AXP192

Enhanced single Cell Li-Battery and Power System Management IC

Revision History

Revision	Date	Description
V1.0	Jun.08,2010	Initial Release Version
V1.1	Mar.20,2015	Change the format of the document

Declaration

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Catalogue

1. Summary

The AXP192 provides an easy to use, fully integrated, ultra-flexible power solution for single cell Li-Ion/Li-Polymer battery and multiple-power applications.

AXP192 contains an USB-Compatible charger, 3 Buck DC-DC converter, 4 low dropout linear regulator, voltage / current / temperature monitor and multi channel 12-Bit ADC. To ensure power system work stably, AXP192 also contains self-protection circuits such as OVP , UVP, OTP and OCP .

The "Intelligent Power Select"(IPS)™ circuit of AXP192 distributes power safely and transparently between the USB, external AC adapter, Li-Battery and the application system. It also allows the application system work without battery or discharged battery.

AXP192 has three input source, including external adapter, USB VBUS input and battery. It also supports use of the rechargeable backup battery.

AXP192 provides TWSI(Two Wire Serial Interface) to communicate with the application processor. Through the interface, processor can enable or disable the outputs, and set the output voltage, as well as get the power status and "fuel gauge" data, High-precision ADC makes it convenient for consumer real-time control and know the system power dissipation, which brings them wonderful experience of device electricity usage that never had before.

AXP192 is available in a 48-pin 6mm x 6mm QFN package.

Applications

- Handhold mobile devices
  Smart cell phone, PMP/MP4, digital camera, handhold navigation devices GPS, PDA, digital broadcast TV receiver
- MID(Mobile internet device)
- Digital photo Frame，portable DVD player, UMPC, and UMPC-like ，Learning machine
- Application Processor systems
- Other battery and multi-power applications

Pin Description
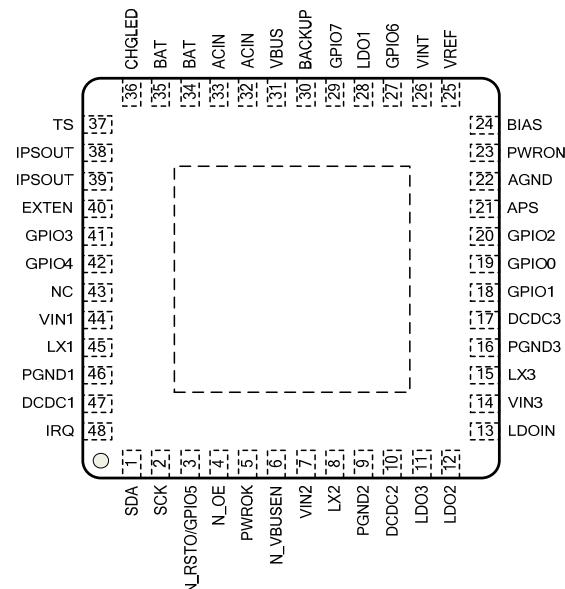
2. Feature

- **Battery Management**
  - Operation Voltage:
    2.9V~6.3V (AMR：-0.3V~11V)
  - Configurable Intelligent Power Select system
  - Current and voltage limit of adaptive USB or AC adapter input
  - The resistance of internal ideal diode lower than 100mΩ
- **Full-integrated Charger**
  - 1.4A charge current with built-in MOSFET
  - Battery temperature monitor
  - USB-Compatible charger
  - High precision as 0.5%
  - support 4.1V/4.15V/4.2V/4.36V battery
  - Charging process control automatically
  - LED driver to indication the charging status
  - Auto adjust the charging current according to the system load
- **Backup Battery**
  - Provide power to RTC module by using the backup battery
  - Integrated an backup battery charger
- **3 Synchronous Step-Down Converters**
  - DC-DC1: can be adjusted between 0.7V~3.5V 25mV/step, 1.2A drive capability
  - DC-DC2: can be adjusted between 0.7V~2.275V 25mV/step, 1.6A drive capability, support VRC
  - DC-DC3: can be adjusted between 0.7V~3.5V 25mV/step, 0.7A drive capability
- **4 LDO's**
  - LDO1:30mA,always on
  - LDO2:low noise LDO, can be adjusted between 1.8V~3.3V,100mV/step, 200mA drive capability
  - LDO3:low noise LDO, can be adjusted between 1.8V~3.3V,100mV/step, 200mA drive capability
  - LDOIO0: low noise LDO, can be adjusted between 1.8V~3.3V,100mV/step, 50mA drive capability

  NOTE: VRC，Voltage Ramp Control

- **Signal Capture**
  - built-in 16 channel 12 Bit ADC
  - 4 external input channels
  - Built-in high precision coulomb counter and fuel-gauge system
  - Wealthily power information，such as the real-time power dissipation (mA or mW)，remaining battery status(% or mAh)，and remaining battery or charging time
  - Low power warning and protection
  - Provide temperature information of chip
- **Host Interface**
  - Host can exchange data with processor by TWSI
  - Flexibility to configure the interrupt management
  - Multi-function GPIO can be set to IO,PWM and other function
  - Built-in timer
  - Four registers can be used to save the data when system shutdown
- **System Management**
  - Soft reset or hardware reset
  - Support soft shutdown or hardware shutdown, and external wakeup
  - Monitoring output voltage, self-diagnostic function
  - PWROK is used for system reset
  - External power source detect (insert/remove/lack of driving capacity)
  - Soft start
  - Over voltage protection /under voltage protection (OVP/UVP)
  - Over current protection (OCP)
  - Over temperature protection (OTP)
  - Support OTG VBUS power state setting/monitoring
- **Fully Integration**
  - High-accuracy internal Reference Voltage（0.5%）
  - Built-in MOSFET

3. Typical Application

GND
10K 1%
37 TS
Li BAT
C1 10uF
34 BAT
35 BAT
IPSOUT
38 IPSOUT
39 IPSOUT
10uF C2
C3 0.22u
GND GND
Adapter
33 ACIN
32 ACIN
2.2ohm
4.7uF C6
31
GND
VBUS
VBUS
2.2ohm
41 GPIO3
4.7uF C6
42 GPIO4
GND
43 NC
IPSOUT 470ohm
36 CHGLED
30 BACKUP
GND
26 VINT
1uF
AGND C6
24 BIAS
200K
IPSOUT 22 Ohm
0.22u C7
AGND
10uF C8
21 APS
AGND
25 VREF
1u
AGND
22 AGND
C9
GND 0 Ohm
4.7uF
19 GPIO0/LDOio0
C10
18 GPIO1
20 GPIO2
GND Power On/Off
23 PWRON

GND
4 N_OE
IPSOUT
6 N_VBUSEN
48 WAKEUP/IRQ
VCCIO
2 SCK
2.2k
1 SDA
2.2k
51k

LDO1 NC/51k

AXP192

DCDC1
47 DCDC1
C11 1nF GND
45 LX1
2.2uH
C12 10uF
44 VIN1 IPSOUT GND
4.7u C13
46 PGND1

DCDC2
10 DCDC2
10uF GND
C14
8 LX2
4.7uH
C15 1nF
7 VIN2 IPSOUT 10u GND
C16
9 PGND2

DCDC3
17 DCDC3
C17 1nF GND
15 LX3
4.7uH
C18 10uF
16 PGND3
14 VIN3 IPSOUT C19 2.2uF GND
1 Ohm
13 LDOIN GND
10uF C20
28 LDO1 LDO1
C21 1uF GND
12 LDO2 LDO2
C22 4.7uF
EXTEN
40 EXTEN
C23 1uF GND
GND
49 EP GND
11 LDO3 LDO3
4.7uF C24
GND
5 PWROK/N_LBO
3 N_RSTO
27 PWREN
29 SYSEN

HOST
SDA
SCK
EXT_WAKEUP
DRVVBUS
SYSEN 10k LDO1
PWREN 10k LDO1
N_RSTI 10k LDO1
RESET 10k VCCIO
Reset GND

In On/off Manner A,5/48PIN pull high to IO power,29PIN pull high to LDO1,27PIN connect to LDO1 or HOST control signal
In On/off Manner B,5/48PIN pull high to LDO1,27/29PIN connect to HOST control signal

4. Absolute Maximum Ratings

Symbol	Description	Value	Units
ACIN	Input Voltage	-0.3 to 11	V
VBUS	Input Voltage	-0.3 to 11	V
T_J	Operating Temperature Range	-40 to 130	℃
Ts	Storage Temperature Range	-40 to 150	℃
T_{LEAD}	Maximum Soldering Temperature (at leads，10sec)	300	℃
V_{ESD}	Maximum ESD stress voltage，Human Mode	>4000	V
P_D	Internal Power Dissipation	2100	mW

5. Electrical Characteristics

V_{IN} =5V， BAT=3.8V， T_A= 25℃

SYMBOL	DESCRIPTION	CONDITIONS	MIN	TYP	MAX	UNITS
ACIN						
V_{IN}	ACIN Input Voltage		3.8		6.3	V
I_{OUT}	V_{OUT} Current Available Before Loading BAT	500mV Voltage Drop		2000		mA
V_{UVLO}	ACIN Under Voltage Lockout			3.8		V
V_{OUT}	IPS Output Voltage		2.9		5.0	V
R_{ACIN}	Internal Ideal Diode On Resistance	PIN to PIN, ACIN to IPSOUT			200	mΩ
VBUS						
V_{IN}	VBUS Input Voltage		3.8		6.3	V
I_{OUT}	V_{OUT} Current Available Before Loading BAT	400mV Voltage Drop		500	900	mA
V_{UVLO}	VBUS Under Voltage Lockout			3.8		V
V_{OUT}	IPS Output Voltage		2.9		5.0	V
R_{VBUS}	Internal Ideal Diode On Resistance	PIN to PIN, VBUS to IPSOUT			300	mΩ
Battery Charger						
V_{TRGT}	BAT Charge Target Voltage		-0.5%	4.2	+0.5%	V
I_{CHRG}	Charge Current			780	1320	mA
I_{TRKL}	Trickle Charge Current			10%		I_{CHRG} mA
V_{TRKL}	Trickle Charge Threshold Voltage			3.0		V
ΔV_{RECHG}	Recharge Battery Threshold Voltage	Threshold Voltage Relative to V_{TARGET}		-100		mV

T_{TIMER1}	Charger Safety Timer Termination Time	Trickle Mode		40		Min
T_{TIMER2}	Charger Safety Timer Termination Time	CC Mode		480		Min
I_{END}	End of Charge Indication Current Ratio	CV Mode		10%	15%	I_{CHRG} mA
Backup Battery						
V_{TRGT}	Backup Battery Charge Target Voltage		2.5	3.0	3.1	V
I_{CHRG}	Backup Battery Charge Current		50	200	400	uA
I_{Backup}	Current when use Backup Battery			10	15	uA
NTC						
V_{TL}	Cold Temperature Fault Threshold Voltage	Charge	0	2.112	3.264	V
		Discharge		3.226		
V_{TH}	Hot Temperature Fault Threshold Voltage	Charge	0	0.397	3.264	V
		Discharge		0.282		
V_{TE}	NTC Disable Threshold Voltage	Falling Threshold Hysteresis		0.2		V
Ideal Diode						
$R_{ds(on)}$	Internal Ideal Diode On Resistance(BAT to IPSOUT)				100	mΩ

SYMBOL	DESCRIPTION	CONDITIONS	MIN	TYP	MAX	UNITS
Off Mode Current						
I_{BATOFF}	OFF Mode Current	BAT=3.8V		27		μA
$I_{SUSPEND}$	USB VBUS suspend Mode current	BAT=3.8V, VBUS=5V, N_VBUSEN=1		86		μA
Logic						
V_{IL}	Logic Low Input Voltage			0.3		V
V_{IH}	Logic High Input Voltage			2		V
TWSI						
V_{CC}	Input Supply Voltage			3.3		V
ADDRESS	TWSI Address			0x68		
f_{SCK}	Clock Operating Frequency			400	1200	kHZ
t_f	Clock Data Fall Time	2.2Kohm Pull High		60		ns
t_r	Clock Data Rise Time	2.2Kohm Pull High		100		ns
DCDC						
f_{OSC}	Oscillator Frequency	Default		1.5		MHz
DCDC1						

I_{VIN1}	Input Current	PFM Mode I_{DC1OUT} =0		26		µA
I_{LIM1}	PMOS Switch Current Limit	PWM Mode		1600		mA
I_{DC1OUT}	Available Output Current	PWM Mode		1200		mA
V_{DC1OUT}	Output Voltage	Default	0.7	3.3	3.5	V
DCDC2						
I_{VIN2}	Input Current	PFM Mode I_{DC2OUT} =0		20		µA
I_{LIM2}	PMOS Switch Current Limit	PWM Mode		2300		mA
I_{DC2OUT}	Available Output Current	PWM Mode		1600		mA
V_{DC2OUT}	Output Voltage Range		0.7	1.25	2.275	V
DCDC3						
I_{VIN3}	Input Current	PFM Mode I_{DC3OUT} =0		20		uA
I_{LIM3}	PMOS Switch Current Limit	PWM Mode		1000		mA
I_{DC3OUT}	Available Output Current	PWM Mode		700		mA
V_{DC3OUT}	Output Voltage Range		0.7	2.5	3.5	V

