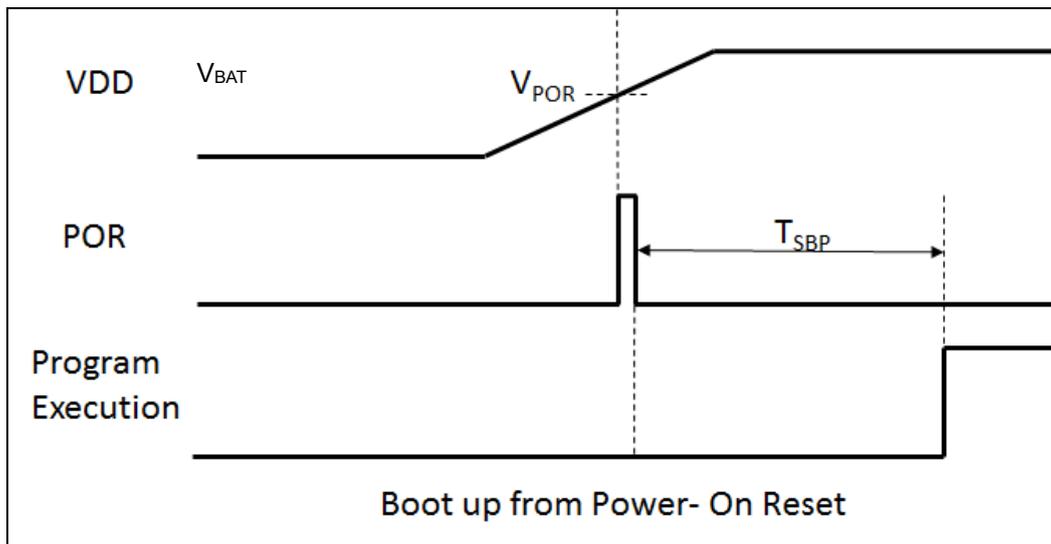
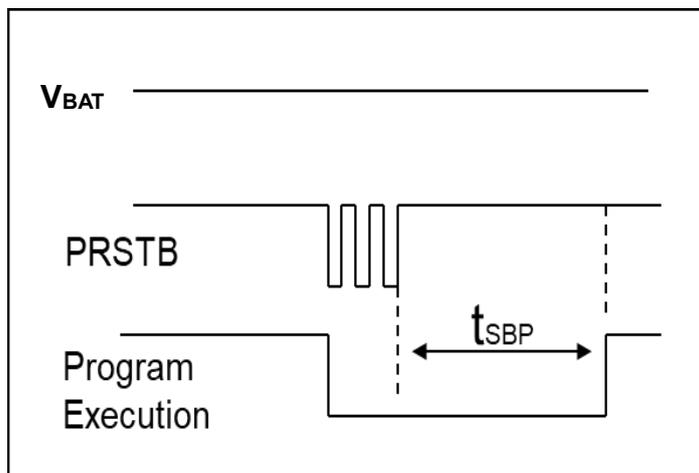
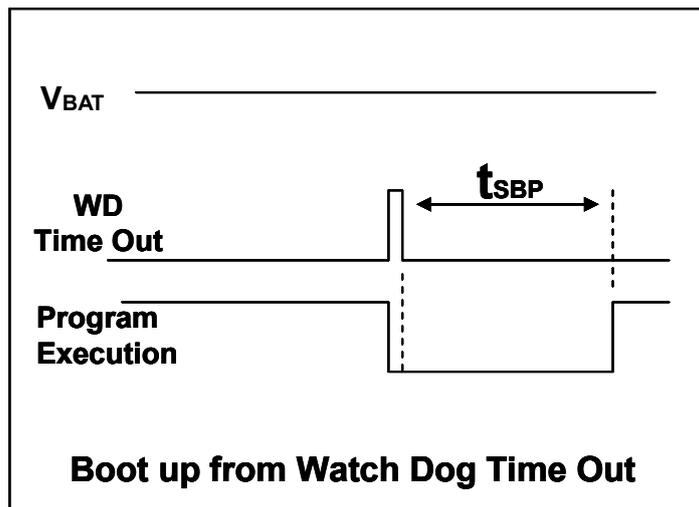
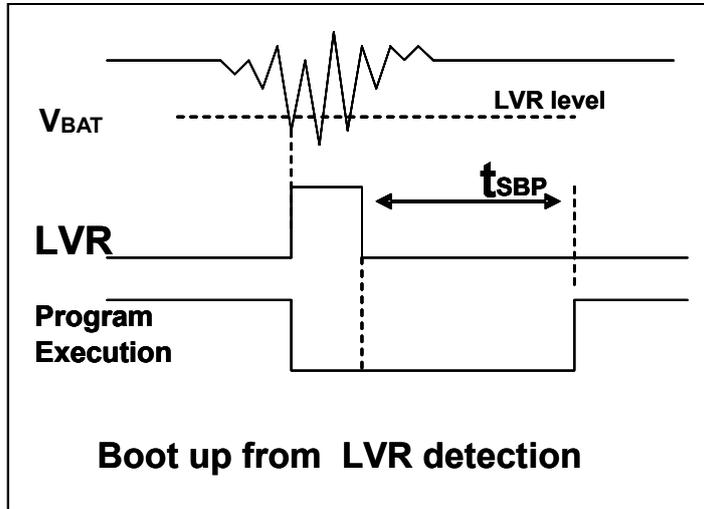


Fig.1: Power-Up Sequence

5.2.1. Timing charts for reset conditions



5.3. Data Memory - SRAM

The access of data memory can be byte or bit operation. Besides data storage, the SRAM data memory is also served as data pointer of indirect access method and the stack memory.

The stack memory is defined in the data memory. The stack pointer is defined in the stack pointer register; the depth of stack memory of each processing unit is defined by the user. The arrangement of stack memory fully flexible and can be dynamically adjusted by the user.

For indirect memory access mechanism, the data memory is used as the data pointer to address the data byte. All the data memory could be the data pointer; it's quite flexible and useful to do the indirect memory access. Since the data width is 8-bit, all the 80 bytes data memory of PMB182(B) can be accessed by indirect access mechanism.

5.4. Oscillator and Clock

There are two oscillator circuits provided by PMB182(B): internal high RC oscillator (IHRC) and internal low RC oscillator (ILRC), and these two oscillators are enabled or disabled by registers `clkmd.4` and `clkmd.2` independently. User can choose one of these two oscillators as system clock source and use ***clkmd*** register to target the desired frequency as system clock to meet different applications.

Oscillator Module	Enable/Disable
IHRC	<code>clkmd.4</code>
ILRC	<code>clkmd.2</code>

Table 2: Two oscillation circuits

5.4.1. Internal High RC oscillator and Internal Low RC oscillator

After boot-up, the IHRC and ILRC oscillators are enabled. The frequency of IHRC can be calibrated to eliminate process variation by ***ihrcr*** register; normally it is calibrated to 16MHz. Please refer to the measurement chart for IHRC frequency verse V_{BAT} and IHRC frequency verse temperature.

The frequency will vary by process, supply voltage and temperature, please refer to DC specification and do not use for accurate timing application.

5.4.2. Chip calibration

The IHRC frequency and bandgap reference voltage may be different chip by chip due to manufacturing variation, PMB182(B) provide the IHRC frequency calibration to eliminate this variation, and this function can be selected when compiling user's program and the command will be inserted into user's program automatically.

The calibration command is shown as below:

```
.ADJUST_IC SYSCLK=IHRC/(p1), IHRC=(p2)MHz, VDD =(p3)V;
```

Where, **p1**=2, 4, 8, 16, 32; In order to provide different system clock.

p2=15 ~ 17; In order to calibrate the chip to different frequency, 16MHz is the usually one.

p3=1.8 ~ 5.5; In order to calibrate the chip under different supply voltage.

5.4.3. IHRC Frequency Calibration and System Clock

During compiling the user program, the options for IHRC calibration and system clock are shown as Table 3:

SYSCLK	CLKMD	IHRCR	Description
○ Set IHRC / 2	= 34h (IHRC / 2)	Calibrated	IHRC calibrated to 16MHz, CLK=8MHz (IHRC/2)
○ Set IHRC / 4	= 14h (IHRC / 4)	Calibrated	IHRC calibrated to 16MHz, CLK=4MHz (IHRC/4)
○ Set IHRC / 8	= 3Ch (IHRC / 8)	Calibrated	IHRC calibrated to 16MHz, CLK=2MHz (IHRC/8)
○ Set IHRC / 16	= 1Ch (IHRC / 16)	Calibrated	IHRC calibrated to 16MHz, CLK=1MHz (IHRC/16)
○ Set IHRC / 32	= 7Ch (IHRC / 32)	Calibrated	IHRC calibrated to 16MHz, CLK=0.5MHz (IHRC/32)
○ Set ILRC	= E4h (ILRC / 1)	Calibrated	IHRC calibrated to 16MHz, CLK=ILRC
○ Disable	No change	No Change	IHRC not calibrated, CLK not changed

Table 3: Options for IHRC Frequency Calibration

Usually, .ADJUST_IC will be the first command after boot up, in order to set the target operating frequency whenever starting the system. The program code for IHRC frequency calibration is executed only one time that occurs in writing the codes into OTP memory; after then, it will not be executed again. If the different option for IHRC calibration is chosen, the system status is also different after boot. The following shows the status of PMB182(B) for different option:

(1) .ADJUST_IC SYSCLK=IHRC/2, IHRC=16MHz, VDD=5V

After boot up, CLKMD = 0x34:

- ◆ IHRC frequency is calibrated to 16MHz@ VDD =5V and IHRC module is enabled
- ◆ System CLK = IHRC/2 = 8MHz
- ◆ Watchdog timer is disabled, ILRC is enabled, PA5 is in input mode

(2) .ADJUST_IC SYSCLK=IHRC/4, IHRC=16MHz, VDD =3.3V

After boot up, CLKMD = 0x14:

- ◆ IHRC frequency is calibrated to 16MHz@ VDD =3.3V and IHRC module is enabled
- ◆ System CLK = IHRC/4 = 4MHz
- ◆ Watchdog timer is disabled, ILRC is enabled, PA5 is in input mode

(3) .ADJUST_IC SYSCLK=IHRC/8, IHRC=16MHz, VDD =2.5V

After boot up, CLKMD = 0x3C:

- ◆ IHRC frequency is calibrated to 16MHz@ VDD =2.5V and IHRC module is enabled
- ◆ System CLK = IHRC/8 = 2MHz
- ◆ Watchdog timer is disabled, ILRC is enabled, PA5 is in input mode

(4) .ADJUST_IC SYSCLK=IHRC/16, IHRC=16MHz, VDD =2.5V

After boot up, CLKMD = 0x1C:

- ◆ IHRC frequency is calibrated to 16MHz@ VDD =2.5V and IHRC module is enabled
- ◆ System CLK = IHRC/16 = 1MHz
- ◆ Watchdog timer is disabled, ILRC is enabled, PA5 is in input mode

(5) .ADJUST_IC SYSCLK=IHRC/32, IHRC=16MHz, VDD=5V

After boot up, CLKMD = 0x7C:

- ◆ IHRC frequency is calibrated to 16MHz@ VDD =5V and IHRC module is enabled
- ◆ System CLK = IHRC/32 = 500KHz
- ◆ Watchdog timer is disabled, ILRC is enabled, PA5 is in input mode

(6) .ADJUST_IC SYSCLK=ILRC, IHRC=16MHz, VDD =5V

After boot up, CLKMD = 0XE4:

- ◆ IHRC frequency is calibrated to 16MHz@ VDD =5V and IHRC module is disabled
- ◆ System CLK = ILRC
- ◆ Watchdog timer is disabled, ILRC is enabled, PA5 is input mode

(7) .ADJUST_IC DISABLE

After boot up, CLKMD is not changed (Do nothing):

- ◆ IHRC is not calibrated
- ◆ System CLK = ILRC
- ◆ Watchdog timer is enabled, ILRC is enabled, PA5 is in input mode

5.4.4. System Clock and LVR level

The clock source of system clock comes from IHRC and ILRC, the hardware diagram of system clock in the PMB182(B) is shown as Fig.2.

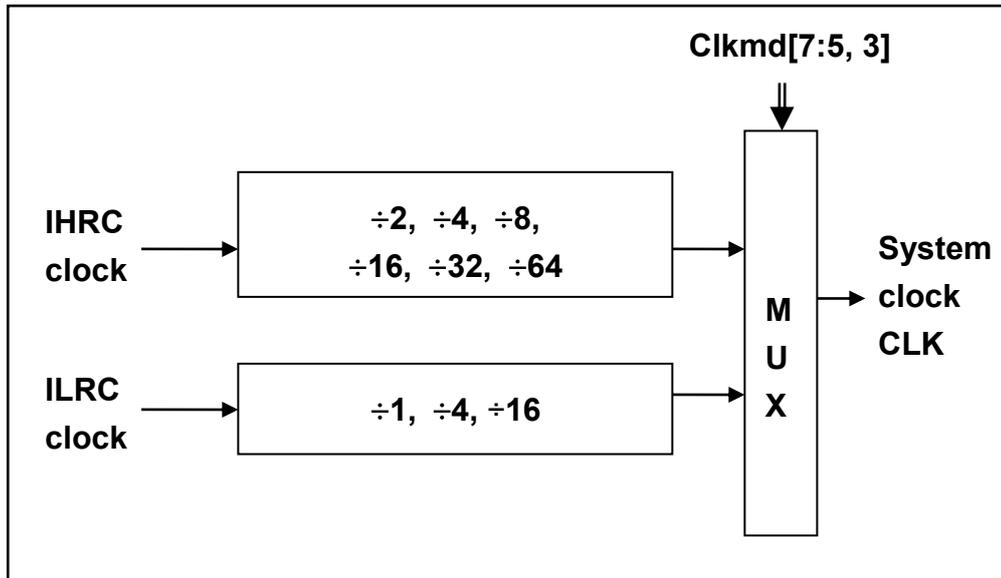


Fig.2: Options of System Clock

User can choose different operating system clock depends on its requirement; the selected operating system clock should be combined with supply voltage and LVR level to make system stable. The LVR level will be selected during compilation. Please refer to Section 4.1.

5.4.5. System Clock Switching

After IHRC calibration, user may want to switch system clock to a new frequency or may switch system clock at any time to optimize the system performance and power consumption. Basically, the system clock of PMB182(B) can be switched among IHRC and ILRC by setting the *clkmd* register at any time; system clock will be the new one after writing to *clkmd* register immediately. **Please notice that the original clock module can NOT be turned off at the same time as writing command to *clkmd* register.** The examples are shown as below and more information about clock switching, please refer to the “Help” → “Application Note” → “IC Introduction” → “Register Introduction” → CLKMD”.

Case 1: Switching system clock from ILRC to IHRC/2

```

...                                     // system clock is ILRC
CLKMD.4      =    1;                // turn on IHRC first to improve anti-interference ability
CLKMD        =    0x34 ;           // switch to IHRC/2, ILRC CAN NOT be disabled here
// CLKMD.2    =    0 ;              // if need, ILRC CAN be disabled at this time
...

```

Case 2: Switching system clock from IHRC/2 to ILRC

```

...                                     // system clock is IHRC/2
CLKMD        =    0xF4 ;           // switch to ILRC, IHRC CAN NOT be disabled here
CLKMD.4     =    0 ;              // IHRC CAN be disabled at this time
...

```

Case 3: Switching system clock from IHRC/2 to IHRC/4

```

...                                     // system clock is IHRC/2, ILRC is enabled here
CLKMD        =    0X14 ;         // switch to IHRC/4
...

```

Case 4: System may hang if it is to switch clock and turn off original oscillator at the same time

```

...                                     // system clock is ILRC
CLKMD        =    0x30 ;         // CAN NOT switch clock from ILRC to IHRC/2 and
                                     // turn off ILRC oscillator at the same time

```

5.5. Charger

The PMB182(B) has a built-in hardware charger. This charger is fully constant current/constant voltage linear charging for single cell Li-ion battery charge management. Due to the internal MOSFET structure, there is no need for external sense resistors or blocking diodes, and the maximum charging current is up to 500 mA. The charger works automatically when power is supplied, and does not require the MCU program to make the startup settings, which means that it can manage the battery charging in the factory default state.

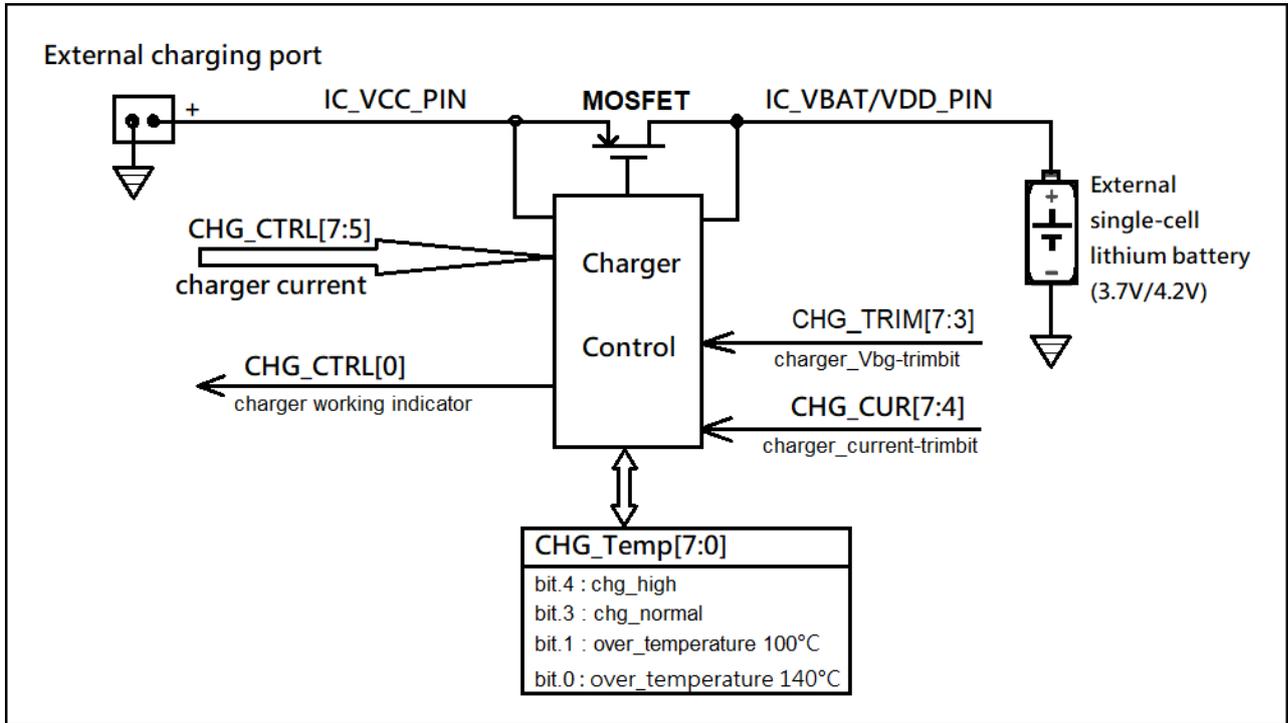
Users can set or adjust the charging current through the three Bits of CHG_CTRL[7:5]. There are 8 groups of charging current can be set, maximum 500mA, minimum 50mA.

MCU program can read register CHG_CTRL[0] to judge the charger working status. The MCU program can read register CHG_Temp[4] to determine if the charging Vcc voltage is greater than Vbat. Read register CHG_Temp[3] to determine if the charging Vcc voltage is too low to make the charger shut down automatically. When CHG_CTRL[4:3] = 0b11 it can be judged that the charging interface is connected and the charging voltage is normal.

The charger also integrates a charging over-temperature protection circuit, and the charging over-temperature protection has two options: 100°C and 140°C. The charging over-temperature protection can be controlled by writing CHG_Temp[1:0]. Charging over-temperature protection can be controlled by writing CHG_Temp[1:0], and reading CHG_Temp[1:0] can determine whether charging over-temperature is triggered or not.

The charging voltage and current of the PMB182(B) charger have been calibrated at the factory and the calibration values are written into the system parameter protection area. When the MCU is successfully powered on and executes the .Adjust_IC macro instruction, the voltage/current factory calibration value of the charger will be filled into the CHG_Trim / CHG_CUR registers, and then the charging voltage and current of the charger will be measured as the factory calibration value, the charging voltage and current of the charger will be uncalibrated when the OTP of the MCU is blank and no program or the power-on failure. CHG_Trim / CHG_CUR registers are not recommended to be rewritten by users. Adjust_IC Disable or write assembly code can be discussed with FAE. If you want to fine tune the charging voltage and current of the charger, you can use ReLoad_Vbat BGTRIM and ReLoad_ChargerCURTRIM macros.

The PMB182(B) detects the battery voltage Vbat by comparing the built-in comparator's Bandgap 1.20V with the VintR voltage divider. The Vbat battery voltage can then be calculated. For more information on how to use the comparator, please refer to the Comparator section.



The charger charging voltage is fixed at 4.2V and the charging current can be set by register CHG_CTRL[7:5]. When the final floating voltage is reached, the charging current will automatically drop to 1/10 of the programmed value set in registers CHG_CTRL[7:5], and the charger will automatically stop the current charging cycle.

After removing the input power (wall outlet or USB power), the PMB182(B) charger IP automatically enters a low current state that reduces the battery leakage current to less than 2uA.

The charger is also designed with other features such as undervoltage lockout, automatic charging and trickle charge mode.

5.5.1. Thermal Limiting

The charger has thermal feedback to regulate the charging current to limit it to high power operation or high ambient temperatures. When the internal temperature of the PMB182(B) IC rises above a preset value of approximately 90°C, the internal thermal feedback loop will reduce the programmed charge current. This feature protects the PMB182(B) from excessive temperatures and allows the user to push the limits of the power handling capability of a given board without damaging the PMB182(B). The charging current can be set based on typical (non-worst case) ambient temperatures, ensuring that the charger automatically reduces the current in worst case scenarios.

5.5.2. Power Dissipation

The conditions that cause the PMB182(B) to reduce charge current through thermal feedback can be approximated by considering the power dissipated in the IC. Nearly all this power dissipation is generated by the internal MOSFET—this is calculated to be approximately:

$$P_D = (V_{CC} - V_{BAT}) \cdot I_{VBAT}$$

where P_D is the power dissipated, V_{VCC} is the input supply voltage, V_{VBAT} is the battery voltage and I_{VBAT} is the charge current. The approximate ambient temperature at which the thermal feedback begins to protect the IC is:

$$T_A = 120^\circ\text{C} - P_D \theta_{JA}$$

$$T_A = 120^\circ\text{C} - (V_{VCC} - V_{VBAT}) \cdot I_{VBAT} \cdot \theta_{JA}$$

Example: The PMB182(B) operating from a 5V USB supply is programmed to supply 400mA full-scale current to a discharged Li-Ion battery with a voltage of 3.75V. Assuming θ_{JA} is 150°C/W (see Board Layout Considerations), the ambient temperature at which the PMB182(B) will begin to reduce the charge current is approximately:

$$T_A = 90^\circ\text{C} - (5\text{V} - 3.75\text{V}) \cdot (400\text{mA}) \cdot 150^\circ\text{C/W}$$

$$T_A = 90^\circ\text{C} - 0.5\text{W} \cdot 150^\circ\text{C/W} = 90^\circ\text{C} - 75^\circ\text{C}$$

$$T_A = 15^\circ\text{C}$$

The PMB182(B) can be used above 15°C ambient, but the charge current will be reduced from 400mA. The approximate current at a given ambient temperature can be approximated by:

$$I_{VBAT} = \frac{90^\circ\text{C} - T_A}{(V_{VCC} - V_{VBAT}) \cdot \theta_{JA}}$$

Using the previous example with an ambient temperature of 60°C, the charge current will be reduced to approximately:

$$I_{VBAT} = \frac{90^\circ\text{C} - 60^\circ\text{C}}{(5\text{V} - 3.75\text{V}) \cdot 150^\circ\text{C/W}} = \frac{30^\circ\text{C}}{187.5^\circ\text{C/A}}$$

$$I_{VBAT} = 160\text{mA}$$

It is important to remember that PMB182(B) applications do not need to be designed for worst-case thermal conditions since the IC will automatically reduce power dissipation when the junction temperature reaches approximately 90°C.

5.5.3. Thermal Considerations

Because of the small size package, it is very important to use a good thermal PC board layout to maximize the available charge current. The thermal path for the heat generated by the IC is from the die to the copper lead frame, through the package leads, (especially the ground lead) to the PC board copper. The PC board copper is the heat sink. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient. The feed through vias to inner or backside copper layers are also useful in improving the overall thermal performance of the charger. Other heat sources on the board, not related to the charger, must also be considered when designing a PC board layout because they will affect overall temperature rise and the maximum charge current.

The following table lists thermal resistance for several different board sizes and copper areas. All measurements were taken in still air on 3/32" FR-4 board with the device mounted on topside.

COPPER AREA		BOARD AREA	THERMAL RESISTANCE JUNCTION-TO-AMBIENT
TOPSIDE	BACKSIDE		
2500mm ²	2500mm ²	2500mm ²	125°C/W
1000mm ²	2500mm ²	2500mm ²	125°C/W
225mm ²	2500mm ²	2500mm ²	130°C/W
100mm ²	2500mm ²	2500mm ²	135°C/W
50mm ²	2500mm ²	2500mm ²	150°C/W

Table4: Measured Thermal Resistance (2-Layer Board)

5.5.4. EPAD

The PCB layout alignment should ensure that the package pins GND and EPAD have a sufficient number of thermal paths to make the thermal paths effective.

5.6. Comparator

One hardware comparator is built inside the PMB182(B); Fig.3 shows its hardware diagram. It can compare signals between two pins or with either internal reference voltage $V_{\text{internal R}}$ or internal bandgap reference voltage. The two signals to be compared, one is the plus input and the other one is the minus input. For the minus input of comparator can be PA3, PA4, Internal bandgap 1.20 volt, PB6, PB7 or $V_{\text{internal R}}$ selected by bit [3:1] of *gpcc* register, and the plus input of comparator can be PA4 or $V_{\text{internal R}}$ selected by bit 0 of *gpcc* register. The output result can be enabled to output to PA0 directly, or sampled by Time2 clock (TM2_CLK) which comes from Timer2 module. The output can be also inversed the polarity by bit 4 of *gpcc* register, the comparator output can be used to request interrupt service.

