DATASHEET

AXP209

Enhanced single Cell Li-Battery and Power System Management IC

X-Powers

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1. Overview

AXP209 is designed to be a highly-integrated power system management IC that is optimized for applications requiring single-cell Li-battery (Li-Ion/Polymer) and multiple output DC-DC converters. It is offering an easy-to-use and flexible complete solution which can fully meet the increasingly complexity of accurate power control required by modern application processor system.

AXP209 Incorporates an adaptive USB-Compatible PWM Charger, 2 Buck DC-DC converters,5 Linear regulators (LDOs), Voltage/Current/Temperature and other multi-channel 12-Bit ADC, as well as 4 Configurable GPIOs. To ensure power system safety and stability, the AXP209 also integrates over/under (OVP / UVP), Over temperature(OTP), and Overcurrent (OCP) Protection circuits.

With Intelligent Power Select, IPS™ circuits, the AXP209 can distribute power safely and transparently among external AC-adapter, Li-battery and application system load. It can still work normally when there is no battery (e.g. deeply discharged/defective battery) but only external input power source.

The AXP209 provides a small, simple solution for obtaining power from three different power sources; single-cell Li-Ion battery, USB port, and AC-adapter. It can also support a rechargeable backup battery too.

To ensure compatibility with a wide range of system processors, AXP209 uses a Two Wire Serial Interface (TWSI), through which application processor is capable of enabling/disabling power rails, programming voltages, accessing internal registers, as well as measurement data (including Fuel Gauge). With the power monitoring results of high precision (1%, determined by the 1% BIAS resistance), end users will always know the real-time power consumption, which can bring them an unprecedented experience of power management.

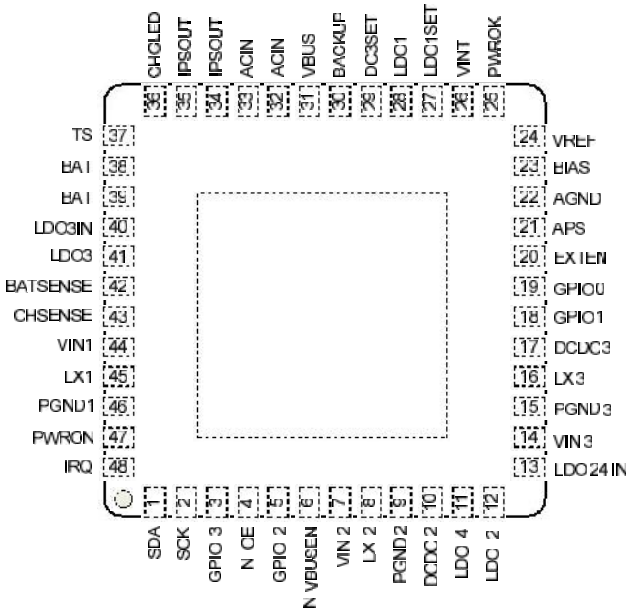
AXP209 Provided 6mm x 6mm 48-pin QFN Package.

Applications

- Handheld mobile devices

  Smart mobile phones, PMP / MP4, Number of Cameras, Digital cameras, Handheld guide, Air Equipment, GPS, PDA, Handheld digital Radio and television receivers
- Mobile Internet Devices, xPad
- Digital photo frame, portable DVD Player Ultra-Mobile PCs UMPC and UMPC-like, Learning machine
- Should With Department Li Device Power Road Department EC
- Application Processor systems Other batteries and multi-power applications

Pin Definition



2. Features

- Intelligent Power Select **(IPS)**
  - Wide input voltage range: 2.9V ~ 6.3V (AMR:-0.3V ~ 11V)
  - Configurable Intelligent Power Delect "IPS™" System
  - Adaptive USB (Support USB3.0) Or AC adapter with current limiting (4.4V / 900mA / 500mA / 100mA)
  - Battery path is less than equivalent resistance of 75mΩ

- Fully Integrated **PWM** Charger
  - Maximum charge current to 1.8A
  - Support battery temperature monitoring
  - Full support of USB compatible chargers (including USB 3.0)
  - High charging accuracy error of less than 0.5%
  - Supports 4.1V/4.15V/4.2V/4.36V and other battery voltages
  - Automatic charging process control and management
  - Can directly drive LED to indicate charging status
  - The system automatically adjusts the charge current to suit the system load

- Backup battery **support**
  - Provision for a backup battery input supply an RTC Module
  - Supports backup battery charging, with adjustable charging current.

- **2** Synchronous Buck Converters
  - DC-DC1: The PWM charger
  - DC-DC2: 1.6A 0.7-2.275V, adjustable 25mV / step, supporting VRC (Voltage ramp control)
  - DC-DC3: 1.2A 0.7-3.5V, adjustable 25mV / step.

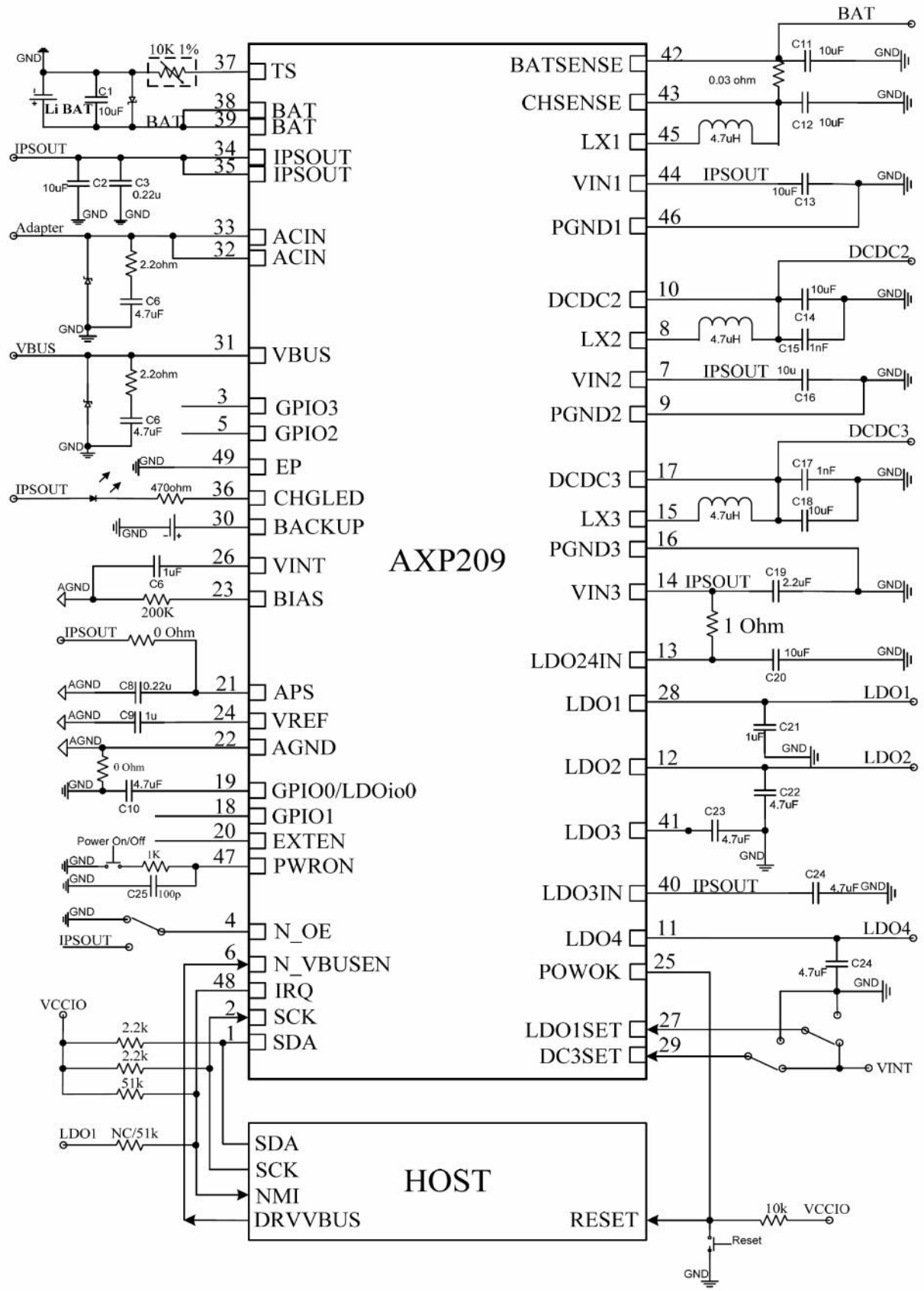
- **5** Linear regulators **(LDO)**
  - LDO1:30mA Always one
  - LDO2: 200mA Low Noise LDO,1.8V ~3.3V, Adjustable 100mV / step
  - LDO3: 200mA 0.7-3.5V Adjustable, 25mV / step
  - LDO4: 200mA Low Noise LDO,1.8V ~ 3.3V Adjustable 100mV / step
  - LDO5: 50mA Low Noise LDO, 1.8-3.3V Adjustable, 100mV / step.

- Timer **(Timer)**
  - 7bit Timer, Timing range 1 ~ 127 minutes
  - Timer Interrupt Output
- Signal Acquisition System **(Signal Capture)**
  - Built-in 12-channel 12 Bit ADC
  - Accept two external analog signal inputs
  - Provide battery and external power supply voltage and current data
  - Built-Precision Coulomb Counter and Fuel gauge system
  - Provide a wealth of power management information, such as instantaneous power (mA or mW), the remaining battery capacity (% or mAh), The state of charge (%) and remaining battery or charging time
  - Two-level low-battery warning and protection
  - Provides chip die temperature data

- Application Processor Interface **(Host Interface)**
  - Host can exchange data through the TWSI (I2C)
  - Flexible interrupt and sleep management
  - Flexible pin function, multiple GPIO can be set as IO, ADC and other functions
  - Built-in configurable timer
  - Provide 12 sets of registers that can retain data when the system is shut down.
- System Management **(System Management)**
  - Support soft and hard reset
  - Support for soft and hard shutdown
  - Support for external wakeup triggers
  - Supports output voltage monitoring and self-diagnostic function
  - Output PWROK indication for system reset or shutdown
  - External power detection (insertion/removal/sufficient current capacity)
  - Supports soft power on via GPIOs
  - Over / under voltage protection (OVP / UVP)
  - Overcurrent protection (OCP)
  - Over-temperature protection (OTP)
  - Support OTG VBUS power state setting / monitoring
- Highly Integrated
  - Internal precision voltage reference (0.5%)
  - Built-in MOSFET
  - Timing and the output voltages can be customized

- Decryption module (Decryption)
  - 128bit OTP password storage
  - Dynamic real-time decryption algorithm

3. Typical Application



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 Body Model	> 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		2500		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			170	mΩ
VBUS						
V_{IN}	VBUS Input Voltage		3.8		6.3	V
I_{OUT}	V_{OUT} Current Available Before Loading BAT			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			1200	1800	mA
I_{TRKL}	Trickle Charge Current			10%		I_{CHRG}

						mA
V_{TRKL}	Trickle Charge Threshold Voltage			3.0		V
V_{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						
$R_{ds\ (on)}$	On Resistance (BAT to IPSOUT)				75	mΩ