SYMBOL	DESCRIPTION	CONDITIONS	MIN	TYP	MAX	UNITS
LDO1						
V_{LDO1}	Output Voltage	I_{LDO1}=1mA	-1%	1.25 1.8 2.5 3.3	1%	V
I_{LDO1}	Output Current			30		mA
LDO2						
V_{LDO2}	Output Voltage	I_{LDO2}=1mA	-1%	3	1%	V
I_{LDO2}	Output Current			200		mA
I_Q	Quiescent Current			100		µA
PSRR	Power Supply Rejection Ratio	I_{LDO2}=60mA，1KHz		TBD		dB
e_N	Output Noise,20-80KHz	Vo=3V , Io=150mA		28		µV$_{RMS}$
LDO3						
V_{LDO3}	Output Voltage	I_{LDO3}=1mA	-1%	3.3	1%	V
I_{LDO3}	Output Current			200		mA
I_Q	Quiescent Current			100		µA
PSRR	Power Supply Rejection Ratio	I_{LDO3}=10mA，1KHz		TBD		dB
e_N	Output Noise,20-80KHz	Vo=1.8V , Io=150mA		18		µV$_{RMS}$
LDO$_{IO0}$						
V_{LDOIO0}	Output Voltage	I_{LDOIO0}=1mA	-1%	3.3	1%	V
I_{LDOIO0}	Output Current			50		mA
I_Q	Quiescent Current			90		µA

PSRR	Power Supply Rejection Ratio	I_{LDOIO0}=10mA，1KHz		TBD		dB
e_N	Output Noise,20-80KHz	Vo=1.8V, Io=30mA		18		μV_{RMS}

6. Typical Characteristics

DC-DC   Efficiency   vs.   Load(3.8Vin)

DC-DC   Load   Transient(Typical)

DC-DC Ripple

V$_{REF}$ vs Temperature

V$_{TRGT}$ vs Temperature

Bat Vtrgt vs Temp
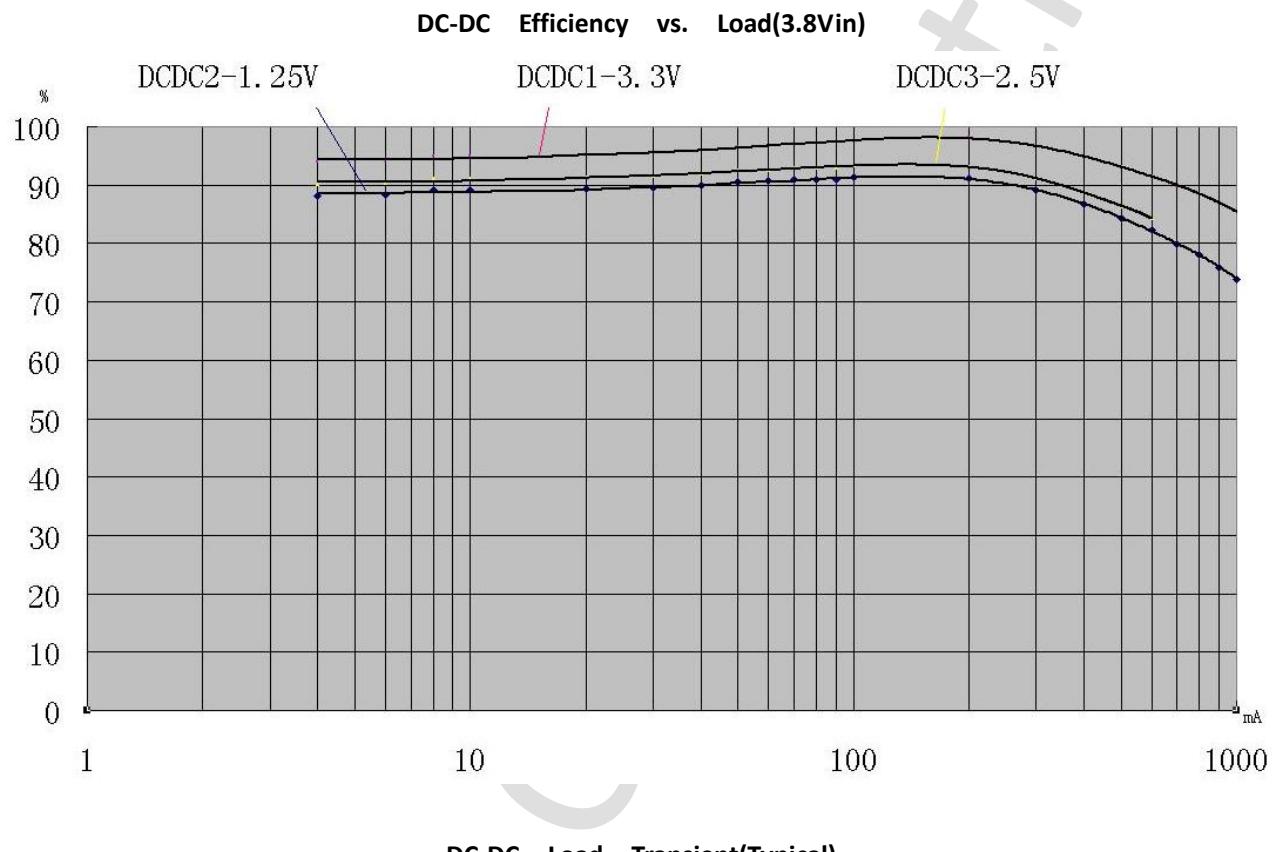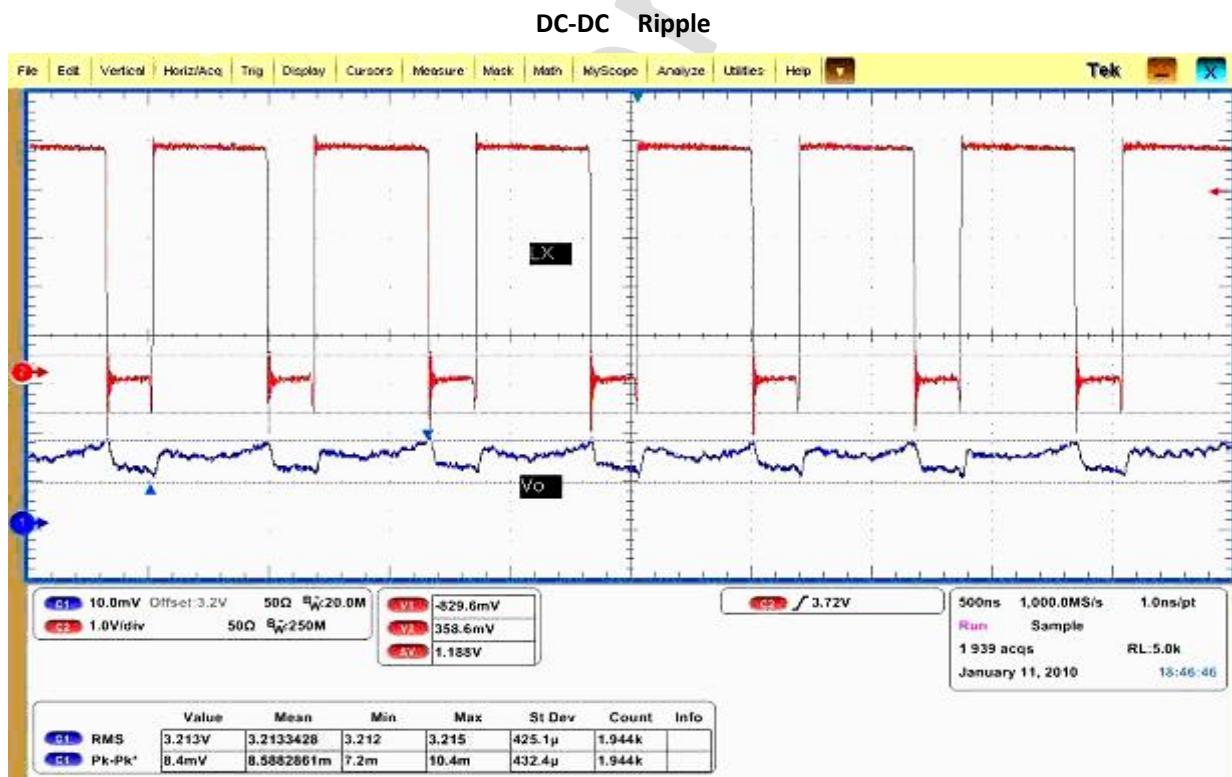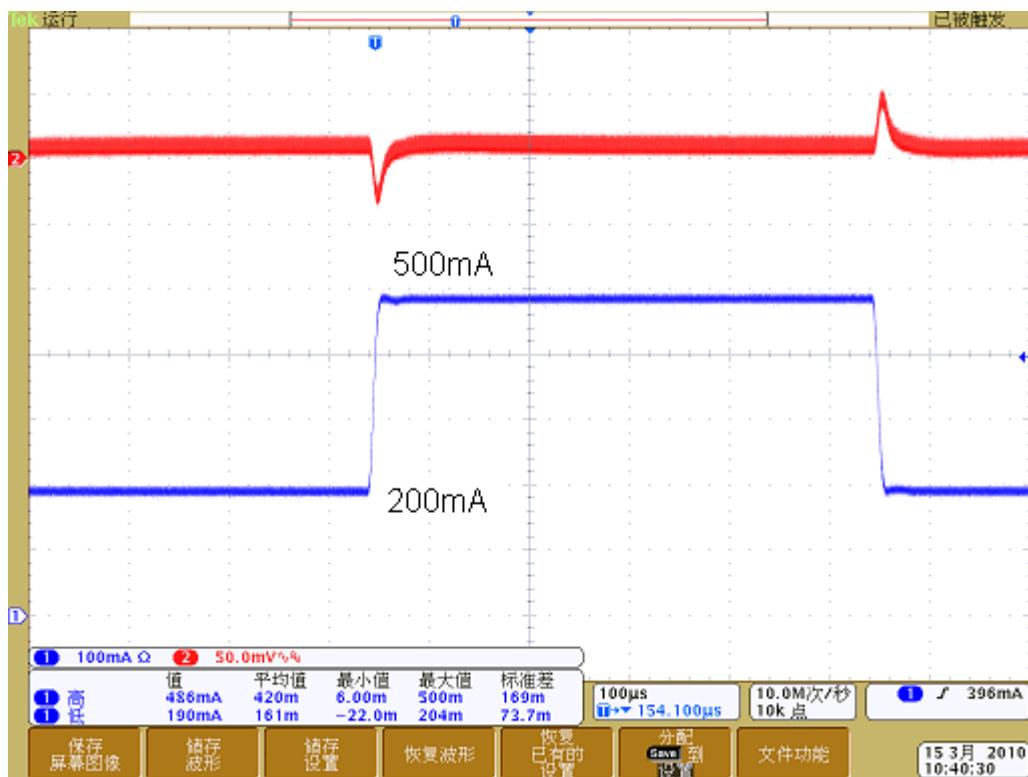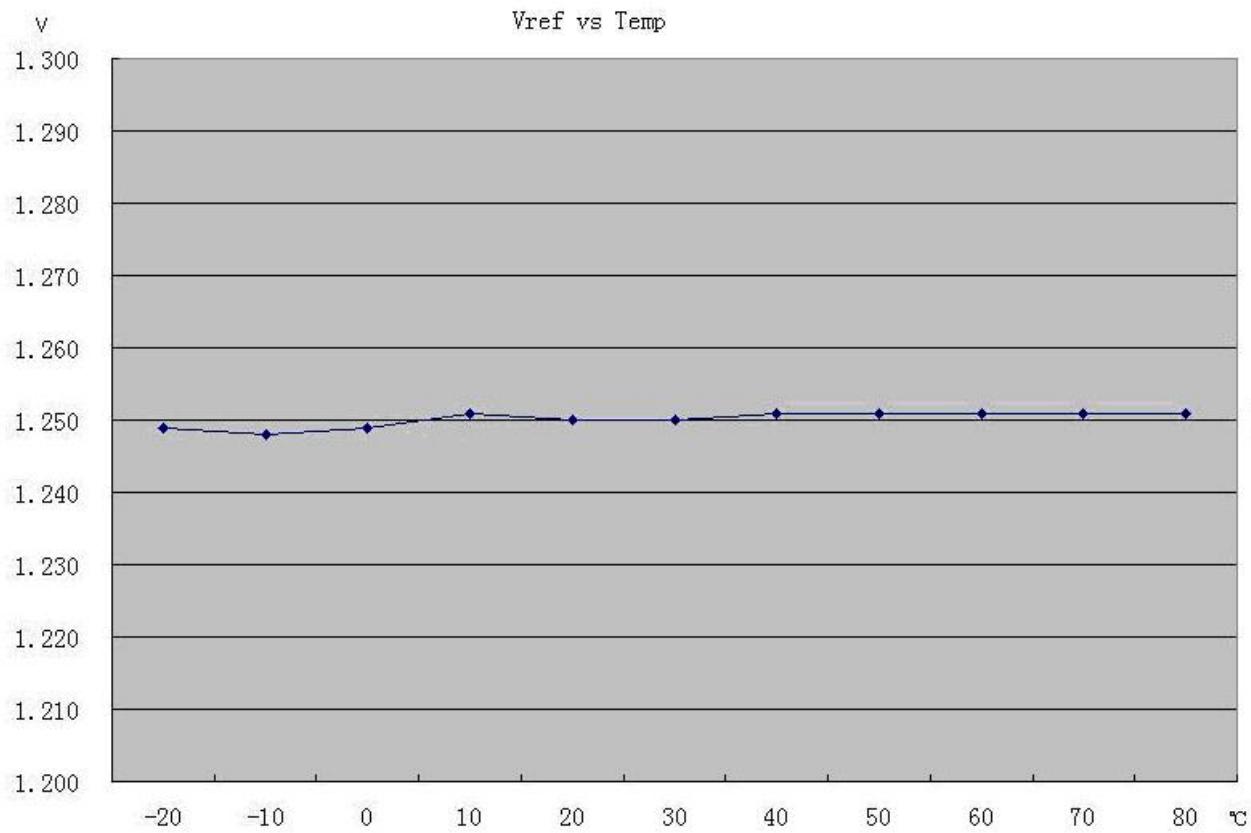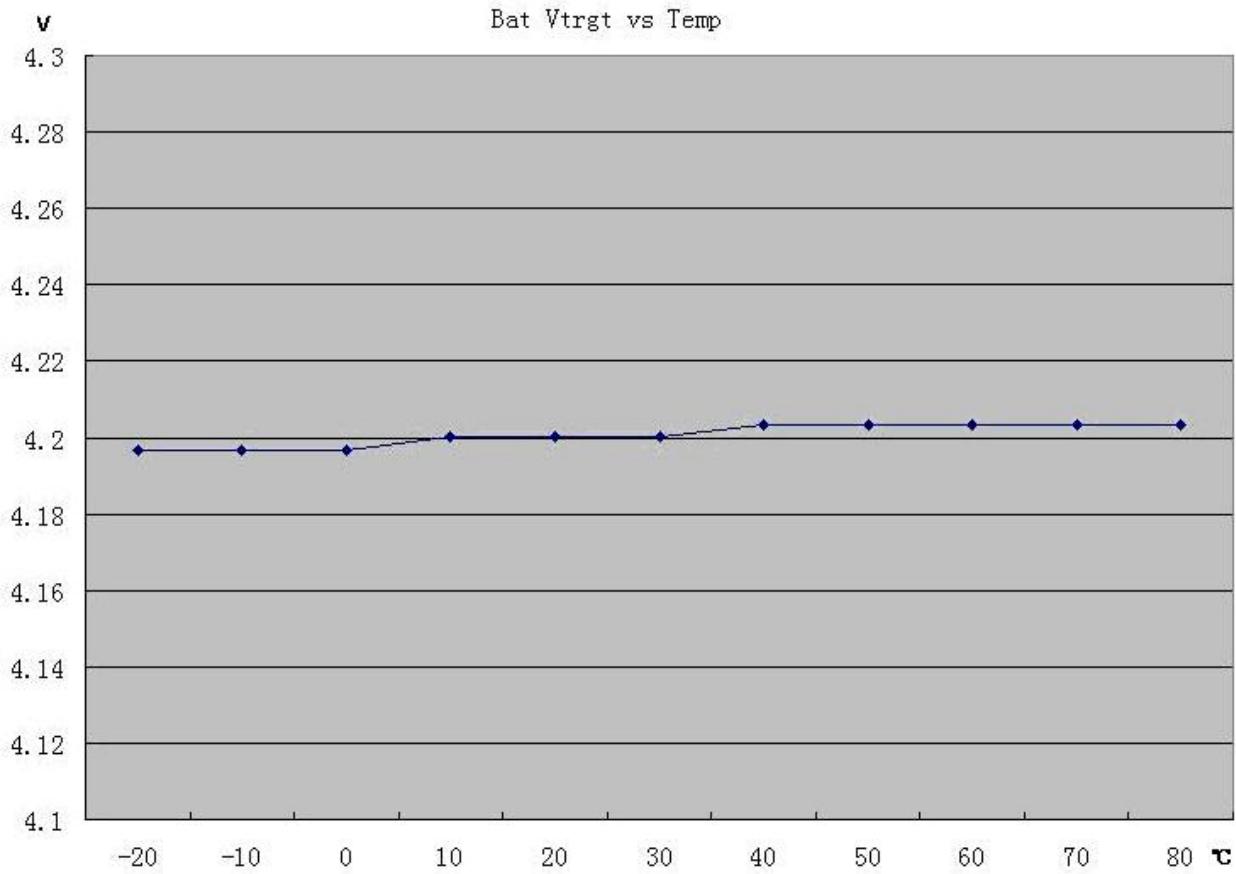
Off Mode Current vs V_{BAT}