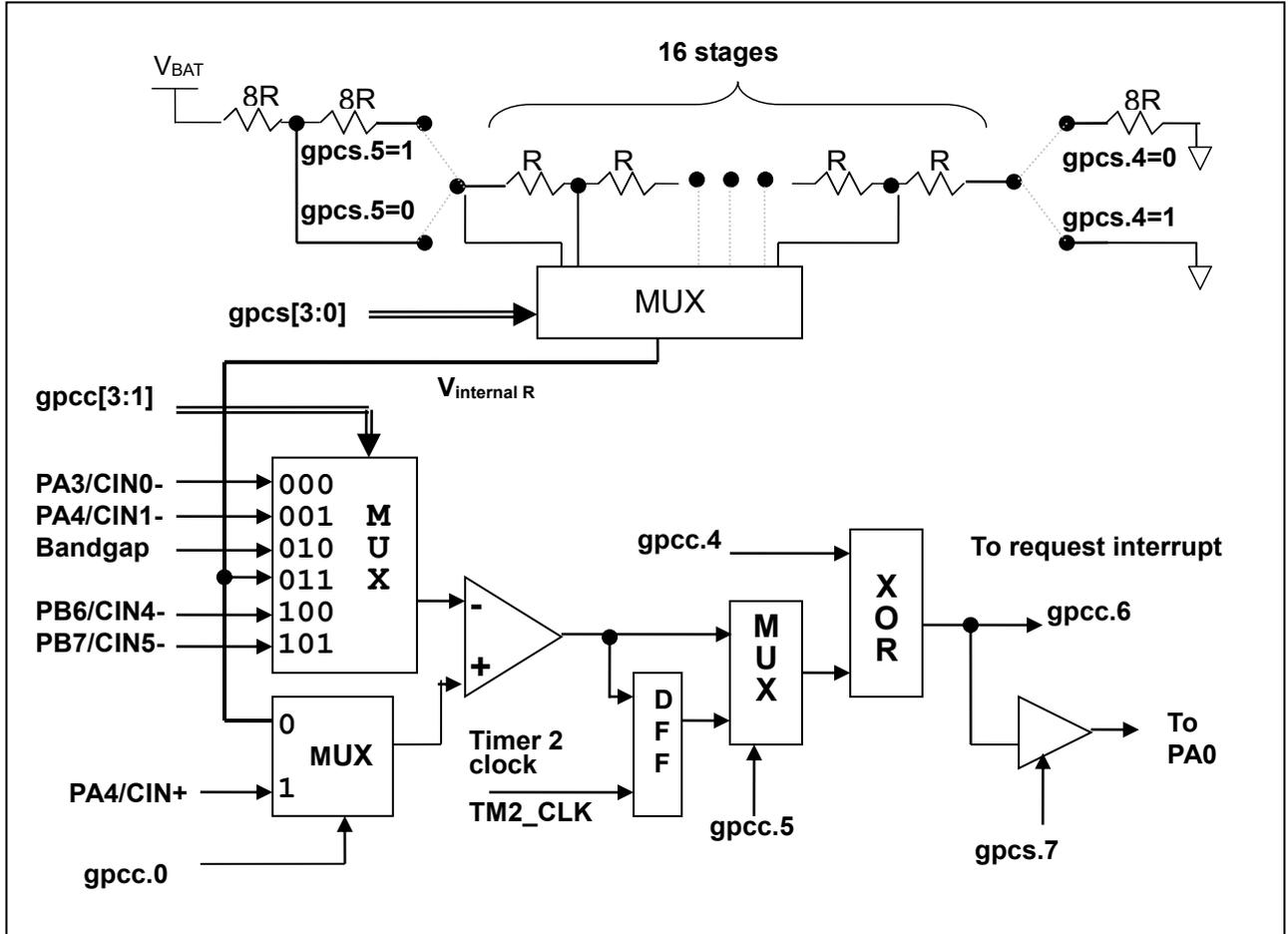


Fig.3: Hardware diagram of comparator

5.6.1. Internal reference voltage ($V_{\text{internal R}}$)

The internal reference voltage $V_{\text{internal R}}$ is built by series resistance to provide different level of reference voltage, bit 4 and bit 5 of **gpcs** register are used to select the maximum and minimum values of $V_{\text{internal R}}$ and bit [3:0] of **gpcs** register are used to select one of the voltage level which is divided-by-16 from the defined maximum level to minimum level. Fig.4 to Fig.7 shows four conditions to have different reference voltage $V_{\text{internal R}}$. By setting the **gpcs** register, the internal reference voltage $V_{\text{internal R}}$ can be ranged from $(1/32) * V_{\text{BAT}}$ to $(3/4) * V_{\text{BAT}}$.

PMB182(B) 8bit OTP with Charge IC

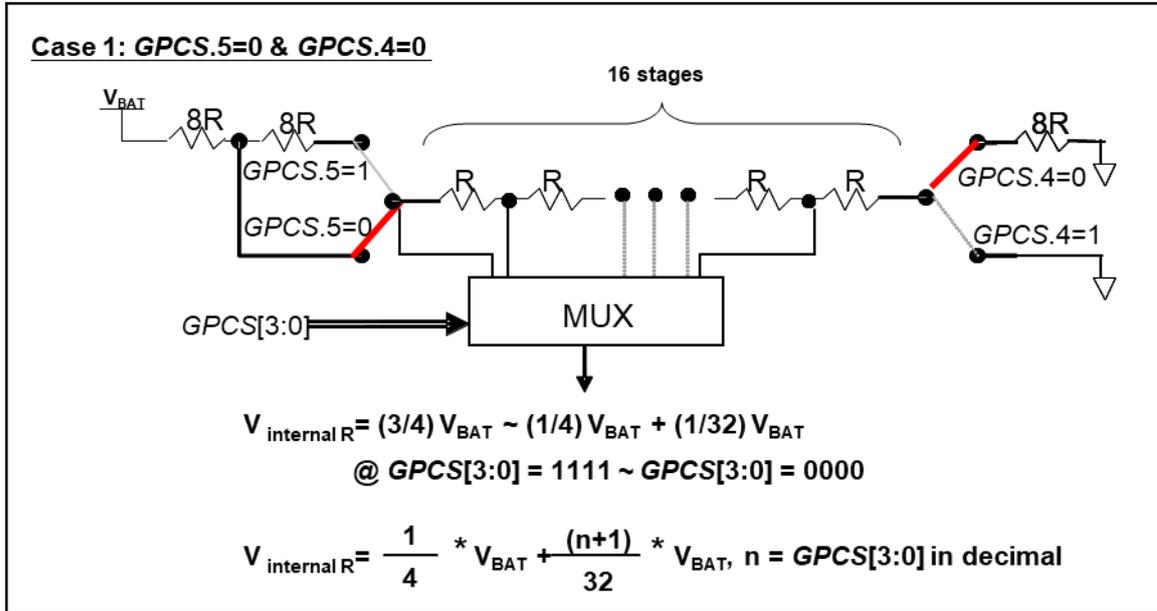


Fig.4: $V_{\text{internal R}}$ hardware connection if $gpcs.5=0$ and $gpcs.4=0$

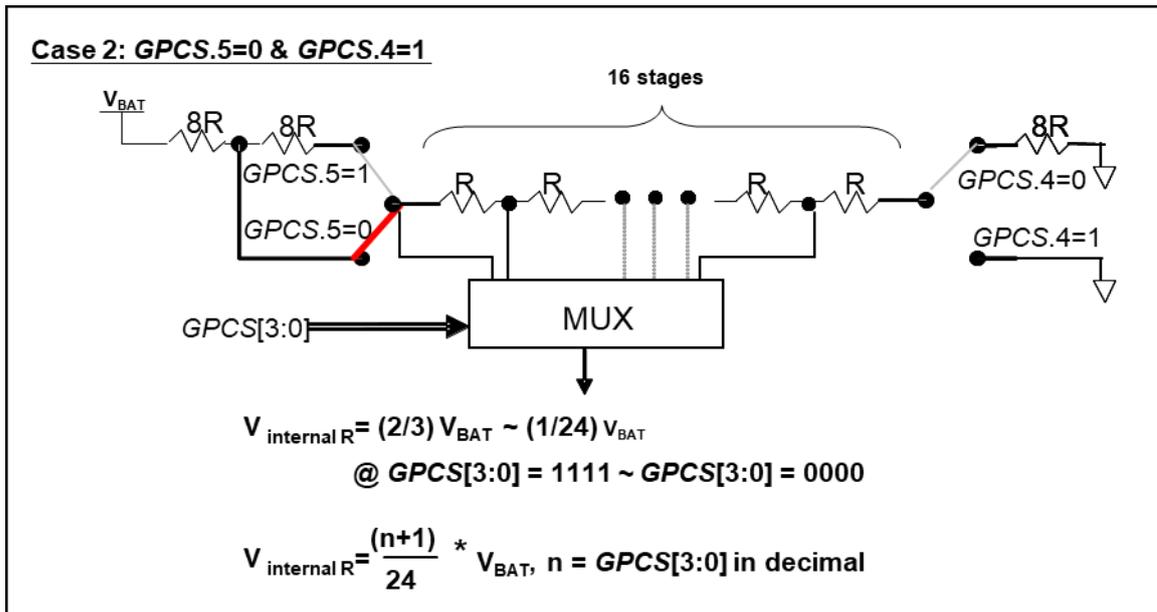


Fig.5: $V_{\text{internal R}}$ hardware connection if $gpcs.5=0$ and $gpcs.4=1$

PMB182(B)

8bit OTP with Charge IC

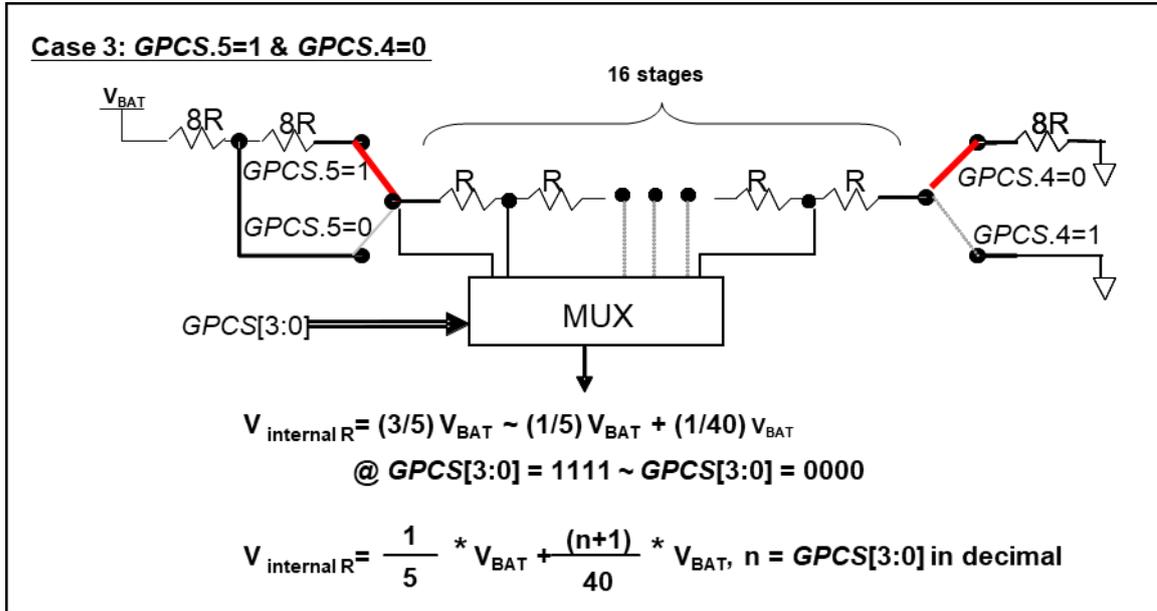


Fig.6: $V_{\text{internal R}}$ hardware connection if $gpcs.5=1$ and $gpcs.4=0$

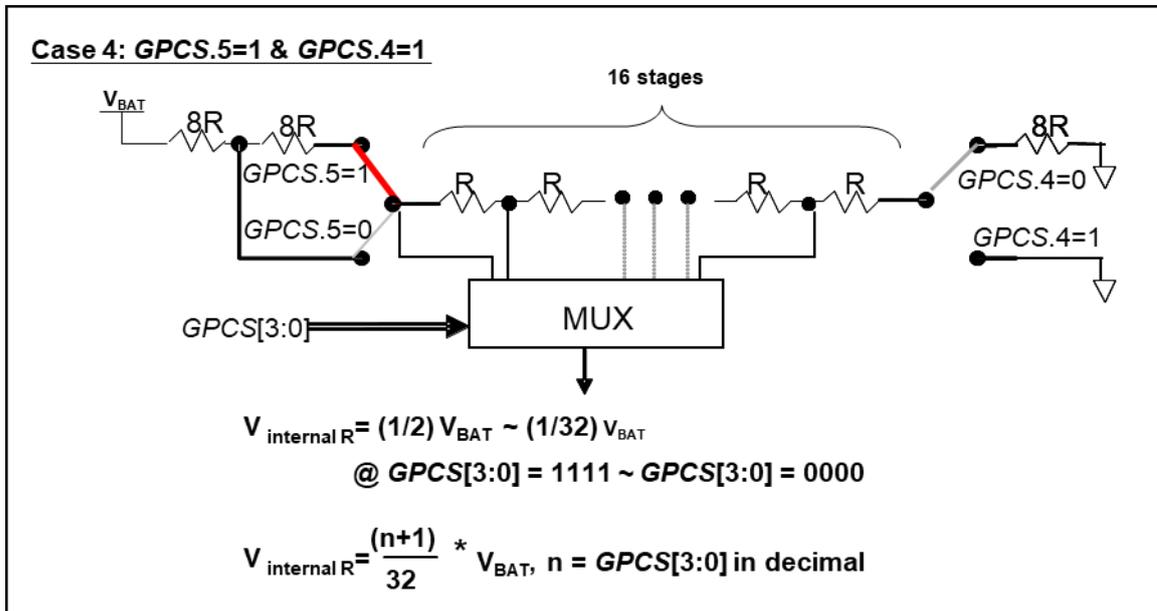


Fig.7: $V_{\text{internal R}}$ hardware connection if $gpcs.5=1$ and $gpcs.4=1$

5.6.2. Using the comparator

Case 1:

Choosing PA3 as minus input and $V_{internal R}$ with $(18/32)*V_{BAT}$ voltage level as plus input. $V_{internal R}$ is configured as the above Figure “gpcs[5:4] = 2b’00” and gpcs [3:0] = 4b’1001 (n=9) to have $V_{internal R} = (1/4)*V_{BAT} + [(9+1)/32]*V_{BAT} = [(9+9)/32]*V_{BAT} = (18/32)*V_{BAT}$.

```

gpcs = 0b0_0_00_1001;           //  $V_{internal R} = V_{BAT} *(18/32)$ 
gpcc = 0b1_0_0_0_000_0;       // enable comp, - input: PA3, + input:  $V_{internal R}$ 
padier = 0bxxxx_0_xxx;        // disable PA3 digital input to prevent leakage current

```

or

```

$ GPCS       $V_{BAT} *18/32$ ;
$ GPCC      Enable, N_PA3, P_R; // - input: N_xx, + input: P_R( $V_{internal R}$ )
PADIER = 0bxxxx_0_xxx;

```

Case 2:

Choosing $V_{internal R}$ as minus input with $(22/40)*V_{BAT}$ voltage level and PA4 as plus input, the comparator result will be inversed and then output to PA0. $V_{internal R}$ is configured as the above Figure “gpcs[5:4] = 2b’10” and gpcs [3:0] = 4b’1101 (n=13) to have $V_{internal R} = (1/5)*V_{BAT} + [(13+1)/40]*V_{BAT} = [(13+9)/40]*V_{BAT} = (22/40)*V_{BAT}$.

```

gpcs = 0b1_0_10_1101;           // output to PA0,  $V_{internal R} = V_{BAT} *(22/40)$ 
gpcc = 0b1_0_0_1_011_1;       // Inverse output, - input:  $V_{internal R}$ , + input: PA4
padier = 0bxxx_0_xxxx;        // disable PA4 digital input to prevent leakage current

```

or

```

$ GPCS      Output,  $V_{BAT} *22/40$ ;
$ GPCC      Enable, Inverse, N_R, P_PA4; // - input: N_R( $V_{internal R}$ ), + input: P_xx
PADIER = 0bxxx_0_xxxx;

```

Note: When selecting output to PA0 output, GPCS will affect the PA3 output function in ICE. Though the IC is fine, be careful to avoid this error during emulation.

5.6.3. Using the comparator and bandgap 1.20V

The internal bandgap module can provide 1.20 volt, it can measure the external supply voltage level. The bandgap 1.20 volt is selected as minus input of comparator and $V_{\text{internal R}}$ is selected as plus input, the supply voltage of $V_{\text{internal R}}$ is V_{BAT} , the V_{BAT} voltage level can be detected by adjusting the voltage level of $V_{\text{internal R}}$ to compare with bandgap. If N (gpscs[3:0] in decimal) is the number to let $V_{\text{internal R}}$ closest to bandgap 1.20 volt, the supply voltage V_{BAT} can be calculated by using the following equations:

For using Case 1: $V_{\text{BAT}} = [32 / (N+9)] * 1.20 \text{ volt ;}$

For using Case 2: $V_{\text{BAT}} = [24 / (N+1)] * 1.20 \text{ volt ;}$

For using Case 3: $V_{\text{BAT}} = [40 / (N+9)] * 1.20 \text{ volt ;}$

For using Case 4: $V_{\text{BAT}} = [32 / (N+1)] * 1.20 \text{ volt ;}$

Case 1:

```

$ GPCS VBAT *12/40;           // 4.0V * 12/40 = 1.2V
$ GPCC Enable, BANDGAP, P_R; // - input: BANDGAP, + input: P_R(Vinternal R)
....
if (GPC_Out)                  // or GPCC.6
{                               // when VBAT > 4V
}
else
{                               // when VBAT < 4V
}

```

5.7. 16-bit Timer (Timer16)

A 16-bit hardware timer (Timer16) is implemented in the PMB182(B), the clock sources of Timer16 may come from system clock (CLK), internal high RC oscillator (IHRC), internal low RC oscillator (ILRC), PA4 and PA0, a multiplex is used to select clock output for the clock source. Before sending clock to the counter16, a pre-scaling logic with divided-by-1, 4, 16, and 64 is used for wide range counting. The 16-bit counter performs up-counting operation only, the counter initial values can be stored from memory by *stt16* instruction and the counting values can be loaded to memory by *ldt16* instruction. A selector is used to select the interrupt condition of Timer16, whenever overflow occurs, the Timer16 interrupt can be triggered. The hardware diagram of Timer16 is shown as Fig.8. The interrupt source of Timer16 comes from one of bit 8 to 15 of 16-bit counter, and the interrupt type can be rising edge trigger or falling edge trigger which is specified in the bit 4 of *integs* register (address 0x0C).

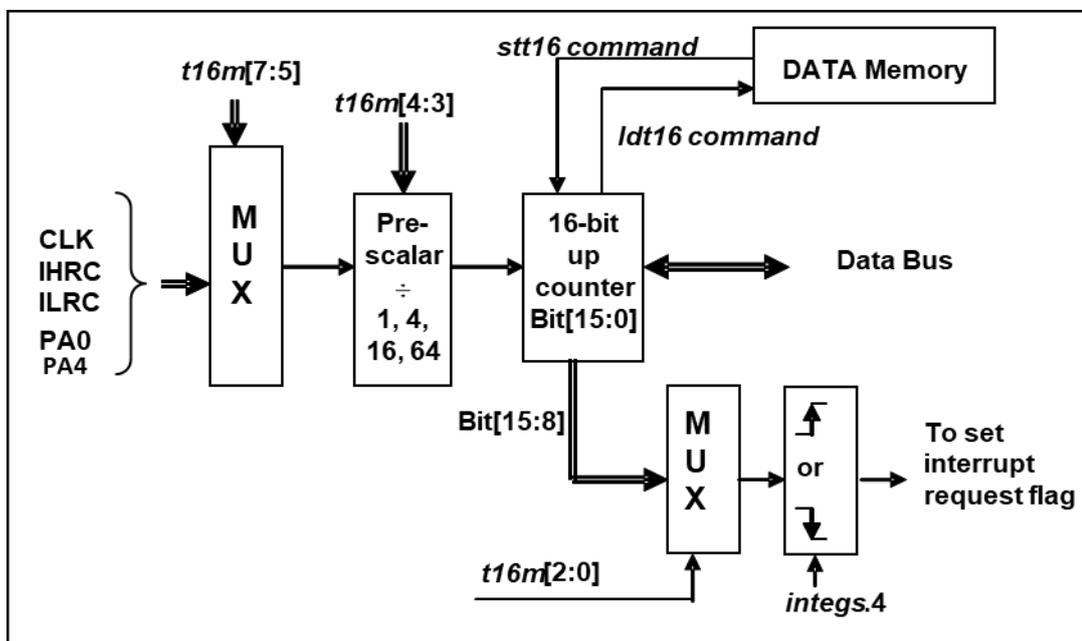


Fig.8: Hardware diagram of Timer16

When using the Timer16, the syntax for Timer16 has been defined in the .INC file. There are three parameters to define the Timer16; 1st parameter is used to define the clock source of Timer16, 2nd parameter is used to define the pre-scalar and the last one is to define the interrupt source. The detail description is shown as below:

```

T16M      IO_RW      0x06
$ 7~5: STOP, SYSCLK, X, PA4_F, IHRC, ILRC, PA0_F      // 1st par.
$ 4~3: /1, /4, /16, /64      // 2nd par.
$ 2~0: BIT8, BIT9, BIT10, BIT11, BIT12, BIT13, BIT14, BIT15      // 3rd par.

```

User can define the parameters of T16M based on system requirement, some examples are shown below and more examples please refer to “Help → Application Note → IC Introduction → Register Introduction → T16M” in IDE utility.

\$ T16M SYSCLK, /64, BIT15;

// choose (SYSCLK/64) as clock source, every 2¹⁶ clock to set INTRQ.2=1
// if using System Clock = IHRC / 2 = 8 MHz
// SYSCLK/64 = 8 MHz/64 = 125KHz, about every 512 mS to generate INTRQ.2=1

\$ T16M PA0_F, /1, BIT8;

// choose PA0 as clock source, every 2⁹ to generate INTRQ.2=1
// receiving every 512 times PA0 to generate INTRQ.2=1

\$ T16M STOP;

// stop Timer16 counting

If Timer16 is operated at free running, the frequency of interrupt can be described as below:

$$F_{INTRQ_T16M} = F_{\text{clock source}} \div P \div 2^{n+1}$$

Where, F is the frequency of selected clock source to Timer16;

P is the selection of t16m [4:3]; (1, 4, 16, 64)

N is the nth bit selected to request interrupt service, for example: n=10 if bit 10 is selected.

5.8. 8-bit Timer (Timer2) with PWM generation

An 8-bit hardware timer (Timer2) with PWM generation is implemented in the PMB182(B). Please refer to Fig.9 shown the hardware diagram of Timer2, the clock sources of Timer2 may come from system clock, internal high RC oscillator (IHRC), internal low RC oscillator (ILRC), NILRC, PA0, PB0, PA4 and comparator. Bit [7:4] of register tm2c are used to select the clock of Timer2. If IHRC is selected for Timer2 clock source, the clock sent to Timer2 will keep running when using ICE in halt state. The output of Timer2 can be sent to pin PA3, PB2 or PB4, depending on bit [3:2] of tm2c register. A clock pre-scaling module is provided with divided-by- 1, 4, 16, and 64 options, controlled by bit [6:5] of tm2s register; one scaling module with divided-by-1~32 is also provided and controlled by bit [4:0] of tm2s register. In conjunction of pre-scaling function and scaling function, the frequency of Timer2 clock (TM2_CLK) can be wide range and flexible.

The Timer2 counter performs 8-bit up-counting operation only; the counter values can be set or read back by tm2ct register. The 8-bit counter will be clear to zero automatically when its values reach for upper bound register in period mode. The upper bound register is used to define the period of timer or duty of PWM. There are two operating modes for Timer2: period mode and PWM mode; period mode is used to generate periodical output waveform or interrupt event; PWM mode is used to generate PWM output waveform with optional 6-bit, 7-bit or 8-bit PWM resolution, Fig.10 shows the timing diagram of Timer2 for both period mode and PWM mode.