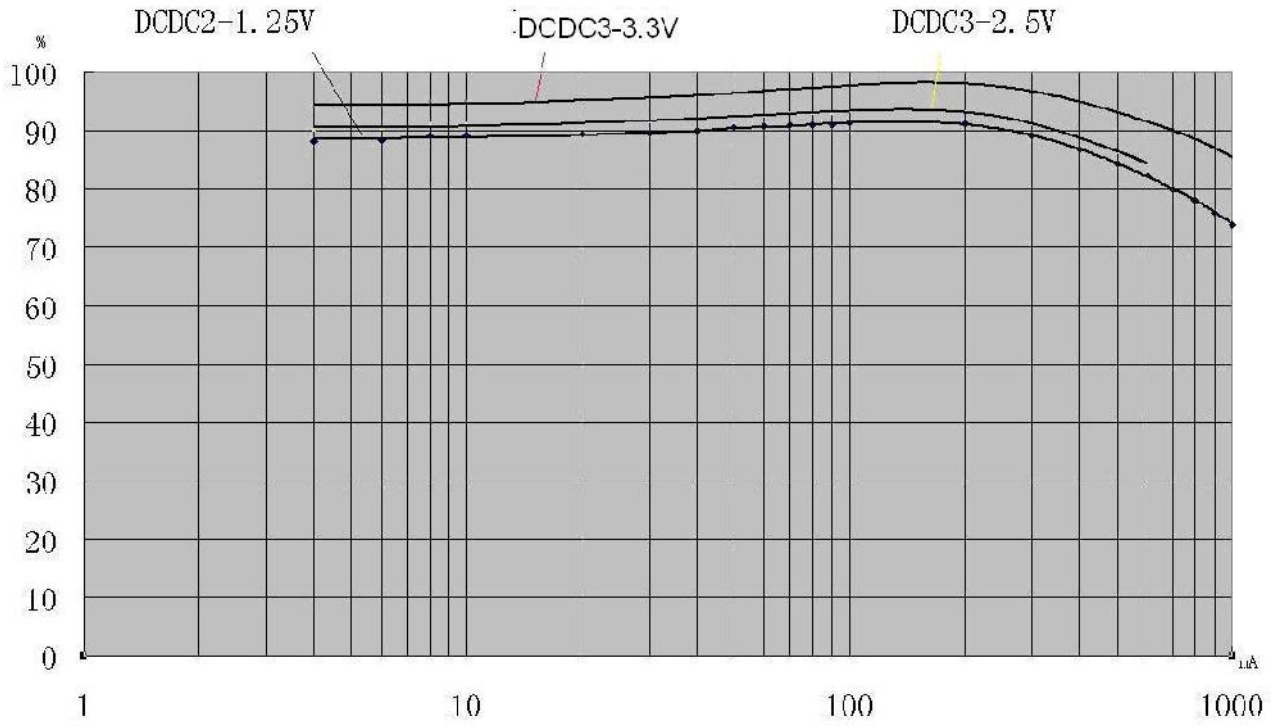
SYMBOL	DESCRIPTION	CONDITIONS	MIN	TYP	MAX	UNITS
Off Mode Current						
I_{BATOFF}	OFF Mode Current	BAT = 3.8V		27		μA
$I_{SUSPEND}$	USB VBUS suspend Mode current	BAT = 3.8V, VBUS = 5V, N_VBUSEN = 1		86		μA
Logic						
V_{IL}	Logic Low Input Voltage			0.3		V
V_{IH}	Logic High Input Voltage			2		V
TWSI						
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 up		60		ns

t_r	Clock Data Rise Time	2.2Kohm Pull up		100		ns
DCDC						
f_{OSC}	Oscillator Frequency	Default		1.5		MHz
DCDC2						
I_{LIM2}	PMOS Switch Current Limit	PWM Mode		2300		mA
I_{DC2OUT}	Available Output Current	PWM Mode			1800	mA
V_{DC2OUT}	Output Voltage Range		0.7		2.275	V
DCDC3						
I_{LIM3}	PMOS Switch Current Limit	PWM Mode		1400		mA
I_{DC3OUT}	Available Output Current	PWM Mode			1000	mA
V_{DC3OUT}	Output Voltage Range		0.7		3.5	V

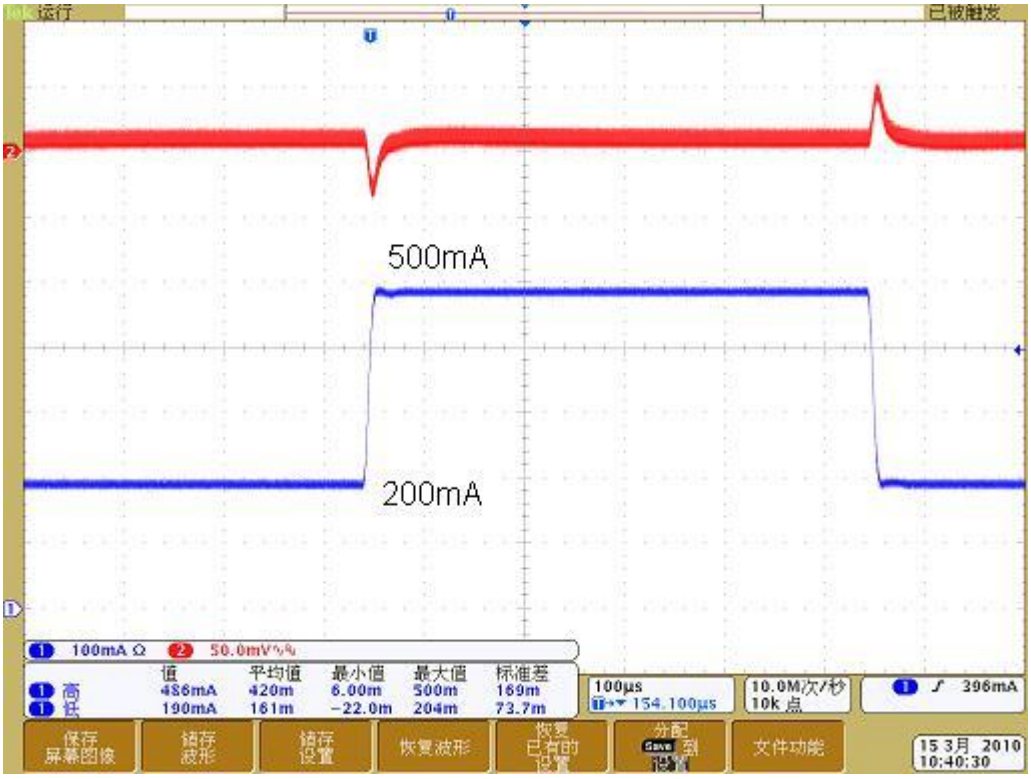
SYMBOL	DESCRIPTION	CONDITIONS	MIN	TYP	MAX	UNITS
LDO1						
V_{LDO1}	Output Voltage	I_{LDO1}= 1mA	-1%	1.3 3.3	1%	V
I_{LDO1}	Output Current			30		mA
LDO2						
V_{LDO2}	Output Voltage	I_{LDO2}= 1mA	1.8		3.3	V
I_{LDO2}	Output Current			200		mA
PSRR	Power Supply Rejection Ratio	I_{LDO2}= 60mA, 1KHz		TBD		dB
e_N	Output Noise, 20-80KHz	Vo = 3V, Io = 150mA		28		μV_{RMS}
LDO3						
V_{LDO3}	Output Voltage	I_{LDO3}= 1mA	0.7		3.5	V
I_{LDO3}	Output Current			200		mA
PSRR	Power Supply Rejection Ratio	I_{LDO3}= 10mA, 1KHz		TBD		dB
e_N	Output Noise, 20-80KHz	Vo = 1.8V, Io = 150mA		TBD		μV_{RMS}
LDO4						
V_{LDO3}	Output Voltage	I_{LDO3}= 1mA	1.8		3.3	V
I_{LDO3}	Output Current			200		mA
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}
LDO5						
V_{LDO5}	Output Voltage	I_{LDO5}= 1mA	1.5		3.3	V
I_{LDO5}	Output Current			50		mA
PSRR	Power Supply Rejection Ratio	I_{LDO5}= 10mA, 1KHz		TBD		dB
e_N	Output Noise, 20-80KHz	Vo = 1.8V, Io = 30mA		18		μV_{RMS}

6. Typical Characteristics

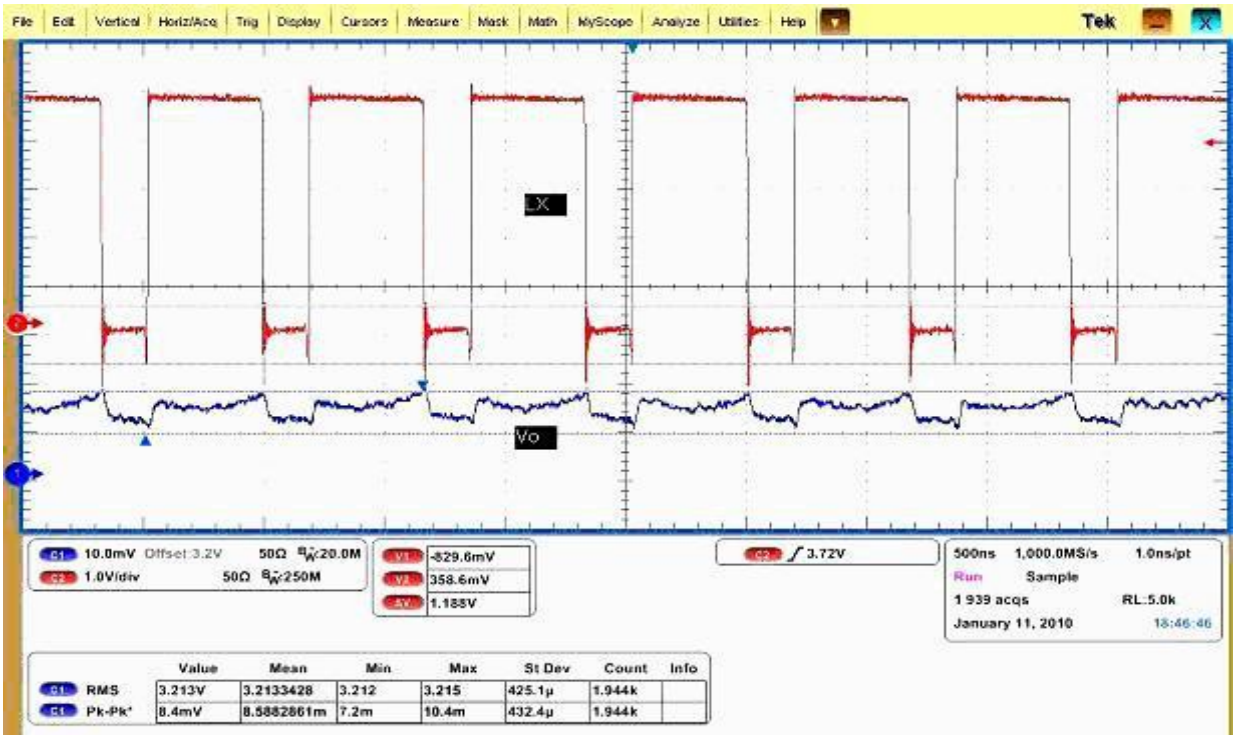
DC-DC Efficiency vs. Load (3.8Vin)