Vbat Off Mode Current
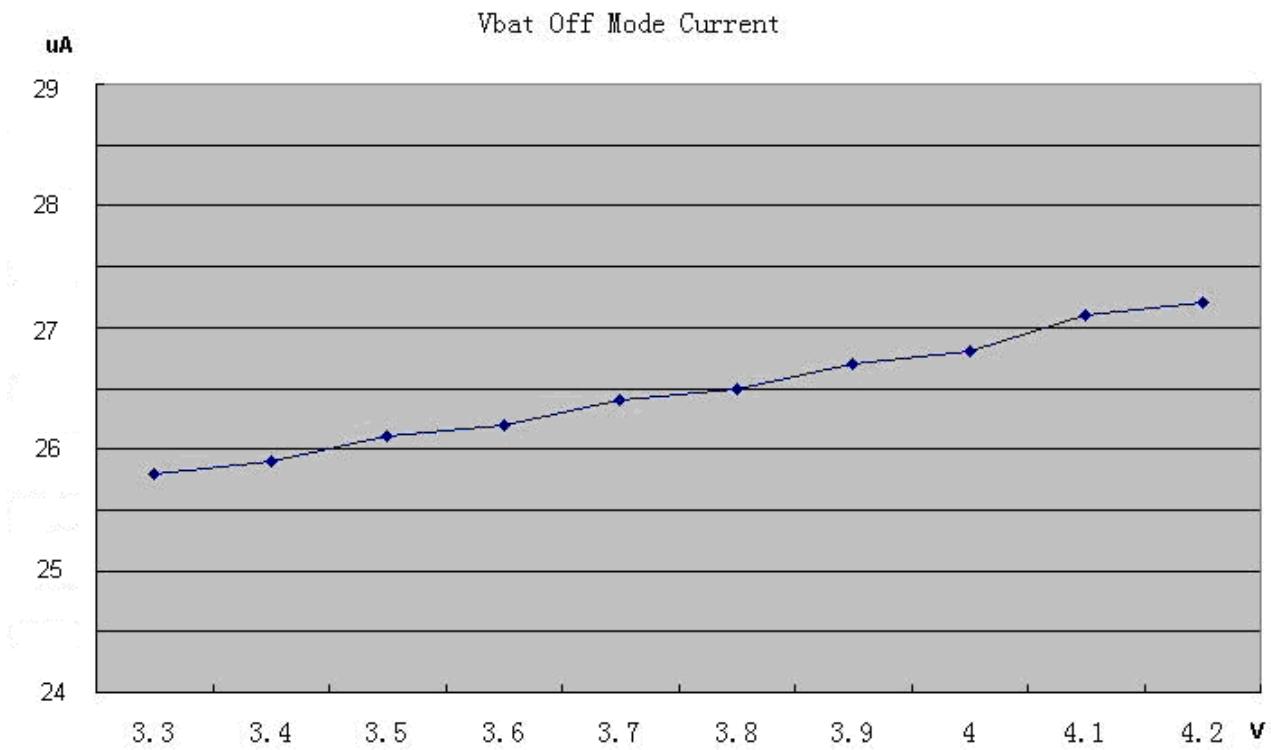
7. Pin Description

Num	Name	Type	Condition	Function Description
1	SDA	IO		Data pin for serial interface, normally it connect a 2.2K resistor to 3.3V I/O power
2	SCK	I		It is the Clock pin for serial interface, normally it connect a 2.2K resistor to 3.3V I/O power
3	N_RSTO	IO	REG9EH[7]	LDO1 Reset output
				GPIO[5]
4	N_OE	I		Power output on/off switch
				GND: on； IPSOUT: off
5	PWROK/ N_LBO	O	SYSEN=LDO1	Power good indication
				Low power detect output
6	N_VBUSEN	I		VBUS to IPSOUT Selection
				GND: IPSOUT select VBUS
				High: IPSOUT do not select VBUS
7	VIN2	PI		DCDC2 input source
8	LX2	IO		Inductor Pin for DCDC2
9	PGND2	G		NMOS Ground for DCDC2
10	DCDC2	I		DC-DC2 feedback pin
11	LDO3	O		Output Pin of LDO3
12	LDO2	O		Output Pin of LDO2
13	LDOIN	PI		Input to LDO2 and LDO3
14	VIN3	PI		DCDC3 input source
15	LX3	IO		Inductor Pin for DCDC3
16	PGND3	G		NMOS GND for DCDC3
17	DCDC3	I		Feed back to DCDC3
18	GPIO1	IO	REG 93H[2:0]	GPIO 2
				PWM 2
				ADC Input
19	GPIO0	IO	REG 90H[2:0]	GPIO 0
				Low noise LDO
				ADC Input
20	GPIO2	IO	REG 92H[2:0]	GPIO 1
				PWM 1
				ADC Input
21	APS	PI		Internal Power Input
22	AGND	G		Analog Ground

23	PWRON	I		Power On-Off key input，Internal 100k pull high to APS
24	BIAS	IO		External 200Kohm 1% resistor
25	VREF	O		Internal reference voltage
26	VINT	PO		Internal logic power, 2.5V
27	PWREN	IO		It is the Low-voltage Power domain enable signal
28	LDO1	O		LDO1 output，for Host RTC block
29	SYSEN	IO		It is the High-voltage Power domain enable signal
30	BACKUP	IO		Backup battery pin
31	VBUS	PI		USB VBUS input
32,33	ACIN	PI		Adapter input
34,35	BAT	IO		Main Battery
36	CHGLED	O		charger status indication
37	TS	I		Battery Temperature sensor input or an external ADC input
38,39	IPSOUT	PO		System power source
40	EXTEN	O		External power module Enable
41	GPIO3	I	REG95H[7]	GPIO3
42	GPIO4	I		GPIO4
43	NC	O		NC
44	VIN1	PI		DCDC1 input source
45	LX1	IO		Inductor Pin for DCDC1
46	PGND1	G		NMOS Ground for DCDC1
47	DCDC1	I		DCDC1 feedback pin
48	IRQ/WAKEUP	IO		IRQ output or wakeup
49	EP	G		Exposed Pad, need to connect to system ground