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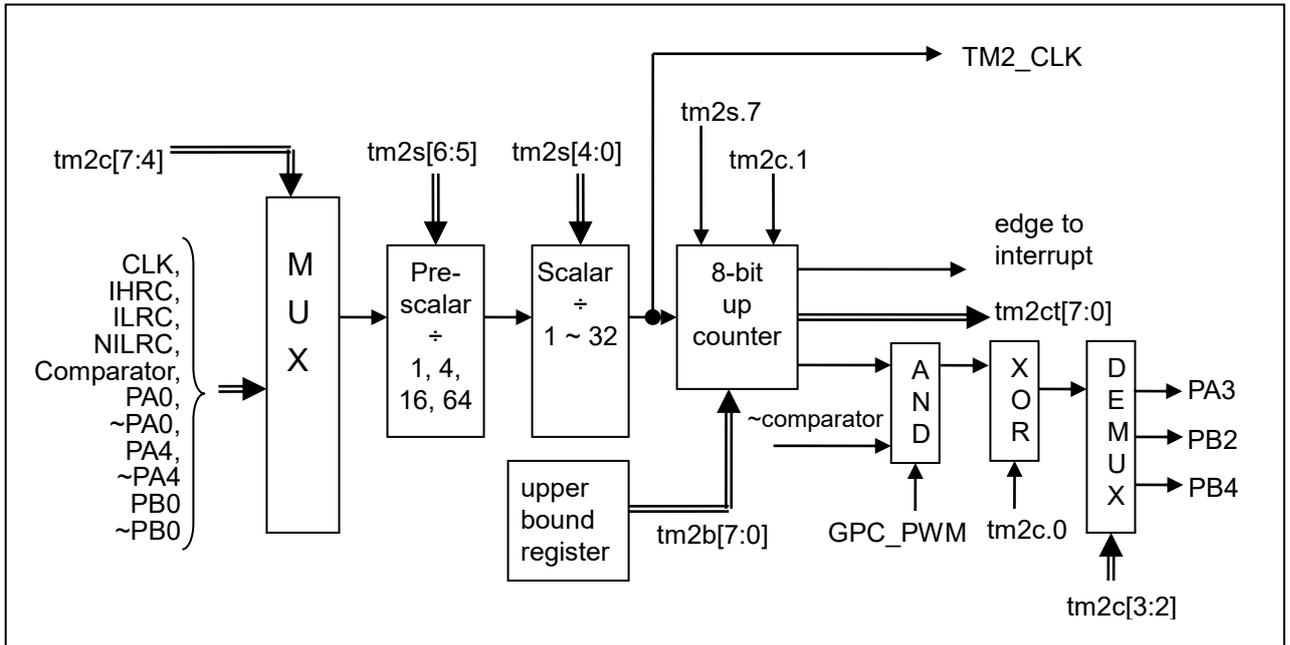


Fig.9: Timer2 hardware diagram

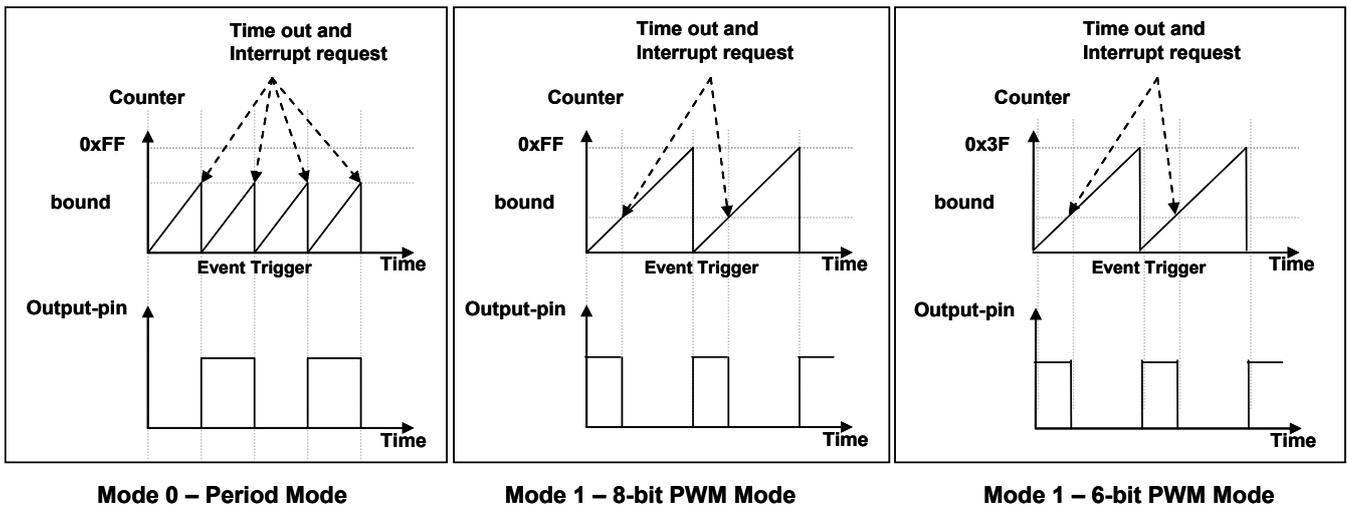


Fig.10: Timing diagram of Timer2 in period mode and PWM mode (tm2c.1=1)

A Code Option GPC_PWM is for the applications which need the generated PWM waveform to be controlled by the comparator result. If the Code Option GPC_PWM is selected, the PWM output stops while the comparator output is 1 and then the PWM output turns on while the comparator output goes back to 0, as shown in Fig. 11.

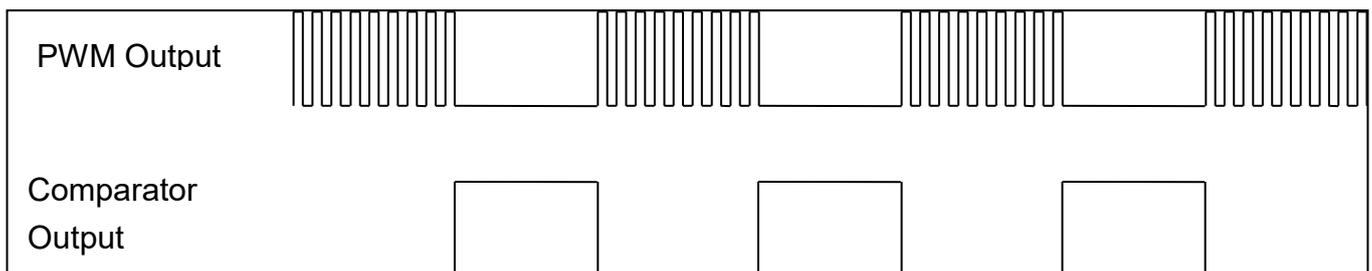


Fig.11: Comparator controls the output of PWM waveform

5.8.1. Using the Timer2 to generate periodical waveform

If periodical mode is selected, the duty cycle of output is always 50%; its frequency can be summarized as below:

$$\text{Frequency of Output} = Y \div [2 \times (K+1) \times S1 \times (S2+1)]$$

Where, $Y = tm2c[7:4]$: frequency of selected clock source

$K = tm2b[7:0]$: bound register in decimal

$S1 = tm2s[6:5]$: pre-scalar ($S1=1, 4, 16, 64$)

$S2 = tm2s[4:0]$: scalar register in decimal ($S2=0 \sim 31$)

Example 1:

$tm2c = 0b0001_1000$, $Y=8MHz$

$tm2b = 0b0111_1111$, $K=127$

$tm2s = 0b0000_00000$, $S1=1$, $S2=0$

→ frequency of output = $8MHz \div [2 \times (127+1) \times 1 \times (0+1)] = 31.25KHz$

Example 2:

$tm2c = 0b0001_1000$, $Y=8MHz$

$tm2b = 0b0111_1111$, $K=127$

$tm2s[7:0] = 0b0111_11111$, $S1=64$, $S2 = 31$

→ frequency of output = $8MHz \div (2 \times (127+1) \times 64 \times (31+1)) = 15.25Hz$

Example 3:

$tm2c = 0b0001_1000$, $Y=8MHz$

$tm2b = 0b0000_1111$, $K=15$

$tm2s = 0b0000_00000$, $S1=1$, $S2=0$

→ frequency of output = $8MHz \div (2 \times (15+1) \times 1 \times (0+1)) = 250KHz$

Example 4:

$tm2c = 0b0001_1000$, $Y=8MHz$

$tm2b = 0b0000_0001$, $K=1$

$tm2s = 0b0000_00000$, $S1=1$, $S2=0$

→ frequency of output = $8MHz \div (2 \times (1+1) \times 1 \times (0+1)) = 2MHz$

The sample program for using the Timer2 to generate periodical waveform from PA3 is shown as below:

```

Void FPPA0 (void)
{
    . ADJUST_IC  SYSCLK=IHRC/2, IHRC=16MHz, VBAT =5V
    ...
    tm2ct = 0x00;
    tm2b = 0x7f;
    tm2s = 0b0_00_00001;           //      8-bit PWM, pre-scalar = 1, scalar = 2
    tm2c = 0b0001_10_0_0;         //      system clock, output=PA3, period mode
    while(1)
    {
        nop;
    }
}

```

5.8.2. Using the Timer2 to generate 8-bit PWM waveform

If 8-bit PWM mode is selected, it should set **tm2c[1]=1** and **tm2s[7]=0**, the frequency and duty cycle of output waveform can be summarized as below:

$$\text{Frequency of Output} = Y \div [256 \times S1 \times (S2+1)]$$

$$\text{Duty of Output} = [(K+1) \div 256] \times 100\%$$

Where, Y = tm2c[7:4] : frequency of selected clock source

K = tm2b[7:0] : bound register in decimal

S1 = tm2s[6:5] : pre-scalar (S1=1, 4, 16, 64)

S2 = tm2s[4:0] : scalar register in decimal (S2=0 ~ 31)

Example 1:

tm2c = 0b0001_1010, Y=8MHz

tm2b = 0b0111_1111, K=127

tm2s = 0b0000_00000, S1=1, S2=0

→ frequency of output = 8MHz ÷ (256 × 1 × (0+1)) = 31.25KHz

→ duty of output = [(127+1) ÷ 256] × 100% = 50%

Example 2:

tm2c = 0b0001_1010, Y=8MHz

tm2b = 0b0111_1111, K=127

tm2s = 0b0111_11111, S1=64, S2=31

→ frequency of output = 8MHz ÷ (256 × 64 × (31+1)) = 15.25Hz

→ duty of output = [(127+1) ÷ 256] × 100% = 50%

Example 3:

```

tm2c = 0b0001_1010, Y=8MHz
tm2b = 0b1111_1111, K=255
tm2s = 0b0000_00000, S1=1, S2=0
→ PWM output keep high
→ duty of output =  $[(255+1) \div 256] \times 100\% = 100\%$ 

```

Example 4:

```

tm2c = 0b0001_1010, Y=8MHz
tm2b = 0b0000_1001, K = 9
tm2s = 0b0000_00000, S1=1, S2=0
→ frequency of output =  $8\text{MHz} \div (256 \times 1 \times (0+1)) = 31.25\text{KHz}$ 
→ duty of output =  $[(9+1) \div 256] \times 100\% = 3.9\%$ 

```

The sample program for using the Timer2 to generate PWM waveform from PA3 is shown as below:

```

void FPPA0 (void)
{
    .ADJUST_IC    SYSCLK=IHRC/2, IHRC=16MHz, VBAT =5V
    wdreset;
    tm2ct = 0x00;
    tm2b = 0x7f;
    tm2s = 0b0_00_00001;           // 8-bit PWM, pre-scalar = 1, scalar = 2
    tm2c = 0b0001_10_1_0;         // system clock, output=PA3, PWM mode
    while(1)
    {
        nop;
    }
}

```

5.8.3. Using the Timer2 to generate 6-bit PWM waveform

If 8-bit PWM mode is selected, it should set $tm2c[1]=1$ and $tm2s[7]=1$, the frequency and duty cycle of output waveform can be summarized as below:

$$\text{Frequency of Output} = Y \div [64 \times S1 \times (S2+1)]$$

$$\text{Duty of Output} = [(K + 1) \div 64] \times 100\%$$

Where, $tm2c[7:4] = Y$: frequency of selected clock source
 $tm2b[7:0] = K$: bound register in decimal
 $tm2s[6:5] = S1$: pre-scalar (S1=1, 4, 16, 64)
 $tm2s[4:0] = S2$: scalar register in decimal (S2=0 ~ 31)

Users can set Timer2 to be 7-bit PWM mode instead of 6-bit mode by using **TM2_Bit** code option. At that time, the calculation factors of the above equations become 128 instead of 64.

Example 1:

$tm2c = 0b0001_1010$, Y=8MHz
 $tm2b = 0b0001_1111$, K=31
 $tm2s = 0b1000_00000$, S1=1, S2=0
 → frequency of output = $8\text{MHz} \div (64 \times 1 \times (0+1)) = 125\text{KHz}$
 → duty = $[(31+1) \div 64] \times 100\% = 50\%$

Example 2:

$tm2c = 0b0001_1010$, Y=8MHz
 $tm2b = 0b0001_1111$, K=31
 $tm2s = 0b1111_11111$, S1=64, S2=31
 → frequency of output = $8\text{MHz} \div (64 \times 64 \times (31+1)) = 61.03 \text{ Hz}$
 → duty of output = $[(31+1) \div 64] \times 100\% = 50\%$

Example 3:

$tm2c = 0b0001_1010$, Y=8MHz
 $tm2b = 0b0011_1111$, K=63
 $tm2s = 0b1000_00000$, S1=1, S2=0
 → PWM output keep high
 → duty of output = $[(63+1) \div 64] \times 100\% = 100\%$

Example 4:

$tm2c = 0b0001_1010$, Y=8MHz
 $tm2b = 0b0000_0000$, K=0
 $tm2s = 0b1000_00000$, S1=1, S2=0
 → frequency = $8\text{MHz} \div (64 \times 1 \times (0+1)) = 125\text{KHz}$
 → duty = $[(0+1) \div 64] \times 100\% = 1.5\%$

5.9. 11-bit PWM Generators

One set of triple 11-bit SuLED (Super LED) hardware PWM generator is implemented in the PMB182(B). It consists of three PWM generators (LPWGM0, LPWGM1 & LPWGM2). Their individual outputs are listed as below:

- LPWGM0 – PA0, PB4, PB5
- LPWGM1 – PA4, PB6, PB7
- LPWGM2 – PA3, PB2, PB3, PA5

Note: 5S-I-S01/2(B) doesn't support the function of the set of 11-bit SuLED hardware PWM generators.

5.9.1. PWM Waveform

A PWM output waveform (Fig.12) has a time-base ($T_{\text{Period}} = \text{Time of Period}$) and a time with output high level (Duty Cycle). The frequency of the PWM output is the inverse of the period ($f_{\text{PWM}} = 1/T_{\text{Period}}$).

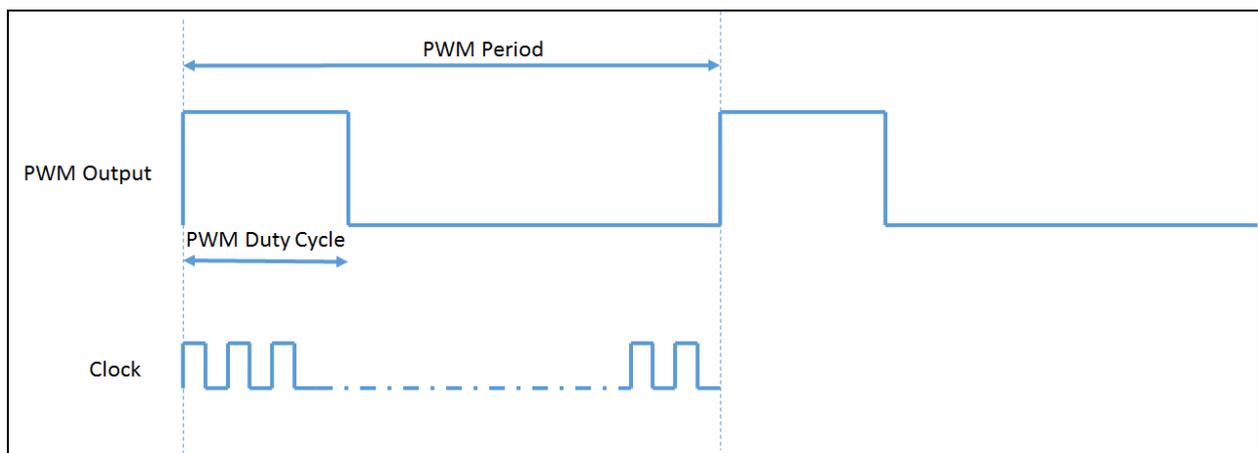


Fig.12: PWM Output Waveform

5.9.2. Hardware Diagram

Fig.13 shows the hardware diagram of the whole set of SuLED 11-bit hardware PWM generators. Those three PWM generators use a common Up-Counter and clock source selector to create the time base, and so the start points (the rising edge) of the PWM cycle are synchronized. The clock source can be IHRC or system clock. The PWM signal output pins that can be selected via *lpwmgxc* register selection. The period of PWM waveform is defined by the common PWM upper bound high and low registers, and the duty cycle of individual PWM waveform is defined by the individual set in the PWM duty high and low registers.

The additional OR and XOR logic of LPWGM0 channel is used to create the complementary switching waveforms with dead zone control. Selecting code option GPC_LPWM can also control the generated PWM waveform by the comparator result.

PMB182(B) 8bit OTP with Charge IC

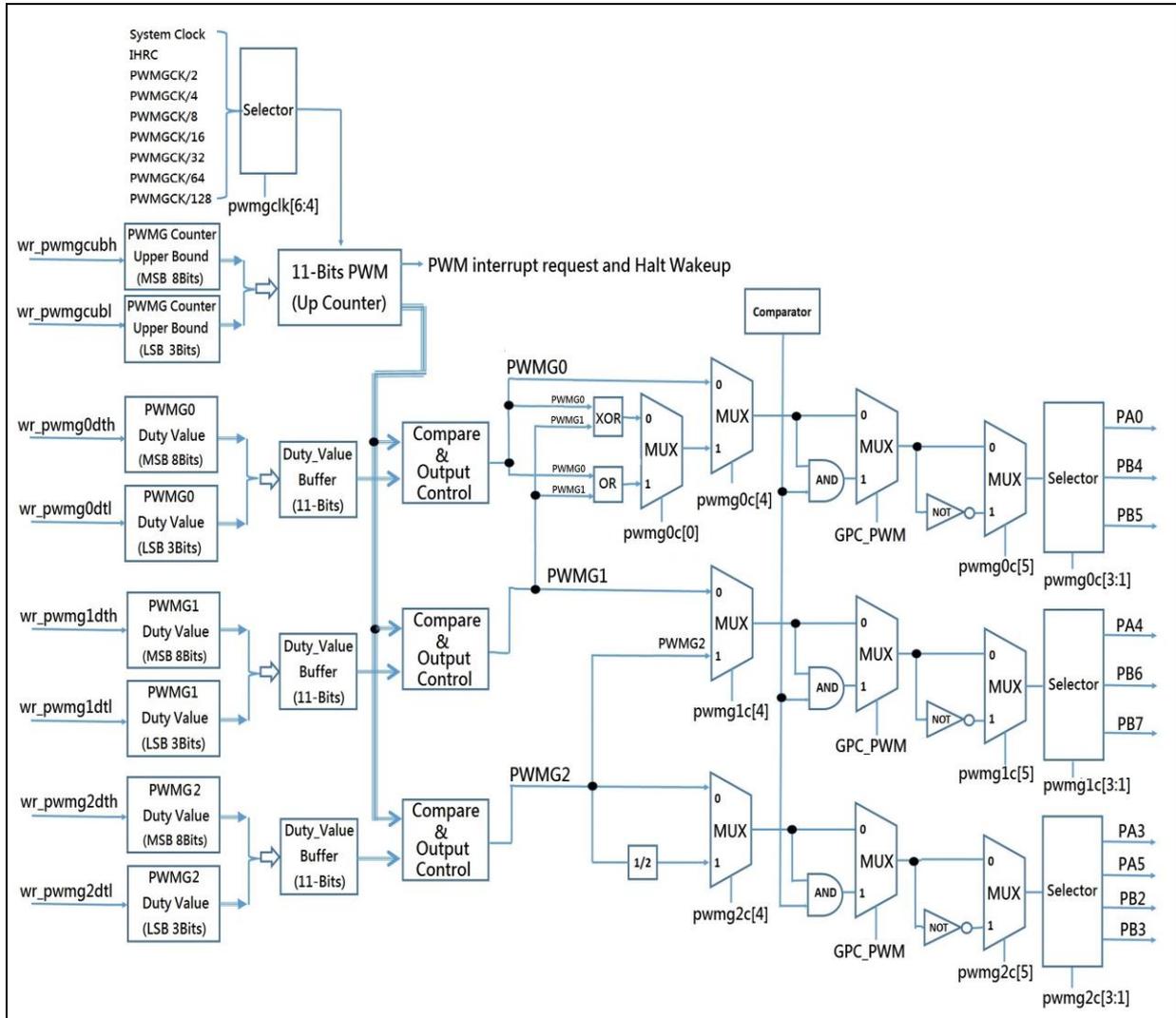


Fig.13: Hardware diagram of whole set of triple SuLED 11-bit PWM generators

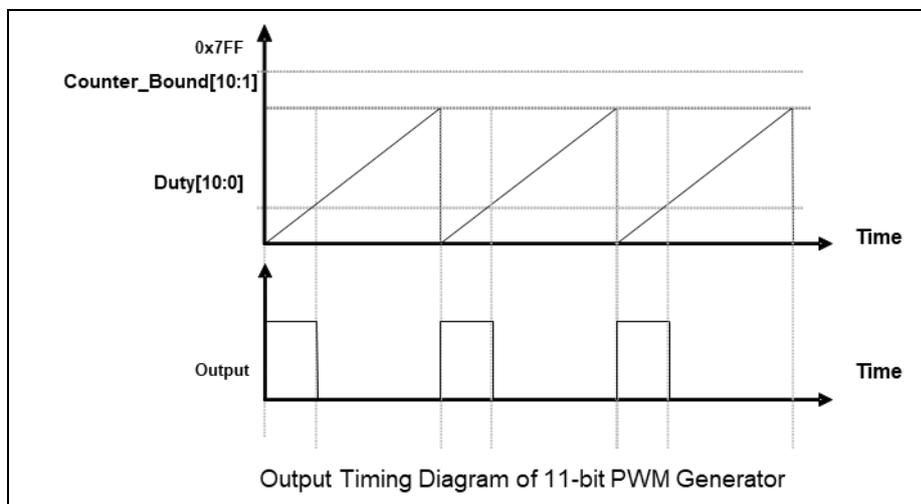


Fig.14: Output Timing Diagram of 11-bit PWM Generator

5.9.3. Equations for 11-bit PWM Generator

$$\text{PWM Frequency } F_{\text{PWM}} = F_{\text{clock source}} \div [P \times (\text{CB10_1} + 1)]$$

$$\text{PWM Duty (in time)} = (1 / F_{\text{PWM}}) \times (\text{DB10_1} + \text{DB0} \times 0.5 + 0.5) \div (\text{CB10_1} + 1)$$

$$\text{PWM Duty (in percentage)} = (\text{DB10_1} + \text{DB0} \times 0.5 + 0.5) \div (\text{CB10_1} + 1) \times 100\%$$

Where, $P = \text{LPWMGCLK}$ [6:4]; pre-scalar $P=1,2,4,8,16,32,64,128$

$\text{DB10_1} = \text{Duty_Bound}[10:1] = \{\text{LPWMGxDTH}[7:0], \text{LPWMGxDTL}[7:6]\}$, duty bound

$\text{DB0} = \text{Duty_Bound}[0] = \text{LPWMGxDTL}[5]$

$\text{CB10_1} = \text{Counter_Bound}[10:1] = \{\text{LPWMGCUBH}[7:0], \text{LPWMGCUBL}[7:6]\}$, counter bound

5.9.4. PWM Waveforms with Complementary Dead Zones

Based on the specific 11 bit PWM architecture of PMB182(B), here we employ PWM2 output and PWM0 inverse output after PWM0 xor PWM1 to generate two PWM waveforms with complementary dead zones. Example program is as follows:

```
#define dead_zone      10           // dead time = 10% * (1/PWM_Frequency) us
#define PWM_Pulse      50           // set 50% as PWM duty cycle

#define PWM_Pulse_1    35           // set 35% as PWM duty cycle
#define PWM_Pulse_2    60           // set 60% as PWM duty cycle
#define switch_time    400*2       // adjusting switch time
// Note: To avoid noise, switch_time must be a multiple of PWM period. In this example PWM period = 400us,
// so switch_time = 400*2 us.

void FPPA0 (void)
{
  .ADJUST_IC      SYSCLK=IHRC/16, IHRC=16MHz, VBAT =5V;
  /******* Generating fixed duty cycle waveform *****
  //----- Set the counter upper bound and duty cycle -----
  LPWMG0DTL      =    0x00;
  LPWMG0DTH      =    PWM_Pulse + dead_zone;

  LPWMG1DTL      =    0x00;
  LPWMG1DTH      =    dead_zone;           // After LPWMG0 xor LPWMG, PWM duty cycle=PWM_Pulse%

  LPWMG2DTL      =    0x00;
  LPWMG2DTH      =    PWM_Pulse + dead_zone*2;

  LPWMGCUBL      =    0x00;
  LPWMGCUBH      =    100;
  //---- Configure clock and pre-scalar -----
  $ LPWMGCLK      Enable, /1, sysclk;
  //----- Output control -----
  $ LPWMG0C      Enable, Inverse, LPWM_Gen, PA0, gen_xor; // After LPWMG0 xor LPWMG,
```

```

// output the inversed waveform through PA0
$ LPWMG1C    Enable, LPWMG1,disable; // disable LPWMG1 output
$ LPWMG2C    Enable, PA3;           // output LPWMG2 waveform through PA3

while(1)
{
    //***** Switching duty cycle *****
    // To avoid the possible instant disappearance of dead zone, user should comply with the following
    // instruction sequence.
    // When increase the duty cycle: 50%/60% → 35%
    LPWMG0DTL    =    0x00;
    LPWMG0DTH    =    PWM_Pulse_1 + dead_zone;
    LPWMG2DTL    =    0x00;
    LPWMG2DTH    =    PWM_Pulse_1 + dead_zone*2;
    .delay    switch_time
    // When decrease the duty cycle: 35% → 60%
    LPWMG2DTL    =    0x00;
    LPWMG2DTH    =    PWM_Pulse_2 + dead_zone*2;
    LPWMG0DTL    =    0x00;
    LPWMG0DTH    =    PWM_Pulse_2 + dead_zone;
    .delay    switch_time
}
}

```

The following figures show the waveforms at different condition.