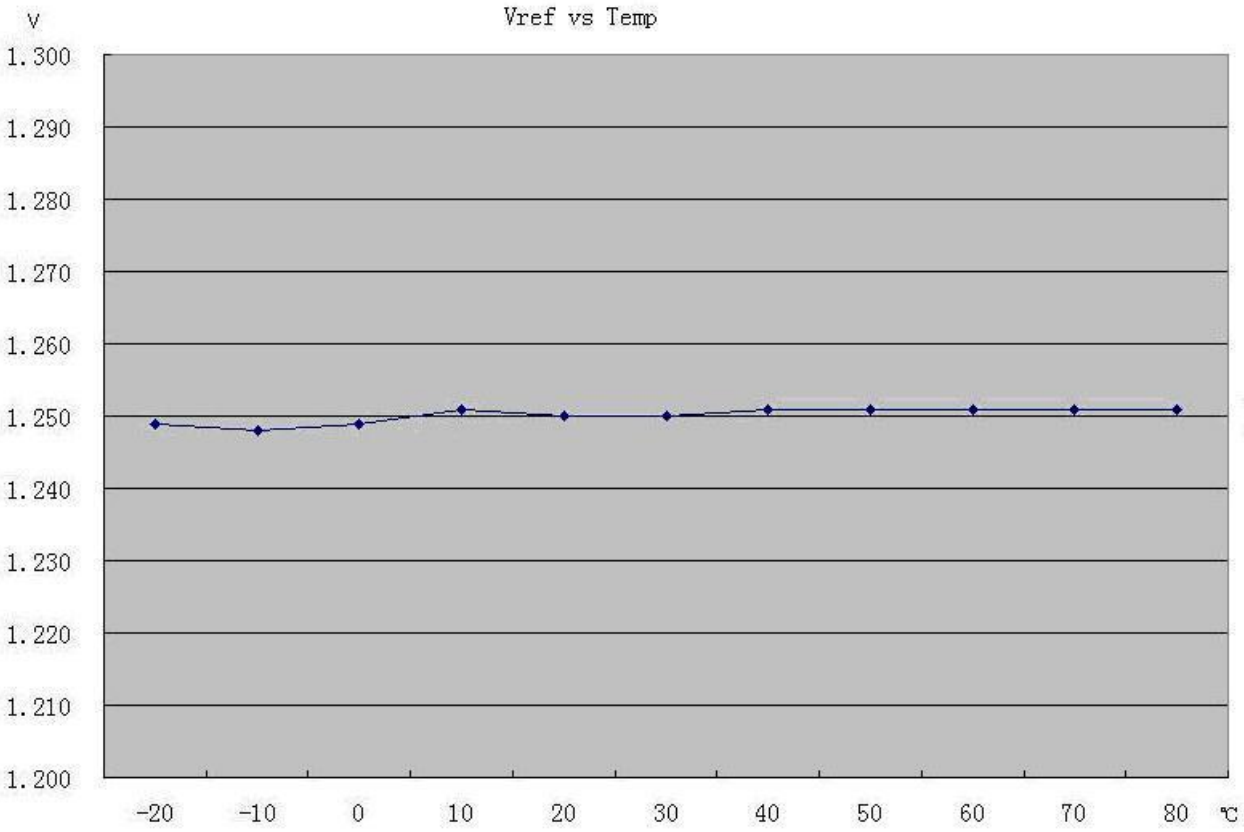
DC-DC Load Transient (Typical)



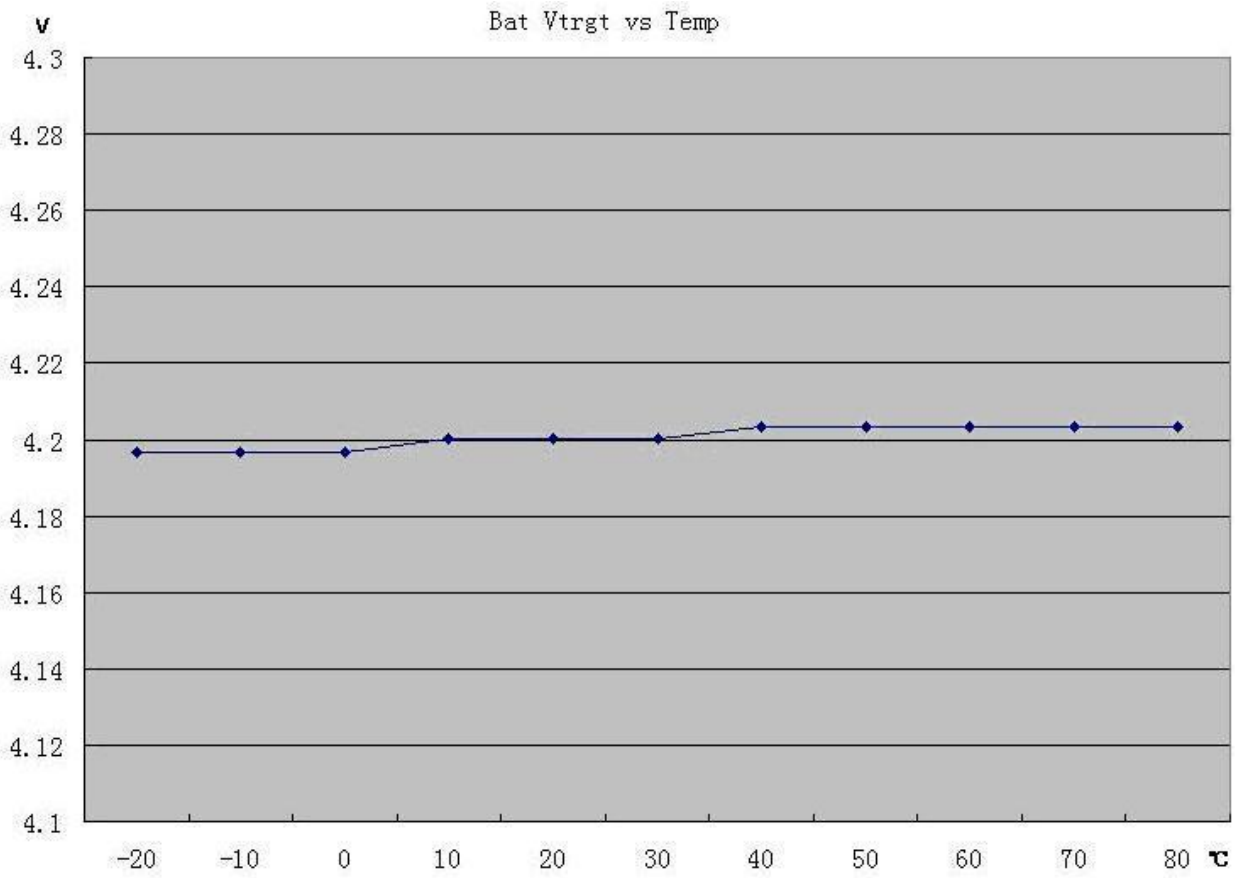
DC-DC Ripple



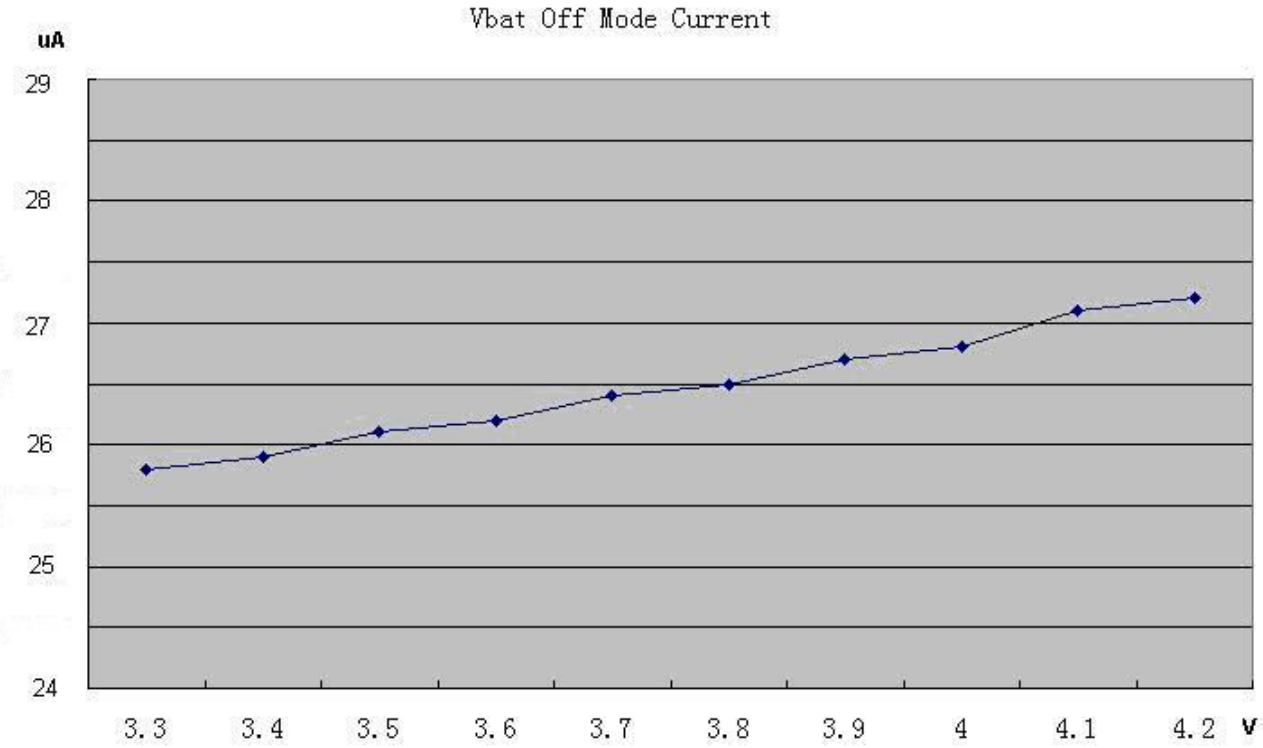
V_{REF} vs Temperature



V_{TRGT} vs Temperature



Off Mode Current vs V_{BAT}

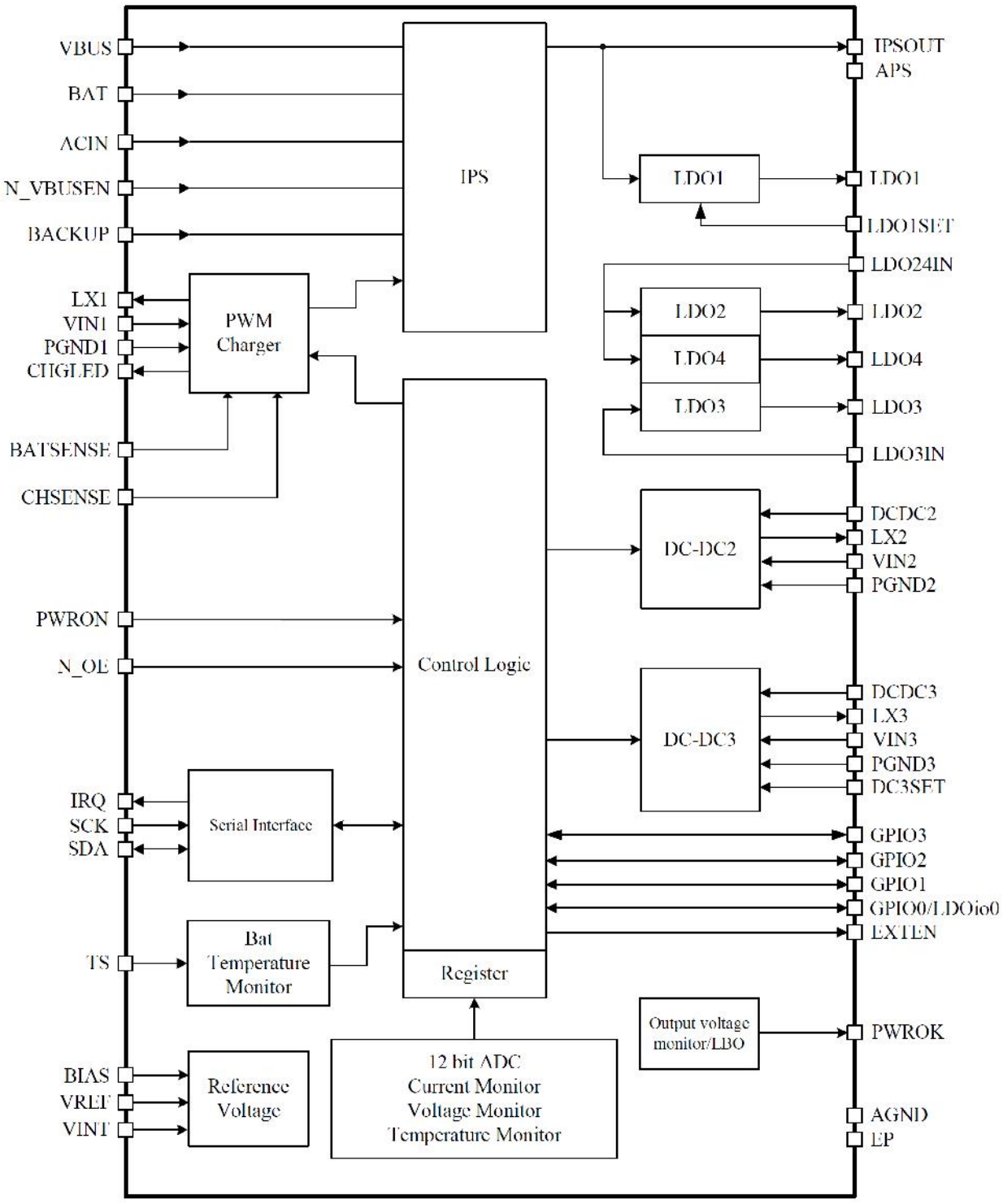


7. Pin Definition

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	GPIO3	IO	REG9EH [7]	GPIO 3
4	N_OE	I		Power output on / off switch GND: on；IPSOUT: off
5	GPIO2	IO	REG92H [2: 0]	GPIO 2
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	LDO4	O		Output Pin of LDO4
12	LDO2	O		Output Pin of LDO2