8. Functional Block Diagram
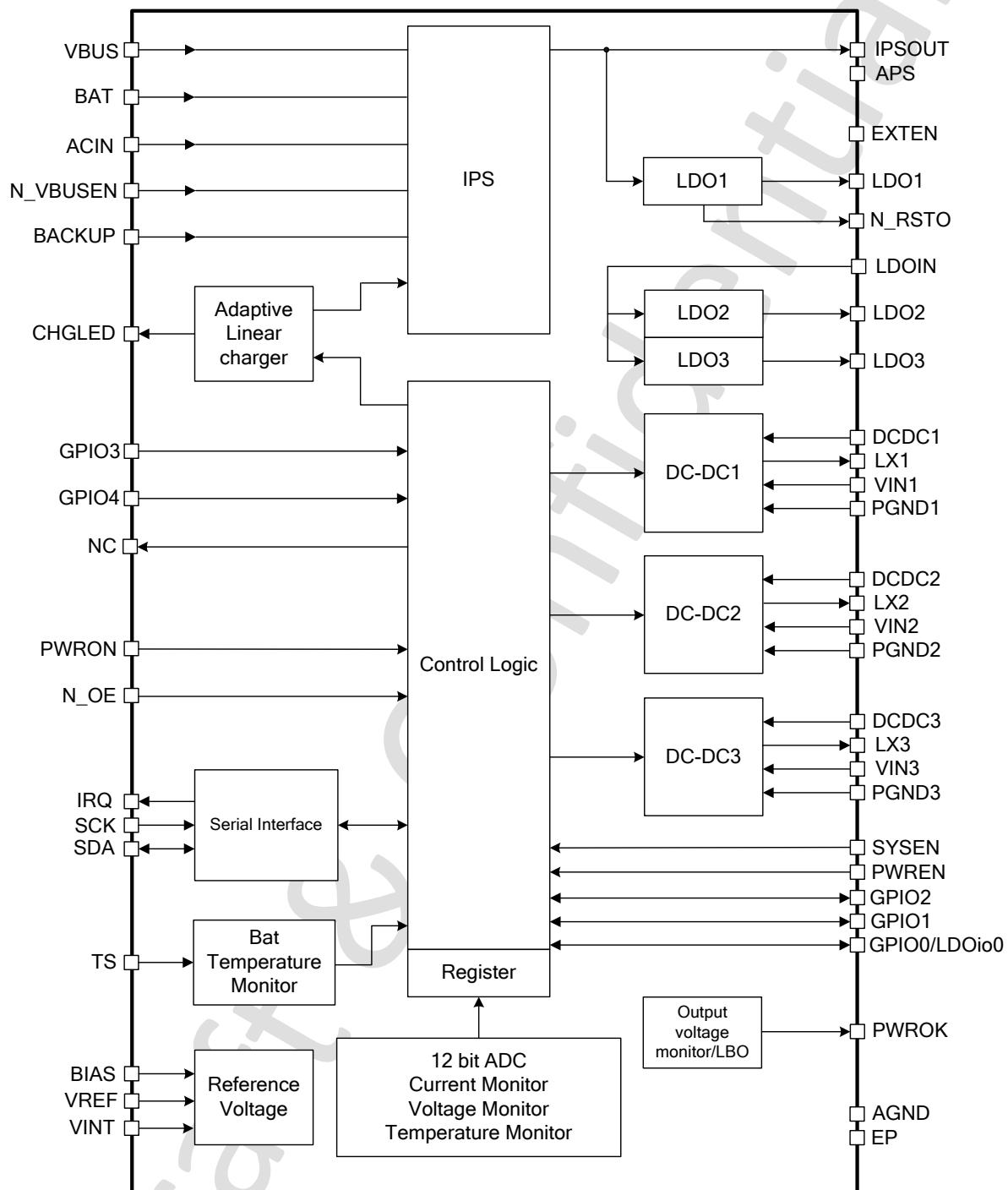
9. Control and Operating

When AXP192 is working, the TWSI interface, SCK/SDA pin is pulled up to the system IO power, the Host can adjust and monitor the status of AXP192 through this interface.

Note: "Host" refers to the processor of the application system

Note: The following "external power" contains the input of ACIN and VBUS

9.1. On/Off and Reset

PEK

A key can be connected between the pin PWRON and GND, which act as an independent switch key, called Power Enable Key (PEK). AXP192 can automatically identify that either the key-press is "long press" or "short press" and make the appropriate response.

Power on trigger Source

1.ACIN, VBUS and the battery access.

2.N_OE changed from high to low.

3.PEK.

Power On

When N_OE from high to low and the main power (ACIN or VBUS> 3.8V, the battery voltage is higher than the shutdown voltage) exist , AXP192 will automatically power on (whether automatically start up or not when the external power is supplied can be set according to external demand).

When N_OE is low and AXP192 is turned off, the PEK will result in the power on actions.

AXP192 can be started up by PEK (the time of pushing the key must be more than "ONLEVEL") . In practice, the timer (Alarm) timeout signal of the system can be connected to PWRON-and be parallel with PEK, low level signals is the equivalent of PEK press, also can cause AXP192 to be started up.

DC-DC and LDO will be soft started in order.

Power Off

When the time of PEK "long-press" longer than IRQLEVEL , through the interrupt service program in PEK, Host can write "1" to the "register REG32H [7]" to inform AXP192 to shutdown, it will turn off all the output except LDO1.

In the following cases, AXP192 will automatically shut down:

1, the input voltage is too low, low power protection;

2, the output voltage too low, overload protection;

3, the input voltage is too high, over-voltage protection (details in the "power-path management" section);

4, N_OE changed from low to high, but AXP192 is not shutdown during the pre-define time;

5, when PEK is longer than OFFLEVEL (default 6S) ,the system automatically disable all output except LDO1;

The mechanism of AXP192 automatic protection, can avoid un-recovery damage to the device when application exception occurs to protect the entire system.

PWROK

The PWROK of AXP192 can be used as the reset signal of the application system. During startup time, PWROK is low, after the output voltage of all channels stability, PWROK will be pulled up in order to assert a power-on reset to the system.

During the application system work as normal, AXP192 monitors the output voltage and load all the time, if in the overload or under voltage situation, PWROK immediately changes to be low, resets application system and then power off to protect the system.

9.2. IPS

AXP192's power input can come from lithium battery BAT, USB VBUS input, external power supply ACIN (such as AC adapter), according to the status of the external power and lithium battery, IPS selects the appropriate source.

- o   only lithium battery exist and no external power input, use lithium battery power to supply;
- o   access to an external power source (VBUS or ACIN), use external power to supply in priority;
- o   the battery is connected, when external power supply removed, immediately switch to lithium battery power supply;
- o   the VBUS and ACIN both exist, use the ACIN power in priority and charge on the lithium battery;
- o   If ACIN capability is not enough to system load and charger, it will open the VBUS path to achieve ACIN / VBUS work together;
- o   If the drive capacity is still insufficient, it will reduce the charge current until 0, and then switch on the battery path to work together.

See the following diagram:
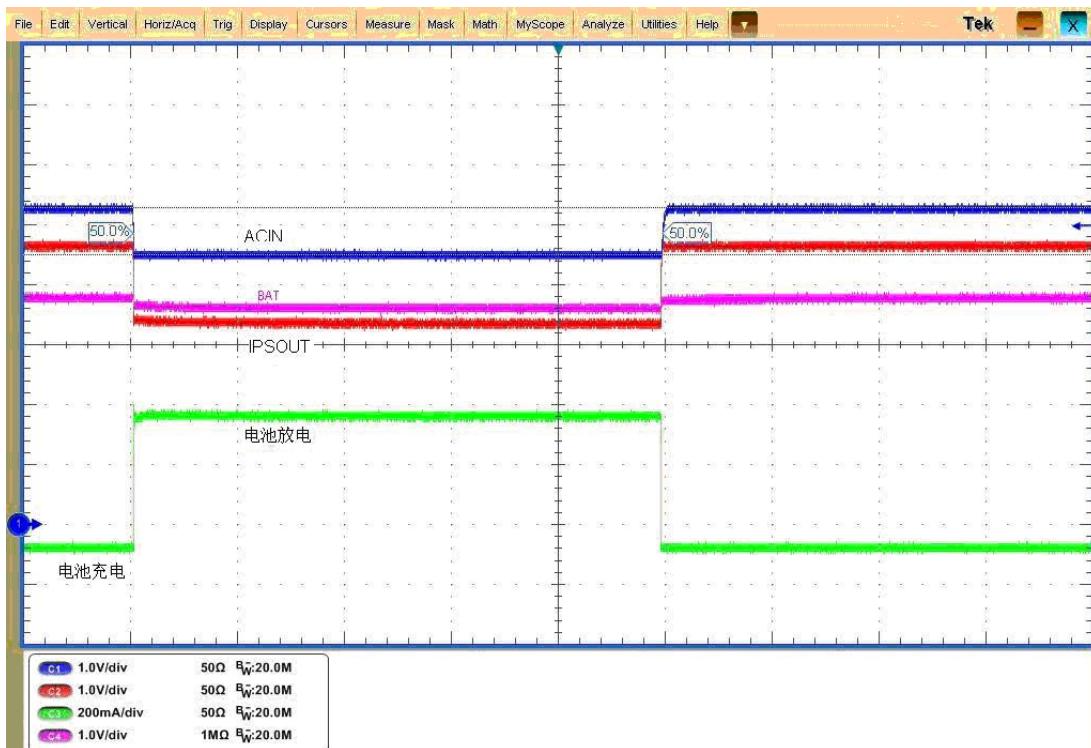
As shown , when ACIN load capacity is insufficient, IPSOUT voltage drops, BAT will been change it status from being charged to discharging, provides current for system load with ACIN together.

Through TWSI, Host can access AXP192 internal register to set the parameters of IPS and read the status.

Voltage / Current limit mode and direct mode

In order to avoid influencing the USB communications, VBUS default works in "VBUS voltage-limiting mode." In this mode, AXP192 will hold VBUS voltage above at a reference voltage VHOLD to meet the USB specification. VHOLD is 4.4V at default, can be adjust at register Reg30H [5:3] .

If the system has the demands to limit the current which is drawn from the USB VBUS, a current limit mode is provided(see Register REG30H [1]), the optional value is 500mA/100mA (register Reg30H [0])

If the system only uses the USB-powered and does not care USB communication, or use the USB-port power adapter, you can set AXP192 to "VBUS direct mode" through modify the register REG30H [6] , then AXP192 will give priority to meet electricity demand for applications. if the USB Host drive capacities is too weak or Power Consumption is too strong, VBUS power system voltage will be less than VHOLD, AXP192 will assert IRQ, tell the Host that VBUS power supply capacity is weak and the USB communication may be invalid, the follow-up actions can be decided by the Host software.

The reaction when the AXP192 is inserted by external power

AXP192 can automatically detect whether the external power inserted or not. After   the external power is valid, it will automatically determine whether the external power supply is available to use or not, and the results will be set in the corresponding register, at the same time assert IRQ.

Register status bits of the external power and the meaning in the following table:

REG00H[7]	Indication the existence of an external adapter power ACIN
REG00H[6]	Indication the available to use or not of the external power adapter ACIN
REG00H[5]	Indication the existence of an external power VBUS
REG00H[4]	Indication the available to use or not of an external power VBUS
REG00H[3]	When VBUS insert, whether VBUS voltage is above VHOLD or not
REG00H[1]	Whether external power ACIN / VBUS is in short the PCB or not
REG00H[0]	Whether the startup is triggered by the ACIN / VBUS or not

When Host receives IRQ7(mean VBUS is weak),together with the status REG00H[3],it will determine whether VBUS low voltage status is because of system load or VBUS is lower than V_{HOLD} at the time insert. That make the host decide the system work on voltage limit mode or change to direct mode.

Use VBUS as power supply or not

AXP192 use VBUS as power supply or not, decided by the status of N_VBUSEN and REG30H[7]:

N_VBUSEN	REG30H[7]	Power Supply	Description
Low	0	VBUS	When VBUS is available and ACIN is unavailable, use VBUS as power supply
Low	1	VBUS	When VBUS is available, can use VBUS as power supply
High	1	VBUS	
High	0	ACIN/BAT	Not use VBUS

Low power warning and low power protection (automatically power off)

AXP192 has two stage of low voltage warning and automatically power off (V_{OFF}) which is compared with APS. Once APS is lower than $V_{WARNING}$, AXP192 sends out IRQ30. If APS is lower than V_{OFF}, AXP192 gets into power off mode, disable all output except LDO1.

$V_{WARNING}$ can be set into LEVEL1/LEVEL2，when APS is lower than LEVEL2, AXP192 sends out IRQ30，after APS is higher than LEVEL1, clear this IRQ automatically.

The default value $V_{WARNING}$ and V_{OFF} is set in REG3AH、REG3BH and REG31H Bit[2:0].

Over-voltage protection

When external power supply voltage higher than 6.2V, AXP192 sends out IRQ1 or IRQ4, which means external power supply is over-voltage. If higher than 7V, AXP192 is powered off automatically.

9.3. Adaptive Charger

AXP192 has integrated a constant current/voltage charger, which can automatically control charge period, internal safety clock can stop charging without CPU. This charger can adjust charge current based on the power dissipation of the system , fuel gauge, small current charge and active mode. Internal temperature detect circuit

can decrease charge current when in over/under temperature.

Startup adaptive charge

The charge function is default enable(register disable, see "REG33H").After insert external power source, AXP192 judges whether external power source can be used for charge or not, when it's available, and charge function is enabled, AXP192 gets into charge mode automatically, and sends IRQ to Host, which indicates the charge process start. Meanwhile, CHGLED was set to low to drive external light-emitting diode indicate AXP192 is in charge mode.