1. The PWM waveform in a fixed-duty cycle:

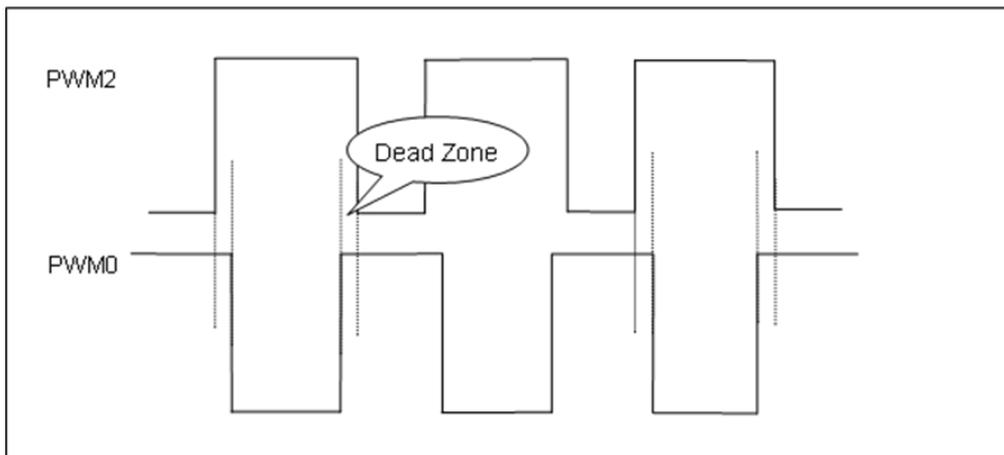


Fig.15: Complementary PWM waveform with dead zones

2. PWM waveform when switching two duty cycles:

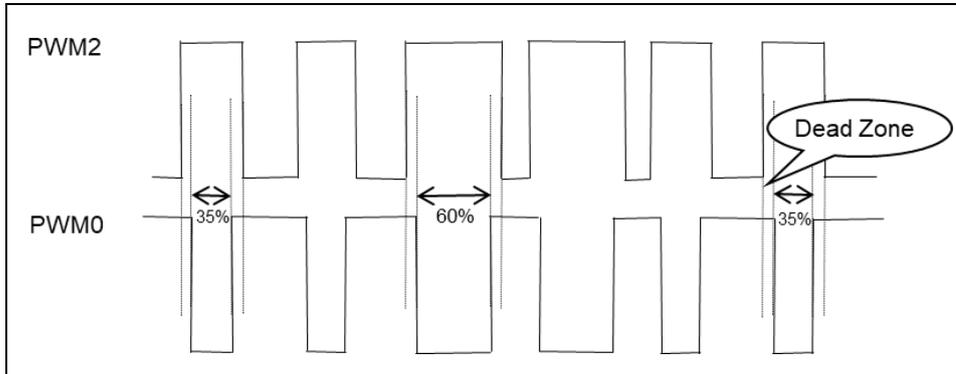


Fig.16: Complementary PWM waveform with dead zones

User can find that above example only provides dead zone where PWM are both in high. If need dead zone where PWM are both in low, you can realize it by resetting each control register's Inverse like:

\$ LPWMG0C Enable,PWM_Gen,PA0,gen_xor;

\$ LPWMG2C Enable,Inverse,PA3;

5.10.WatchDog Timer

The watchdog timer (WDT) is a counter with clock coming from ILRC. WDT can be cleared by power-on-reset or by command **wdreset** at any time. There are four different timeout periods of watchdog timer to be chosen by setting the **misc** register, it is:

- ◆ 8k ILRC clocks period if register misc[1:0]=00 (default)
- ◆ 16k ILRC clocks period if register misc[1:0]=01
- ◆ 64k ILRC clocks period if register misc[1:0]=10
- ◆ 256k ILRC clocks period if register misc[1:0]=11

The frequency of ILRC may drift a lot due to the variation of manufacture, supply voltage and temperature; user should reserve guard band for save operation. Besides, the watchdog period will also be shorter than expected after Reset or Wakeup events. It is suggested to clear WDT by **wdreset** command after these events to ensure enough clock periods before WDT timeout.

When WDT is timeout, PMB182(B) will be reset to restart the program execution. The relative timing diagram of watchdog timer is shown as Fig.17.

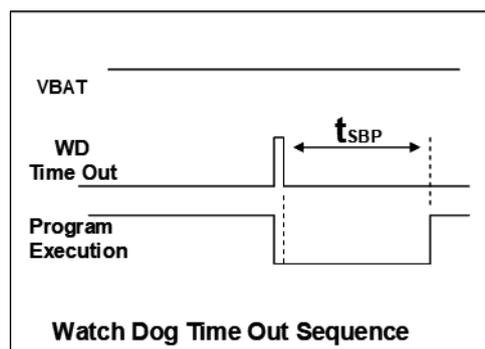


Fig.17: Sequence of Watch Dog Time Out

5.11. Interrupt

There are 6 interrupt lines for PMB182(B):

- ◆ External interrupt PA0/PB5
- ◆ External interrupt PA4/PA4
- ◆ Timer16 interrupt
- ◆ GPC interrupt
- ◆ LPWMG interrupt
- ◆ Timer2 interrupt

Every interrupt request line has its own corresponding interrupt control bit to enable or disable it; the hardware diagram of interrupt function is shown as Fig.18. All the interrupt request flags are set by hardware and cleared by writing *intrq* register. When the request flags are set, it can be rising edge, falling edge or both, depending on the setting of register *integs*. All the interrupt request lines are also controlled by *engint* instruction (enable global interrupt) to enable interrupt operation and *disgint* instruction (disable global interrupt) to disable it.

The stack memory for interrupt is shared with data memory and its address is specified by stack register *sp*. Since the program counter is 16 bits width, the bit 0 of stack register *sp* should be kept 0. Moreover, user can use *pushaf* / *popaf* instructions to store or restore the values of *ACC* and *flag* register *to* / *from* stack memory. Since the stack memory is shared with data memory, the stack position and level are arranged by the compiler in Mini-C project. When defining the stack level in ASM project, users should arrange their locations carefully to prevent address conflicts.

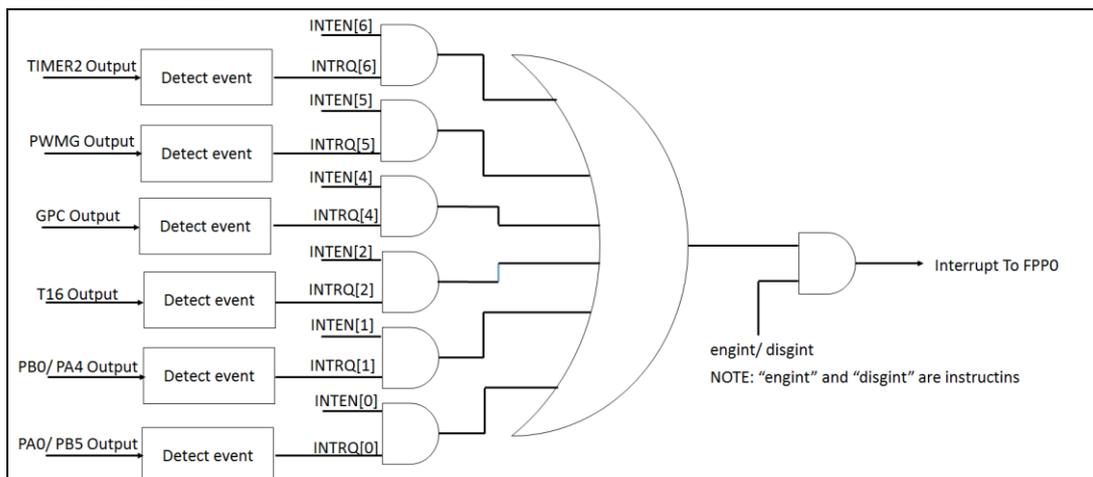


Fig.18: Hardware diagram of interrupt controller

Once the interrupt occurs, its operation will be:

- ◆ The program counter will be stored automatically to the stack memory specified by register *sp*.
- ◆ New *sp* will be updated to *sp+2*.
- ◆ Global interrupt will be disabled automatically.
- ◆ The next instruction will be fetched from address 0x010.

During the interrupt service routine, the interrupt source can be determined by reading the *intrq* register.

Note: Even if INTEN=0, INTRQ will be still triggered by the interrupt source.

After finishing the interrupt service routine and issuing the *reti* instruction to return back, its operation will be:

- ◆ The program counter will be restored automatically from the stack memory specified by register *sp*.
- ◆ New *sp* will be updated to *sp-2*.
- ◆ Global interrupt will be enabled automatically.
- ◆ The next instruction will be the original one before interrupt.

User must reserve enough stack memory for interrupt, two bytes stack memory for one level interrupt and four bytes for two levels interrupt. And so on, two bytes stack memory is for *pushaf*. For interrupt operation, the following sample program shows how to handle the interrupt, noticing that it needs four bytes stack memory to handle one level interrupt and *pushaf*.

```

void      FPPA0 (void)
{
    ...
    $ INTEN PA0;      // INTEN =1; interrupt request when PA0 level changed
    INTRQ = 0;        // clear INTRQ
    ENGINT            // global interrupt enable
    ...
    DISGINT           // global interrupt disable
    ...
}

void      Interrupt (void) // interrupt service routine
{
    PUSHAF            // store ALU and FLAG register

    // If INTEN.PA0 will be opened and closed dynamically,
    // user can judge whether INTEN.PA0 =1 or not.
    // Example: If (INTEN.PA0 && INTRQ.PA0) {...}

    // If INTEN.PA0 is always enable,
    // user can omit the INTEN.PA0 judgement to speed up interrupt service routine.

    If (INTRQ.PA0)
    {
        // Here for PA0 interrupt service routine
        INTRQ.PA0 = 0; // Delete corresponding bit (take PA0 for example)
        ...
    }
    ...
    // X : INTRQ = 0; // It is not recommended to use INTRQ = 0 to clear all at the end of the
                    // interrupt service routine.
                    // It may accidentally clear out the interrupts that have just occurred
                    // and are not yet processed.
    POPAF           // restore ALU and FLAG register
}

```

5.12. Power-Save and Power-Down

There are three operational modes defined by hardware: ON mode, Power-Save mode and Power-Down modes. ON mode is the state of normal operation with all functions ON, Power-Save mode (“**stopexe**”) is the state to reduce operating current and CPU keeps ready to continue, Power-Down mode (“**stopsys**”) is used to save power deeply. Therefore, Power-Save mode is used in the system which needs low operating power with wake-up occasionally and Power-Down mode is used in the system which needs power down deeply with seldom wake-up. Table 5 shows the differences in oscillator modules between Power-Save mode (“**stopexe**”) and Power-Down mode (“**stopsys**”).

Differences in oscillator modules between STOPSYS and STOPEXE				
	IHRC	ILRC	NILRC	EOSC
STOPSYS	Stop	Stop	No Change	Stop
STOPEXE	No Change	No Change	No Change	No Change

Table 5: Differences in oscillator modules between STOPSYS and STOPEXE

5.12.1. Power-Save mode (“**stopexe**”)

Using “**stopexe**” instruction to enter the Power-Save mode, only system clock is disabled, remaining all the oscillator modules active. For CPU, it stops executing; however, for Timer16, counter keep counting if its clock source is not the system clock. The wake-up sources for “**stopexe**” can be IO-toggle or Timer16 counts to set values when the clock source of Timer16 is IHRC or ILRC modules, NILRC wake-up of TM2C or wake-up by comparator when setting *GPCC.7=1* and *GPCS.6=1* to enable the comparator wake-up function at the same time. Wake-up from input pins can be considered as a continuation of normal execution, the detail information for Power-Save mode shows below:

- IHRC and EOSC oscillator modules: No change, keep active if it was enabled.
- ILRC oscillator modules: must remain enabled, need to start with ILRC when be wakening up.
- System clock: Disable, therefore, CPU stops execution.
- OTP memory is turned off.
- Timer counter: Stop counting if its clock source is system clock or the corresponding oscillator module is disabled; otherwise, it keeps counting. (The Timer contains TM16, TM2, LPWMG0, LPWMG1, LPWMG2.)
- Wake-up sources:
 - a. IO toggle wake-up: IO toggling in digital input mode (*PAC* bit is 1 and *PADIER* bit is 1)
 - b. Timer wake-up: If the clock source of Timer is not the SYSCLOCK, the system will be awakened when the Timer counter reaches the set value.
 - c. TM2C wake up with NILRC clock source:
 - d. Comparator wake-up: It need setting *GPCC.7=1* and *GPCS.6=1* to enable the comparator wake-up function at the same time. Please note: the internal 1.20V bandgap reference voltage is not suitable for the comparator wake-up function.

An example shows how to use Timer16 to wake-up from “**stopexe**”:

```

$ T16M    ILRC, /1, BIT8           // Timer16 setting
...
WORD     count = 0;
STT16    count;
stopexe;
...

```

The initial counting value of Timer16 is zero and the system will be woken up after the Timer16 counts 256 ILRC clocks.

5.12.2. Power-Down mode (“*stopsys*”)

Power-Down mode is the state of deeply power-saving with turning off all the oscillator modules. By using the “*stopsys*” instruction, this chip will be put on Power-Down mode directly. It is recommending to set GPCC.7=0 to disable the comparator before the command “*stopsys*”. The following shows the internal status of PMB182(B) detail when “*stopsys*” command is issued:

- All the oscillator modules are turned off.
- OTP memory is turned off.
- The contents of SRAM and registers remain unchanged.
- Wake-up sources: IO toggle in digital mode (PADIER bit is 1)

Wake-up from input pins can be considered as a continuation of normal execution. To minimize power consumption, all the I/O pins should be carefully manipulated before entering power-down mode. The reference sample program for power down is shown as below:

```

CLKMD    =    0xF4;    //    Change clock from IHRC to ILRC
CLKMD.4 =    0;      //    disable IHRC
...
while (1)
{
    STOPSYS;          //    enter power-down
    if (...) break;   //    if wakeup happen and check OK, then return to high speed,
                        //    else stay in power-down mode again
}
CLKMD    =    0x34;   //    Change clock from ILRC to IHRC/2

```

5.12.3. Wake-up

After entering the Power-Down or Power-Save modes, the PMB182(B) can be resumed to normal operation by toggling IO pins or NILRC wake-up of TM2C. Wake-up from timer are available for Power-Save mode ONLY. Table 6 shows the differences in wake-up sources between STOPSYS and STOPEXE.

Differences in wake-up sources between STOPSYS and STOPEXE				
	IO Toggle	NILRC wake-up of TM2C	Timer16 wake-up	Comparator wake-up
STOPSYS	Yes	Yes	No	No
STOPEXE	Yes	Yes	Yes	Yes

Table 6: Differences in wake-up sources between Power-Save mode and Power-Down mode

When using the IO pins to wake-up the PMB182(B), registers *padier* should be properly set to enable the wake-up function for every corresponding pin. The time for normal wake-up is about 3000 ILRC clocks counting from wake-up event; fast wake-up can be selected to reduce the wake-up time by *misc* register, and the time for fast wake-up is about 45 ILRC clocks from IO toggling.

Suspend mode	Wake-up mode	Wake-up time (t_{wup}) from IO toggle
STOPEXE suspend or STOPSYS suspend	Fast wake-up	$45 * T_{ILRC}$, Where T_{ILRC} is the time period of ILRC
STOPEXE suspend or STOPSYS suspend	Normal wake-up	$3000 * T_{ILRC}$, Where T_{ILRC} is the clock period of ILRC

Table 7: Differences in wake-up time between Fast/Normal wake-up

Please notice that when Code Option is set to Fast boot-up, no matter which wake-up mode is selected in *misc.5*, the wake-up mode will be forced to be FAST. If Normal boot-up is selected, the wake-up mode is determined by *misc.5*.

5.13. IO Pins

All the pins can be independently set into two states output or input by configuring the data registers (*pa*, *pb*, *pc*), control registers (*pac*, *pbc*, *pcc*) and pull-high/pull-low resistor (*paph/papl*, *pbph/pbpl*, *pcph/pcpl*). All these pins have Schmitt-trigger input buffer and output driver with CMOS level. When it is set to output low, the pull- high resistor is turned off automatically. If user wants to read the pin state, please notice that it should be set to input mode before reading the data port; if user reads the data port when it is set to output mode, the reading data comes from data register, NOT from IO pad. As an example, Table 8 shows the configuration table of bit 0 of port A. The hardware diagram of IO buffer is also shown as Fig.19.

<i>pa.0</i>	<i>pac.0</i>	<i>papl.0</i>	<i>paph.0</i>	Description
X	0	0	0	Input without pull- high/pull-low resistor
X	0	0	1	Input with pull- high resistor, without pull-low resistor
X	0	1	0	Input with pull-low resistor, without pull- high resistor
0	1	0	X	Output low without pull-low resistor
0	1	1	X	Output low with pull-low resistor
1	1	X	0	Output high without pull- high resistor
1	1	X	1	Output high with pull- high resistor

Table 8: PA0 Configuration Table

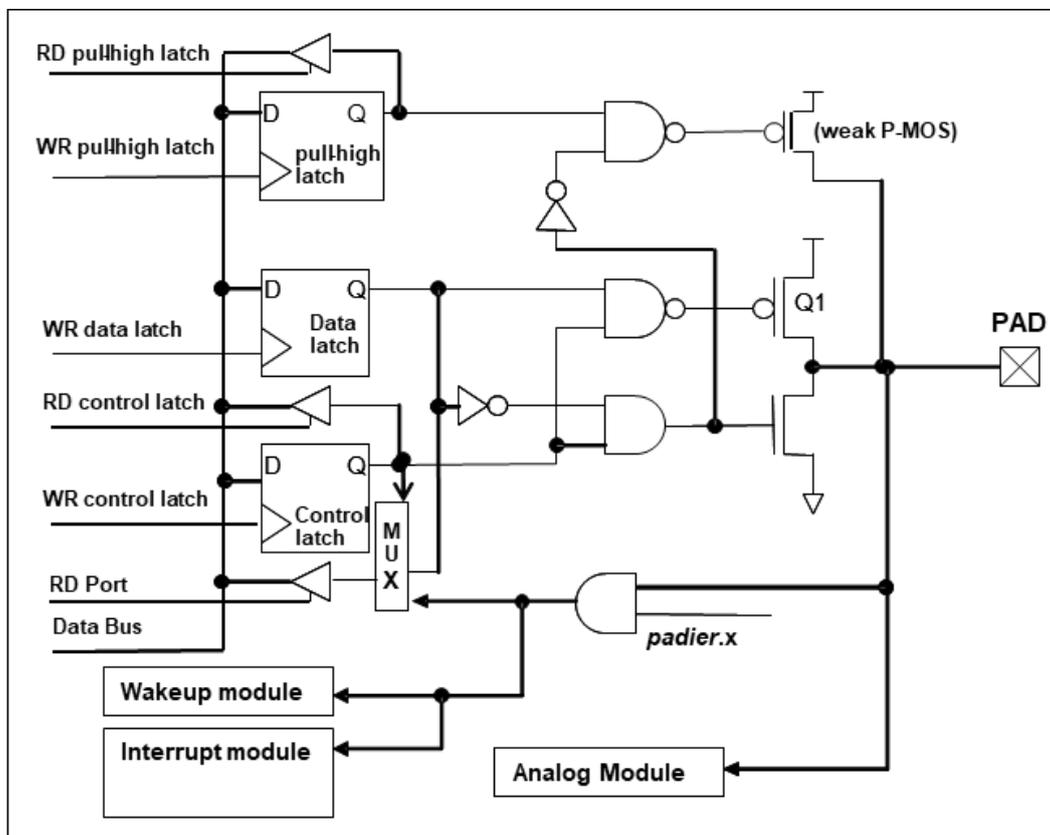


Fig.19: Hardware diagram of IO buffer

All the IO pins have the same structure. The corresponding bits in registers *padier*, *pbdiar* and *pcdiar* should be set to low to prevent leakage current for those pins are selected to be analog function. When PMB182(B) is put in power-down or power-save mode, every pin can be used to wake-up system by toggling its state. Therefore, those pins needed to wake-up system must be set to input mode and set the corresponding bits of registers *padier*, *pbdiar* and *pcdiar* to high. The same reason, *padier.0* should be set high when PA0 is used as external interrupt pin, *pbdiar.0* for PB0, *padier.4* for PA4 and *pbdiar.5* for PB5.

5.14. Reset, LVR and LVD

5.14.1. Reset

There are many causes to reset the PMB182(B), once reset is asserted, most of all the registers in PMB182(B) will be set to default values, system should be restarted once abnormal cases happen, or by jumping program counter to address 0x00.

After a power-on reset or LVR reset occurs, if VDD is greater than VDR (data storage voltage), the value of the data memory will be retained, but if the SRAM is cleared after re-power, the data cannot be retained; if VDD is less than VDR, the data the value of the memory will be turned into an unknown state that is in an indeterminate state.

If a reset occurs, and there is an instruction or syntax to clear SRAM in the program, the previous data will be cleared during program initialization and cannot be retained.

The content will be kept when reset comes from PRSTB pin or WDT timeout.

5.14.2. LVR reset

By code option, there are 8 different levels of LVR from 1.8V to 4.0V for reset. Usually, user selects LVR reset level to be in conjunction with operating frequency and supply voltage.

5.14.3. LVD

By code option, user can use LVDC[7:2] select different levels of LVD from 1.85V to 5V, LVD can provide more accurate voltage for user confirm the voltage level.

6. IO Registers

6.1. ACC Status Flag Register (*flag*), IO address = 0x00

Bit	Reset	R/W	Description
7 - 4	-	-	Reserved. Please do not use.
3	0	R/W	OV (Overflow Flag). This bit is set to be 1 whenever the sign operation is overflow.
2	0	R/W	AC (Auxiliary Carry Flag). There are two conditions to set this bit, the first one is carry out of low nibble in addition operation and the other one is borrow from the high nibble into low nibble in subtraction operation.
1	0	R/W	C (Carry Flag). There are two conditions to set this bit, the first one is carry out in addition operation, and the other one is borrow in subtraction operation. Carry is also affected by shift with carry instruction.
0	0	R/W	Z (Zero Flag). This bit will be set when the result of arithmetic or logic operation is zero; Otherwise, it is cleared.

6.2. Stack Pointer Register (*sp*), IO address = 0x02

Bit	Reset	R/W	Description
7 - 0	-	R/W	Stack Pointer Register. Read out the current stack pointer, or write to change the stack pointer.

6.3. Clock Mode Register (*clkmd*), IO address = 0x03

Bit	Reset	R/W	Description		
7 - 5	111	R/W	System clock (CLK) selection:		
			Type 0, clkmd[3]=0	Type 1, clkmd[3]=1	
			<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; vertical-align: top;"> 000: IHRC÷4 001: IHRC÷2 010: reserved 011: reserved 10X: reserved 110: ILRC÷4 111: ILRC (default) </td> <td style="width: 50%; vertical-align: top;"> 000: IHRC÷16 001: IHRC÷8 010: ILRC÷16 (ICE does NOT Support.) 011: IHRC÷32 100: IHRC÷64 101: reserved 11x: reserved </td> </tr> </table>	000: IHRC÷4 001: IHRC÷2 010: reserved 011: reserved 10X: reserved 110: ILRC÷4 111: ILRC (default)	000: IHRC÷16 001: IHRC÷8 010: ILRC÷16 (ICE does NOT Support.) 011: IHRC÷32 100: IHRC÷64 101: reserved 11x: reserved
000: IHRC÷4 001: IHRC÷2 010: reserved 011: reserved 10X: reserved 110: ILRC÷4 111: ILRC (default)	000: IHRC÷16 001: IHRC÷8 010: ILRC÷16 (ICE does NOT Support.) 011: IHRC÷32 100: IHRC÷64 101: reserved 11x: reserved				
4	1	R/W	Internal High RC Enable. 0 / 1: disable / enable.		
3	0	R/W	Clock Type Select. This bit is used to select the clock type in bit [7:5]. 0 / 1: Type 0 / Type 1		
2	1	R/W	Internal Low RC Enable. 0 / 1: disable / enable. If ILRC is disabled, watchdog timer is also disabled.		
1	1	R/W	WatchDog Enable. 0 / 1: disable / enable.		
0	0	R/W	Pin PA5/PRSTB function. 0 / 1: PA5 / PRSTB.		

6.4. Interrupt Enable Register (*inten*), IO address = 0x04

Bit	Reset	R/W	Description
7	0	R/W	Reserved.
6	0	R/W	Enable interrupt from Timer2. 0 / 1: disable / enable.
5	0	R/W	Enable interrupt from LPWMG. 0 / 1: disable / enable.
4	0	R/W	Enable interrupt from comparator. 0 / 1: disable / enable.
3	0	R/W	Reserved.
2	0	R/W	Enable interrupt from Timer16 overflow. 0 / 1: disable / enable.
1	0	R/W	Enable interrupt from PA4 or PB0. 0 / 1: disable / enable.
0	0	R/W	Enable interrupt from PA0 or PB5. 0 / 1: disable / enable.

6.5. Interrupt Request Register (*intrq*), IO address = 0x05

Bit	Reset	R/W	Description
7	-	R/W	Reserved.
6	-	R/W	Interrupt Request from Timer2, this bit is set by hardware and cleared by software. 0 / 1: No request / Request.
5	-	R/W	Interrupt Request from LPWM, this bit is set by hardware and cleared by software. 0 / 1: No request / Request.
4	-	R/W	Interrupt Request from comparator, this bit is set by hardware and cleared by software. 0 / 1: No request / Request.
3	-	R/W	Reserved.
2	-	R/W	Interrupt Request from Timer16, this bit is set by hardware and cleared by software. 0 / 1: No request / Request.
1	-	R/W	Interrupt Request from pin PA4 or PB0, this bit is set by hardware and cleared by software. 0 / 1: No Request / request.
0	-	R/W	Interrupt Request from pin PA0 or PB5, this bit is set by hardware and cleared by software. 0 / 1: No Request / request.

6.6. Timer16 mode Register (*t16m*), IO address = 0x06

Bit	Reset	R/W	Description
7 - 5	000	R/W	Timer16 Clock source selection. 000: disable. 001: CLK (system clock). 010: reserved. 011: PA4 falling edge (from external pin). 100: IHRC. 101: EOSC. 110: ILRC. 111: PA0 falling edge (from external pin)
4 - 3	00	R/W	Timer16 clock pre-divider. 00: ÷1 01: ÷4 10: ÷16 11: ÷64
2 - 0	000	R/W	Interrupt source selection. Interrupt event happens when the selected bit status is changed. 0 : bit 8 of Timer16 1 : bit 9 of Timer16 2 : bit 10 of Timer16 3 : bit 11 of Timer16 4 : bit 12 of Timer16 5: bit 13 of Timer16 6: bit 14 of Timer16 7: bit 15 of Timer16

6.7. MISC Register (*misc*), IO address = 0x08

Bit	Reset	R/W	Description
7 - 6	-	-	Reserved.
5	0	WO	Enable fast Wake up. Fast wake-up is NOT supported when EOSC is enabled. 0: Normal wake up. The wake-up time is 3000 ILRC clocks (Not for fast boot-up) 1: Fast wake up. The wake-up time is 45 ILRC clocks.
4	-	-	Reserved.
3	-	-	Reserved.
2	0	WO	Disable LVR function. 0 / 1 : Enable / Disable
1 - 0	00	WO	Watch dog time out period. 00: 8k ILRC clock period. 01: 16k ILRC clock period. 10: 64k ILRC clock period. 11: 256k ILRC clock period.