13	LDO24IN	PI		Input to LDO2 and LDO4
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	REG93H [2: 0]	GPIO 1
				ADC Input
19	GPIO0	IO	REG90H [2: 0]	GPIO 0
				Low noise LDO / Switch
				ADC Input
20	EXTEN	O		External Power Enable
21	APS	PI		Internal Power Input
22	AGND	G		Analog Ground
34	BIAS	IO		External 200Kohm 1% resistor
24	VREF	O		Internal reference voltage
25	PWROK	O		Power Good Indication OutPut
26	VINT	PO		Internal logic power, 2.5V
27	LDO1SET	I		It set the LDO1 default voltage.
28	LDO1	O		LDO1 output, for Host RTC block
29	DC3SET	I		It set the DCDC3 default voltage
30	BACKUP	IO		Backup battery pin
31	VBUS	PI		USB VBUS input
32, 33	ACIN	PI		Adapter input
34, 35	IPSOUT	IO		Main Battery
36	CHGLED	O		charger status indication
37	TS	I		Battery Temperature sensor input or an external ADC input
38, 39	BAT	PO		System power source
40	LDO3IN	O		LDO3 input source
41	LDO3	I		Output Pin of LDO3
42	BATSENSE	I		Current sense port1
43	CHSENSE	O		Current sense port2
44	VIN1	PI		DCDC1 input source
45	LX1	IO		Inductor Pin for DCDC1
46	PGND1	G		NMOS Ground for DCDC1
47	PWRON	I		Power On-Off key input, Internal 100k pull high to APS
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 Operation

When AXP209 powers on and TWS interface SCK / SDA pins are pulled to host IO voltage source, the host can then adjust and monitor the AXP209. This provides flexible adjustment and monitoring options, and a wealth of information.

Note: "Host" Referring to the main application processor
Note: "External power supply" refers to ACIN And VBUS Inputs.

9.1 Power On / Off & Reset

Button(PEK)

AXP209 PWRON Pin can be connected to GND through a button, as a Power Enable Key (PEK) or hibernation/wake button. The AXP209 can automatically identify long and short button presses and react accordingly.

Power on Sources:

1. ACIN, VBUS, and battery
2. N_OE transition from high to low.
3. PEK press

Power On

System power-on is initiated whenever the following conditions occur:

1. When N_OE is low, and upon connection of a power supply that meets the requirements (ACIN Or VBUS > 3.8V, and the battery voltage is higher than the shutdown voltage), AXP209 will automatically boot (Automatic booting on power supply connection can be configured by the developer).
2. N_OE is low and the system is powered off, press PEK can power on AXP209. If required the Host
3. When there is a valid external power source or battery present and N_OE changes from high to low, AXP209 will be turned on.

After power on, DC-DC and LDO will be soft booted in a preset timing sequence, and then either the Host or PWREN the pin can enable/disable power.

Shutdown (Power off)

When you push-and-hold PEK longer than IRQLEVEL, HOST can write “1” into“REG32H [7]” to inform AXP202 to shutdown, which can disable all power output except LDO1.

System power-off is initiated whenever the following conditions occur:

1. Input voltage is too low(Low-Power Protection)
2. Power output voltage is too low due to overload(Overload Protection)

3. Input voltage is too high(Overvoltage Protection)(See more details in chapter " Intelligent Power Select"
4. Have waited more than 2S(default) when N_OE changes from hight to low
5. Push PEK longer more than OFFLEVEL(Default 6S), and system will cut off all power output except LDO1(there is no need for an extra RESET key)

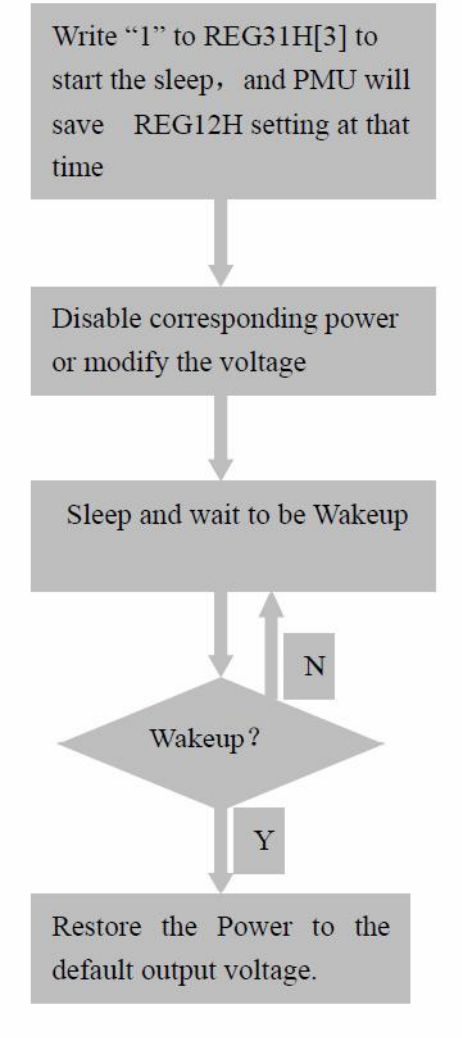
Note: With the automatic protection mechanism, AXP209 can protect the whole system by preventing components suffering from irreversible damage due to system abnormality.

Sleep and wakeup

When the running system needs to enter Sleep mode, REG31H [3] will determine whether one or several power rails should be disabled or change to other voltage. Wakeup can be trigged by either PEK signal, or the rising/falling edge of GPIO0, GPIO1, GPIO2, GPIO3 (To be the rising or falling edge, or both can be programmed by REG90H[7:6], REG92H[7:6], REG93H[7:6], and REG95H[7:6]), with all power rails resume to default voltage in default power on timing sequence.

NOTE: PEK IRQ（REG42H[1]), GPIO0 INPUT Edge IRQ (REG44H[0]), GPIO1 INPUT Edge IRQ (REG44H[1]), GPIO2 INPUT Edge IRQ（REG44H[2]), GPIO3 INPUT Edge IRQ (REG44H[3]) should be enabled to notify the processor to exit Sleep Mode via IRQ PIN.

See control process under sleep and wakeup modes as below:



System reset function and output monitoring (PWROK)

The PWROK in AXP209 can be used as the reset signal for the application system. During AXP209 startup, PWROK outputs low level, which will then be pulled high to startup and reset the system after all output voltage reaches the regulated value.

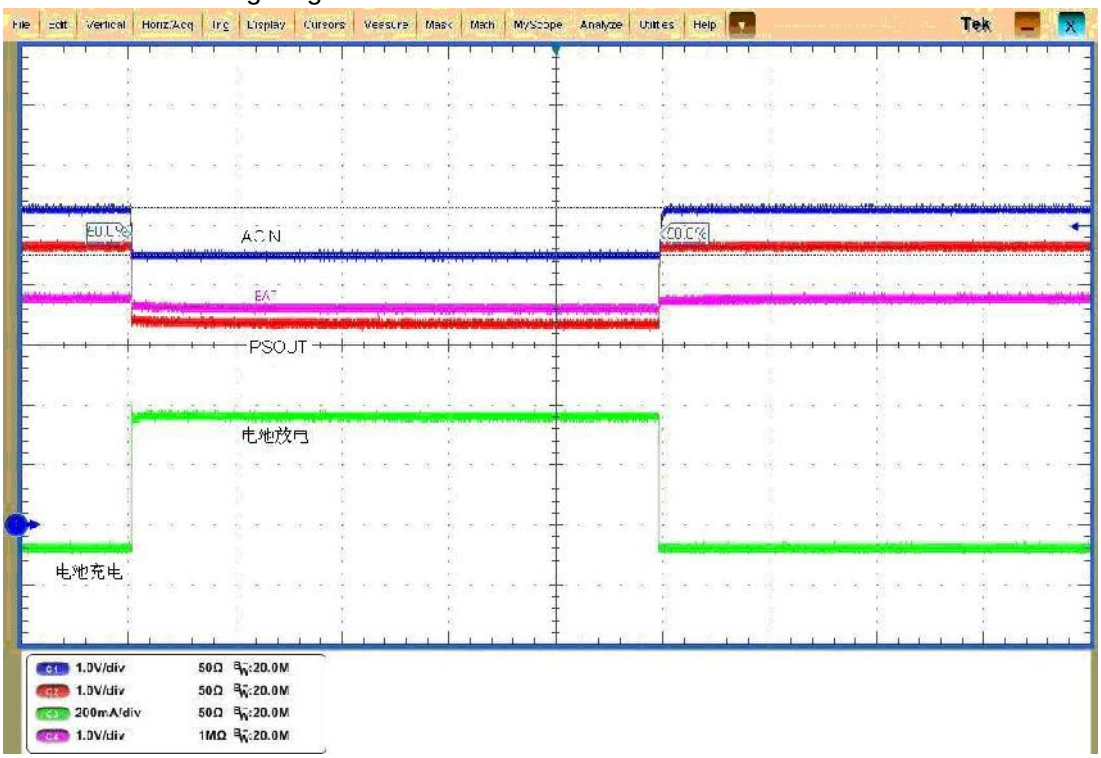
Under normal operation, the AXP209 will be always monitoring the voltage and load status. If overload or under-voltage occurs, the PWROK will instantly be driven low to reset the system and prevent data losses.

9.2 Power path management (IPS)

The AXP209 power input can come from lithium battery (BAT),USB VBUS Input, external power supply (ACIN). The IPS will select an appropriate power source depending on the battery and external power conditions.

O When only the battery is available, no external power input, the battery powers the system;
O When there is a valid external power source(VBUS Or ACIN), is is the preferred power supply.
O When the external power is removed, the IPS will seamlessly switch over to battery power.
O When both VBUS and ACIN are available, ACIN will be used to power the system and recharge the lithium battery;
O If the ACIN cannot provide sufficient current, VBUS is also connected to source more current;
O If the drive capacity is still insufficient, then the charge current is reduced to zero, the battery is used to power the system.

Therefore, compatibility of the system with external powers of different drive ability can be dramatically improved, and no special customized adapters are required to be provided on the part of manufacturers.
Please refer to the following diagram.



As shown above, when ACIN provides insufficient load ability, IPSOUT voltage will fall, and BAT will change from charge to discharge to supply load current together with ACIN.