Charge voltage current diagram
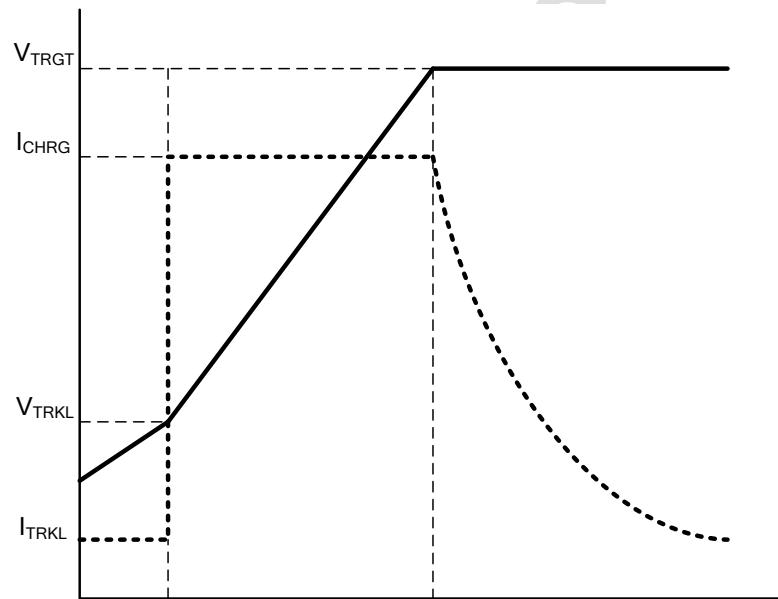
Two indicate voltage

V_{TRGT}，charge target voltage. V_{TRGT} can be set by register, 4.2V by default (see REG33H[6:5]). Meanwhile, when external power source is lower than 4.2V, AXP192 will adjust V_{TRGT} by itself.

V_{RCH}，automatic recharge voltage. $V_{RCH}=V_{TRGT}-0.1V$.

Charge current

Charge current can be set by REG33H[3:0], whose default value is 450mA or 780mA.

Charge flow

If battery voltage is lower than 3.0V, charger goes into pre-charge mode, charge current is1/10 of set value. If after 40 minutes(which can be set by REG34H), battery voltage can not reach 3.0V, the charger goes into active mode. See detail in "battery active mode".

Once battery is higher than 3.0V, charger goes into constant current mode. If charge current is lower than 65% of the set value, the system sends out IRQ17, which informs "External power source is weak, charge current

doesn't reach the target value, so the charge time will be longer, if you want to reduce the charge time, you should insert a more powerful source or disable the system load".

When the battery reaches V_{TRGT}, the charger goes into constant voltage mode from constant current mode, charge current decrease.

In constant voltage mode, When charge current is lower than 10% or 15% of the set value(which can be set by REG33H), charge period is over, AXP192 sends out IRQ13, CHGLED indicate stop status. When battery voltage is lower than V_{RCH} again, AXP192 can recharge automatically, and sends out IRQ12.

In non-pre-charge mode, if after 480 minutes(which can be set by REG34H), charge period is not over, the charger goes into battery active mode.

Battery active mode

In battery active mode (timing counter timeout), the charger sends out IRQ10, which indicate battery may be damaged.

In battery active mode, Charger use small current to charge battery all the time, if the battery voltage reaches V_{RCH}, the charger exits active mode, and sends out IRQ11.

AXP192 uses REG01H to indicate charger is in battery active mode or not.

CHGLED

CHGLED pin indicate charge mode and warning mode, it has four statuss: charge、not charge、battery abnormal warning and external power source overvoltage warning. CHGLED is NMOS Open Drain output, which   can be showed by using a current limit resistance drive a light-emitting diode and is printed in the table:

Status	Active	Description
In charge	Output low	
Not in charge	High Z	
Battery abnormal	25% duty 1Hz flip	Charger goes into battery active mode, or battery under/over temperature
Over voltage	25% duty 4Hz flip	External power supply input voltage is over

Battery temperature detect

In charge or use, AXP192 can gauge temperature though a temperature sensitive resistance connected with TS pin. The circuit is showed as follows:
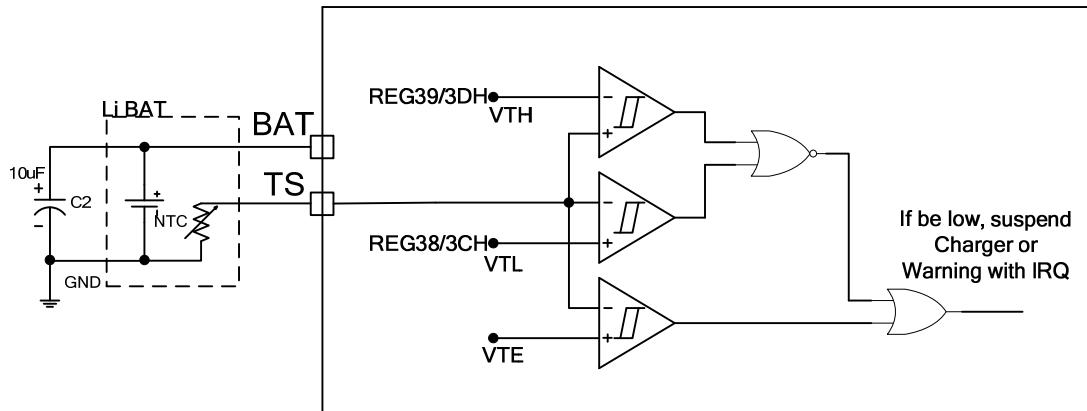
In this figure, VTH/VTL is high temperature and low temperature threshold, which are set by REG38H/39H/3CH/3DH,VTE=0.2V. Use 10Kohm on 25℃、accuracy is 1% NTC temperature sensitive resistance by suggest. AXP192 output constant current in TS pin, which can be set to 20uA、40uA、60uA or 80uA(see REG84H) according to different NTC resistance. Through the temperature sensitive resistance, we can get a voltage , AXP192 use ADC to convert voltage to digital signal, and compare with the set value, sends IRQ or pause charge.

If the battery doesn't have a temperature sensitive resistance, TS pin can be connected into ground, then AXP192 disable battery temperature detect function.

Battery detect

AXP192 can check battery is presence or not, and set in register(see REG01H) and sends out IRQ13、IRQ14.

Battery detect function can be enable or disable by Host(see REG32H).

9.4. Backup Battery

AXP192 supports backup battery use and charge. When main power supplies(BAT/ACIN/VBUS) don't exist, LDO1 input source is backup battery,   to keep part of circuits such as system real time clock.

When main power supplies exist, charge backup battery though setting REG35H[7], whose target voltage is 3.0V(which can be set by REG35H[6:5])、default charge current is 200uA(which can be set by REG35H[1:0]).

9.5. Multi-Outputs

AXP192's multi-output is showed as follows:

Output	Type	Application example	Drive ability
DCDC1	BUCK	3.3V I/O	1200 mA
DCDC2	BUCK	1.25Vcore	1600 mA
DCDC3	BUCK	2.5Vddr	700 mA
LDO1	LDO	RTC	30 mA
LDO2	LDO	Analog/FM	200 mA
LDO3	LDO	1.8V HDMI	200 mA
LDO$_{IO0}$	LDO	Vmic	50 mA

AXP192 has integrated 3 Buck DC-DC converters, 4 low dropout linear regulator, multi-startup time sequence and control mode. DC-DC switch frequency is 1.5MHz by default, which can be set by register, outside circuit use small inductance and capacitance. 3 DC-DC converters can be set to PWM mode or auto mode (that AXP192 automatically switches based on load),see "REG80H".

DC-DC1/2/3

DCDC1/3 output voltage range is 0.7-3.5V，DCDC2 output voltage range is 0.7-2.275V, which can be set by register(see "REG23H 26H 27H 29H").

DCDC1/2/3 recommend output capacitance is 10uF X7R ceramics capacitance. When output voltage is set to higher than 2.5V, 2.2uH inductance is a recommendation. But under 2.5V, 4.7uH inductance is a recommendation, whose saturation current should be greater than 50% of max load current.

Recommend inductance and capacitance is showed as follows:

Inductance		
Type	Current spec	Current internal resistance
Murata LQH55PN2R2NR0	2100mA@2.2uH	30mOhm
Murata LQH55PN4R7NR0	1400mA@4.7uH	60mOhm
Murata LQH44PN2R2MP0	2000mA@2.2uH	49mOhm
Murata LQH44PN4R7MP0	1700mA@2.2uH	80mOhm
TDK VLF5010ST-2R2M2R3	2700mA@2.2uH	41mOhm
TDK VLF5014ST-4R7M1R7	1700mA@4.7uH	98mOhm
TDK SLF6045T-4R7N2R4-3PF	2400mA@4.7uH	27mOhm
Capacitance.		
Type	Temperature characteristic	Tolerance
TDK C2012X5R0J475K	X5R/X7R	10%@4.7uF
TDK C2012X5R0J106K	X5R/X7R	10%@10uF
Murata GRM31E71A475K	X7R	10%@4.7uF
Murata GRM21E71A106K	X7R	10%@10uF
Murata GRM31E71A106K	X7R	10%@10uF

LDO1

LDO1 always on, which can supply power to real time clock of system, and its output current is 30mA.

LDO2/3

LDO2/3 low-noise LDO, which can supply power to analog circuits of application system, and its output current is 200mA。

LDO$_{IO0}$

LDO$_{IO0}$ use low-noise design also, its output current is 50mA。

Soft Start

All of DC-DC and LDO support soft start to avoid the pulse current when startup.

Self-diagnose: load control and current limit protection

All DC-DC converters and LDO's have the function of load control and current limit protection. When load current is over than its ability, output voltage will drop. When one of the 3 DC-DC output voltages is lower than 85% of the set value, AXP192 is powered off automatically. Meanwhile the system can record which power rail makes system powered off(see REG46H[5:2]),and sends out IRQ.

All DC-DC don't need Scotty diode and the feed back resistance circuit. If the application circuits don't use any DC-DC, just floating LX pin, but the VIN and PGND should connect as normal.

9.6. Default Voltage/Timing Setting

The default value of the output voltage or timing sequence can be customized as applications need.

Timing sequence: there are 8 steps, 0-7，the eighth step means that not enable as default, step 0 to 6 means the first to seventh, the time interval between ever step can be set to 1,4,16mS.

Default voltage: The DCDC/LDO default can be set from 1V to 3.3V.

9.7. Signal Capture

The multi channel 12-bit ADC of AXP192 not only measure the cell voltage but also measure the cell current and external power source voltage and current, meanwhile internally integrates with the batteries' charge-discharge coulomb-counter. According to these data, Host can calculate accurately the battery power , what's more , can get the rich batteries' information like the real-time power consumption, the remaining

battery power, the progress of charging, the remaining time to work and the remaining time to charge completely and etc.

Enable or disable ADC and sample rate can be set through registers REG82H, 83H, 84H, and the result will be put into corresponding register, referred to ADC data register class of instructions. Among that the input range of GPIO can set through the register REG85H. whether the direction of the battery current is charging or discharging indicated by register REG00H[2].

Channel	000H	STEP	FFFH
Battery Voltage	0mV	1.1mV	4.5045V
Bat discharge current	0mA	0.5mA	4.095A
Bat charge current	0mA	0.5mA	4.095A
ACIN volatge	0mV	1.7mV	6.9615V
ACIN current	0mA	0.625mA	2.5594A
VBUS voltage	0mV	1.7mV	6.9615V
VBUS current	0mA	0.375mA	1.5356A
Internal temperature	-144.7℃	0.1℃	264.8℃
APS voltage	0mV	1.4mV	5.733V
TS pin input	0mV	0.8mV	3.276V
GPIO0	0/0.7V	0.5mV	2.0475/2.7475V
GPIO1	0/0.7V	0.5mV	2.0475/2.7475V
GPIO2	0/0.7V	0.5mV	2.0475/2.7475V
GPIO[3]	0/0.7V	0.5mV	2.0475/2.7475V

9.8. Multi-Function Pin Description

GPIO[7:0]
Use as GPIO[7:0]、ADC Input（to monitor external signal）、LDO、PWM，and so on., see detail in the description of REG90H-9FH.

N_RSTO
Use as LDO1 status signal （up to LDO1）or GPIO5，see detail in the description of REG9EH.

CHGLED
Use as GPO and warning signal such as charge status、over temperature/voltage warning and so on, see detail in the description of REG32H.

9.9. Timer

AXP192 includes an internal timer, which can change the timer through setting register REG8AH[6:0] whose LSB is one Minute, reset the timer after timeout.