6.8. External Oscillator setting Register (*eoscr*), IO address = 0x0a

Bit	Reset	R/W	Description
7	0	WO	Enable external crystal oscillator. 0 / 1 : Disable / Enable.
6 - 5	00	WO	External crystal oscillator selection. 00 : reserved. 01 : Low driving capability, for lower frequency, ex: 32KHz crystal oscillator. 10 : Middle driving capability, for middle frequency, ex: 1MHz crystal oscillator. 11 : High driving capability, for higher frequency, ex: 4MHz crystal oscillator.
4 - 1	-	-	Reserved. Please keep 0 for future compatibility.
0	0	WO	Power-down the Bandgap and LVR hardware modules. 0 / 1: normal / power-down. Note: If bandgap be disabled, there will only ILRC/T16/TM2 and I/O function can be used.

6.9. Interrupt Edge Select Register (*integs*), IO address = 0x0c

Bit	Reset	R/W	Description
7 - 5	-	-	Reserved.
4	0	WO	Timer16 edge selection. 0 : rising edge of the selected bit to trigger interrupt. 1 : falling edge of the selected bit to trigger interrupt.
3 - 2	-	-	PA4 or PB0 edge selection. 00: both rising edge and falling edge of the selected bit to trigger interrupt. 01: rising edge of the selected bit to trigger interrupt. 10: falling edge of the selected bit to trigger interrupt. 11: reserved.
1 - 0	00	WO	PA0 or PB5 edge selection. 00: both rising edge and falling edge of the selected bit to trigger interrupt. 01: rising edge of the selected bit to trigger interrupt. 10: falling edge of the selected bit to trigger interrupt. 11: reserved.

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6.10. Port A Digital Input Enable Register (*padier*), IO address = 0x0d

Bit	Reset	R/W	Description
7	0	WO	Enable PA7 digital input and wake-up event. 1 / 0: enable / disable. If this bit is set to low, PA7 is analog input and can NOT be used to wake-up the system.
6	0	WO	Enable PA6 digital input and wake-up event. 1 / 0: enable / disable. If this bit is set to low, PA6 is analog input and can NOT be used to wake-up the system.
5	0	WO	Enable PA5 digital input and wake-up event. 1 / 0: enable / disable. If this bit is set to low, PA5 is analog input and can NOT be used to wake-up the system.
4 - 3	00	WO	Enable PA4-PA3 digital input and wake-up event. 1 / 0: enable / disable. This bit should be set to low when PA4 is assigned as comparator input to prevent leakage current. If these bit are set to low, PA4-PA3 are analog input and can NOT be used to wake-up the system.
2	-	-	Reserved. (Please keep 00 for future compatibility)
1 - 0	00	WO	Enable PA0-PA1 digital input, wake-up event and interrupt request. 1 / 0: enable / disable. This bit can be set to low to disable wake-up from PA0 toggling and interrupt request from this pin. If this bit is set to low, PA0-PA1 is analog input and can NOT be used to wake-up the system, interrupt from this pin is also disabled.

6.11. Port B Digital Input Enable Register (*pbdir*), IO address = 0x0e

Bit	Reset	R/W	Description
7 - 6	11	WO	Enable PB7~PB6 digital input and wake-up event. 1 / 0: enable / disable. The bit should be set to low when the pad is assigned as comparator input to prevent leakage current. If the bit is set to low, the pad can NOT be used to wake-up the system.
5	1	WO	Enable PB5 digital input and wake-up event and interrupt request. 1 / 0: enable / disable. This bit can be set to low to disable wake-up from PB5 toggling and interrupt request from this pin.
4 - 1	1111	WO	Enable PB4~PB1 digital input and wake-up event. 1 / 0: enable / disable. The bit should be set to low when the pad is assigned as comparator input to prevent leakage current. If the bit is set to low, the pad can NOT be used to wake-up the system.
0	1	WO	Enable PB0 digital input and wake-up event and interrupt request. 1 / 0: enable / disable. This bit can be set to low to disable wake-up from PB0 toggling and interrupt request from this pin.

6.12. Port C Digital Input Enable Register (*pcdir*), IO address = 0x07

Bit	Reset	R/W	Description
7 - 3	-	-	Reserved.
2 - 0	1	WO	Enable PC2~PC0 digital input and wake-up event. 1 / 0: enable / disable. The bit should be set to low when the pad is assigned as comparator input to prevent leakage current. If the bit is set to low, the pad can NOT be used to wake-up the system.

6.13. Port A Data Register (*pa*), IO address = 0x10

Bit	Reset	R/W	Description
7 - 0	0x00	R/W	Data register for Port A.

6.14. Port A Control Register (*pac*), IO address = 0x11

Bit	Reset	R/W	Description
7 - 0	0x00	R/W	Port A control registers. This register is used to define input mode or output mode for each corresponding pin of port A. 0 / 1: input / output.

6.15. Port A Pull-High Register (*paph*), IO address = 0x12

Bit	Reset	R/W	Description
7 - 0	0x00	R/W	Port A pull-high register. This register is used to enable the internal pull-high device on each corresponding pin of port A and this pull high function is active only for input mode. 0 / 1 : disable / enable.

6.16. Port A Pull-Low Register (*papl*), IO address = 0x1E

Bit	Reset	R/W	Description
7 - 0	0x00	R/W	Port A pull-low register. This register is used to enable the internal pull-low device on each corresponding pin of port A and this pull low function is active only for input mode. 0/ 1 : disable / enable

6.17. Port B Data Register (*pb*), IO address = 0x14

Bit	Reset	R/W	Description
7 - 0	0x00	R/W	Data register for Port B.

6.18. Port B Control Register (*pbcb*), IO address = 0x15

Bit	Reset	R/W	Description
7 - 0	0x00	R/W	Port B control register. This register is used to define input mode or output mode for each corresponding pin of port B. 0 / 1: input / output

6.19. Port B Pull-High Register (*pbph*), IO address = 0x16

Bit	Reset	R/W	Description
7 - 0	0x00	R/W	Port B pull-high register. This register is used to enable the internal pull-high device on each corresponding pin of port B and this pull high function is active only for input mode. 0 / 1 : disable / enable

6.20. Port B Pull-Low Register (*pbpl*), IO address = 0x1F

Bit	Reset	R/W	Description
7 - 0	0x00	R/W	Port B pull-low register. This register is used to enable the internal pull-low device on each corresponding pin of port B and this pull low function is active only for input mode. 0 / 1 : disable / enable.

6.21. Port C Data Register (*pc*), IO address = 0x27

Bit	Reset	R/W	Description
7 - 3	-	-	Reserved.
2 - 0	0x00	R/W	Data register for Port C.

6.22. Port C Control Register (*pcc*), IO address = 0x2A

Bit	Reset	R/W	Description
7 - 3	-	-	Reserved.
2 - 0	0x00	R/W	Port C control register. This register is used to define input mode or output mode for each corresponding pin of port C. 0 / 1: input / output.

6.23. Port C Pull-High Register (*pcph*), IO address = 0x2B

Bit	Reset	R/W	Description
7 - 3	-	-	Reserved.
2 - 0	0x00	R/W	Port C pull-high register. This register is used to enable the internal pull-high device on each corresponding pin of port C and this pull high function is active only for input mode. 0 / 1 : disable / enable.

6.24. Port C Pull-Low Register (*pcpl*), IO address = 0x2D

Bit	Reset	R/W	Description
7 - 3	-	-	Reserved.
2 - 0	0x00	R/W	Port C pull-low register. This register is used to enable the internal pull-low device on each corresponding pin of port C and this pull low function is active only for input mode. 0 / 1: disable / enable.

6.25. Comparator Control Register (*gpcc*), IO address = 0x18

Bit	Reset	R/W	Description
7	0	R/W	Enable comparator. 0 / 1: disable / enable. When this bit is set to enable, please also set the corresponding analog input pins to be digital disable to prevent IO leakage.
6	-	RO	Comparator result of comparator. 0: plus input < minus input. 1: plus input > minus input.
5	0	R/W	Select whether the comparator result output will be sampled by TM2_CLK? 0: result output NOT sampled by TM2_CLK. 1: result output sampled by TM2_CLK.
4	0	R/W	Inverse the polarity of result output of comparator. 0: polarity is NOT inverted. 1: polarity is inverted.
3 - 1	000	R/W	Selection the minus input (-) of comparator. 000 : PA3 001 : PA4 010 : Internal 1.20 volt bandgap reference voltage (not suitable for the comparator wake-up function). 011 : $V_{internal R}$ 100 : PB6

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Bit	Reset	R/W	Description
			101 : PB7 11X: reserved
0	0	R/W	Selection the plus input (+) of comparator. 0 : V _{internal R} 1 : PA4

6.26. Comparator Selection Register (*gpcs*), IO address = 0x19

Bit	Reset	R/W	Description
7	0	WO	Comparator output enable (to PA0). 0 / 1: disable / enable. (Please avoid this situation: GPCS will affect the PA3 output function when selecting output to PA0 output in ICE.)
6	0	WO	Wakeup by comparator enable. (The comparator wakeup effectively when gpcc.6 electrical level changed) 0 / 1: disable / enable.
5	0	WO	Selection of high range of comparator.
4	0	WO	Selection of low range of comparator.
3 - 0	0000	WO	Selection the voltage level of comparator. 0000 (lowest) ~ 1111 (highest)

6.27. Timer2 Control Register (*tm2c*), IO address = 0x1c

Bit	Reset	R/W	Description
7 - 4	0000	R/W	Timer2 clock selection. 0000 : disable 0001 : CLK (system clock) 0010 : IHRC or IHRC *2 (by code option TM2_source) (ICE doesn't support IHRC *2.) 0011 : EOSC 0100 : ILRC 0101 : comparator output 0110 : NILRC 0111 : reserved 1000 : PA0 (rising edge) 1001 : ~PA0 (falling edge) 1010 : Reserved 1011 : Reserved 1100 : PA4 (rising edge) 1101 : ~PA4 (falling edge) Notice: In ICE mode and IHRC is selected for Timer2 clock, the clock sent to Timer2 does NOT be stopped. Timer2 will keep counting when ICE is in halt state.
3 - 2	00	R/W	Timer2 output selection. 00 : disable 01 : PB2 10 : PA3

Bit	Reset	R/W	Description
			11 : PB4
1	0	R/W	TM2 Mode 0: Period Mode 1: PWM Mode
0	0	R/W	Inverse the polarity of result output of TM2. 0: polarity is NOT inverted. 1: polarity is inverted.

6.28. Timer2 Scalar Register (*tm2s*), IO address = 0x17

Bit	Reset	R/W	Description
7	0	WO	PWM resolution selection. 0 : 8-bit 1 : 6-bit or 7-bit (by code option TM2_bit) (ICE doesn't support 7-bit.)
6 - 5	00	WO	Timer2 clock pre-scalar. 00 : ÷ 1 01 : ÷ 4 10 : ÷ 16 11 : ÷ 64
4 - 0	00000	WO	Timer2 clock scalar.

6.29. Timer2 Counter Register (*tm2ct*), IO address = 0x1d

Bit	Reset	R/W	Description
7 - 0	0x00	R/W	Bit [7:0] of Timer2 counter register.

6.30. Timer2 Bound Register (*tm2b*), IO address = 0x09

Bit	Reset	R/W	Description
7 - 0	0x00	WO	Timer2 bound register.

6.31. Low Voltage Detect Control Register (*lvdc*), IO address = 0x30

Bit	Reset	R/W	Description
7 - 2	000000	WO	Set LVD level: in the range of 1.85~5V, increment by 0.05V.
1	-	-	Reserved.
0	0	RO	The detect result between LVD & V _{BAT} . 0: V _{BAT} > LVD level. 1: V _{BAT} < LVD level.

6.32. LPWVG0 control Register (*lpwvg0c*), IO address = 0x20

Bit	Reset	R/W	Description
7	-	-	Reserved.
6	-	RO	Output status of LPWVG0 generator.
5	0	WO	Enable to inverse the polarity of LPWVG0 generator output. 0 / 1: disable / enable.
4	0	WO	LPWVG0 output selection. 0: LPWVG0 Output 1: LPWVG0 XOR LPWVG1 or LPWVG0 OR LPWVG1 (by pvg0c.0)
3 - 1	000	R/W	LPWVG0 Output Port Selection 000: LPWVG0 Output Disable 001: LPWVG0 Output to PB5 010: Reserved 011: LPWVG0 Output to PA0 100: LPWVG0 Output to PB4 1xx: Reserved
0	0	R/W	LPWVG0 output pre- selection. 0: LPWVG0 XOR LPWVG1 1: LPWVG0 OR LPWVG1

6.33. LPWVG Clock Register (*lpwvgclk*), IO address = 0x21

Bit	Reset	R/W	Description
7	0	WO	LPWVG Disable/ Enable 0: LPWVG Disable 1: LPWVG Enable
6 - 4	000	WO	LPWVG clock pre-scalar. 000: ÷1 001: ÷2 010: ÷4 011: ÷8 100: ÷16 101: ÷32 110: ÷64 111: ÷128
3 - 1	-	-	Reserved
0	0	WO	LPWVG clock source selection 0: System Clock 1: IHRC or IHRC*2 (by code option PWM_Source)

6.34. LPWMG0 Duty Value High Register (*lpwmg0dth*), IO address = 0x22

Bit	Reset	R/W	Description
7 - 0	-	WO	Bit[10:3] of LPWMG0 Duty.

6.35. LPWMG0 Duty Value Low Register (*lpwmg0dtl*), IO address = 0x23

Bit	Reset	R/W	Description
7 - 5	-	WO	Bit[2:0] of LPWMG0 Duty.
4 - 0	-	-	Reserved.

Note: It's necessary to write LPWMG0 Duty_Value Low Register before writing LPWMG0 Duty_Value High Register.

6.36. LPWMG Counter Upper Bound High Register (*lpwmgcubh*), IO address = 0x24

Bit	Reset	R/W	Description
7 - 0	-	WO	Bit[10:3] of LPWMG Counter Bound.

6.37. LPWMG Counter Upper Bound Low Register (*lpwmgcubl*), IO address = 0x25

Bit	Reset	R/W	Description
7 - 6	-	WO	Bit[2:1] of LPWMG Counter Bound.
5 - 0	-	-	Reserved.

6.38. LPWMG1 control Register (*lpwmg1c*), IO address = 0x26

Bit	Reset	R/W	Description
7	-	-	Reserved.
6	-	RO	Output status of LPWMG1 generator.
5	0	R/W	Enable to inverse the polarity of LPWMG1 generator output. 0 / 1: disable / enable.
4	0	R/W	LPWMG1 output selection: 0: LPWMG1 1: LPWMG2
3 - 1	000	R/W	LPWMG1 Output Port Selection: 000: LPWMG1 Output Disable 001: LPWMG1 Output to PB6 010: Reserved 011: LPWMG0 Output to PA4 100: LPWMG0 Output to PB7 1xx: Reserved
0	-	R/W	Reserved.

6.39. LPWMG1 Duty Value High Register (*lpwmg1dth*), IO address = 0x28

Bit	Reset	R/W	Description
7 - 0	-	WO	Bit[10:3] of LPWMG1 Duty

6.40. LPWMG1 Duty Value Low Register (*lpwmg1dtl*), IO address = 0x29

Bit	Reset	R/W	Description
7 - 5	-	WO	Bit[2:0] of LPWMG1 Duty.
4 - 0	-	-	Reserved

Note: It's necessary to write LPWMG1 Duty_Value Low Register before writing LPWMG1 Duty_Value High Register.

6.41. LPWMG2 Duty Value High Register (*lpwmg2dth*), IO address = 0x2E

Bit	Reset	R/W	Description
7 - 0	-	WO	Bit[10:3] of LPWMG2 Duty

6.42. LPWMG2 Duty Value Low Register (*lpwmg2dtl*), IO address = 0x2F

Bit	Reset	R/W	Description
7 - 5	-	WO	Bit[2:0] of LPWMG2 Duty
4 - 0	-	-	Reserved

Note: It's necessary to write LPWMG2 Duty_Value Low Register before writing LPWMG2 Duty_Value High Register.

6.43. LPWMG2 control Register (*lpwmg2c*), IO address = 0x2C

Bit	Reset	R/W	Description
7	-	-	Reserved.
6	-	RO	Output status of LPWMG2 generator.
5	0	R/W	Enable to inverse the polarity of LPWMG2 generator output. 0 / 1: disable / enable.
4	0	R/W	LPWMG2 output selection: 0: LPWMG2 1: LPWMG2 ÷2
3 - 1	000	R/W	LPWMG2 Output Port Selection: 000: LPWMG2 Output Disable 001: LPWMG2 Output to PB3 010: Reserved 011: LPWMG2 Output to PA3 100: LPWMG2 Output to PB2 101: LPWMG2 Output to PA5 1xx: Reserved
0	-	R/W	Reserved.

6.44. Charger Current Control Register (*chg_ctrl*), IO address = 0x34

Bit	Reset	R/W	Description
7 - 5	011	R/W	000 : 500mA 001 : 400mA 010 : 350mA 011 : 300mA 100 : 250mA 101 : 200mA 110 : 100mA 111 : 50mA
4 - 2	-	-	Reserved.
1 - 0	0	R/W	VBAT Select 00 = 4.2V 01 = 4.1V 10 = 4.35V 11 = 3.6V

6.45. Charger Current Control Register (*chg_temp*), IO address = 0x35

Bit	Reset	R/W	Description
7	0 / 1	RO	Battery is not full / full.
6	0 / 1	RO	Charging module working indicator. When reading "1", the charger starts charging. 0 : Charging completed or stopped. 1 : Start charging or charging.
5	-	-	Reserved.
4	-	RO	The status indicator bit of Vcc voltage source. It can be used to judge the status of charging Vcc 1: Vcc < V _{BAT} 0: Vcc > V _{BAT}
3	-	RO	Charging action indicator bit. 1: Charging in progress. Vcc is too low and charger shutdown. 0: Vcc is normal.
2	-	RO	Reserved.
1	-	RO	Over temperature charging protection bit (Temperature less than 140). Read "1" to trigger the over-temperature protection, and read "0" to be normal.
0	-	-	Reserved.

6.46. Charger Current Control Register (*chg_opr*), IO address = 0x36

Bit	Reset	R/W	Description
7	1	WO	Enable charger function mode. 0/1: Disable/Enable.
6	1	WO	Reserved, only 0 can be written.
5	1	WO	Reserved, only 1 can be written.
4 - 0	1	-	Reserved.

Note: Setting the *chg_opr* register with a Byte Write

6.47. Charger Charge Voltage Calibration Register (*chg_trim*), IO address = 0x32

Bit	Reset	R/W	Description
7 - 3	0XF	WO	Charger charging voltage calibration bit. 0b_1111_1:Vbat=max ; 0b_0000_0:Vbat=min The <i>.Adjust_IC</i> macro command will automatically fill in the value of the calibration parameter after execution, and it is not recommended that users change it arbitrarily by themselves.
2	0	WO	Charger CV Mode Vbat Voltage Output 0 / 1: Disable / Enable (For verification test use only, VCC >= +5V, user modification is not recommended.)
1	0	WO	Reserved, write value needs to be 0
0	0	RO	Reserved, write value needs to be 0

Note:

- (1) Users who want to dynamically micro-adjust the charging voltage of the charger in the program, or rewrite the *chg_trim* to the value of the calibration parameter, can use the macro instruction *ReLoad_VbatBGTRIM*.
- (2) Using the macro command *Charger_CVMode*, the charger will switch to CV Mode, which is only for the VBAT pin to measure the full voltage value when the battery is empty and not connected to the Li-ion battery.
- (3) Using the macro instruction *Charger_CCMODE* or *ReLoad_VbatBGTRIM*, the charger will switch back to CC Mode.
- (4) *.Adjust_IC* macro command supports micro-adjustment of charger charging voltage correction parameters, just add the following command "REG:CHG_TRIM = -0x08";

```
//chg_cur[7:0] = CP_TrimParameter - 0x08; //chg_cur[7:0] = CP_TrimParameter
```

Example.

```
.ADJUST_IC SYSCLK=ILRC (IHRC/16), IHRC=16MHz, VDD=4.2V O_WDRST, X_FIRST, REG:CHG_CUR = -0x08;
```

- (5) If the charger trim value is changed by the user, the message "The charger trim value of this PDK file has been modified" will appear in the pop-up window when Write downloads the PDK.

6.48. Charger Charge Current Calibration Register (*chg_cur*), IO address = 0x33

Bit	Reset	R/W	Description
7 - 4	0X8	WO	Charger charging voltage calibration bit. 0b_1111_1:Vbat=max ; 0b_0000_0:Vbat=min The .Adust_IC macro command will automatically fill in the value of the calibration parameter after execution, and it is not recommended that users change it arbitrarily by themselves.
3-0	0	WO	Charger CV Mode Vbat Voltage Output 0 / 1: Disable / Enable (For verification test use only, VCC >= +5V, user modification is not recommended.)

Note

- (1) Users who want to dynamically micro-adjust the charging current of the charger in the program, or rewrite *chg_cur* to the value of the calibration parameter, can use the macro instruction `ReLoad_ChargerCURTRIM`.
- (2) `.Adjust_IC` macro command supports micro-adjustment of the charger charge current correction parameter by simply adding the following command `"REG:CHG_CUR = -0x10"; //chg_cur[7:0] = CP_TrimParameter - 0x10`.

Example.
`.ADJUST_IC SYSCLK=ILRC (IHRC/16), IHRC=16MHz, VDD=4.2V O_WDRST, X_FIRST, REG:CHG_CUR = -0x10;`
- (3) If the charger trim value is changed by the user, the message "The charger trim value of this PDF file has been modified" will appear when Writer downloads the PDK.

7. Instructions

Symbol	Description
ACC	Accumulator (Abbreviation of accumulator)
a	Accumulator (symbol of accumulator in program)
sp	Stack pointer
flag	ACC status flag register
I	Immediate data
&	Logical AND
 	Logical OR
←	Movement
^	Exclusive logic OR
+	Add
–	Subtraction
~	NOT (logical complement, 1's complement)
⌘	NEG (2's complement)
OV	Overflow (The operational result is out of range in signed 2's complement number system)
Z	Zero (If the result of ALU operation is zero, this bit is set to 1)
C	Carry (The operational result is to have carry out for addition or to borrow carry for subtraction in unsigned number system)
AC	Auxiliary Carry (If there is a carry out from low nibble after the result of ALU operation, this bit is set to 1)
M.n	Only addressed in 0~0x3F (0~63) is allowed
IO.n	Only addressed in 0~0x3F (0~63) is allowed

7.1. Data Transfer Instructions

<i>mov</i> a, I	<p>Move immediate data into ACC. Example: <i>mov</i> a, 0x0f; Result: a ← 0fh; Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>mov</i> M, a	<p>Move data from ACC into memory Example: <i>mov</i> MEM, a; Result: MEM ← a Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>mov</i> a, M	<p>Move data from memory into ACC Example: <i>mov</i> a, MEM ; Result: a ← MEM; Flag Z is set when MEM is zero. Affected flags: 『Y』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>mov</i> a, IO	<p>Move data from IO into ACC Example: <i>mov</i> a, pa ; Result: a ← pa; Flag Z is set when pa is zero. Affected flags: 『Y』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>mov</i> IO, a	<p>Move data from ACC into IO Example: <i>mov</i> pa, a; Result: pa ← a Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>ldt16</i> word	<p>Move 16-bit counting values in Timer16 to memory in word. Example: <i>ldt16</i> word; Result: word ← 16-bit timer Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p> <p>Application Example:</p> <pre> ----- word T16val ; // declare a RAM word ... clear lb@ T16val ; // clear T16val (LSB) clear hb@ T16val ; // clear T16val (MSB) stt16 T16val ; // initial T16 with 0 ... set1 t16m.5 ; // enable Timer16 ... set0 t16m.5 ; // disable Timer 16 ldt16 T16val ; // save the T16 counting value to T16val ----- </pre>

<i>stt16</i> word	<p>Store 16-bit data from memory in word to Timer16. Example: <i>stt16</i> word; Result: 16-bit timer ←word Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV Application Example:</p> <hr style="border-top: 1px dashed black;"/> <pre> word T16val ; // declare a RAM word ... mov a, 0x34 ; mov lb@ T16val , a ; // move 0x34 to T16val (LSB) mov a, 0x12 ; mov hb@ T16val , a ; // move 0x12 to T16val (MSB) stt16 T16val ; // initial T16 with 0x1234 ... </pre> <hr style="border-top: 1px dashed black;"/>
<i>idxm</i> a, index	<p>Move data from specified memory to ACC by indirect method. It needs 2T to execute this instruction. Example: <i>idxm</i> a, index; Result: a ← [index], where index is declared by word. Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV Application Example:</p> <hr style="border-top: 1px dashed black;"/> <pre> word RAMIndex ; // declare a RAM pointer ... mov a, 0x5B ; // assign pointer to an address (LSB) mov lb@RAMIndex, a ; // save pointer to RAM (LSB) mov a, 0x00 ; // assign 0x00 to an address (MSB), should be 0 mov hb@RAMIndex, a ; // save pointer to RAM (MSB) ... idxm a, RAMIndex ; // mov memory data in address 0x5B to ACC </pre> <hr style="border-top: 1px dashed black;"/>

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<i>idxm</i> index, a	<p>Move data from ACC to specified memory by indirect method. It needs 2T to execute this instruction.</p> <p>Example: <i>idxm</i> index, a;</p> <p>Result: [index] ← a; where index is declared by word.</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p> <p>Application Example:</p> <hr/> <pre> word RAMIndex ; // declare a RAM pointer ... mov a, 0x5B ; // assign pointer to an address (LSB) mov lb@RAMIndex, a ; // save pointer to RAM (LSB) mov a, 0x00 ; // assign 0x00 to an address (MSB), should be 0 mov hb@RAMIndex, a ; // save pointer to RAM (MSB) ... mov a, 0xA5 ; idxm RAMIndex, a ; // mov 0xA5 to memory in address 0x5B </pre> <hr/>
<i>xch</i> M	<p>Exchange data between ACC and memory</p> <p>Example: <i>xch</i> MEM ;</p> <p>Result: MEM ← a , a ← MEM</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>pushaf</i>	<p>Move the ACC and <i>flag</i> register to memory that address specified in the stack pointer.</p> <p>Example: <i>pushaf</i>;</p> <p>Result: [sp] ← {flag, ACC}; sp ← sp + 2 ;</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p> <p>Application Example:</p> <hr/> <pre> .romadr 0x10 ; // ISR entry address pushaf ; // put ACC and flag into stack memory ... // ISR program ... // ISR program popaf ; // restore ACC and flag from stack memory reti ; </pre> <hr/>
<i>popaf</i>	<p>Restore ACC and <i>flag</i> from the memory which address is specified in the stack pointer.</p> <p>Example: <i>popaf</i>;</p> <p>Result: sp ← sp - 2 ; {Flag, ACC} ← [sp] ;</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>