The Host can set IPS parameters and read the feedback by using internal registers in AXP209 via TWSI.

Voltage Limiting/Current Limiting mode and Direct Mode

In order not to affect the USB communication, VBUS is always working under Voltage-Limit mode by default. In this mode, AXP209 ensures that VBUS voltage remains above a configurable reference voltage VHOLD which can meet the USB specification. The default VHOLD is 4.4V, adjustable in Reg30H [5:3] register.

If the system has limit on current obtained from USB VBUS, a current-limit mode is provided (See REG30H[1] register), with 900mA/500mA/100mA (Reg30H [0]) selectable.

If the system just utilizes the USB for power supply rather than communication, or the USB power adapter is utilized, AXP209 can be set to “VBUS Direct Mode” by modifying register REG30H[6], and then AXP202 will give priority to the application power demand. When the drive ability of USB Host is insufficient or system power consumption is large then the VBUS voltage is lower than VHOLD, AXP202 will release IRQ to indicate the weak power supply ability of Host VBUS, which may affect USB communication, and then Host software will follow up.

AXP209’s Reaction to External Power Supply Connection

AXP209 can automatically detect the connection of external power and judge whether the power is usable or not. The result will be set in corresponding registers, and IRQ will be asserted to inform the Host at the same time.
The following table has listed the status bits and meanings of external power registers:

Status register bits	Description
Register REG00H [7]	Indicates the presence of external ACIN
Register REG00H [6]	Indicates whether the external ACIN is usable or not
Register REG00H [5]	Indicates the presence of external VBUS
Register REG00H [4]	Indicates whether the external VBUS is usable or not
Register REG00H [3]	Indicates whether the VBUS voltage is above V_{HOLD} when used
Register REG00H [1]	Indicates whether ACIN/VBUS short circuits on PCB or not
Register REG00H [0]	Indicates whether the system is triggered to startup by ACIN/VBUS

The status bit indicating “whether the VBUS voltage is above V_{HOLD} or not when used” allows the Host to judge when it receives IRQ7 (indicating weak supply ability) whether VBUS is pulled low by system load input or the external power itself is below V_{HOLD}, which may facilitate Host software to decide either to keep on working in Voltage-Limit mode or switch to Direct Mode.

When to Select VBUS as Input Power

N_VBUSEN and register REG30H[7]: is used to determined when shall VBUS be used as the power supply

N_VBUSEN	**REG30H [7]**	Input Power	Description
Low	0	VBUS	Select if VBUS is valid and no ACIN is available
Low	1	VBUS	Select if VBUS is valid

High	1	VBUS	Select if VBUS is valid
High	0	ACIN / BAT	Don't select VBUS

Low-Power Warning and Low-Power Protection (Automatic Poweroff)

The value of $V_{WARNING}$ (low-power warning voltage) and V_{OFF}(automatic shutdown voltage) can be configured. If the system power is found to be lower than $V_{WARNING}$, IRQ19/IRQ20 will be released. If APS is lower than V_{OFF}, AXP202 will automatically enter Shutdown Mode, and disable all other outputs except LDO1.

There are two-levels in $V_{WARNING}$, namely, LEVEL 1 and LEVEL 2, which can be defined differently in applications. For example, use LEVEL1 to indicate insufficient power while LEVEL 2 can be used to indicate the oncoming shutdown.
The default values of $V_{WARNING}$ and V_{OFF} can be respectively set in registers REG3AH、REG3BH and REG31H[2:0].

Over-Voltage Protection

If the external power voltage exceeds 6.3V, AXP209 will send IRQ1/4 for indication. If the external power voltage exceeds 7V, AXP209 will automatically shutdown the system.

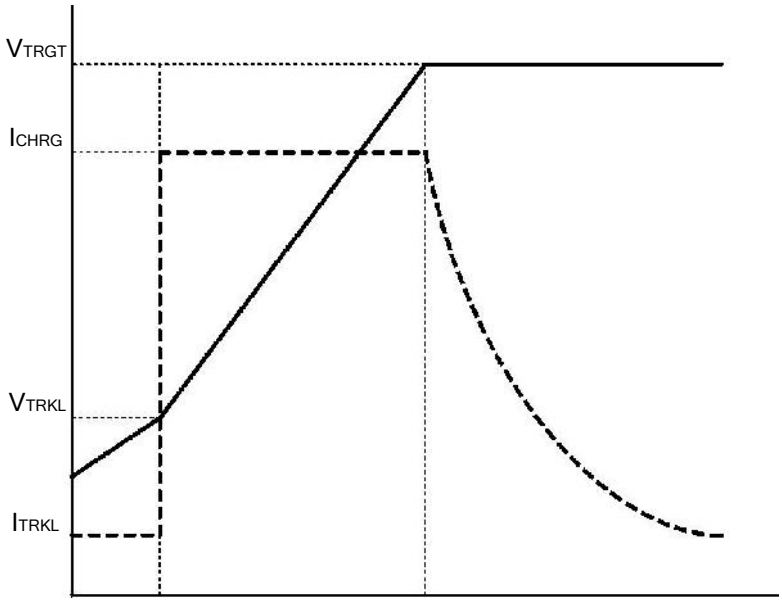
9.3 Adaptive PWM Charger

The AXP209 integrates a constant current/voltage PWM charger to automatically control the charge cycle, with a built-in safety clock capable of automatic charge termination without host processor intervention. This charger features automatic charge current scaling in accordance with the system power consumption, as well as battery detection, trickle charge and activation. In addition, the built-in temperature detection circuit can automatically decrease the charge current when the temperature is too high or too low. Compared with traditional linear chargers, this PWM charger features dramatic efficiency increase and power consumption decrease in systems that require large power consumption and fast battery charging, and thus greatly improve the system temperature performance.

Adaptive Charging Startup

The default state of the charger is "Enabled". (It can be programmed via registers. Refer to register REG33H.) When external power is plugged in, AXP209 will firstly judge whether it is suitable. If the charger is suitable for the power, and the charge function is allowed, AXP209 will automatically start the charge, and send IRQ to Host. At the same time, GHGLED pin will output low level to drive external LED to indicate the charging state.

Charging voltage and current:



V_{TRGT} = charge target voltage. The V_{TRGT} is 4.2V by default, which can be set via a register (Refer to "REG33H[6:5]") . At the same time, AXP209 will automatically adjust the charge target voltage when external power voltage is low.

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

Charging current

The charge current is 500mAor 1200mA by default, which can be set by REG33H [3:0].

Charging Process

If the battery voltage is lower than 3.0V, the charger will automatically enter the pre-charge mode, with charge current being 1/10 of the preset value. If the battery voltage is still below 3.0V 40 minutes later (adjustable, see "REG34H"), the charger will automatically enter the battery activate mode. Refer to "Battery Activate Mode" section for details.

Once the battery voltage exceeds 3.0V, the charger enters constant current mode. If the charge current is below 65% of the preset value, the system will send IRQ17 to indicate that "drive ability of external power is insufficient", as a result, the charge current is lower than the preset value, which may lead to longer charge time, so stronger power is preferred, or power-consuming functions should be disabled to shorten the charge time.

When the battery voltage reaches the V_{TRGT}, the charger will switch from the constant current mode to constant voltage mode, and the charge current will taper off.

When the charge current is lower than 10% or 15% (adjustable, see register "REG33H") of the preset value, a charge cycle ends, and AXP202 will release IRQ18 while the CHGLED pin will stop indicating the charging state. When the battery voltage is below V_{RCH} again, the automatic charge will restart, and IRQ17 will be issued.

In non-precharge mode, if the charge cycle is not ending after 480 minutes (adjustable, refer to register “REG34H”), the charger will automatically enter the battery activate mode.

Battery activation mode

At the entering the battery activation mode from either pre-charge mode or constant current mode (the timer expires), AXP209 will issue IRQ10 in both cases to indicate that the battery may be damaged/faulty. In battery activate mode, the charger always inputs relatively low current to batteries. AXP209 will exit activate mode and release IRQ11 only if the battery voltage has reached V_{RCH}. AXP209 will indicate whether the charger is in battery activate mode or not in register REG01H.

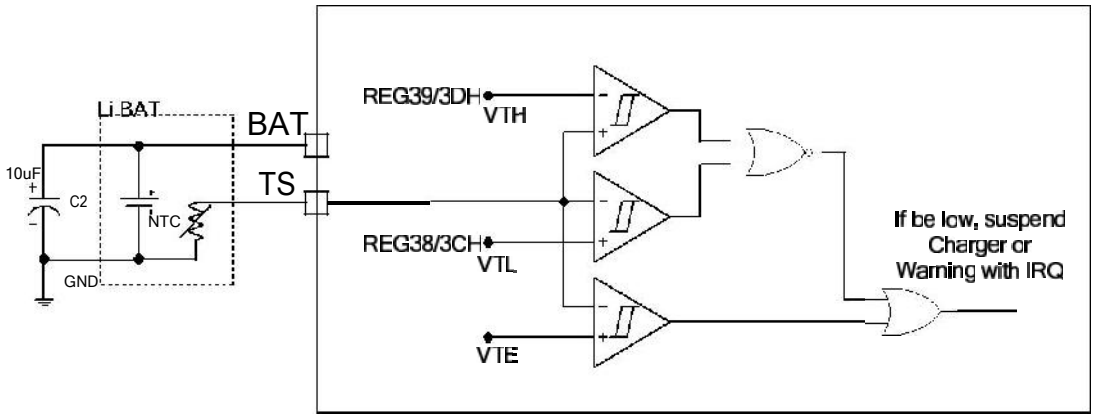
CHGLED

CHGLED pin is used to indicate charge state and warning. There are four states, namely, charging, not charging, battery abnormal warning, and external power over-voltage warning. CHGLED is NMOS Open Drain output, so a LED can be directly driven by a current-limit resistor to show the four states. The following table has displayed its two operation modes.

REG34H [4]	Status	CHGLED State	Comments
0	Charging	Low	
	Not charging	Hi Z	
	Battery abnormal	1Hz Flashing	The charger enters the battery activate mode, or the battery temperature is too high/low.
	Overvoltage	4Hz Flashing	External power input voltage is too high
1	Charging	1Hz Flashing	
	Can not be charged	Hi	No external power supply
	Not charging	Low	
	Overvoltage	4Hz Flashing	External power input voltage is too high, or the battery temperature is too high, too low

Battery temperature detection

The AXP209 can connect a temperature-sensitive resistor via the TS pin to monitor the battery temperature when the battery is charging or discharging. The diagram is shown below.



In the diagram above, VTH/VTL refers to the high temperature threshold and low temperature threshold, which is programmable via registers REG38H/39H/3CH/3DH respectively. VTE=0.2V. The temperature sensitive resistor suggested is a NTC temperature-sensitive resistor, which is 10Kohm and 1% accuracy at 25℃. The AXP209 will send a constant current via TS pin, and the current can be set as 20uA, 40uA, 60uA, and 80uA (See registerREG84H) to adapt to different NTC resistors. When the current goes through the temperature-sensitive resistor, a voltage is generated, which will be measured by ADC, and compared with regulated value to release corresponding IRQ or suspend the charge.

If the resistance value of temperature-sensitive resistor is too high or too low, extra resistors can be placed in series or parallel to expand the detect extent. If the battery does not incorporate a themistor, the TS pin can be linked to the ground, and in that case, AXP209 will automatically disable the battery temperature monitoring function.

Battery Detection

AXP209 will automatically detect the battery presence, record the result in registers (refer to REG01H) and send IRQ13, IRQ14.

Battery detection can be enabled and disabled by the Host. (Refer to register REG32H.)

9.4 Backup battery

The AXP209 supports backup battery charging and discharge. When no main power(BAT/ACIN/VBUS) is available, LDO1 will choose the backup battery to support the operation of some circuits, such as the system real-time clock, etc.