9.10. TWSI and IRQ
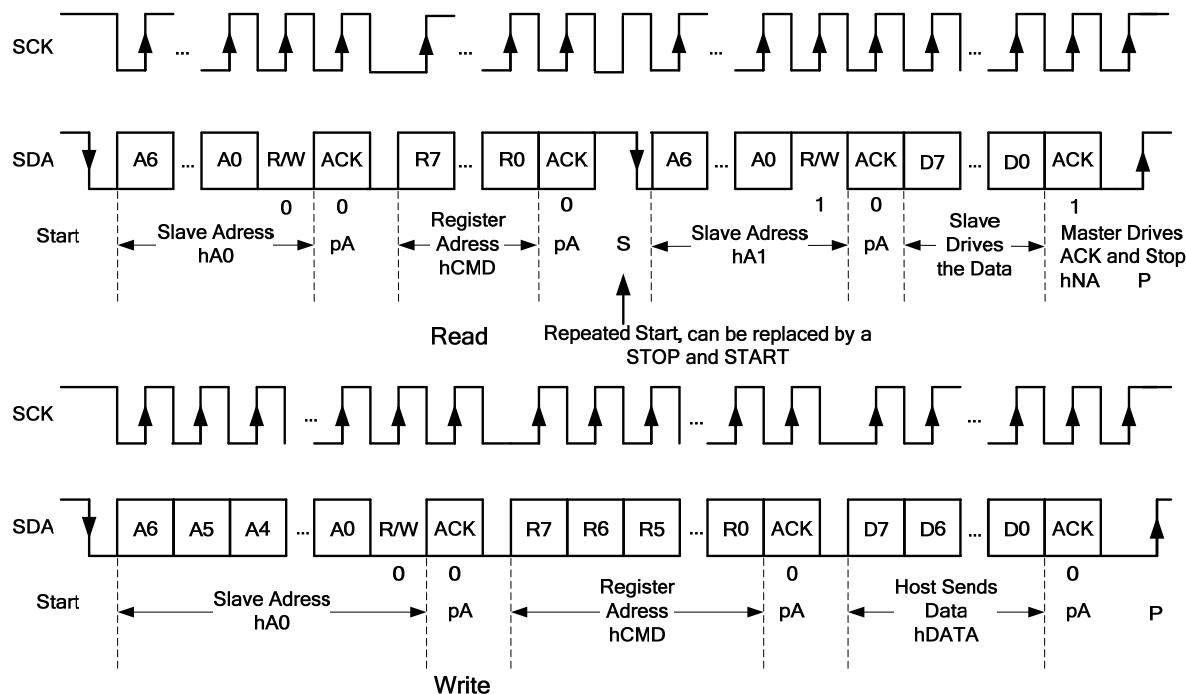
Figure 9-1. Single Read and Write
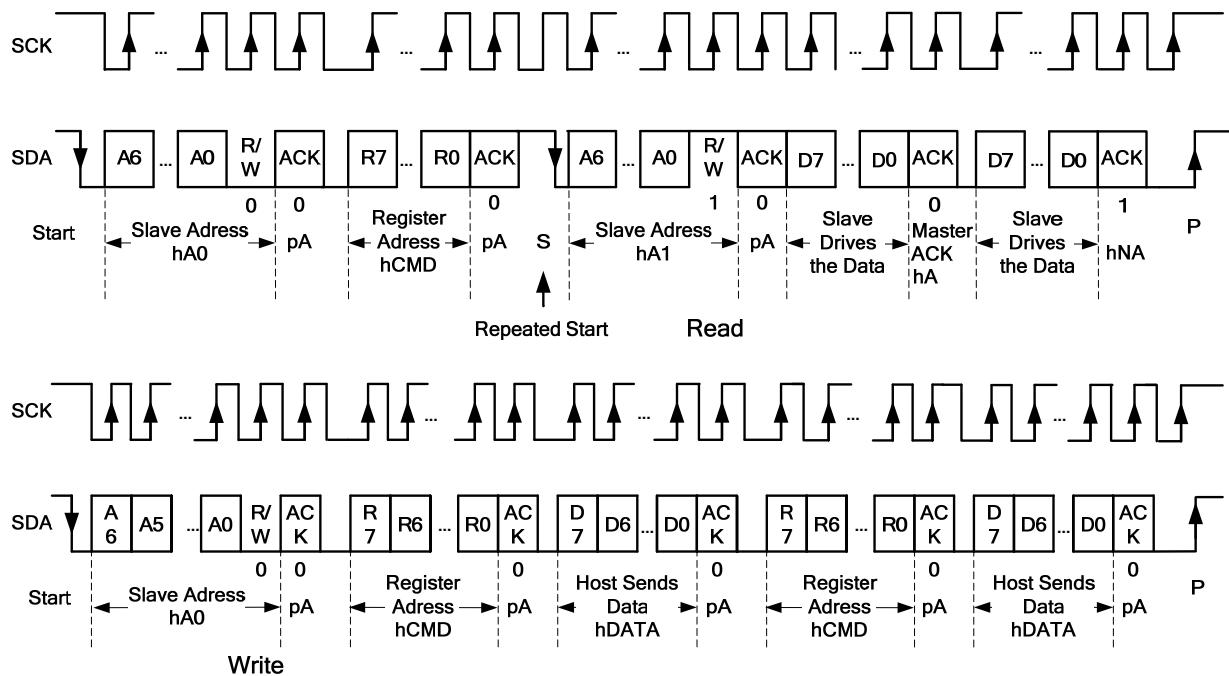
Figure 9-2. Multi Read and Write

Host can access registers through TWSI, its time sequence is as illustrated in shown picture, support standard 100KHz or 400KHz , and the maximum speed is up to 1.2MHz, while it supports read and write operation, that device address 69H is to read and 68H to write. In certain cases, AXP192 reminds Host through pulling down the interrupt mechanism of IRQ, and puts the IRQ status into corresponding register(refer to register REG44H, register REG45H, register REG47H), and cancel the interruption by adding 1 to the appropriate register. IRQ output raise(increase its resistance by 51k from outside), when there are no events of interruption. Each IRQ can be blocked through IRQ register(refer to register REG40H, register REG41H, register REG42H, REG43H).

Location	IRQ	Description	Location	IRQ	Description
REG44H[7]	IRQ1	ACIN overvoltage	REG 46H[7]	IRQ16	IC internal over temperature
REG44H[6]	IRQ2	ACIN insert	REG 46H[6]	IRQ17	Charge current not enough
REG 44H[5]	IRQ3	ACIN remove	REG 46H[5]	IRQ18	DCDC1 under voltage
REG 44H[4]	IRQ4	VBUS overvoltage	REG 46H[4]	IRQ19	DCDC2 under voltage
REG 44H[3]	IRQ5	VBUS insert	REG 46H[3]	IRQ20	DCDC3 under voltage
REG 44H[2]	IRQ6	VBUS remove	REG 46H[2]		Reserved
REG 44H[1]	IRQ7	VBUS valid but lower than V_{HOLD}	REG 46H[1]	IRQ22	Short time key press
REG 44H[0]		Reserved	REG 46H[0]	IRQ23	Long time key press
REG 45H[7]	IRQ8	Battery is present	REG 47H[7]	IRQ24	Power on by N_OE
REG 45H[6]	IRQ9	Battery not present	REG 47H[6]	IRQ25	Power off by N_OE

REG 45H[5]	IRQ10	Into battery active mode	REG 47H[5]	IRQ26	VBUS valid
REG 45H[4]	IRQ11	Quit battery active mode	REG 47H[4]	IRQ27	VBUS invalid
REG 45H[3]	IRQ12	Charging	REG 47H[3]	IRQ28	VBUS Session Valid
REG 45H[2]	IRQ13	Charge finished	REG 47H[2]	IRQ29	VBUS Session End
REG 45H[1]	IRQ14	Battery over temperature	REG 47H[1]		Reserved
REG 45H[0]	IRQ15	Battery under temperature	REG 47H[0]	IRQ30	Under voltage warning

9.11. Registers

9.11.1. power supply control class

Location	Description	R/W	Default
00	Power supply status register	R	
01	Power supply mode/charging status register	R	
04	OTG VBUS status register	R	
06-09	Data buffer register	R/W	F0/0F/00/FF
10	EXTEN & DC-DC2 switch register	R/W	X5H
12	DC-DC1/3 & LDO2/3switch register	R/W	XFH
23	DC-DC2 voltage set register	R/W	16H
25	DC-DC2 voltage slope set register	R/W	00H
26	DC-DC1voltage set register	R/W	68H
27	DC-DC3 voltage set register	R/W	48H
28	LDO2/3 voltage set register	R/W	CFH
30	VBUS-IPSOUT access set register	R/W	60H
31	V_{OFF} power off voltage set register	R/W	X3H
32	Power off、battery detect、CHGLED control register	R/W	46H
33	Charging control register1	R/W	C8H
34	Charging control register2	R/W	41H
35	Backup battery charging control register	R/W	22H
36	PEK parameter set register	R/W	5DH
37	DCDC switch frequency set register	R/W	08H
38	Battery charging under temperature warning set register	R/W	A5H
39	Battery charging over temperature warning set register	R/W	1FH
3A	APS under voltage Level1 set register	R/W	68H
3B	APS under voltage Level2 set register	R/W	5FH

3C	Battery discharging under temperature warning set register	R/W	FCH
3D	Battery discharging over temperature warning set register	R/W	16H
80	DCDC mode set register	R/W	E0H
82	ADC enable set register 1	R/W	83H
83	ADC enable set register 2	R/W	80H
84	ADC sample frequency set, TS pin control register	R/W	32H
85	GPIO [3:0] input range set register	R/W	X0H
8A	Timer control register	R/W	00H
8B	VBUS monitor set register	R/W	00H
8F	Over temperature power off control register	R/W	01H

9.11.2. GPIO control class

Location	Description	R/W	Default
90	GPIO0 control register	R/W	07H
91	GPIO0 LDO mode output voltage set register	R/W	A0H
92	GPIO1 control register	R/W	07H
93	GPIO2 control register	R/W	07H
94	GPIO[2:0] signal status register	R/W	00H
95	GPIO[4:3] function control register	R/W	00H
96	GPIO[4:3] signal status register	R/W	00H
97	GPIO[2:0] pull down control register	R/W	00H
98	PWM1 frequency set register	R/W	00H
99	PWM1 duty ratio set register 1	R/W	16H
9A	PWM1 duty ratio set register 2	R/W	0BH
9B	PWM2 frequency set register	R/W	00H
9C	PWM2 duty ratio set register 1	R/W	16H
9D	PWM2 duty ratio set register 2	R/W	0BH
9E	GPIO5 control register	R/W	20H

9.11.3. IRQ control class

Location	Description	R/W	Default
40	IRQ enable control register 1	R/W	D8H
41	IRQ enable control register 2	R/W	FFH
42	IRQ enable control register 3	R/W	3BH
43	IRQ enable control register 4	R/W	C1H

44	IRQ status register 1	R/W	00H
45	IRQ status register 2	R/W	00H
46	IRQ status register 3	R/W	00H
47	IRQ status register 4	R/W	00H

9.11.4. ADC data class

Location	Description	R/W
56	ACIN voltage ADC data high 8 bit	R
57	ACIN voltage ADC data low 4 bit	R
58	ACIN current ADC data high 8 bit	R
59	ACIN current ADC data low 4 bit	R
5A	VBUS voltage ADC data high 8 bit	R
5B	VBUS voltage ADC data low 4 bit	R
5C	VBUS current ADC data high 8 bit	R
5D	VBUS current ADC data low 4 bit	R
5E	AXP192 internal temperature monitor ADC data High 8 bit	R
5F	AXP192 internal temperature monitor ADC data low 4 bit	R
62	TS input ADC data High 8 bit，monitor battery temperature by default	R
63	TS input ADC data low 4 bit，monitor battery temperature by default	R
64	GPIO0 voltage ADC data high 8 bit	R
65	GPIO0 voltage ADC data low 4 bit	R
66	GPIO1 voltage ADC data high 8 bit	R
67	GPIO1 voltage ADC data low 4 bit	R
68	GPIO2 voltage ADC data high 8 bit	R
69	GPIO2 voltage ADC data low 4 bit	R
6A	GPIO[3] voltage ADC data high 8 bit	R
6B	GPIO[3] voltage ADC data low 4 bit	R
70	Battery instantaneous power high 8 bit	R
71	Battery instantaneous power middle 8 bit	R
72	Battery instantaneous power low 8 bit	R
78	Battery voltage high 8 bit	R
79	Battery voltage low 4 bit	R
7A	Battery charging current high 8 bit	R
7B	Battery charging current low 5 bit	R
7C	Battery discharging current high 8 bit	R
7D	Battery discharging current low 5 bit	R
7E	APS voltage high 8 bit	R
7F	APS voltage low 4 bit	R

Location	Description	R/W	Default
B0	Battery charging coulomb counter data register 3	R/W	00H
B1	Battery charging coulomb counter data register 2	R/W	00H
B2	Battery charging coulomb counter data register 1	R/W	00H
B3	Battery charging coulomb counter data register 0	R/W	00H
B4	Battery discharging coulomb counter data register 3	R/W	00H
B5	Battery discharging coulomb counter data register 2	R/W	00H
B6	Battery discharging coulomb counter data register 1	R/W	00H
B7	Battery discharging coulomb counter data register 0	R/W	00H
B8	Coulomb counter control register	R/W	00H

9.11.5. REG 00H: power supply status

Bit	Description	R/W
7	ACIN present indicator 0:ACIN not present; 1:ACIN present	R
6	Indicate whether ACIN is valid or not	R
5	VBUS present indicate 0:VBUS not present; 1:VBUS present	R
4	Indicate whether VBUS is valid or not	R
3	Indicate VBUS is above V_{HOLD} before insert	R
2	Indicate battery current direction 0: battery discharging; 1: battery charging	R
1	Indicate whether ACIN and VBUS input pin is in short on PCB or not	R
0	Indicate trigger boot by ACIN/ VBUS or not 0: not be ACIN/VBUS; 1: be ACIN/VBUS	R

9.11.6. REG 01H: power supply work mode and charging status indicator

Bit	Description	R/W
7	Indicate whether AXP192 is over temperature or not 0: not over temperature; 1: over temperature	R
6	Charging indicate 0: not be charging or charge finished; 1:charging	R
5	Battery present status indicator 0: no battery connects to AXP192; 1:battery has connected to AXP192	R
4	Reserved	R

3	Indicate whether battery goes into active mode or not 0:not in battery active mode; 1:in battery active mode	R
2	Indicate whether charging current is less than expected current 0: actual charging current equal to expected current; 1: actual charging current less than expected current	R
1-0	Reserved	R

9.11.7. REG 04H:USB OTG VBUS status indicator

Bit	Description	R/W
7-3	Reserved	
2	Indicate whether VBUS is valid or not, 1: valid	R
1	Indicate whether VBUS Session A/B is valid or not, 1: valid	R
0	Indicate Session End status, 1: valid	R

9.11.8. REG 06-09H:data buffer 0-3

Notice: if either external power supply、battery or backup battery is present, this 4 byte data will be saved, not affected by the power on/off status of the system.