7.2. Arithmetic Operation Instructions

<i>add</i> a, l	Add immediate data with ACC, then put result into ACC Example: <i>add</i> a, 0x0f ; Result: $a \leftarrow a + 0fh$ Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV
<i>add</i> a, M	Add data in memory with ACC, then put result into ACC Example: <i>add</i> a, MEM ; Result: $a \leftarrow a + MEM$ Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV
<i>add</i> M, a	Add data in memory with ACC, then put result into memory Example: <i>add</i> MEM, a ; Result: $MEM \leftarrow a + MEM$ Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV
<i>addc</i> a, M	Add data in memory with ACC and carry bit, then put result into ACC Example: <i>addc</i> a, MEM ; Result: $a \leftarrow a + MEM + C$ Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV
<i>addc</i> M, a	Add data in memory with ACC and carry bit, then put result into memory Example: <i>addc</i> MEM, a ; Result: $MEM \leftarrow a + MEM + C$ Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV
<i>addc</i> a	Add carry with ACC, then put result into ACC Example: <i>addc</i> a ; Result: $a \leftarrow a + C$ Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV
<i>addc</i> M	Add carry with memory, then put result into memory Example: <i>addc</i> MEM ; Result: $MEM \leftarrow MEM + C$ Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV
<i>nadd</i> a, M	Add negative logic (2's complement) of ACC with memory Example: <i>nadd</i> a, MEM ; Result: $a \leftarrow \overline{a} + MEM$ Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV
<i>nadd</i> M, a	Add negative logic (2's complement) of memory with ACC Example: <i>nadd</i> MEM, a ; Result: $MEM \leftarrow \overline{MEM} + a$ Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV
<i>sub</i> a, l	Subtraction immediate data from ACC, then put result into ACC. Example: <i>sub</i> a, 0x0f ; Result: $a \leftarrow a - 0fh$ ($a + [2's \text{ complement of } 0fh]$) Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV
<i>sub</i> a, M	Subtraction data in memory from ACC, then put result into ACC Example: <i>sub</i> a, MEM ; Result: $a \leftarrow a - MEM$ ($a + [2's \text{ complement of } M]$) Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV

<i>sub</i> M, a	<p>Subtraction data in ACC from memory, then put result into memory</p> <p>Example: <i>sub</i> MEM, a;</p> <p>Result: $MEM \leftarrow MEM - a$ ($MEM + [2\text{'s complement of } a]$)</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>
<i>subc</i> a, M	<p>Subtraction data in memory and carry from ACC, then put result into ACC</p> <p>Example: <i>subc</i> a, MEM;</p> <p>Result: $a \leftarrow a - MEM - C$</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>
<i>subc</i> M, a	<p>Subtraction ACC and carry bit from memory, then put result into memory</p> <p>Example: <i>subc</i> MEM, a ;</p> <p>Result: $MEM \leftarrow MEM - a - C$</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>
<i>subc</i> a	<p>Subtraction carry from ACC, then put result into ACC</p> <p>Example: <i>subc</i> a;</p> <p>Result: $a \leftarrow a - C$</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>
<i>subc</i> M	<p>Subtraction carry from the content of memory, then put result into memory</p> <p>Example: <i>subc</i> MEM;</p> <p>Result: $MEM \leftarrow MEM - C$</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>
<i>inc</i> M	<p>Increment the content of memory</p> <p>Example: <i>inc</i> MEM ;</p> <p>Result: $MEM \leftarrow MEM + 1$</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>
<i>dec</i> M	<p>Decrement the content of memory</p> <p>Example: <i>dec</i> MEM;</p> <p>Result: $MEM \leftarrow MEM - 1$</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>
<i>clear</i> M	<p>Clear the content of memory</p> <p>Example: <i>clear</i> MEM ;</p> <p>Result: $MEM \leftarrow 0$</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>

7.3. Shift Operation Instructions

<i>sr a</i>	<p>Shift right of ACC, shift 0 to bit 7</p> <p>Example: <i>sr a</i> ;</p> <p>Result: $a(0, b7, b6, b5, b4, b3, b2, b1) \leftarrow a(b7, b6, b5, b4, b3, b2, b1, b0)$, $C \leftarrow a(b0)$</p> <p>Affected flags: 『N』 Z 『Y』 C 『N』 AC 『N』 OV</p>
<i>src a</i>	<p>Shift right of ACC with carry bit 7 to flag</p> <p>Example: <i>src a</i> ;</p> <p>Result: $a(c, b7, b6, b5, b4, b3, b2, b1) \leftarrow a(b7, b6, b5, b4, b3, b2, b1, b0)$, $C \leftarrow a(b0)$</p> <p>Affected flags: 『N』 Z 『Y』 C 『N』 AC 『N』 OV</p>
<i>sr M</i>	<p>Shift right the content of memory, shift 0 to bit 7</p> <p>Example: <i>sr MEM</i> ;</p> <p>Result: $MEM(0, b7, b6, b5, b4, b3, b2, b1) \leftarrow MEM(b7, b6, b5, b4, b3, b2, b1, b0)$, $C \leftarrow MEM(b0)$</p> <p>Affected flags: 『N』 Z 『Y』 C 『N』 AC 『N』 OV</p>
<i>src M</i>	<p>Shift right of memory with carry bit 7 to flag</p> <p>Example: <i>src MEM</i> ;</p> <p>Result: $MEM(c, b7, b6, b5, b4, b3, b2, b1) \leftarrow MEM(b7, b6, b5, b4, b3, b2, b1, b0)$, $C \leftarrow MEM(b0)$</p> <p>Affected flags: 『N』 Z 『Y』 C 『N』 AC 『N』 OV</p>
<i>sl a</i>	<p>Shift left of ACC shift 0 to bit 0</p> <p>Example: <i>sl a</i> ;</p> <p>Result: $a(b6, b5, b4, b3, b2, b1, b0, 0) \leftarrow a(b7, b6, b5, b4, b3, b2, b1, b0)$, $C \leftarrow a(b7)$</p> <p>Affected flags: 『N』 Z 『Y』 C 『N』 AC 『N』 OV</p>
<i>slc a</i>	<p>Shift left of ACC with carry bit 0 to flag</p> <p>Example: <i>slc a</i> ;</p> <p>Result: $a(b6, b5, b4, b3, b2, b1, b0, c) \leftarrow a(b7, b6, b5, b4, b3, b2, b1, b0)$, $C \leftarrow a(b7)$</p> <p>Affected flags: 『N』 Z 『Y』 C 『N』 AC 『N』 OV</p>
<i>sl M</i>	<p>Shift left of memory, shift 0 to bit 0</p> <p>Example: <i>sl MEM</i> ;</p> <p>Result: $MEM(b6, b5, b4, b3, b2, b1, b0, 0) \leftarrow MEM(b7, b6, b5, b4, b3, b2, b1, b0)$, $C \leftarrow MEM(b7)$</p> <p>Affected flags: 『N』 Z 『Y』 C 『N』 AC 『N』 OV</p>
<i>slc M</i>	<p>Shift left of memory with carry bit 0 to flag</p> <p>Example: <i>slc MEM</i> ;</p> <p>Result: $MEM(b6, b5, b4, b3, b2, b1, b0, C) \leftarrow MEM(b7, b6, b5, b4, b3, b2, b1, b0)$, $C \leftarrow MEM(b7)$</p> <p>Affected flags: 『N』 Z 『Y』 C 『N』 AC 『N』 OV</p>
<i>swap a</i>	<p>Swap the high nibble and low nibble of ACC</p> <p>Example: <i>swap a</i> ;</p> <p>Result: $a(b3, b2, b1, b0, b7, b6, b5, b4) \leftarrow a(b7, b6, b5, b4, b3, b2, b1, b0)$</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>

7.4. Logic Operation Instructions

<i>and</i> a, I	<p>Perform logic AND on ACC and immediate data, then put result into ACC</p> <p>Example: <i>and</i> a, 0x0f ;</p> <p>Result: $a \leftarrow a \& 0fh$</p> <p>Affected flags: 『Y』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>and</i> a, M	<p>Perform logic AND on ACC and memory, then put result into ACC</p> <p>Example: <i>and</i> a, RAM10 ;</p> <p>Result: $a \leftarrow a \& RAM10$</p> <p>Affected flags: 『Y』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>and</i> M, a	<p>Perform logic AND on ACC and memory, then put result into memory</p> <p>Example: <i>and</i> MEM, a ;</p> <p>Result: $MEM \leftarrow a \& MEM$</p> <p>Affected flags: 『Y』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>or</i> a, I	<p>Perform logic OR on ACC and immediate data, then put result into ACC</p> <p>Example: <i>or</i> a, 0x0f ;</p> <p>Result: $a \leftarrow a 0fh$</p> <p>Affected flags: 『Y』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>or</i> a, M	<p>Perform logic OR on ACC and memory, then put result into ACC</p> <p>Example: <i>or</i> a, MEM ;</p> <p>Result: $a \leftarrow a MEM$</p> <p>Affected flags: 『Y』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>or</i> M, a	<p>Perform logic OR on ACC and memory, then put result into memory</p> <p>Example: <i>or</i> MEM, a ;</p> <p>Result: $MEM \leftarrow a MEM$</p> <p>Affected flags: 『Y』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>xor</i> a, I	<p>Perform logic XOR on ACC and immediate data, then put result into ACC</p> <p>Example: <i>xor</i> a, 0x0f ;</p> <p>Result: $a \leftarrow a \wedge 0fh$</p> <p>Affected flags: 『Y』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>xor</i> IO, a	<p>Perform logic XOR on ACC and IO register, then put result into IO register</p> <p>Example: <i>xor</i> pa, a ;</p> <p>Result: $pa \leftarrow a \wedge pa$; // pa is the data register of port A</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>xor</i> a, M	<p>Perform logic XOR on ACC and memory, then put result into ACC</p> <p>Example: <i>xor</i> a, MEM ;</p> <p>Result: $a \leftarrow a \wedge RAM10$</p> <p>Affected flags: 『Y』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>xor</i> M, a	<p>Perform logic XOR on ACC and memory, then put result into memory</p> <p>Example: <i>xor</i> MEM, a ;</p> <p>Result: $MEM \leftarrow a \wedge MEM$</p> <p>Affected flags: 『Y』 Z 『N』 C 『N』 AC 『N』 OV</p>

<i>not</i> a	<p>Perform 1's complement (logical complement) of ACC Example: <i>not</i> a ; Result: a ← ~a Affected flags: 『Y』 Z 『N』 C 『N』 AC 『N』 OV Application Example:</p> <hr/> <pre> mov a, 0x38 ; // ACC=0X38 not a ; // ACC=0XC7 </pre> <hr/>
<i>not</i> M	<p>Perform 1's complement (logical complement) of memory Example: <i>not</i> MEM ; Result: MEM ← ~MEM Affected flags: 『Y』 Z 『N』 C 『N』 AC 『N』 OV Application Example:</p> <hr/> <pre> mov a, 0x38 ; mov mem, a ; // mem = 0x38 not mem ; // mem = 0xC7 </pre> <hr/>
<i>neg</i> a	<p>Perform 2's complement of ACC Example: <i>neg</i> a ; Result: a ← \overline{a} Affected flags: 『Y』 Z 『N』 C 『N』 AC 『N』 OV Application Example:</p> <hr/> <pre> mov a, 0x38 ; // ACC=0X38 neg a ; // ACC=0XC8 </pre> <hr/>
<i>neg</i> M	<p>Perform 2's complement of memory Example: <i>neg</i> MEM ; Result: MEM ← \overline{MEM} Affected flags: 『Y』 Z 『N』 C 『N』 AC 『N』 OV Application Example:</p> <hr/> <pre> mov a, 0x38 ; mov mem, a ; // mem = 0x38 not mem ; // mem = 0xC8 </pre> <hr/>

<i>comp</i> a, M	<p>Compare ACC with the content of memory</p> <p>Example: <i>comp a, MEM;</i></p> <p>Result: Flag will be changed by regarding as (a - MEM)</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p> <p>Application Example:</p> <hr style="border-top: 1px dashed black;"/> <pre> mov a, 0x38 ; mov mem, a ; comp a, mem ; // Z flag is set as 1 mov a, 0x42 ; mov mem, a ; mov a, 0x38 ; comp a, mem ; // C flag is set as 1 </pre> <hr style="border-top: 1px dashed black;"/>
<i>comp</i> M, a	<p>Compare ACC with the content of memory</p> <p>Example: <i>comp MEM, a;</i></p> <p>Result: Flag will be changed by regarding as (MEM - a)</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>

7.5. Bit Operation Instructions

<i>set0</i> IO.n	<p>Set bit n of IO port to low</p> <p>Example: <i>set0 pa.5 ;</i></p> <p>Result: set bit 5 of port A to low</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>set1</i> IO.n	<p>Set bit n of IO port to high</p> <p>Example: <i>set1 pa.5 ;</i></p> <p>Result: set bit 5 of port B to high</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>swapc</i> IO.n	<p>Swap the bit n of IO port with carry bit</p> <p>Example: <i>swapc IO.0;</i></p> <p>Result: $C \leftarrow IO.0, IO.0 \leftarrow C$</p> <p>When IO.0 is a port to output pin, carry C will be sent to IO.0;</p> <p>When IO.0 is a port from input pin, IO.0 will be sent to carry C;</p> <p>Affected flags: 『N』 Z 『Y』 C 『N』 AC 『N』 OV</p> <p>Application Example1 (serial output) :</p> <hr style="border-top: 1px dashed black;"/> <pre> ... set1 pac.0 ; // set PA.0 as output ... set0 flag.1 ; // C=0 swapc pa.0 ; // move C to PA.0 (bit operation), PA.0=0 set1 flag.1 ; // C=1 swapc pa.0 ; // move C to PA.0 (bit operation), PA.0=1 ... </pre>

	<p>-----</p> <p>Application Example2 (serial input) :</p> <p>-----</p> <pre> ... set0 pac.0 ; // set PA.0 as input ... swapc pa.0 ; // read PA.0 to C (bit operation) src a ; // shift C to bit 7 of ACC swapc pa.0 ; // read PA.0 to C (bit operation) src a ; // shift new C to bit 7, old C ... </pre> <p>-----</p>
<i>set0</i> M.n	<p>Set bit n of memory to low</p> <p>Example: <i>set0</i> MEM.5 ;</p> <p>Result: set bit 5 of MEM to low</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>set1</i> M.n	<p>Set bit n of memory to high</p> <p>Example: <i>set1</i> MEM.5 ;</p> <p>Result: set bit 5 of MEM to high</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>

7.6. Conditional Operation Instructions

<i>ceqsn</i> a, l	<p>Compare ACC with immediate data and skip next instruction if both are equal.</p> <p>Flag will be changed like as ($a \leftarrow a - l$)</p> <p>Example: <i>ceqsn</i> a, 0x55 ;</p> <pre> inc MEM ; goto error ; </pre> <p>Result: If a=0x55, then “goto error”; otherwise, “inc MEM”.</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>
<i>ceqsn</i> a, M	<p>Compare ACC with memory and skip next instruction if both are equal.</p> <p>Flag will be changed like as ($a \leftarrow a - M$)</p> <p>Example: <i>ceqsn</i> a, MEM;</p> <p>Result: If a=MEM, skip next instruction</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>
<i>cneqsn</i> a, M	<p>Compare ACC with memory and skip next instruction if both are not equal.</p> <p>Flag will be changed like as ($a \leftarrow a - M$)</p> <p>Example: <i>cneqsn</i> a, MEM;</p> <p>Result: If a≠MEM, skip next instruction</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>
<i>cneqsn</i> a, l	<p>Compare ACC with immediate data and skip next instruction if both are no equal.</p> <p>Flag will be changed like as ($a \leftarrow a - l$)</p> <p>Example: <i>cneqsn</i> a, 0x55 ;</p> <pre> inc MEM ; goto error ; </pre>

	<p>Result: If $a \neq 0x55$, then “goto error”; Otherwise, “inc MEM”.</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>
<i>t0sn</i> IO.n	<p>Check IO bit and skip next instruction if it's low</p> <p>Example: <i>t0sn</i> pa.5;</p> <p>Result: If bit 5 of port A is low, skip next instruction</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>t1sn</i> IO.n	<p>Check IO bit and skip next instruction if it's high</p> <p>Example: <i>t1sn</i> pa.5 ;</p> <p>Result: If bit 5 of port A is high, skip next instruction</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>t0sn</i> M.n	<p>Check memory bit and skip next instruction if it's low</p> <p>Example: <i>t0sn</i> MEM.5 ;</p> <p>Result: If bit 5 of MEM is low, then skip next instruction</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>t1sn</i> M.n	<p>Check memory bit and skip next instruction if it's high</p> <p>EX: <i>t1sn</i> MEM.5 ;</p> <p>Result: If bit 5 of MEM is high, then skip next instruction</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>izsn</i> a	<p>Increment ACC and skip next instruction if ACC is zero</p> <p>Example: <i>izsn</i> a;</p> <p>Result: $a \leftarrow a + 1$, skip next instruction if $a = 0$</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>
<i>dzsn</i> a	<p>Decrement ACC and skip next instruction if ACC is zero</p> <p>Example: <i>dzsn</i> a;</p> <p>Result: $A \leftarrow A - 1$, skip next instruction if $a = 0$</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>
<i>izsn</i> M	<p>Increment memory and skip next instruction if memory is zero</p> <p>Example: <i>izsn</i> MEM;</p> <p>Result: $MEM \leftarrow MEM + 1$, skip next instruction if $MEM = 0$</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>
<i>dzsn</i> M	<p>Decrement memory and skip next instruction if memory is zero</p> <p>Example: <i>dzsn</i> MEM;</p> <p>Result: $MEM \leftarrow MEM - 1$, skip next instruction if $MEM = 0$</p> <p>Affected flags: 『Y』 Z 『Y』 C 『Y』 AC 『Y』 OV</p>

7.7. System control Instructions

<i>call</i> label	<p>Function call, address can be full range address space</p> <p>Example: <i>call</i> function1;</p> <p>Result: [sp] ← pc + 1 pc ← function1 sp ← sp + 2</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>goto</i> label	<p>Go to specific address which can be full range address space</p> <p>Example: <i>goto</i> error;</p> <p>Result: Go to error and execute program.</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>ret</i> l	<p>Place immediate data to ACC, then return</p> <p>Example: <i>ret</i> 0x55;</p> <p>Result: A ← 55h ret ;</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>ret</i>	<p>Return to program which had function call</p> <p>Example: <i>ret</i>;</p> <p>Result: sp ← sp - 2 pc ← [sp]</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>reti</i>	<p>Return to program from interrupt service routine. After this command is executed, global interrupt is enabled automatically.</p> <p>Example: <i>reti</i>;</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>nop</i>	<p>No operation</p> <p>Example: <i>nop</i>;</p> <p>Result: nothing changed</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>wdreset</i>	<p>Reset Watchdog timer.</p> <p>Example: <i>wdreset</i> ;</p> <p>Result: Reset Watchdog timer.</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p>
<i>pcadd</i> a	<p>Next program counter is current program counter plus ACC.</p> <p>Example: <i>pcadd</i> a;</p> <p>Result: pc ← pc + a</p> <p>Affected flags: 『N』 Z 『N』 C 『N』 AC 『N』 OV</p> <p>Application Example:</p> <hr style="border-top: 1px dashed black;"/> <pre> ... mov a, 0x02 ; pcadd a ; // PC <- PC+2 goto err1 ; goto correct ; // jump here goto err2 ; goto err3 ; </pre>

7.9. Summary of affected flags by Instructions

Instruction	Z	C	AC	OV	Instruction	Z	C	AC	OV	Instruction	Z	C	AC	OV
<i>mov a, l</i>	-	-	-	-	<i>mov M, a</i>	-	-	-	-	<i>mov a, M</i>	Y	-	-	-
<i>mov a, IO</i>	Y	-	-	-	<i>mov IO, a</i>	-	-	-	-	<i>ldt16 word</i>	-	-	-	-
<i>stt16 word</i>	-	-	-	-	<i>idxm a, index</i>	-	-	-	-	<i>idxm index, a</i>	-	-	-	-
<i>xch M</i>	-	-	-	-	<i>pushaf</i>	-	-	-	-	<i>popaf</i>	Y	Y	Y	Y
<i>add a, l</i>	Y	Y	Y	Y	<i>add a, M</i>	Y	Y	Y	Y	<i>add M, a</i>	Y	Y	Y	Y
<i>addc a, M</i>	Y	Y	Y	Y	<i>addc M, a</i>	Y	Y	Y	Y	<i>addc a</i>	Y	Y	Y	Y
<i>addc M</i>	Y	Y	Y	Y	<i>sub a, l</i>	Y	Y	Y	Y	<i>sub a, M</i>	Y	Y	Y	Y
<i>sub M, a</i>	Y	Y	Y	Y	<i>subc a, M</i>	Y	Y	Y	Y	<i>subc M, a</i>	Y	Y	Y	Y
<i>subc a</i>	Y	Y	Y	Y	<i>subc M</i>	Y	Y	Y	Y	<i>inc M</i>	Y	Y	Y	Y
<i>dec M</i>	Y	Y	Y	Y	<i>clear M</i>	-	-	-	-	<i>sr a</i>	-	Y	-	-
<i>src a</i>	-	Y	-	-	<i>sr M</i>	-	Y	-	-	<i>src M</i>	-	Y	-	-
<i>sl a</i>	-	Y	-	-	<i>slc a</i>	-	Y	-	-	<i>sl M</i>	-	Y	-	-
<i>slc M</i>	-	Y	-	-	<i>swap a</i>	-	-	-	-	<i>and a, l</i>	Y	-	-	-
<i>and a, M</i>	Y	-	-	-	<i>and M, a</i>	Y	-	-	-	<i>or a, l</i>	Y	-	-	-
<i>or a, M</i>	Y	-	-	-	<i>or M, a</i>	Y	-	-	-	<i>xor a, l</i>	Y	-	-	-
<i>xor IO, a</i>	-	-	-	-	<i>xor a, M</i>	Y	-	-	-	<i>xor M, a</i>	Y	-	-	-
<i>not a</i>	Y	-	-	-	<i>not M</i>	Y	-	-	-	<i>neg a</i>	Y	-	-	-
<i>neg M</i>	Y	-	-	-	<i>set0 IO.n</i>	-	-	-	-	<i>set1 IO.n</i>	-	-	-	-
<i>set0 M.n</i>	-	-	-	-	<i>set1 M.n</i>	-	-	-	-	<i>ceqsn a, l</i>	Y	Y	Y	Y
<i>ceqsn a, M</i>	Y	Y	Y	Y	<i>t0sn IO.n</i>	-	-	-	-	<i>t1sn IO.n</i>	-	-	-	-
<i>t0sn M.n</i>	-	-	-	-	<i>t1sn M.n</i>	-	-	-	-	<i>izsn a</i>	Y	Y	Y	Y
<i>dzsn a</i>	Y	Y	Y	Y	<i>izsn M</i>	Y	Y	Y	Y	<i>dzsn M</i>	Y	Y	Y	Y
<i>call label</i>	-	-	-	-	<i>goto label</i>	-	-	-	-	<i>ret l</i>	-	-	-	-
<i>ret</i>	-	-	-	-	<i>reti</i>	-	-	-	-	<i>nop</i>	-	-	-	-
<i>pcadd a</i>	-	-	-	-	<i>engint</i>	-	-	-	-	<i>disgint</i>	-	-	-	-
<i>stopsys</i>	-	-	-	-	<i>stopexe</i>	-	-	-	-	<i>reset</i>	-	-	-	-
<i>wdreset</i>	-	-	-	-	<i>nadd M, a</i>	Y	Y	Y	Y	<i>cneqsn a, l</i>	Y	Y	Y	Y
<i>cneqsn a, M</i>	Y	Y	Y	Y	<i>comp a, M</i>	Y	Y	Y	Y	<i>nadd a, M</i>	Y	Y	Y	Y
<i>comp M, a</i>	Y	Y	Y	Y	<i>swapc IO.n</i>	-	Y	-	-					

7.10. BIT definition

Bit access of RAM is only available for address from 0x00 to 0x3F.