When there is a main power, REG35H[7] can be set to charge the backup battery, whose target voltage is 3.0V by default (adjustable via REG35H[6:5]) and charge current is 200uA by default (adjustable via REG35H[1:0]).

9.5 Multi-channel power output

AXP209 provides multiple Output voltages as follows:

Output path	Type	Default voltage	Application examples	Drive capability
DCDC2	BUCK	Configurable	1.25Vcore	1600 mA
DCDC3	BUCK	Configurable	2.5Vddr	700 mA
LDO1	LDO	Configurable	RTC	30 mA
LDO2	LDO	Configurable	Analog / FM	200 mA
LDO3	LDO	Configurable	1.3V PLL	200 mA
LDO4	LDO	Configurable	1.8V HDMI	200 mA
LDO5	LDO	Configurable	Vmic	50 mA

AXP209 comes with two synchronous step-down DC-DCs, five LDOs, as well as multiple timing and controlling methods. The operating frequency of DC-DC converters is 1.5MHz by default, which is adjustable via registers. External small inductors and capacitors can be connected as well. In addition, both DC-DCs can be set in PWM mode or auto mode (automatically switchable according to the AXP209 load). See register REG80H.

DC-DC2 / 3

DCDC3 output voltage ranges from 0.7 V to 3.5V, and output voltage of DCDC2 is ranged from 0.7-2.275V, which can be programmed via registers.(refer to “Register REG23H 27H”).

DCDC2/3 output capacitor is recommended to use small ESR ceramic capacitors above 10uF X7R; when the output voltage is set above 2.5V，2.2uH inductors is recommended; when the output voltage is set under 2.5V, 4.7uH inductors is recommended. Besides, the inductor saturation current should be more than 50% of the largest demanded current.

The following is a list of recommended inductor-capacitor:

Inductor		
Model	**Current specifications**	**DC 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
Capacitor		
Model	**Temperature characteristics**	**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 is always on and can be used to supply continuous power for application RTC with 30mA drive ability of 30mA.

LDO2/3/4

LDO2/4 output noise is as low as 18uVrms，and can be used to supply power for analog circuits of application system. LDO3 can supply power for systems like SRAM or PLL with 200mA drive ability.

LDO5

LDO5 also features the low noise design, and its drive ability is 50mA.

Soft Start

All DC-DCs and LDOs support soft start which can avoid the impact of dramatic current change on the input path in system boot stage.

Self-diagnosis: Load monitoring and current limiting

All DC-DCs and LDOs support load monitoring and current-limit functions. When the load current exceeds its drive ability, all output voltages will decrease to protect the internal circuits. When the two DC-DCs output voltage is lower than 85% of the set voltage, AXP209 will automatically shutdown. At the same time, the system will record the detailed output voltage that has lead to automatic shutdown (refer to register REG46H[5:2]) and issue a corresponding IRQ.

All DC-DCs do not require external Schottky diodes and resister divider feedback circuits. If a certain DC-DC is unnecessary in the application, just float the corresponding LX pins.

9.6 The default voltage/Start timing settings(Default Voltage / Timing Setting)

The AXP209 provides customizable default voltage settings of each power supply and start up timing.

Boot Timing: includes 8 levels, and the interval between each level can be set, from 1, 4, 16, 32 ms.

Default voltage setting: Each DC-DC / LDO can be set from the lowest to the highest voltage of the range.

LDO1SET PIN For setting **LDO1** initial voltage:

LDO1SET	LDO1SET = GND	LDO1SET = VINT
LDO1 Voltage	1.3V	3.3V

DC3SET PIN For setting **DC-DC3** initial voltage:

DC3SET	DC3SET = GND	DC3SET = APS	DC3SET = floating
DC-DC3 Voltage	1.8V	3.3V / 2.5V	1.2V / 1.5V

For more information, see “The default configuration instructions” section.

9.7 Signal Acquisition System

Simple battery monitors estimate the battery energy by measuring the battery voltage. However, the multiple 12-bit ADCs in the AXP209 can measure battery voltage, as well as battery current and external power voltage and current. It integrates battery charge and discharge coulomb counter. Using this data, the Host is capable of calculating accurately the battery energy and other battery data, such as the system real-time consumption, remaining battery energy, battery charge progress, remaining battery using time and charge time, etc.

The enabled state and sampling rate of each ADC can be set via registers REG82H, 83H, 84H. The sampling results will be saved in corresponding registers, and reference can be made to the ADC data in Register Instruction section. The input range of GPIO[1:0] can be set via register REG85H, while register REG00H[2] is used to indicate the battery charge/discharge current directions.

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 voltage	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	-144.7C	0.1C	264.8C
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

9.8 Multifunction Pin Description(Multi-Function Pin Description)

GPIO [3: 0]

GPIO[3:0] Can be defined as ADC Input (monitoring external signals), or LDO, etc. Please refer to REG90H-96H Instruction for details.

CHGLED

Features charge state indication, over-temperature/over-voltage warning, and GPO. Please refer to REG32H Instruction section for details.

9.9 Timer

AXP209 Contains a 7 bit Internal timer, the value is set by register REG8AH [6: 0]. If the register is set to 0, the timer is disabled. If REG8AH [6: 0] = A, The timer starts count from 0 to A and sets REG8AH [7], also

issuing a timer interrupt. Write 1 in register REG8AH [7] to clear the flag and re-start timing. Clearing interrupt flag will not re-start counting. The minimum step size for the timer is 1 minute, and the timing range 1 ~ 127 Minutes.

9.10 Decryption

AXP209 Contains a decryption module. The Host writes data to REG300-REG30F to be decrypted, and then writes 1 to the register REGB8H [1] to start decryption. After the decryption is complete, status bit REGB8 [0] is set to 1. Then the Host can read back the decrypted data from REG31x. Starts again automatically when the decryption AXP209 status bits are clared.

9.11 HOST Interface timing and interrupt (TWSI and IRQ)

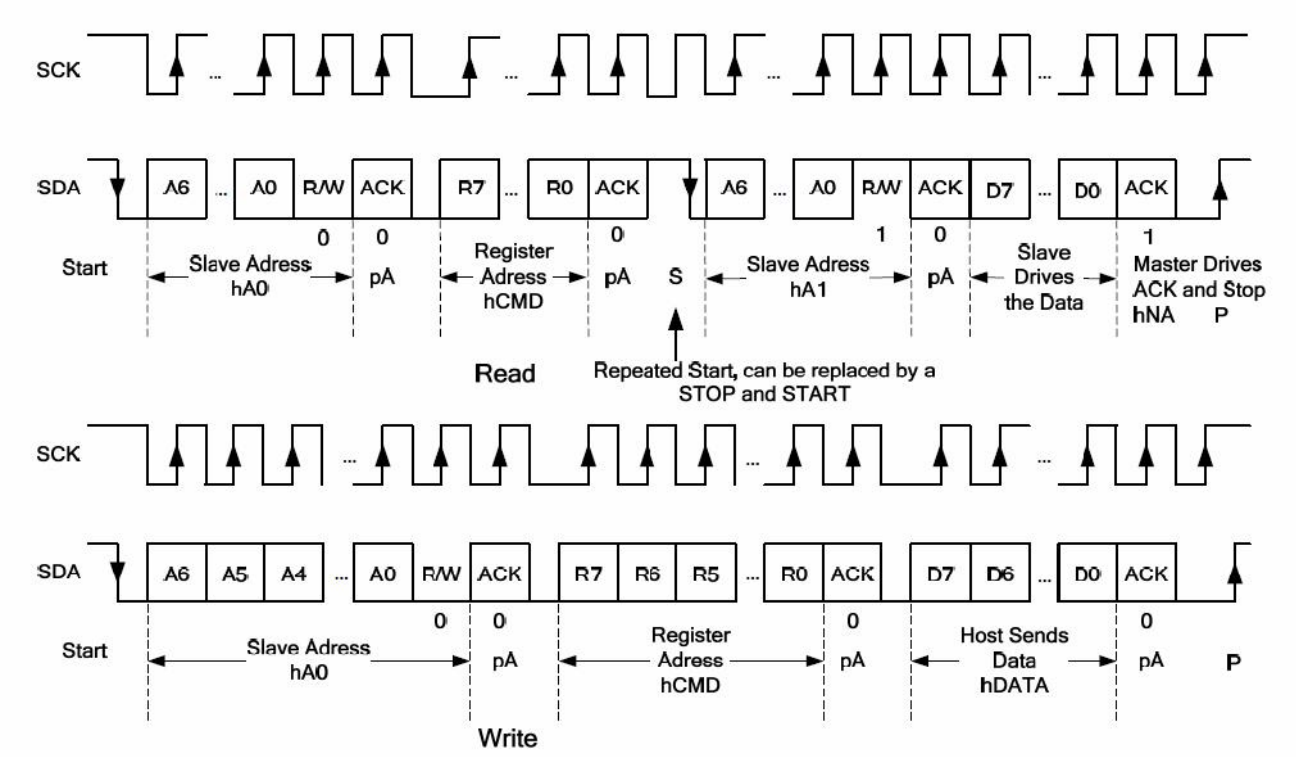


Figure 1: Single Read and Write

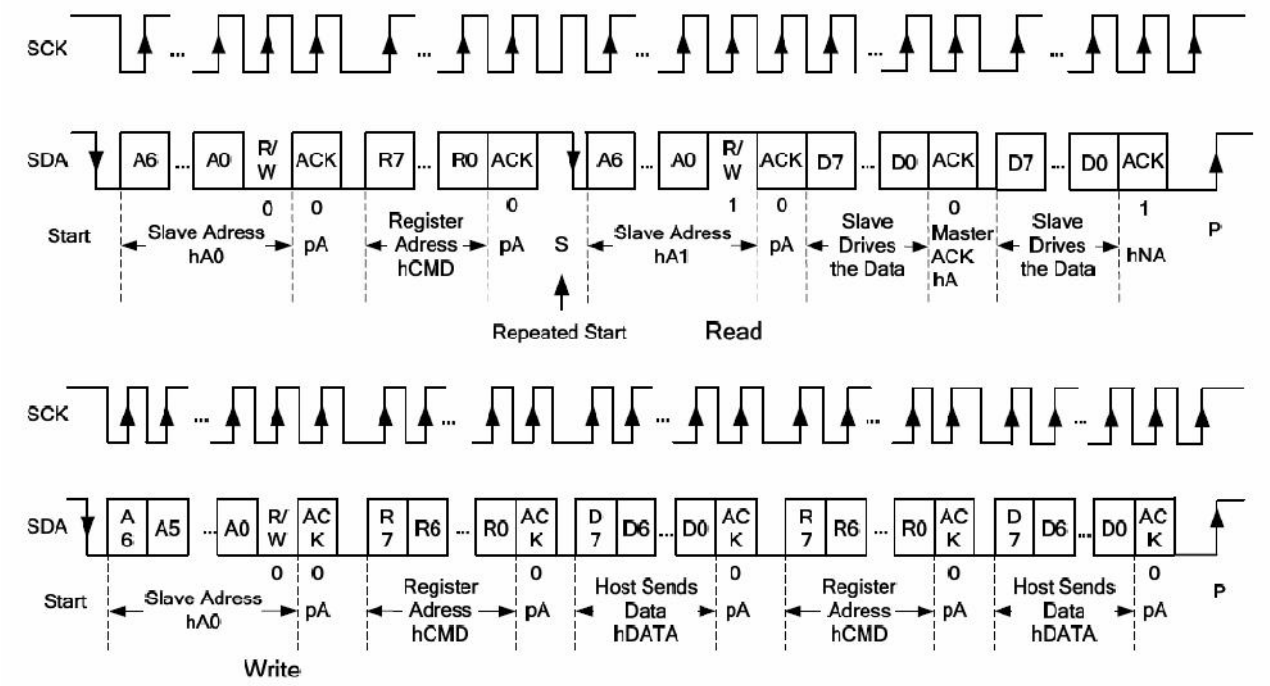


Figure 2: Multi Read and Write

Host can access the AXP209 registers via the TWSI interface, and the operation timing is shown above. Standard 100KHz or 400KHz frequency is supported, and the highest rate can reach 1.2MHz. In addition, multi read and write operation is supported, and the device addresses are 69H (READ) and 68H (WRITE).