9.11.9. REG 10H:EXTEN & DC-DC2 output control

Default: XXH

Bit	Description		R/W	Default
7-3	Reserved			
2	EXTEN switch control	0:disable; 1:enable	RW	X
1	Reserved			
0	DC-DC2 switch control	0:disable; 1:enable	RW	X

Notice: X mean its value considered by condition

9.11.10. REG 12H:DC-DC1/3 & LDO2/3 output control

Default: XFH

Bit	Description		R/W	Default
7-4	Reserved			
3	LDO3 switch control	0:disable; 1:enable	RW	X

2	LDO2 switch control		RW	X
1	DC-DC3 switch control		RW	X
0	DC-DC1 switch control		RW	X

9.11.11. REG 23H:DC-DC2 output voltage set

Default: 16H

Bit	Description		R/W	Default
7-6	Reserved			
5	DC-DC2 output voltage Bit5	0.7-2.275V，25mV/step	RW	X
4	DC-DC2 output voltage Bit4		RW	X
3	DC-DC2 output voltage Bit3		RW	X
2	DC-DC2 output voltage Bit2		RW	X
1	DC-DC2 output voltage Bit1		RW	X
0	DC-DC2 output voltage Bit0		RW	X

9.11.12. REG 25H: DC-DC2 dynamic voltage parameter set

Default: 00H

Bit	Description		R/W	Default
7-3	Reserved			
2	DC-DC2 VRC enable control 0:enable; 1:disable		RW	0
1	Reserved		RW	0
0	DC-DC2 VRC voltage slope control	0: 25mV/15.625us=1.6mV/us 1: 25mV/31.250us=0.8mV/us	RW	0

9.11.13. REG 26H:DC-DC1 output voltage set

Default: 68H

Bit	Description		R/W	Default
7	Reserved			
6	DC-DC1 output voltage Bit6	0.7-3.5V，25mV/step	RW	X
5	DC-DC1 output voltage Bit5		RW	X
4	DC-DC1 output voltage Bit4		RW	X
3	DC-DC1 output voltage Bit3		RW	X

2	DC-DC1 output voltage Bit2		RW	X
1	DC-DC1 output voltage Bit1		RW	X
0	DC-DC1 output voltage Bit0		RW	X

9.11.14. REG 27H:DC-DC3 output voltage set

Default: 48H

Bit	Description		R/W	Default
7	Reserved			
6	DC-DC3 output voltage Bit6	0.7-3.5V, 25mV/step	RW	X
5	DC-DC3 output voltage Bit5		RW	X
4	DC-DC3 output voltage Bit4		RW	X
3	DC-DC3 output voltage Bit3		RW	X
2	DC-DC3 output voltage Bit2		RW	X
1	DC-DC3 output voltage Bit1		RW	X
0	DC-DC3 output voltage Bit0		RW	X

9.11.15. REG 28H:LDO2/3 output voltage set

Default: CFH

Bit	Description		R/W	Default
7	LDO2 output voltage Bit3	1.8-3.3V, 100mV/step	RW	X
6	LDO2 output voltage Bit2		RW	X
5	LDO2 output voltage Bit1		RW	X
4	LDO2 output voltage Bit0		RW	X
3	LDO3 output voltage Bit3	1.8-3.3V, 100mV/step	RW	X
2	LDO3 output voltage Bit2		RW	X
1	LDO3 output voltage Bit1		RW	X
0	LDO3 output voltage Bit0		RW	X

9.11.16. REG 30H:VBUS-IPSOUT access management

Default:6XH

Bit	Description	R/W	Default
7	When VBUS is valid, VBUS-IPSOUT access choose control signal 0:be enable or not by N_VBUSEN pin	RW	0

Bit	Description		R/W	Default
	1:VBUS-IPSOUT access is enable, regardless of N_VBUSEN status			
6	VBUS V_{HOLD} limit voltage control 0: not limited; 1: limited		RW	1
5	V_{HOLD} Bit 2	000: 4.0V; 001: 4.1V; 010: 4.2V	RW	1
4	V_{HOLD} Bit 1	011: 4.3V; 100: 4.4V; 101: 4.5V	RW	0
3	V_{HOLD} Bit 0	110: 4.6V; 111: 4.7V	RW	0
2	Reserved			
1	VBUS limit current control enable signal 0: disable; 1:enable		RW	X
0	When VBUS limit current control is enable, choose limit value 0:500mA; 1:100mA		RW	0

9.11.17. REG 31H:V_{OFF} power off voltage set

Default:X3H

Bit	Description		R/W	Default
7-3	Reserved			
2	V_{OFF} Bit2	000-2.6V; 001-2.7V; 010-2.8V;	RW	0
1	V_{OFF} Bit1	011-2.9V; 100-3.0V; 101-3.1V;	RW	1
0	V_{OFF} Bit0	110-3.2V; 111-3.3V	RW	1

9.11.18. REG 32H:power off、battery check and CHGLED pin control

Default:46H

Bit	Description		R/W	Default
7	Power off control 1: close AXP192 output		RW	0
6	Battery monitor function set: 0:disable; 1:enable		RW	1
5-4	CHGLED pin function	00: high Z 01: 25% 1Hz flip 10: 25% 4Hz flip 11: output low	RW	00
3	CHGLED pin function	0: control by charge 1: control by REG 32HBit[5:4]	RW	0
2	Reserved			
1-0	After N_OE from low to high, AXP192 power off delay time	00: 0.5S; 01: 1S; 10: 2S; 11: 3S	RW	10

9.11.19. REG 33H: charging control 1

Default: C8H

Bit	Description	R/W	Default
7	Charging enable control bit, include internal access and external access 0:disable; 1:enable	RW	1
6:5	Charging target voltage 00:4.1V； 01:4.15V； 10:4.2V； 11:4.36V	RW	10
4	Charge finished current 0: when charging current is less than 10% set value, finish charging 1: when charging current is less than 15% set value, finish charging	RW	0
3-0	Internal charging current 0000:100mA； 0001:190mA； 0010:280mA； 0011:360mA； 0100:450mA； 0101:550mA； 0110:630mA； 0111:700mA； 1000:780mA； 1001:880mA； 1010:960mA； 1011:1000mA； 1100:1080mA； 1101:1160mA； 1110:1240mA； 1111:1320mA	RW	1000

9.11.20. REG 34H: charging control 2

Default:41H

Bit	Description		R/W	Default
7	Pre-charge overtime Bit1	00: 30 min； 01: 40min；	RW	0
6	Pre-charge overtime Bit0	10: 50min； 11: 60min	RW	1
5-3	External access charging current Range 300-1000mA， 100mA/step， Default:300mA		RW	000
2	External access enable set while charging 0:disable; 1:enable		RW	0
1	In constant current mode overtime Bit1	00: 7Hours； 01: 8Hours； 10: 9Hours； 11: 10Hours	RW	0
0	In constant current mode overtime Bit0		RW	1

9.11.21. REG 35H: Backup battery charge control

Default: 22H

Bit	Description	R/W	Default
7	Backup battery charging enable control 0:disable; 1:enable	RW	0

6:5	Backup battery charging target voltage 00:3.1V；01:3.0V；10:3.0V；11:2.5V		RW	01
4-2	Reserved			
1:0	Backup battery charging current	00: 50uA； 01: 100uA； 10: 200uA； 11: 400uA	RW	10

9.11.22. REG 36H:PEK press key parameter set

Default: 5DH

Bit	Description		R/W	Default
7	Power on time Bit1	00: 128mS； 01: 256mS；	RW	0
6	Power on time Bit0	10: 512mS； 11: 1S.	RW	1
5	Long time key press time Bit1	00: 1S； 01: 1.5S；	RW	0
4	Long time key press time Bit0	10: 2S； 11: 2.5S.	RW	1
3	When key press time is longer than power off time, auto power off function 0:disable; 1:enable		RW	1
2	After power on, PWROK signal delay 0:32mS； 1:64mS		RW	1
1	Power off time Bit1	00: 4S； 01: 6S；	RW	0
0	Power off time Bit0	10: 8S； 11: 10S	RW	1

9.11.23. REG 37H:DC-DC work frequency set

Default: 08H

Bit	Description		R/W	Default
7-4	Reserved			
3	DC-DC switch frequency Bit 3	5% per step,default1.5MHz	RW	1
2	DC-DC switch frequency Bit 2		RW	0
1	DC-DC switch frequency Bit 1		RW	0
0	DC-DC switch frequency Bit 0		RW	0

9.11.24. REG 38H:$V_{LTF-charge}$ battery charging low temperature threshold set

Default:A5H

Bit	Description		R/W	Default
7-0	In charge, low temperature	M*10H，when M=A5H, $V_{LTF-charge}$ =2.112V,	RW	A5H

threshold，M	range :0V~3.264V		

$V_{LTF-charge}$ = M *10H * 0.0008V

9.11.25. REG 39H:$V_{HTF-charge}$ battery charging high temperature threshold set

Default:1FH

Bit	Description		R/W	Default
7-0	In charge, high temperature threshold, N	N*10H，when N=1FH, $V_{HTF-charge}$ =0.397V, range:0V~3.264V	RW	1FH

$V_{HTF-charge}$ = N *10H * 0.0008V

9.11.26. REG 3AH:APS low voltage level 1

Default:68H

Bit	Description	R/W	Default
7-0	APS low voltage level 1	RW	68H

9.11.27. REG 3BH:APS low voltage level 2

Default:5FH

Bit	Description	R/W	Default
7-0	APS low voltage level 2	RW	5FH

REG3AH、REG3BH corresponding APS voltage is:(suppose register value is n):
Vwarning = 2.8672 + 1.4mV * n * 4

9.11.28. REG 3CH:$V_{LTF-discharge}$ battery discharging low temperature threshold set

Default: FCH

Bit	Description		R/W	Default
7-0	In discharge, low temperature threshold set，M	M*10H ， when M=FCH, $V_{LTF-discharge}$ =3.226V; range 0V~3.264V	RW	FCH

$V_{LTF-discharge}$ = M *10H * 0.0008V

9.11.29. REG 3DH:$V_{HTF-discharge}$ battery discharging high temperature threshold set

Default:16H

Bit	Description	R/W	Default

7-0	In discharge, high temperature threshold set，N	N*10H，when N=16H, $V_{HTF-discharge}$ 0.282V; range 0V~3.264V	RW	16H

$V_{HTF-discharge}$ = N *10H * 0.0008V

9.11.30. REG 80H:DC-DC work mode choose

Default:E0H

Bit	Description		R/W	Default
7-4	Reserved			
3	DC-DC1 work mode control	0:PFM/PWM auto switch	RW	0
2	DC-DC2 work mode control	1: fixed PWM	RW	0
1	DC-DC3 work mode control		RW	0
0	Reserved			

9.11.31. REG 82H:ADC enable 1

Default:83H

Bit	Description		R/W	Default
7	Battery voltage ADC enable	0:disable; 1:enable	RW	1
6	Battery current ADC enable		RW	0
5	ACIN voltage ADC enable		RW	0
4	ACIN current ADC enable		RW	0
3	VBUS voltage ADC enable		RW	0
2	VBUS current ADC enable		RW	0
1	APS voltage ADC enable		RW	1
0	TS pin ADC function enable		RW	1

9.11.32. REG 83H:ADC enable 2

Default:80H

Bit	Description		R/W	Default
7	AXP192 internal temperature monitor ADC enable	0:disable; 1:enable	RW	1
6-4	Reserved			
3	GPIO0 ADC function enable	0:disable; 1:enable	RW	0
2	GPIO1 ADC function enable		RW	0
1	GPIO2 ADC function enable		RW	0