8. Code Options

Option	Selection	Description
Security	Enable	OTP content is protected and program cannot be read back
	Disable	OTP content is not protected so program can be read back
LVR	4.0V	Select LVR = 4.0V
	3.5V	Select LVR = 3.5V
	3.0V	Select LVR = 3.0V
	2.7V	Select LVR = 2.7V
	2.5V	Select LVR = 2.5V
	2.2V	Select LVR = 2.2V
	2.0V	Select LVR = 2.0V
	1.8V	Select LVR = 1.8V
Interrupt Src0	PA.0	INTEN/INTRQ.Bit0 is from PA.0
	PB.5	INTEN/INTRQ.Bit0 is from PB.5
Interrupt Src1	PB.0	INTEN/INTRQ.Bit1 is from PB.0
	PA.4	INTEN/INTRQ.Bit1 is from PA.4
GPC_PWM	Disable	Comparator does not control all PWM outputs
	Enable	Comparator controls all PWM outputs (ICE does NOT Support.)
LPWM_Source	16MHZ	When Lpwmgclk.0= 1, LPWMG clock source = IHRC = 16MHZ
	32MHZ	When Lpwmgclk.0= 1, LPWMG clock source = IHRC*2 = 32MHZ (ICE does NOT Support.)
TM2_Source	16MHZ	When tm2c[7:4]= 0010, TM2 clock source = IHRC = 16MHZ
	32MHZ	When tm2c[7:4]= 0010, TM2 clock source = IHRC*2 = 32MHZ (ICE does NOT Support.)
TM2_Bit	6 Bit	When tm2s.7=1, TM2 PWM resolution is 6 Bit
	7 Bit	When tm2s.7=1, TM2 PWM resolution is 7 Bit (ICE does NOT Support.)
Comparator_Edge	All_Edge	The comparator will trigger an interrupt on the rising edge or falling edge
	Rising_Edge	The comparator will trigger an interrupt on the rising edge
	Falling_Edge	The comparator will trigger an interrupt on the falling edge
CheckROM_Enhancement	Newer (Default)	Added a verification mechanism in the programmer after data is written. Requires use with IDE / Writer software version V1.03A5 or later for programming. (Note: The checksum may differ from that of older compiled versions)
	Older	Compatible with older versions (prior to IDE / Writer V1.03A5)

9. Special Notes

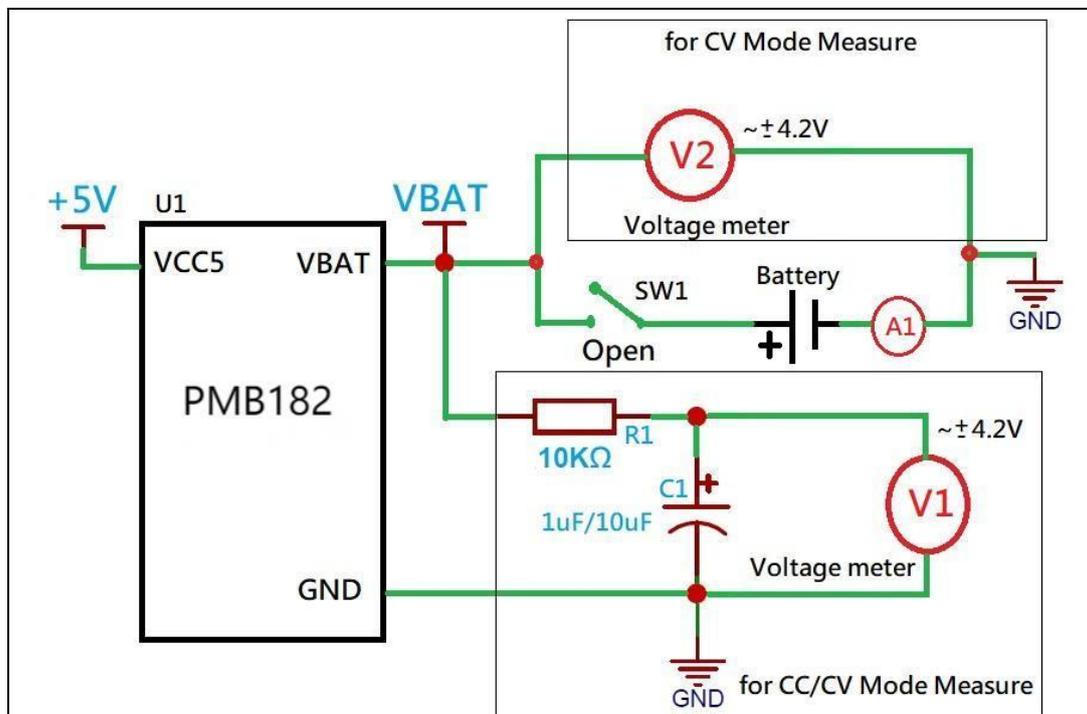
This chapter is to remind user who use PMB182(B) series IC in order to avoid frequent errors upon operation.

9.1. Using IC

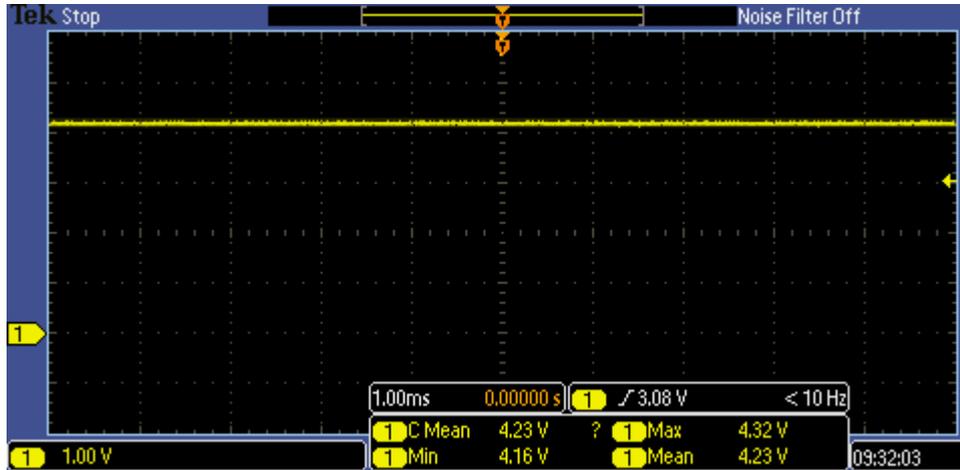
9.1.1. Charger Use and Setting

(1) Charging voltage and current measurement

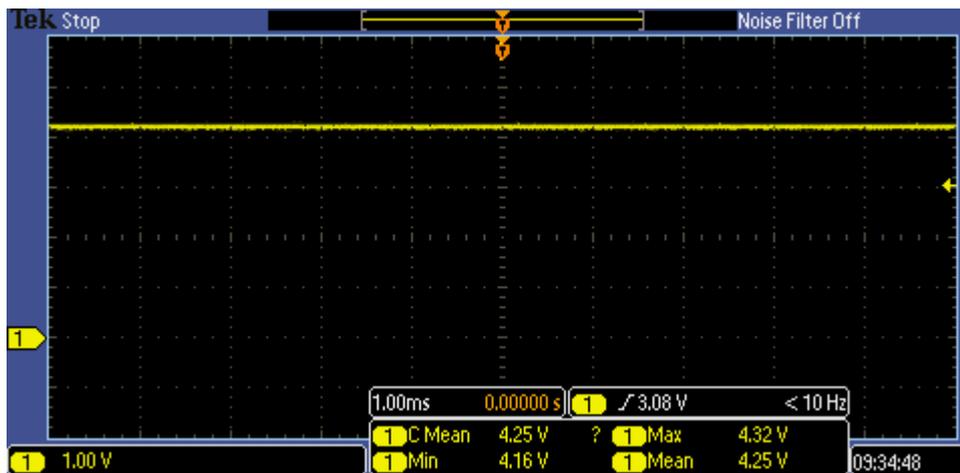
- ◆ The PMB182(B) charger and the MCU execution program work independently of each other, and the MCU reset does not affect the charging action.
- ◆ Charging voltage and current measurements on an empty PMB182(B) charger are the voltage/current values when the charger is not loaded with calibration parameters.
- ◆ The PMB182(B) will write calibration parameters for the charger after the program has started working properly, at which time the PMB182(B) charger can be electrically measured.
- ◆ The wiring diagram for measuring the full voltage of the PMB182(B) charger is shown as follows: in CC Mode, you need to connect an RC circuit in series at the VBAT pin (to simulate the equivalent circuit of the battery's internal resistance), and the voltmeter V1 is connected in parallel to the capacitor C1, while in CV Mode, you can connect the voltmeter V2 in parallel to the VBAT pin.



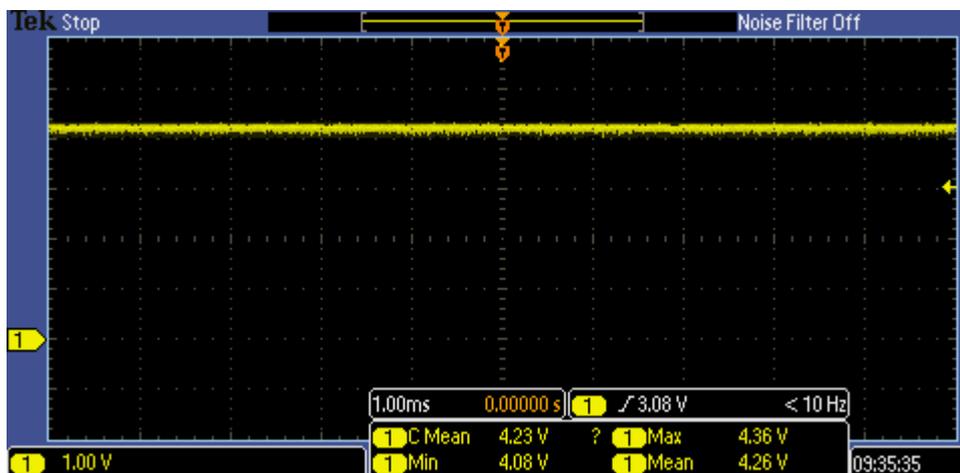
V1 Voltage waveform: (CC Mode, R1 = 10Kohm , C1 = 1uF)



V1 voltage waveform: (CV Mode, R1 = 10Kohm , C1 = 1uF)



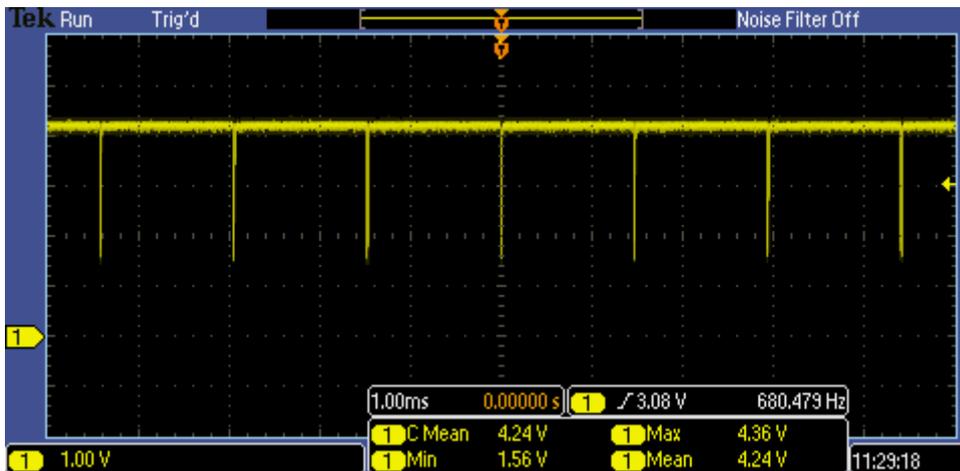
V2 voltage waveform: (CV Mode, No R1 and C1)



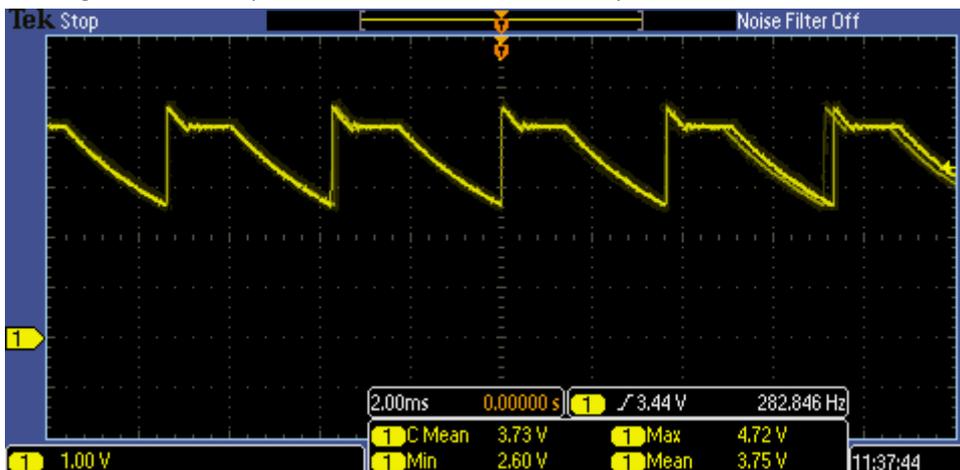
PMB182(B) 8bit OTP with Charge IC

- ◆ The average voltage measured when the VBAT pin is not connected to the battery or only connected to the filter/electrolytic capacitor in CC mode may be low due to the charging/discharging effect of the charger on the external capacitor. Charge re-cycle time is about 1~3ms when charging to 4.2V, if VBAT pin is not connected to battery or only connected to capacitor, the average voltage measured by voltmeter will be lower due to the discharge time. For example, if a voltmeter is used to measure the VBAT voltage directly, adding a 1uF capacitor to the VBAT pin will result in a measurement error (much lower than the target value) because the discharge time will be longer, resulting in a lower average value measured by the voltmeter. The waveform is shown below

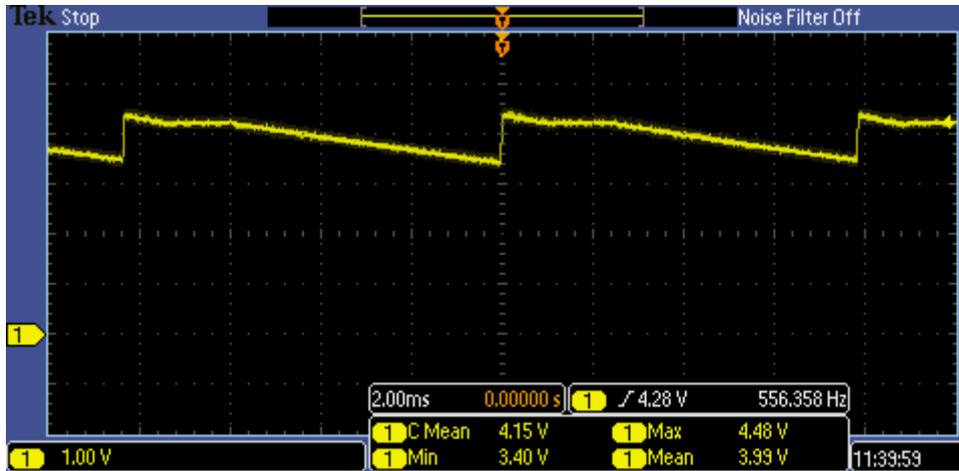
V2 voltage waveform: (CC Mode, No R1 and C1)



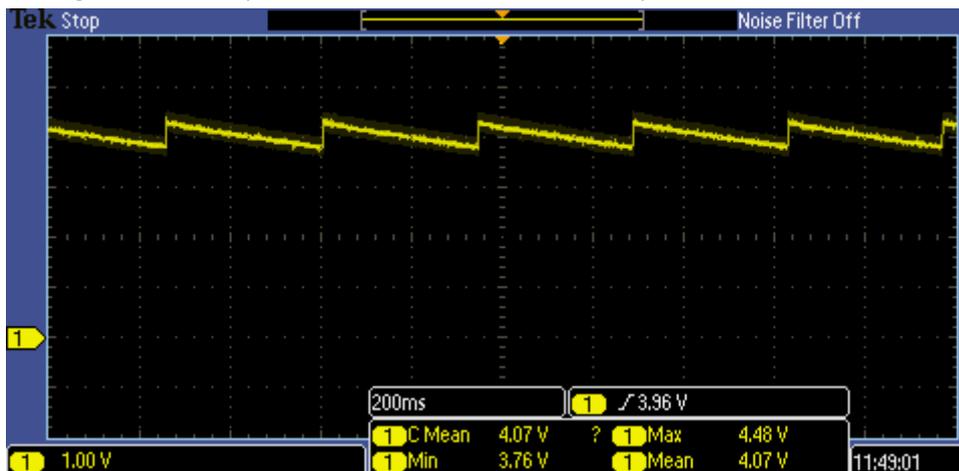
V2 voltage waveform: (CC Mode, R1 = 0R , C1 = 1uF)



V2 voltage waveform: (CC Mode, R1 = 0R , C1 = 4.7uF)



V2 voltage waveform: (CC Mode, R1 = 0R , C1 = 470uF)



- ◆ Versions of IDE 0.99D8 and later provide several advanced macro commands to modify the charger calibration parameters, which are not recommended to be changed by users. If you have any concerns, please consult the technical engineers of the original manufacturer or distributor. If the charger trim value is changed by the user, a message "The charger trim value of this PDK file has been modified" will appear when Writer downloads the writing file.

9.1.2. IO pin usage and setting

- (1) IO pin is set to be digital input
 - ◆ When IO is set as digital input, the level of V_{ih} and V_{il} would changes with the voltage and temperature. Please follow the minimum value of V_{ih} and the maximum value of V_{il} .
 - ◆ The value of internal pull high resistor would also change with the voltage, temperature and pin voltage. It is not the fixed value.

- (2) IO pin as digital input and enable wakeup function
 - ◆ Configure IO pin as input
 - ◆ Set corresponding bit to “1” in PXDIER
 - ◆ For those IO pins of PA that are not used, PADIER[1:2] should be set low in order to prevent them from leakage.

- (3) PA5 is set to be PRSTB input pin
 - ◆ Configure PA5 as input
 - ◆ Set CLKMD.0=1 to enable PA5 as PRSTB input pin

- (4) PA5 is set to be input pin and to connect with a push button or a switch by a long wire
 - ◆ Needs to put a $>33\Omega$ resistor in between PA5 and the long wire
 - ◆ Avoid using PA5 as input in such application.

9.1.3. Interrupt

- (1) When using the interrupt function, the procedure should be:
 - Step1: Set INTEN register, enable the interrupt control bit
 - Step2: Clear INTRQ register
 - Step3: In the main program, using ENGINT to enable CPU interrupt function
 - Step4: Wait for interrupt. When interrupt occurs, enter to Interrupt Service Routine
 - Step5: After the Interrupt Service Routine being executed, return to the main program
 - *Use DISGINT in the main program to disable all interrupts
 - *When interrupt service routine starts, use PUSHAF instruction to save ALU and FLAG register. POPAF instruction is to restore ALU and FLAG register before RETI as below:

```

void Interrupt (void) // Once the interrupt occurs, jump to interrupt service routine
{
    // enter DISGINT status automatically, no more interrupt is
    // accepted
    PUSHAF;
    ...
    POPAF;
} // RETI will be added automatically. After RETI being executed, ENGINT status
// will be restored
          
```

- (2) INTEN and INTRQ have no initial values. Please set required value before enabling interrupt function.

9.1.4. System clock switching

System clock can be switched by CLKMD register. **Please notice that, NEVER switch the system clock and turn off the original clock source at the same time.** For example: When switching from clock A to clock B, please switch to clock B first; and after that turn off the clock A oscillator through CLKMD.

- ◆ Example : Switch system clock from ILRC to IHRC/2
CLKMD = 0x36; // switch to IHRC, *ILRC can not be disabled here*
CLKMD.2 = 0; // ILRC can be disabled at this time
- ◆ **ERROR:** Switch ILRC to IHRC and turn off ILRC simultaneously
CLKMD = 0x50; // MCU will hang

9.1.5. Watchdog

Watchdog is open by default, but the program executes ADJUST_IC ten, and the watchdog will be closed. To use the watchdog, you need to reconfigure the open. Watchdog will be inactive once ILRC is disabled.

9.1.6. TIMER time out

When select \$ INTEGS BIT_R (default value) and T16M counter BIT8 to generate interrupt, if T16M counts from 0, the first interrupt will occur when the counter reaches to 0x100 (BIT8 from 0 to 1) and the second interrupt will occur when the counter reaches 0x300 (BIT8 from 0 to 1). Therefore, selecting BIT8 as 1 to generate interrupt means that the interrupt occurs every 512 counts. Please notice that if T16M counter is restarted, the next interrupt will occur once Bit8 turns from 0 to 1.

If select \$ INTEGS BIT_F (BIT triggers from 1 to 0) and T16M counter BIT8 to generate interrupt, the T16M counter changes to an interrupt every 0x200/0x400/0x600/. Please pay attention to two differences with setting INTEGS methods.

9.1.7. IHRC

- (1) The IHRC frequency calibration is performed when IC is programmed by the writer.
- (2) Because the characteristic of the Epoxy Molding Compound (EMC) would some degrees affects the IHRC frequency (either for package or COB), if the calibration is done before molding process, the actual IHRC frequency after molding may be deviated or becomes out of spec. Normally, the frequency is getting slower a bit.
- (3) It usually happens in COB package or Quick Turnover Programming (QTP). And PADAUK would not take any responsibility for this situation.
- (4) Users can make some compensatory adjustments according to their own experiences. For example, users can set IHRC frequency to be 0.5% ~ 1% higher and aim to get better re-targeting after molding.

9.1.8. LVR

LVR level selection is done at compile time. User must select LVR based on the system working frequency and power supply voltage to make the MCU work stably.

The following are Suggestions for setting operating frequency, power supply voltage and LVR level:

SYSCLK	V _{BAT}	LVR
2MHz	≥ 2.2V	≥ 2.0V
4MHz	≥ 2.5V	≥ 2.5V
8MHz	≥ 3.0V	≥ 3.0V

Table 9: LVR setting for reference

- (1) The setting of LVR (1.8V ~ 4.0V) will be valid just after successful power-on process.
- (2) User can set MISC.2 as “1” to disable LVR. However, V_{BAT} must be kept as exceeding the lowest working voltage of chip; Otherwise IC may work abnormally.
- (3) The LVR function will be invalid when IC in stopexe or stopsys mode.

9.1.9. Programming Writing

There are 4 pins for using the writer to program: PA4, PA6, V_{BAT} and GND.

Please use 5S-P-003x or later version to program PMB182(B) real chip. (3S-P-002 or elder versions do not support programming PMB182(B))

- Special notes about voltage and current while Multi-Chip-Package(MCP) or On-Board Programming

- (1) V_{BAT} may be higher than 9.5V, and its maximum current may reach about 20mA.
- (2) All other signal pins level (except GND) are the same as V_{BAT}.

User should confirm when using this product in MCP or On-Board Programming, the peripheral components or circuit will not be damaged by the above voltages, and will not clam the above voltages.

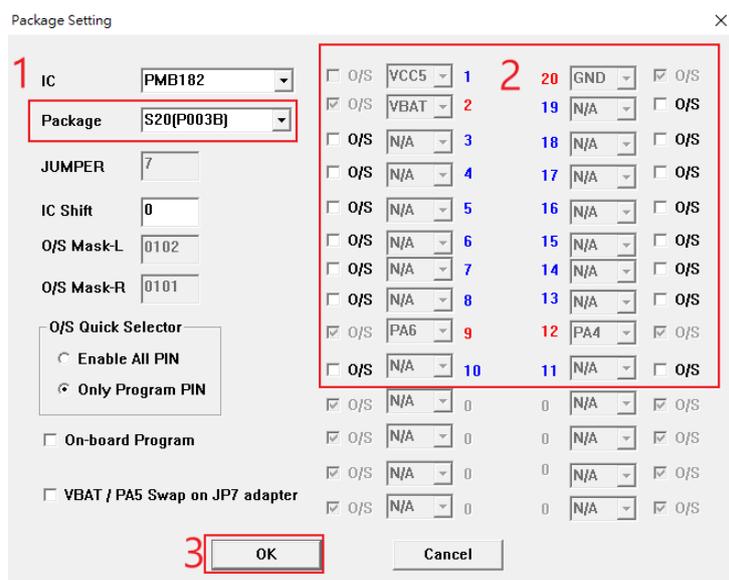
Important Cautions :

- **You MUST follow the instructions on APN004 and APN011 for programming IC on the handler.**
- **Connecting a 0.01uF capacitor between V_{BAT} and GND at the handler port to the IC is always good for suppressing disturbance. But please DO NOT connect with > 0.01uF capacitor, otherwise, programming may be fail.**

9.1.9.1. Using 5S-P-003B to write PMB182(B)

For 5S-P-003B to write PMB182(B), Use jumper7 to adapt program signal connection. The connection of signal depends on the IC package. Please refer to. Chapter 5 of the Writer user manual to find example and make the jumper-7 adaptive board for target IC package. User can get the user manual from the following linker web page.

<http://www.padauk.com.tw/en/technical/index.aspx?kind=27>



Load PDK from GUI, insert JP7 and then input IC on the socket without shift. After LCDM displays IC ready, it can be written.

Note: O/S Test for VCC5 pins is not supported on Program Write

PMB182(B) 8bit OTP with Charge IC

In addition, the information of Convert PDK can also be directly defined in the program, as follows:

```
//          1          2  3  4  5  6  7  8  9  10  11  12  13  14  15
// S20      pin_cnt    vbat pa0 pa3 pa4 pa5 pa6 pa7 gnd vcc5 agnd  mask1 mask2 shift option
.writer package 20,      2,  0,  0, 12,  0,  9,  0, 20,  1,  0,  0x102, 0x101,  0,  0x0
```

For example, make JP7 writer signal connection of SOP-20, as the following.

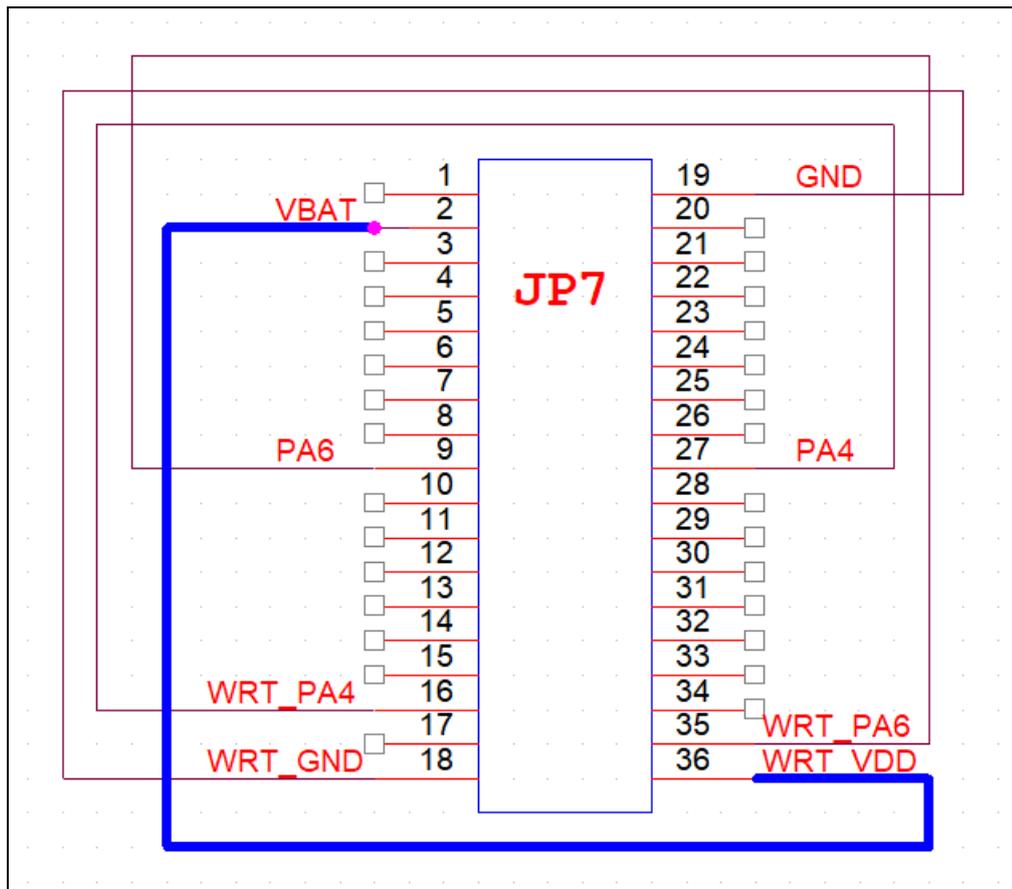


Fig. 20: schematic diagram of Jumper7 for P003B

Insert JP7 and input IC on the socket without shift. After LCDM displays IC ready, it can be written.