When certain events occur, AXP209 will inform the Host by pulling down the IRQ interrupt line, and the interrupt state will be stored in interrupt state registers (See registers REG48H, REG49H, REG4AH, REG4BH and REG4CH). The interrupt can be cleared by writing 1 to corresponding state register bit. When there is no interrupt, IRQ output will be pulled high (by 51K external pull-up resistor). Each interrupt can be masked via interrupt control registers (Refer to registers REG40H, REG41H, REG42H, REG43H, and REG44H).

Location	Interrupt	Meaning	Location	Interrupt	Meaning
Register 48H [7]	IRQ1	Power supply ACIN over voltage	Register 4AH [3]	IRQ20	DCDC3 Voltage is too low
Register 48H [6]	IRQ2	Power supply ACIN Inserted	Register 4AH [2]	Reservations	
Register 48H [5]	IRQ3	Power supply ACIN Removed	Register 4AH [1]	IRQ22	PEK Short press
Register 48H [4]	IRQ4	Power supply VBUS Overvoltage	Register 4AH [0]	IRQ23	PEK Press
Register 48H [3]	IRQ5	Power supply VBUS Inserted	Register 4BH [7]	IRQ24	N_OE Boot
Register 48H [2]	IRQ6	Power supply VBUS Removed	Register 4BH [6]	IRQ25	N_OE Shutdown
Register 48H [1]	IRQ7	VBUS Voltage is less than VHOLD	Register 4BH [5]	IRQ26	VBUS Effective
Register 48H [0]	Reserved		Register 4BH [4]	IRQ27	VBUS Invalid
Register 49H [7]	IRQ8	Battery access	Register 4BH [3]	IRQ28	VBUS Session Valid
Register 49H [6]	IRQ9	Remove the battery	Register 4BH [2]	IRQ29	VBUS Session End
Register 49H [5]	IRQ10	Into the battery activation mode	Register 4BH [1]	IRQ30	Low battery warning LEVEL1

Register 49H [4]	IRQ11	Exit battery activation mode	Register 4BH [0]	IRQ31	Low battery warning LEVEL2
Register 49H [3]	IRQ12	Charging	Register 4CH [7]	IRQ32	Timer interrupt
Register 49H [2]	IRQ13	Charging complete	Register 4CH [6]	IRQ33	PEK Rising edge
Register 49H [1]	IRQ14	Battery temperature is too high	Register 4CH [5]	IRQ34	PEK Falling edge
Register 49H [0]	IRQ15	Battery temperature is too low	Register 4CH [4]	Reserved	
Register 4AH [7]	IRQ16	IC Internal over-temperature	Register 4CH [3]	IRQ35	GPIO3 Edge trigger input
Register 4AH [6]	IRQ17	Charging current shortage	Register 4CH [2]	IRQ36	GPIO2 Edge trigger input
Register 4AH [5]	IRQ18	DCDC1 Voltage is too low	Register 4CH [1]	IRQ37	GPIO1 Edge trigger input
Register 4AH [4]	IRQ19	DCDC2 Voltage is too low	Register 4CH [0]	IRQ38	GPIO0 Edge trigger input

10 Registers

Group 1: Power Control

Address	Register Description	**R / W**	Default value
00	Power Status Register	R	
01	Power Mode/Charging Status Register	R	
02	OTG VBUS Status Register	R	
04-0F	Data buffer register	R / W	00H
12	DC-DC2 / 3 & LDO2 / 3/4 & EXTEN Control Register	R / W	XXH
23	DC-DC2 Voltage setting register	R / W	XXH
25	DC-DC2/LDO3 Voltage ramp parameter	R / W	00H
27	DC-DC3 Voltage setting register	R / W	XXH
28	LDO2 / 3 Voltage setting register	R / W	XXH
30	VBUS-IPSOUT Path setting register	R / W	60H
31	V_{OFF} Shutdown voltage setting register	R / W	X3H
32	Shutdown, battery detection, CHGLED Control	R / W	46H
33	Charge control register 1	R / W	CXH
34	Charge control register 2	R / W	41H
35	Backup battery charging control register	R / W	22H
36	PEK Parameter setting register	R / W	5DH
37	DCDC Converter operating frequency setting	R / W	08H
38	Battery charging low temperature alarm setting	R / W	A5H
39	Battery charging temperature alarm setting	R / W	1FH
3A	APS Low Power Level1 Setting register	R / W	68H
3B	APS Low Power Level2 Setting register	R / W	5FH
3C	Battery discharge and low temperature alarm setting register	R / W	FCH
3D	Battery discharge temperature alarm setting	R / W	16H
80	DCDC Work mode setting register	R / W	E0H
82	ADC Enable setting register 1	R / W	83H

83	ADC Enable setting register 2	R / W	80H
84	ADC Sample rate settings, TS pin Control Register	R / W	32H
85	GPIO [1: 0]Input range setting register	R / W	X0H
86	GPIO1 ADC IRQ Rising edge threshold setting	R / W	FFH
87	GPIO1 ADC IRQ Falling threshold setting	R / W	00H
8A	Timer control register	R / W	00H
8B	VBUS Monitoring setting register	R / W	00H
8F	Over temperature shutdown control	R / W	01H

Group 2:GPIO Control

Address	Register Description	**R / W**	Default value
90	GPIO0 Control Register	R / W	07H
91	LDO5 Output voltage setting 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	GPIO3 Control Register	R / W	00H

Group 3: Interrupt Control

Address	Register Description	**R / W**	Default value
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 Enable Control Register 5	R / W	00H
48	IRQ Status Register 1	R / W	00H
49	IRQ Status Register 2	R / W	00H
4A	IRQ Status Register 3	R / W	00H
4B	IRQ Status Register 4	R / W	00H
4C	IRQ Status Register 5	R / W	00H

Group 4: ADC Data

Address	Register Description	**R / W**
56 [7: 0]	ACIN Voltage ADC Data High 8 Bit	R
57 [3: 0]	ACIN Voltage ADC Data Low 4 Bit	R
58 [7: 0]	ACIN Current ADC Data High 8 Bit	R
59 [3: 0]	ACIN Current ADC Data Low 4 Bit	R
5A [7: 0]	VBUS Voltage ADC Data High 8 Bit	R
5B [3: 0]	VBUS Voltage ADC Data Low 4 Bit	R
5C [7: 0]	VBUS Current ADC Data High 8 Bit	R

5D [3: 0]	VBUS Current ADC Data Low 4 Bit	R
5E [7: 0]	AXP209 Internal temperature monitoring ADC Data High 8 Bit	R
5F [3: 0]	AXP209 Internal temperature monitoring ADC Data Low 4 Bit	R
62 [7: 0]	TS Input ADC Data High 8 Bit, the default monitor battery temperature	R
63 [3: 0]	TS Input ADC Data Low 4 Bit, the default monitor battery temperature	R
64 [7: 0]	GPIO0 Voltage ADC Data High 8 Bit	R
65 [3: 0]	GPIO0 Voltage ADC Data Low 4 Bit	R
66 [7: 0]	GPIO1 Voltage ADC Data High 8 Bit	R
67 [3: 0]	GPIO1 Voltage ADC Data Low 4 Bit	R
70 [7: 0]	High instantaneous power battery 8 Bit	R
71 [7: 0]	Instantaneous power in the battery 8 Bit	R
72 [7: 0]	Instantaneous battery power is low 8 Bit	R
78 [7: 0]	Battery voltage is high 8 Bit	R
79 [3: 0]	Battery voltage is low 4 Bit	R
7A [7: 0]	Battery charge current high 8 Bit	R
7B [3: 0]	Battery charge current low 4 Bit	R
7C [7: 0]	Battery discharge current high 8 Bit	R
7D [4: 0]	Battery discharge current low 5 Bit	R
7E [7: 0]	System IPSOUT High Voltage 8 Bit	R
7F [3: 0]	System IPSOUT Voltage Low 4 Bit	R

Note: The battery-powered power calculation method

Pbat = 2 * Register values * Voltage LSB * Current LSB / 1000.

Where the voltage LSB is 1.1mV; Current LSB is 0.5mA, Calculated in units of mW.

Address	Register Description	**R / W**	Default value
B0	Coulomb charging the battery meter data register[31:24]	R / W	00H
B1	Coulomb charging the battery meter data register[23:16]	R / W	00H
B2	Coulomb charging the battery meter data register[15: 8]	R / W	00H
B3	Coulomb charging the battery meter data register[7: 0]	R / W	00H
B4	Coulomb gauge battery discharge data register[31:24]	R / W	00H
B5	Coulomb gauge battery discharge data register[23:16]	R / W	00H
B6	Coulomb gauge battery discharge data register[15: 8]	R / W	00H
B7	Coulomb gauge battery discharge data register[7: 0]	R / W	00H
B8	Coulomb gauge and encryption module control register	R / W	00H
B9	Power measurement result register	R / W	00H

Coulomb calculation method:

C= 65536 * current LSB *（charge coulomb counter value - discharge coulomb counter value） / 3600 / ADC sample rate.

Refer to REG84H setting for ADC sample rate；the current LSB is 0.5mA；unit of the calculation result is mAh.

10.1 REG 00H:Input power status

Bit	Description	R / W
7	ACIN presence indication 0: ACIN Does not exist;1: ACIN Exist	R
6	Instructions ACIN Is available	R
5	VBUS presence indication 0: VBUS Does not exist;1: VBUS Exist	R
4	Indicates if VBUS is useable	R
3	Indicating whether the VBUS voltage is above V_{HOLD} before used.	R
2	Indicates that the battery current direction 0:Battery discharging; 1:The battery is charging	R
1	Indicating whether ACIN and VBUS input short circuit on PCB	R
0	Indicating whether the boot source is ACIN or VBUS 0: Boot source isn't ACIN/VBUS； 1: Boot source is ACIN/VBUS.	R

10.2 REG 01H:Power mode and charge status indication

Bit	Description	R / W
7	Indicates AXP209 over-temperature 0:Not too hot; 1:Over Temperature	R
6	Charging indicator 0:Not charging or charging has been completed; 1:Charging	R
5	Battery connected indicator 0:No battery is connected to the AXP209; 1:The battery is connected to the AXP209	R
4	Reservations can not be changed	R
3	Indicate whether the battery charger entered into activation mode 0:Did not enter the cell activation mode; 1:Has entered the cell activation mode	R
2	Indicates the charging current is less than the expected current 0:The actual charge current equal to the desired current; 1:The actual charge current is less than the desired current	R
1-0	Reserved, can not be changed	R

10.3 REG 02H: USB OTG VBUS Status Indication

Bit	Description	R / W
7-3	Reserved, can not be changed	
2	Indicating whether VBUS is valid or not，1 means "valid"	R
1	Indicating whether VBUS is valid or not，1 means "valid"	R
0	Indicating Session End status，1 means "valid"	R

10.4 REG 04-0FH: Data Cache

Note: As long as the external power supply, battery or backup battery power exists, this data will not be lost.