0	GPIO[3] ADC function enable		RW	0

9.11.33. REG 84H: ADC sample rate set, TS pin control

Default:32H

Bit	Description		R/W	Default
7	ADC sample rate Bit 1	25×2^n	RW	0
6	ADC sample rate Bit 0	Sample rate: 25，50，100，200Hz	RW	0
5-4	TS pin output current set: 00:20uA；01:40uA；10:60uA；11:80uA		RW	11
3	Reserved			
2	TS pin function choose 0:battery temperature monitor; 1:external ADC input access		RW	0
1-0	TS pin current output set	00:disable	RW	1
		01:output current when in charge	RW	0
		10:output when ADC sampling, to save energy		
		11:always enable		

9.11.34. REG 85H: ADC input range

Default:X0H

Bit	Description		R/W	Default
7-4	Reserved			
3	GPIO3 ADC input range	0:0-2.0475V	RW	0
2	GPIO2 ADC input range	1:0.7-2.7475V	RW	0
1	GPIO1 ADC input range		RW	0
0	GPIO0 ADC input range		RW	0

9.11.35. REG 8AH: timer control

Default:00H

Bit	Description	R/W	Default
7	Timer timeout Set 1 clear this status	RW	0
6-0	Set time, unit is minute 0000000:close this timer	RW	0000000

9.11.36. REG 8BH:VBUS pin monitor SRP function control

Default:00H

Bit	Description	R/W	Default
7-6	Reserved		
5-4	VBUS valid voltage set 00:4.0V；　01:4.15V；　10:4.45V；　11:4.55V	RW	00
3	VBUS Valid monitor function set:0:disable, 1:enable	RW	0
2	VBUS Session monitor function set: 0:disable, 1:enable	RW	0
1	Discharge VBUS discharge function set 0: remove VBUS discharge resistor; 1: use VBUS discharge resistor	RW	0
0	Charge VBUS charge function set 0:remove VBUS charge resistor; 1: use VBUS charge resistor	RW	0

9.11.37. REG 8FH: over temperature power off function set

Default:01H

Bit	Description	R/W	Default
7-3	Reserved	RW	0
2	AXP192 internal over temperature power off function set 0:not power off;　1:power off	RW	0
1-0	Reserved		

9.11.38. REG 90H:GPIO0 function set

Default:07H

Bit	Description		R/W	Default
7-3	Reversed,not change			
2	GPIO0 pin function Bit 2	000:NMOS open drain output 001:General input function 010:low noise LDO	RW	1
1	GPIO0 pin function Bit 1	100:ADC in 101: Low output	RW	1
0	GPIO0 pin function Bit 0	11X: Floating	RW	1

9.11.39. REG 91H:GPIO0 in LDO mode, output voltage set

Default:A0H

Bit	Description	R/W	Default
7-4	GPIO0 in LDO mode, output voltage 0000: 1.8V； 0001: 1.9V； 0010: 2.0V； 0011: 2.1V； 0100: 2.2V； 0101: 2.3V； 0110: 2.4V； 0111: 2.5V； 1000: 2.6V； 1001: 2.7V； 1010: 2.8V； 1011: 2.9V； 1100: 3.0V； 1101: 3.1V； 1110: 3.2V； 1111: 3.3V	RW	1010
3-0	Reserved		

9.11.40. REG 92H:GPIO1function set

Default:07H

Bit	Description		R/W	Default
7-3	Reversed,not change			
2	GPIO1 pin function Bit 2	000:NMOS open drain output 001: General input function 010:PWM1, high output is VINT	RW	1
1	GPIO1 pin function Bit 1	100:ADC input 101:Low output	RW	1
0	GPIO1 pin function Bit 0	11X:Floating	RW	1

9.11.41. REG 93H:GPIO2 function set

Default:07H

Bit	Description		R/W	Default
7-3	Reversed,not change			
2	GPIO2 pin function Bit 2	000:NMOS open drain output 001:General input function 010:PWM2, high output is VINT	RW	1
1	GPIO2 pin function Bit 1	100:ADC input 101:Low output	RW	1
0	GPIO2 pin function Bit 0	11X: Floating	RW	1

9.11.42. REG 94H:GPIO[2:0] signal status set and monitor

Default:00H

Bit	Description		R/W	Default
7	Reserved		R	
6	GPIO2 input status	0:Low	R	
5	GPIO1 input status	1:High	R	
4	GPIO0 input status		R	
3	Reserved			
2	GPIO2 output set	0:Low, Ground NMOS open	RW	0
1	GPIO1 output set	1:Float, NMOS close	RW	0
0	GPIO0 output set		RW	0

9.11.43. REG 95H:GPIO[4:3] pin function set

Default:00H

Bit	Description		R/W	Default
7-4	Reserved		RW	0
3:2	GPIO4 pin function Bit 1-0	00:External charge control 01:NMOS open drain output pin 4 10: General input pin 4 11:Undefine	RW	00
1:0	GPIO3pin function Bit1-0	00: External charge control 01:NMOS open drain output pin 3 10: General input pin 3 11:ADC input	RW	00

9.11.44. REG 96H: GPIO[4:3] signal status set and monitor

Default: 00H

Bit	Description		R/W	Default
7-6	Reserved		R	
5	GPIO4 input status	0:Low	R	
4	GPIO3 input status	1:High	R	
3-2	Reserved			
1	GPIO4 output	0:Low, NMOS open	RW	0

| 0 | GPIO3 output | 1:Float, NMOS close | RW | 0 |

9.11.45. REG 97H: when GPIO[2:0] is used as input, pull down set

Default: 00H

Bit	Description		R/W	Default
7-3	Reserved			
2	GPIO2 as input, pull down resistor control	0:Remove	RW	0
1	GPIO1 as input, pull down resistor control	1:Connect	RW	0
0	GPIO0 as input, pull down resistor control		RW	0

9.11.46. REG 98H:PWM1 output frequency set

Default:00H

Bit	Description	R/W	Default
7-0	PWM1 output frequency X	RW	00H

9.11.47. REG 99H:PWM1 duty ratio set 1

Default:16H

Bit	Description	R/W	Default
7-0	PWM1 duty ratio Y1	RW	16H

9.11.48. REG 9AH:PWM1 duty ratio set 2

Default:0BH

Bit	Description	R/W	Default
7-6	PWM1 duty ratio Y2	RW	0BH

9.11.49. REG 9BH:PWM2 output frequency set

Default:00H

Bit	Description	R/W	Default

7-0	PWM2 output frequency X	RW	00H

9.11.50. REG 9CH:PWM2 duty ratio set 1

Default:16H

Bit	Description	R/W	Default
7-0	PWM2 duty ratio Y1	RW	16H

9.11.51. REG 9DH:PWM2 duty ratio set 2

Default:0BH

Bit	Description	R/W	Default
7-6	PWM2 duty ratio Y2	RW	0BH

Notice: PWM output frequency = 2.25MHz / (X+1) / Y1

PWM output duty ratio = Y2 / Y1

9.11.52. REG 9EH: N_RSTO pin function set

Default:20H

Bit	Description	R/W	Default
7	N_RSTO pin function 0: N_RSTO， LDO1 status monitor; 1:General I/O pin 5	RW	0
6	N_RSTO as general I/O pin 5 0:NMOS open drain output; 1:General input function	RW	0
5	N_RSTO as output pin 5 0:Low, NMOS open； 1:Float，NMOS close	RW	1
4	N_RSTO as input pin 5 0:Low; 1:High	R	
3-0	Reserved	RW	0000

9.11.53. REG 40H:IRQ enable 1

Default:D8H

Bit	Description	R/W	Default
7	ACIN over voltage IRQ enable	RW	1
6	ACIN insert IRQ enable	RW	1
5	ACIN remove IRQ enable	RW	0
4	VBUS over voltage IRQ enable	RW	1
3	VBUS insert IRQ enable	RW	1
2	VBUS remove IRQ enable	RW	0
1	VBUS valid, but lower than V_{HOLD} IRQ enable	RW	0
0	Reserved	RW	0

9.11.54. REG 41H:IRQ enable 2

Default: FFH

Bit	Description	R/W	Default
7	Battery insert IRQ enable	RW	1
6	Battery remove IRQ enable	RW	1
5	Battery active mode IRQ enable	RW	1
4	Quit battery active mode IRQ enable	RW	1
3	Charging IRQ enable	RW	1
2	Charge finished IRQ enable	RW	1
1	Battery over temperature IRQ enable	RW	1
0	Battery under temperature IRQ enable	RW	1

9.11.55. REG 42H:IRQ enable 3

Default:3BH

Bit	Description	R/W	Default
7	AXP192 internal over temperature IRQ enable	RW	0
6	Charge current not enough IRQ enable	RW	0
5	DC-DC1 under voltage IRQ enable	RW	1
4	DC-DC2 under voltage IRQ enable	RW	1
3	DC-DC3 under voltage IRQ enable	RW	1
2	Reserved		
1	Short time key press IRQ enable	RW	1
0	Long time key press IRQ enable	RW	1

9.11.56. REG 43H:IRQ enable 4

Default:C1H

Bit	Description	R/W	Default
7	Power on by N_OE IRQ enable	RW	1
6	Power off by N_OE IRQ enable	RW	1
5	VBUS valid IRQ enable	RW	0
4	VBUS invalid IRQ enable	RW	0
3	VBUS Session A/B IRQ enable	RW	0
2	VBUS Session End IRQ enable	RW	0
1	Reserved	RW	1
0	APS under voltage IRQ enable	RW	1

9.11.57. REG 44H:IRQ status1

Default:00H

Bit	Description	R/W	Default
7	ACIN over voltage IRQ status	RW	0
6	ACIN insert IRQ status	RW	0
5	ACIN remove IRQ status	RW	0
4	VBUS over voltage IRQ status	RW	0
3	VBUS insert IRQ status	RW	0
2	VBUS remove IRQ status	RW	0
1	VBUS valid, but lower than V_{HOLD}IRQ status	RW	0
0	Reserved	RW	0

9.11.58. REG 45H:IRQ status2

Default:00H

Bit	Description	R/W	Default
7	Battery insert IRQ status	RW	0
6	Battery remove IRQ status	RW	0
5	Battery active mode IRQ status	RW	0
4	Quit battery active mode IRQ status	RW	0
3	Charging IRQ status	RW	0
2	Charge finished IRQ status	RW	0
1	battery over temperature IRQ status	RW	0

| 0 | battery under temperature IRQ status | RW | 0 |

9.11.59. REG 46H:IRQ status3

Default:00H

Bit	Description	R/W	Default
7	AXP192 internal over temperature IRQ status	RW	0
6	Charge current not enough IRQ status	RW	0
5	DC-DC1 under voltage IRQ status	RW	0
4	DC-DC2 under voltage IRQ status	RW	0
3	DC-DC3 under voltage IRQ status	RW	0
2	Reserved		
1	Short time key press IRQ status	RW	0
0	Long time key press IRQ status	RW	0

Notice: Set 1 to any of IRQ status register will clear corresponding status.

9.11.60. REG 47H:IRQ status4

Default:00H

Bit	Description	R/W	Default
7	Power on by N_OE IRQ status	RW	0
6	Power off by N_OE IRQ status	RW	0
5	VBUS valid IRQ status	RW	0
4	VBUS invalid IRQ status	RW	0
3	VBUS Session A/B IRQ status	RW	0
2	VBUS Session End IRQ status	RW	0
1	Reserved	RW	0
0	APS under voltage IRQ status，when APS voltage is lower than Warning Leve2,then set 1, when is above Warning Level1, set 0.	RW	0

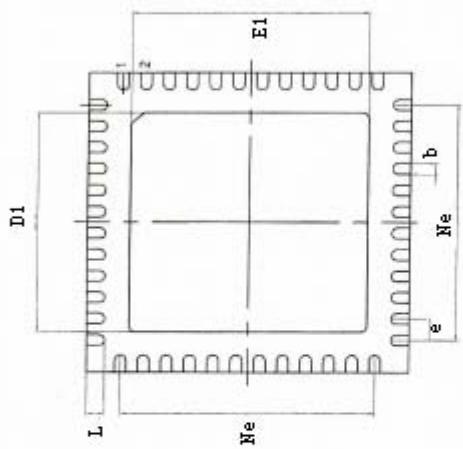### 9.11.61. REG B8H: Coulomb counter control

Default:00H

Bit	Description	R/W	Default
7	Coulomb counter open/close	RW	0
6	Coulomb counter pause, 1: pause, then clear itself	RW	0
5	Clear coulomb counter control, 1:clear coulomb counter, then clear itself	RW	0

| 4-0 | Reserved | | RW | 0 |

10. Package

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.72	0.82	0.92
A1	—	0.01	0.05
b	0.18	0.22	0.28
c	0.18	0.20	0.23
D	5.90	6.00	6.10
D1	4.10REF		
e	0.40BSC		
Ne	4.40BSC		
E	5.90	6.00	6.10
E1	4.10REF		
L	0.35	0.40	0.45

48PIN QFN