9.1.9.2. Using 5S-P-003 to write PMB182(B)

5S-P-003 and 5S-P-003B writing PMB182(B) in the likely way. But user should be take care the following thing.

1. Convert the PDK file from GUI

Enter the writing interface from the IDE, then click “Convert” → “To Package”. In the “Package Setting” interface, select the package with the suffix [P003] (as shown in Figure.21), then click “V_{BAT} /PA5 Swap on JP7 adapter”. After confirming information about the IC pin, save and use the newly generated PDK file. Please refer to Figure 21 and Figure 22 for specific operation steps.

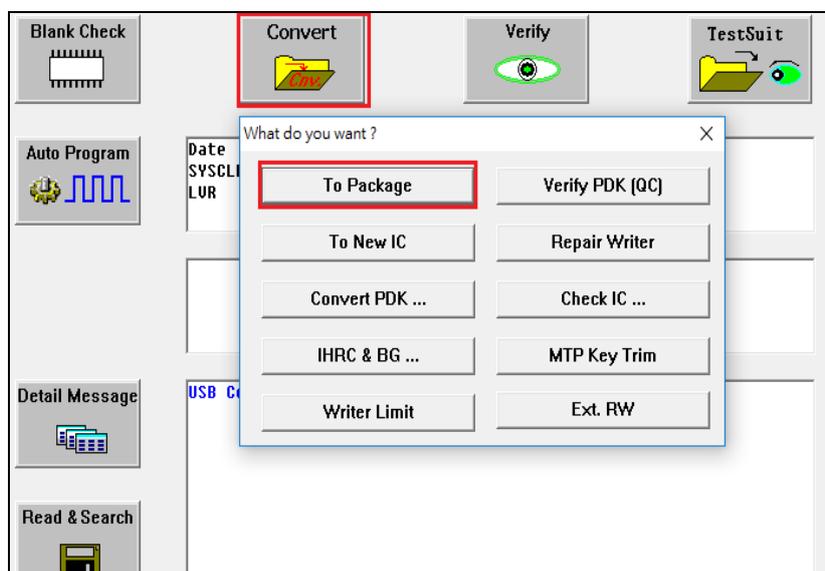


Fig.21: convert the PDK file

Note: O/S Test for VCC5 pins is not supported on Program Write

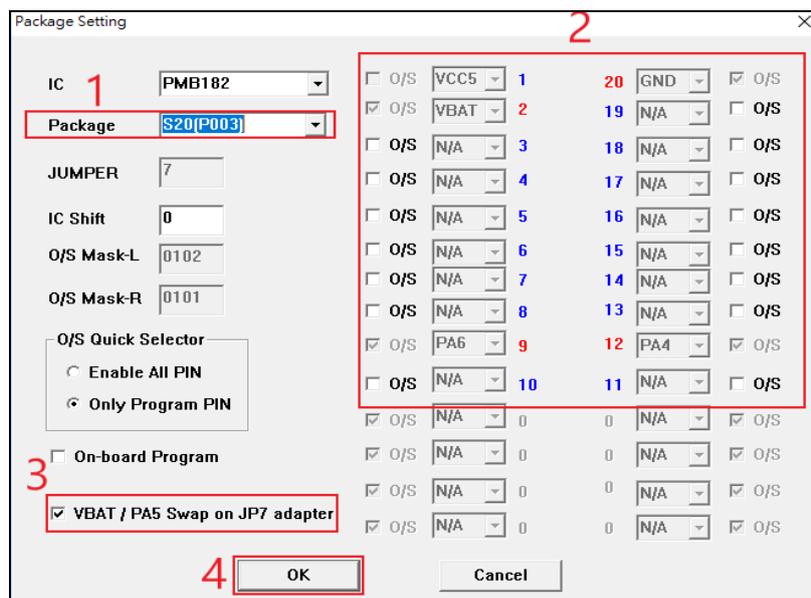


Fig.22: package setting

PMB182(B) 8bit OTP with Charge IC

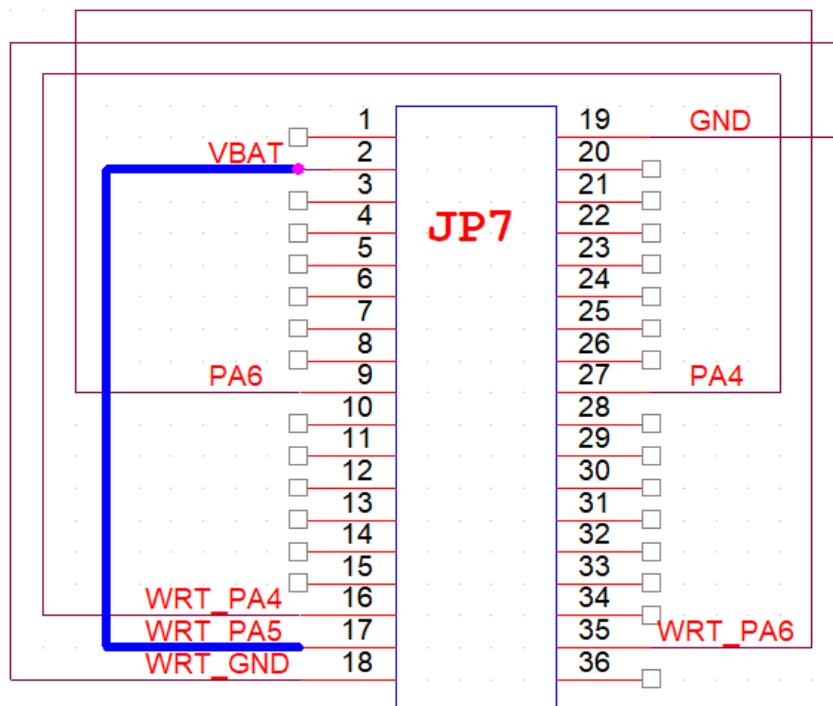
In addition, the information of Convert PDK can also be directly defined in the program, as follows

```

//          1          2  3  4  5  6  7  8  9  10  11  12  13  14  15
// S20     pin_cnt    vbat pa0 pa3 pa4 pa5 pa6 pa7 gnd vcc5 agnd mask1 mask2 shift option
.writer package 20,      2,  0,  0, 12,  0,  9,  0, 20,  1,  0,  0x102, 0x101,  0,  0x10
// option
// bit2 - onboard
// bit4 - vbat/vpp swap
// others - reserved

```

2. As shown in figure 23, it is the Jumper7 connection method. (using SOP20 as example)



Note: Writer PA5-PIN MUST connect to IC-V_{BAT}

Fig.23: schematic diagram of Jumper7 for P003

3. Insert JP7 and input IC on the socket without shift. After LCDM displays IC ready, it can be written.

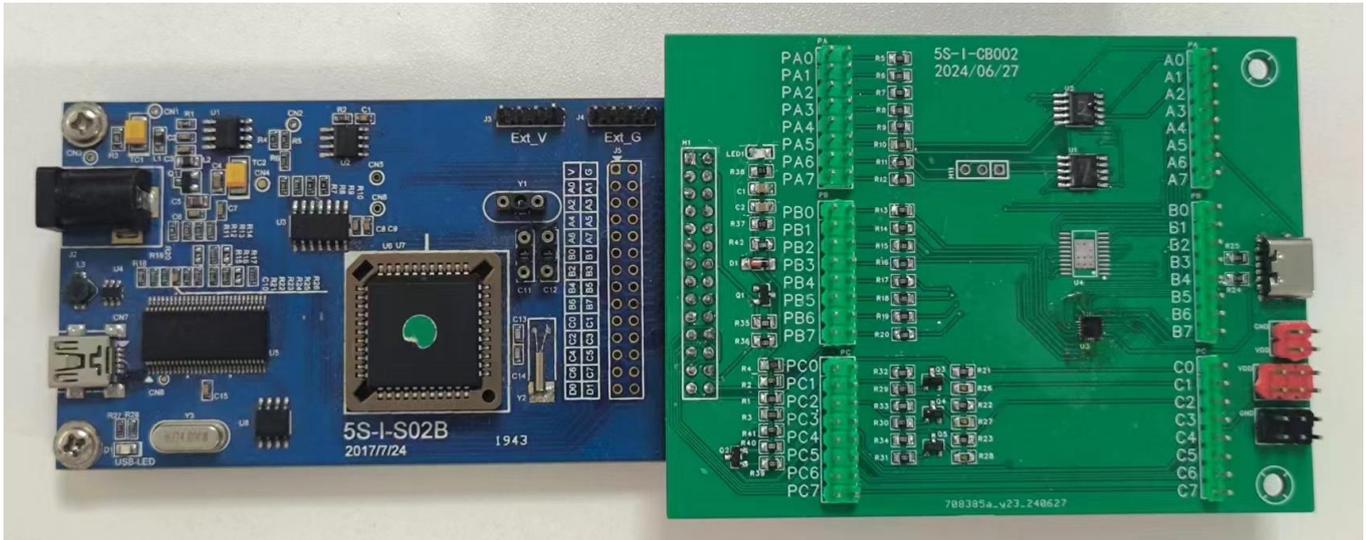
5S-P-003 writing PMB182(B) other package of IC in the same way, and both use the V_{BAT} /PA5 swap method. The principle and steps are similar to 5S-P-003 writing PMB182(B)-SOP20. Please pay attention to changing the package setting and jumper7 connect method to correspond to another package, which will not be repeated here.

9.1.10. Application Manual

For more precautions on the use of the charger, refer to the APN-021 documentation instructions.

9.2. Using ICE

5S-I-CB002 is a simulation tool launched by PADAUK Technology. It needs to be used with PADAUK Technology's IDE software for online simulation. When using 5S-I-CB002, it needs to be used with 5S-I-S01/2 (B). Refer to the following pictures:



5S-I-CB002 Simulation Notes:

1. 5S-I-CB002 must be matched with 5S-I-S01/2 (B) series emulators to simulate functions such as PxPL/ LPWM/ LVDC/ TIMER2/ GPC/ CHARGE
2. 5S-I-CB002 power supply by PDK5S-I-S01/2 (B) In order to stabilize the power supply, please connect 5S-I-S01/S02 (B) to the DC9V power adapter.
3. IDE version 1.01B5 starts supporting emulation of 5S-I-CB002.
4. When emulating PxPL/ LPWM/ LVDC/ TIMER2/ GPC/ CHARGE related functions, 5S-I-S01/2(B) will communicate with the emulation board 5S-I-CB002, so the emulation timing is slow with the actual IC, and the main affected registers are intrq/ PxPL/ LVDC/ CHGC/ CHGS/ LPWMGCLK/ LPWMGCUBH/ LPWMGCUBL/ LPWMGxC/ LPWMGxDTH/ LPWMGxDTL/ GPCC/ GPCS/ LPWMGxDTL/ GPCC/ GPCS/ LPWMGCLK/ LPWMGCUBH/ LPWMGCUBL/ LPWMGxC/ LPWMGxDTH/ LPWMGxDTL/ GPCC/ GPCS/ TM2CT/ TM2B/ TM2S/ TM2C.
5. During simulation, the communication between ICE and 5S-I-CB002 will delay the trigger of the interrupt, and the delay time is about 0~ 335us.
6. Using T16 interrupt timing, interrupt timing error, 5S-I-S01/2(B) and 5S-I-CB002 communication will switch the system clock, and will make the interrupt delay trigger, this phenomenon often occurs in the timer clock source selection SYSCLK or when the timing time is shorter. Therefore, it is recommended to simulate a single timing interrupt period $\geq 10\text{ms}$.
7. Emulation does not support the comparator wakeup

8. Emulation does not support GPC control PWM signal.
9. When emulating GPC/Timer2/LPWM, the interrupt does not support hardware trigger, and the interrupt trigger signal can only be obtained by polling.
10. Since the IC program on 5S-I-CB002 is 8M, when simulating Timer2 or LPWM, the system clock is selected as SYSCLK, and the module is running at 8M, i.e., the system clock is forced to 8M, but the actual IC is the normal system clock.
11. Timer2 or LPWM emulation does not support 32M clock, but the actual IC is OK.
12. Timer2 emulation does not support 7BIT resolution.
13. Emulation of PMB182(B), the operation of the PC IO port should be noted, PC7 in the battery to ensure that the output is high, not connected to the battery to ensure that the output is low
14. When not connected to the battery, 5S-I-S01/2(B) than 5S-I-CB002 voltage to be higher than 0.3V-0.4V (5S-I-CB002 diode on the cause)

WDT period	5S-I-S01/2(B)	PMB182(B)
misc[1:0]=00	2048 * T _{ILRC}	8192 * T _{ILRC}
misc[1:0]=01	4096 * T _{ILRC}	16384 * T _{ILRC}
misc[1:0]=10	16384 * T _{ILRC}	65536 * T _{ILRC}
misc[1:0]=11	256 * T _{ILRC}	262144 * T _{ILRC}

9.3. Typical Application

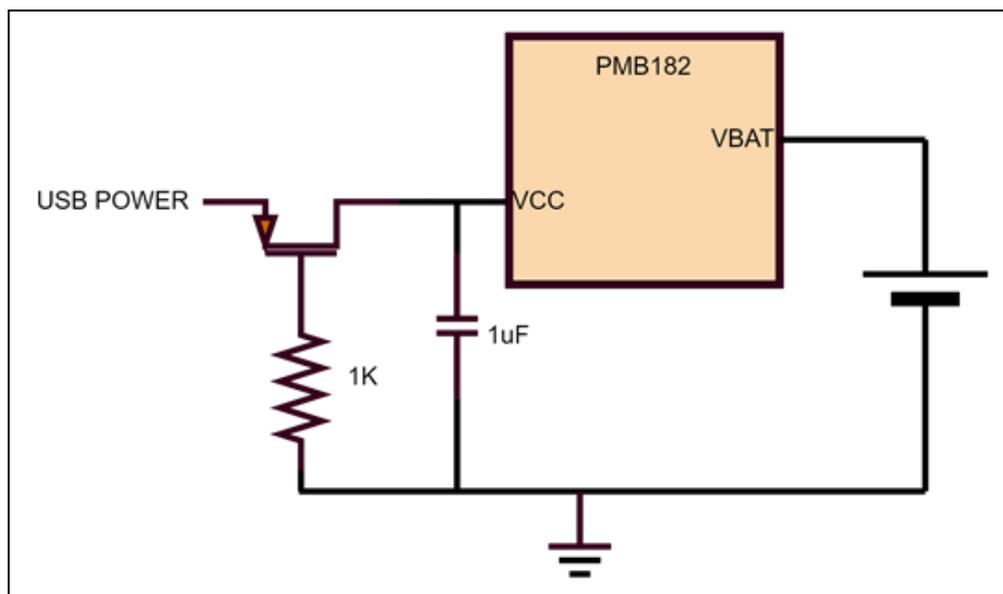


Fig.24: Basic Li-Ion Charger with Reverse Polarity Input Protection

PMB182(B) 8bit OTP with Charge IC

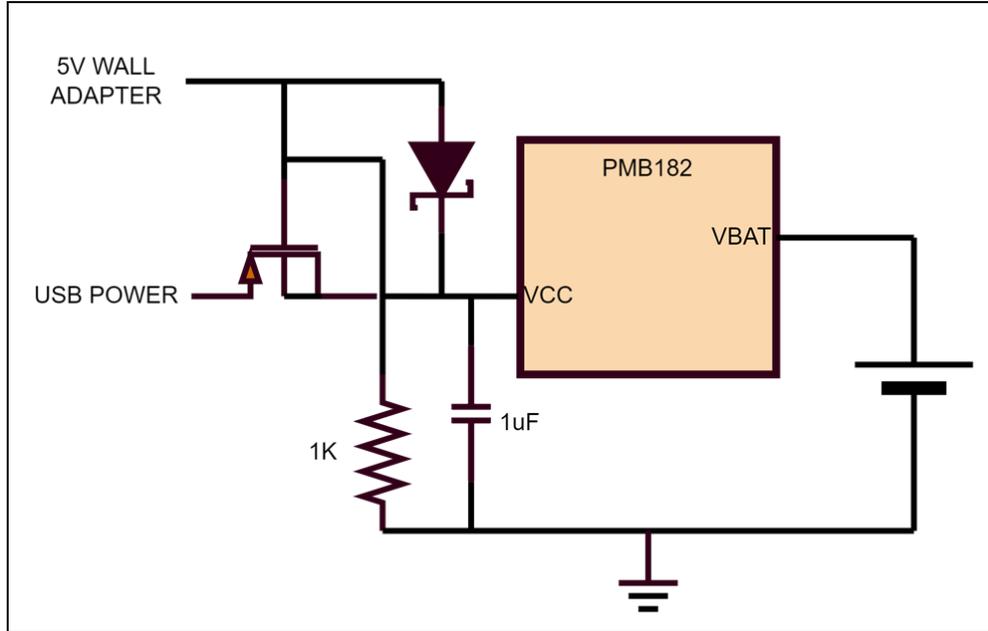


Fig.25: USB/Wall Adapter Power Li-Ion Charger

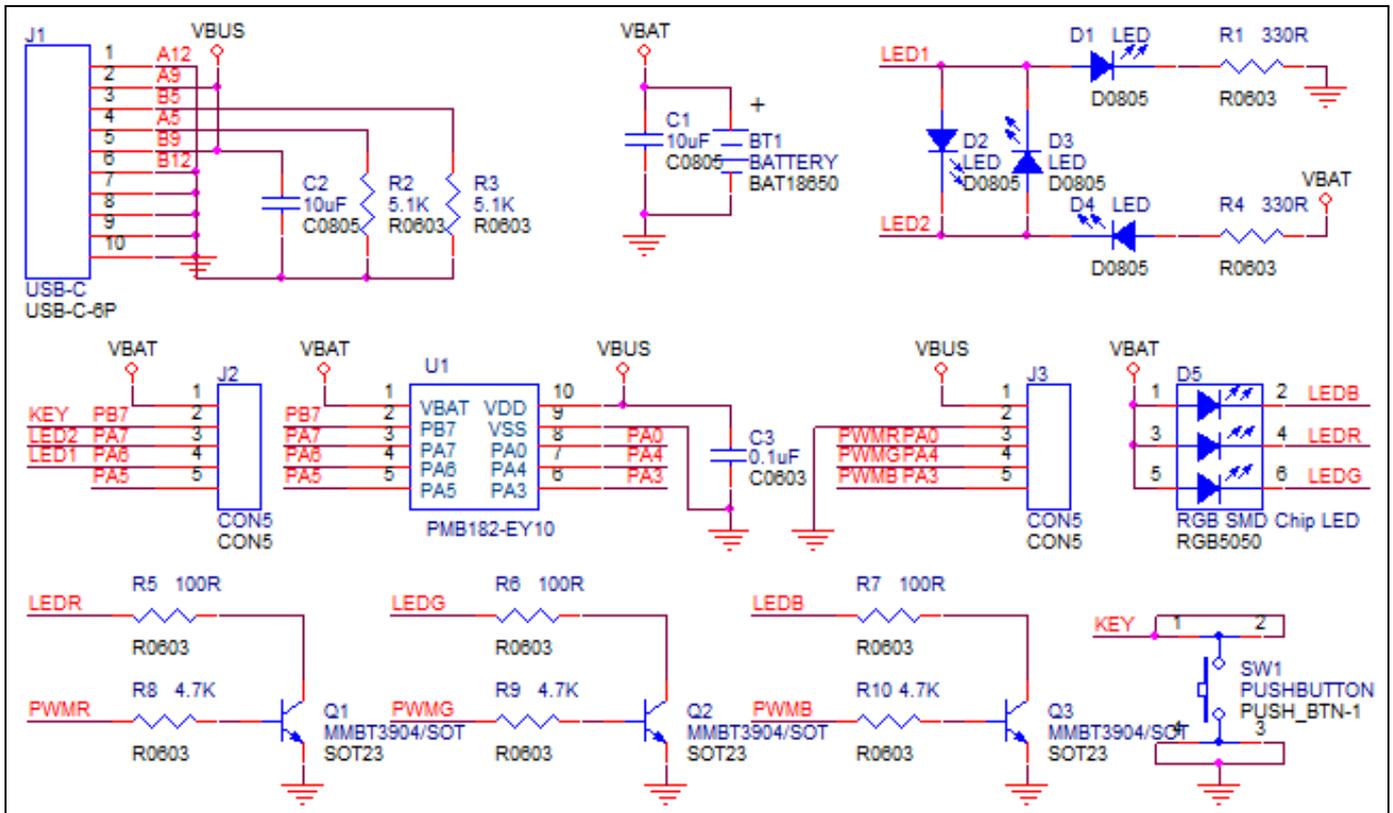


Fig.26: Schematic Diagram of Light Control with Li-Ion Charge

9.4. Program Countermeasures for Lithium Ion Battery Power-Up and Jitter Interference

During the manufacturing process of PMB182(B) application boards, there is often a need to connect the Li-ion battery electrode pads with the application boards through spot welding process. This will cause the power supply on the application board to be unstable, resulting in jittery interference in the PMB182(B) power-up waveform. This process may last for tens to hundreds of milliseconds, which is a harsh challenge for the chip to power on and off, and may cause the chip to crash, the program to run away, abnormal functions, and system parameters to be messed up...and so on. To address this situation, the following settings can be used in the program to enhance the stability of the PMB182(B) IC during power-on and power jitter.

(1) CodeOption setting:

- CodeOption Boot speed selection Slow. (If the chip has support for this function)

(2) The power-up program prioritizes the IO output low and delay settings before .Adjust_IC:

- The power-on startup program executes IO output low with ILRC priority (before .Adjust_IC).
- After IO output low, execute delay with ILRC system frequency (before .Adjust_IC).
- Add x_first to the parameters of .Adjust_IC.
- It is recommended to power on with a delay of 100ms ~ 200ms before entering Stopexe Mode.

(3) System frequency:

- It is recommended to keep the system frequency for ILRC operation after the IC is powered on and turned on until it enters the Stopexe / Stopsys mode.
- It is recommended to switch the system frequency to high frequency operation only after Stopexe / Stopsys wake up.
- It is recommended to set the system clock frequency below 1MHz (inclusive) to improve stability.
- It is recommended that the ILRC can always be enabled, so that it can be switched directly when switching from high frequency to low frequency.
- When switching the system main frequency from ILRC to IHRC, it is necessary to enable IHRC first and wait for the running time of two or more instructions before switching. Avoid doing Enable IHRC and switching frequency in one line of instruction.

```
//-----
// Macro Name: PowerOn_Delay
// Parameter: none
//
//-----
byte pndt;
PowerOn_Delay macro      // delay 2048 ILRC period = 20.48ms
    PA = 0x00;
```

```

    PAC = 0xFF;          // change to Output Mode
    pndt = 0xFF;
    do
    {
        nop; nop; nop; nop; nop; }
    while(pndt--);
    PAC = 0x00;          // change to Output Mode
endm

void FPPA0 (void)
{
    #if _SYS(AT_EV)
        $ MISC WDT_64K;                // 64K*ILRC = 640ms
    #endif
    PowerOn_Delay //delay 20ms
    .ADJUST_IC     SYSCLK=ILRC (IHRC/16), IHRC=16MHz, VDD=4.2V, O_WDRST, X_FIRST;
    .wdreset;
    .delay 7000    // delay 70ms for VDD = 5V
//---- ReLoad_All_Param
    ReLoad_IHRC                //Reload IHRCR Parameter
    ReLoad_ChargerCURTRIM     //Reload Charger Current Trim Bits
    ReLoad_VbatBGTRIM         //Reload Charger Vbat Trim Bits
    $ MISC WDT_64K;            // 64K*ILRC = 640ms
    .wdreset;
    $ CLKMD IHRC/16, En_IHRC, En_ILRC, En_WatchDog;

    while(1)
    {
        .delay 10000;
        $ PA.6 Out, High;
        .delay 10000;
        $ PA.6 Out, Low;
    }
}

```

(4) Watchdog:

- Keeps the watchdog as Enable and does not turn off the watchdog. .Adjust_IC's parameter plus **O_WDTRST**.
- The watchdog does not need to be turned off when entering Sleep Stopexe Mode, the chip hardware will automatically turn off the watchdog and re-enable the watchdog after wakeup, and the watchdog counter will be cleared as well.
- It is recommended that the execution cycle of the watchdog clear instruction is not too intensive. It is recommended to execute it once in the main program.
- If interrupts are used, it is not recommended to add the watchdog clear instruction in the interrupt program.
- When switching the system frequency, it is necessary to pay attention to keep the watchdog on to avoid shutting down the watchdog by mistake.
- It is recommended to set the watchdog time to 64K ILRC, which is about 640ms. considering the frequency drift error of ILRC, it is recommended to clear the watchdog period with a time error of 320ms ~ 1280ms.

(5) Stopexe/Stopsys Wakeup

- It is recommended that the **ReLoad_IHRC / ReLoad_ChargerCURTRIM / ReLoad_VbatBGTRIM** macros can be executed after stopexe/Stopsys wake up to rewrite the system calibration parameter registers once again.