10.5 REG 12H:Power Output Control

The default value: XXH

Bit	Description		R / W	Default value
7	Reserved, can not be changed		RW	X
6	LDO3 Switch Control	0:Shut down; 1:Turn on	RW	X
5	Reserved, can not be changed		RW	X
4	DC-DC2 Switch Control	0:Shut down; 1:Turn on	RW	X
3	LDO4 Switch Control		RW	X
2	LDO2 Switch Control		RW	X
1	DC-DC3 Switch Control		RW	X
0	EXTEN Switch Control		RW	X

10.6 REG 23H: DC-DC2 output voltage setting

The default value: XXH

Bit	Description		R / W	Default value
7-6	Reserved, can not be changed			
5-0	DC-DC2 The output voltage is set	0.7-2.275V,25mV / step Vout = [0.7+ (Bit5-0) * 0.025] V	RW	X

10.7 REG 25H: DC-DC2 / LDO3 Dynamic voltage scaling parameter settings

The default value: 00H

Bit	Description		R / W	Default value
7-4	Reserved, can not be changed			
3	LDO3 VRC Enable Control 0:Turn on; 1:Shut down		RW	0
2	DC-DC2 VRC Enable Control 0:Turn on; 1:Shut down		RW	0
1	LDO3 VRC soft start control	0: 25mV / 15.625us = 1.6mV / us 1: 25mV / 31.250us = 0.8mV / us	RW	0
0	DC-DC2 VRC soft start control	0: 25mV / 15.625us = 1.6mV / us 1: 25mV / 31.250us = 0.8mV / us	RW	0

10.8 REG 27H: DC-DC3 output voltage setting

The default value: XXH

Bit	Description		R / W	Default value
7	Reserved, can not be changed			
6-0	DC-DC3 output voltage setting	0.7-3.5V, 25mV / step Vout = [0.7+ (Bit6-0) * 0.025] V	RW	X

10.9 REG 28H: LDO2 / 4 output voltage setting

The default value: XXH

Bit	Description		R / W	Default value
7-4	LDO2 output voltage setting	1.8-3.3V, 100mV / step Vout = [1.8+ (Bit7-4) * 0.1] V	RW	X
3-0	LDO4 output voltage setting	1.25, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.5, 2.7, 2.8, 3.0, 3.1, 3.2, 3.3	RW	X

10.10 REG 29H: LDO3 output voltage setting

The default value: XXH

Bit	Description		R / W	Default value
7	LDO3 Mode selection: 0:LDO Mode, the voltage is set by [6: 0] 1：enable/disable control mode, voltage is determined by LDO3IN.		RW	0
6-0	LDO3 output voltage setting	0.7-2.275V,25mV / step Vout = [0.7+ (Bit6-0) * 0.025] V	RW	X

10.11 REG 30H: VBUS-IPSOUT Power Path Management

The default value: 6XH

Bit	Description		R / W	Default value
7	VBUS-IPSOUT Path selection control signal source 0:By N_VBUSEN pin controls whether to enable this path 1: VBUS-IPSOUT enabled, regardless of N_VBUSEN State		RW	0
6	VBUS V_{HOLD} voltage limiting control 0: No voltage drop limit ; 1: Limit the voltage drop		RW	1
5-3	V_{HOLD} Set	V_{HOLD}= [4.0+ (Bit5-3) * 0.1] V	RW	100
2	Reserved, can not be changed			
1-0	VBUS current-limit selection when current-limit is enabled 00:900mA ; 01:500mA; 10:100mA; 11:no limit		RW	0

10.12 REG 31H: V_{OFF} Shutdown voltage setting

The default value: X3H

Bit	Description		R / W	Default value
7-4	Reserved, can not be changed			
3	Sleep Mode PEK or GPIO edge wakeup enable settings: 0: Disable 1: Enable This bit will be automatically cleared to 0 after writing, so “1 ”should be rewritten whenever entering Sleep mode.			
2-0	V_{OFF} Setting	V_{OFF}= [2.6+ (Bit2-0) * 0.1] V Default: 2.9V	RW	011

10.13 REG 32H:Shutdown settings, battery detection, and CHGLED Pin control

The default value: 46H

Bit	Description		R / W	Default value
7	Shutdown Control This bit is write 1 will shutdown the AXP209 outputs		RW	0
6	Battery monitoring function setting bit: 0:Shut down; 1:Turn on		RW	1
5-4	CHGLED Pin function setting	00: Hi 01: 25% 1Hz Flashing 10: 25% 4Hz Flashing 11: Output Low	RW	00
3	CHGLED Pin control settings	0: Controlled by charging 1: Controlled by REG 32H [5: 4]	RW	0
2	Output off timing sequence control	0: Shutdown simultaneously 1: Shutdown in reverse sequence to startup	RW	0
1-0	Shutdown delay time after N_OE changes from low to high	00: 128mS; 01: 1S; 10: 2S; 11: 3S	RW	10

10.14 REG 33H:Charge Control 1

The default value: CXH

Bit	Description	R / W	Default value
7	Charging function enable control bit 0:Disable, 1:Enable	RW	1
6-5	Charging target voltage setting 00: 4.1V; 01: 4.15V; 10: 4.2V; 11: 4.36V	RW	10

4	Charge termination current settings 0:End when charging current is less than 10% of the set value 1:End when charging current is less than 15% of the set value	RW	0
3-0	Charge current setting I_{charge}= [300+ (Bit3-0) * 100] mA	RW	X

10.15 REG 34H:Charge Control 2

The default value: 45H

Bit	Description		R / W	Default value
7	Pre-charge timeout setting Bit 1	00: 40 min; 01: 50min;	RW	0
6	Pre-charge timeout setting Bit 0	10: 60min; 11: 70min	RW	1
5	Reserved, can not be changed			
4	CHGLED Mode Selection 0:Constant on when Charging 1:Flashes when charging		RW	0
3-2	Reserved, can not be changed			
1-0	Constant current mode timeout setting Bit 1-0	00: 6Hours; 01: 8Hours; 10: 10Hours; 11: 12Hours	RW	01

10.16 REG 35H:Backup battery charge control

The default value: 22H

Bit	Description		R / W	Default value
7	Backup battery charge enable control 0:Disable; 1:Enable		RW	0
6-5	Backup battery voltage target setting 00: 3.1V; 01: 3.0V; 10: 3.6V; 11: 2.5V		RW	01
4-2	Reserved, can not be changed			
1-0	Spare battery charging current is set	00: 50uA; 01: 100uA; 10: 200uA; 11: 400uA	RW	10

10.17 REG 36H: PEK Key parameter settings

The default value: 9DH

Bit	Description	R / W	Default value

7-6	Startup press time settings	00: 128mS; 01: 3S; 10: 1S; 11: 2S.	RW	01
5-4	Long press time setting	00: 1S; 01: 1.5S;10: 2S; 11: 2.5S.	RW	01
3	Automatic shutdown on long press time exceeding the shutdown time 0:Disable; 1:Enable		RW	1
2	PWROK Signal Delay after power-up completed 0: 8mS; 1: 64mS		RW	1
1-0	Shutdown time setting	00: 4S; 01: 6S; 10: 8S; 11: 10S.	RW	01

10.18 REG 37H: DC-DC Operating frequency settings

The default value: 08H

Bit	Description		R / W	Default value
7-4	Reserved, can not be changed			
3-0	DC-DC switching frequency	Each level changes by 5% The default value 1.5MHz F = [1 +/- (Bit3-0) * 5%)] * 1.5MHz	RW	1000

10.19 REG 38H: $V_{LTF\text{-}charge}$ Battery charging low temperature threshold settings

The default value: A5H

Bit	Description		R / W	Default value
7-0	Battery Under-temperature threshold setting when the battery is charging, M	M*10H, When M=A5H, corresponding voltage is 2.112V Voltage range 0V ~ 3.264V	RW	A5H

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

10.20 REG 39H: $V_{HTF\text{-}charge}$ Battery charging high temperature threshold setting

The default value: 1FH

Bit	Description		R / W	Default value
7-0	When charging the battery temperature threshold setting,N	N*10H, When N=1FH, the corresponding voltage is 0.397V Voltage range 0V ~ 3.264V	RW	1FH

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

10.21 REG 3AH: System IPSOUT Vwarning Level1

The default value: 68H

Bit	Description	R / W	Default value
7-0	System IPSOUT Vwarning Level1	RW	68H

10.22 REG 3BH: System IPSOUT Vwarning Level2

The default value: 5FH

Bit	Description	R / W	Default value
7-0	System IPSOUT Vwarning Level2	RW	5FH

REG3AH, REG3BHVoltage corresponding to the following relationship (where the register value is n):

Vwarning = 2.8672 + 1.4mV * n * 4

10.23 REG 3CH: $V_{LTF\text{-}discharge}$ Battery discharge under temperature threshold settings

The default value: FCH

Bit	Description		R / W	Default value
7-0	Battery under-temperature threshold setting when the battery is discharging, M	M*10H, when M=FC, corresponding voltage is 3.226V ; Voltage ranges from 0V~3.264	RW	FCH

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

10.24 REG 3DH: $V_{HTF\text{-}discharge}$ Battery discharge over temperature threshold settings

The default value: 16H

Bit	Description		R / W	Default value
7-0	When discharging the battery under temperature threshold setting,N	N*10H, when N=16H, corresponding voltage is 0.282V ; Voltage ranges from 0V~3.264V	RW	16H

$V_{LTF\text{-}discharge}$ = N * 10H * 0.0008V

10.25 REG 80H: DC-DC Operating mode selection

The default value: E0H

Bit	Description		R / W	Default value
7-3	Reserved, can not be changed			
2	DC-DC2 Control mode	0: PFM / PWM Automatic switching	RW	0
1	DC-DC3 Control mode	1:Fixed PWM	RW	0
0	Reserved, can not be changed			

10.26 REG 82H: ADC Enable 1

The default value: 83H

Bit	Description	R / W	Default value

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 is enabled		RW	1

10.27 REG 83H: ADC Enable 2

The default value: 80H

Bit	Description		R / W	Default value
7	AXP209 Internal temperature monitoring ADC Enable	0:Disable, 1:Enable	RW	1
6-4	Reserved, can not be changed			
3	GPIO0 ADC Function is enabled	0:Disable, 1:Enable	RW	0
2	GPIO1 ADC Function is enabled		RW	0
1-0	Reserved, can not be changed			

10.28 REG 84H: ADC Sampling rate settings, TS Pin control

The default value: 32H

Bit	Description		R / W	Default value
7-6	ADC Sampling rate settings	25×2^n Sampling rates is 25, 50, 100, 200Hz	RW	0
5-4	TS Pin output current setting: 00: 20uA; 01: 40uA; 10: 60uA; 11: 80uA		RW	11
3	Reserved, can not be changed			
2	TS Pin function select 0:Battery temperature monitoring function,1:External independent ADC		RW	0
1-0	TS Current output setting	00:Disabled	RW	1
		01:Output current only when charging 10: Only when ADC is sampling input 11:Always enabled	RW	0

10.29 REG 85H: ADC Input Range

The default value: X0H

Bit	Description		R / W	Default value
7-2	Reserved, can not be changed			
1	GPIO1 ADC Input Range	0: 0-2.0475V	RW	0
0	GPIO0 ADC Input Range	1: 0.7-2.7475V	RW	0

10.30 REG 86H: GPIO1 ADC IRQ Rising edge threshold setting

The default value: FFH

Bit	Description	R / W	Default value
7-0	One LSB is 8mV	RW	FF

10.31 REG 87H: GPIO1 ADC IRQ Falling edge of the threshold setting

The default value: 00H

Bit	Description	R / W	Default value
7-0	A LSB For 8mV	RW	00

10.32 REG 8AH:Timer Control

The default value: 00H

Bit	Description	R / W	Default value
7	Timer expired Write 1 Clear this state	RW	0
6-0	Set the time, in minutes Write all 0's to disable this timer	RW	0000000

10.33 REG 8BH: VBUS Pin Monitoring and SRP Function Control

The default value: 00H

Bit	Description	R / W	Default value
7-6	Reserved, can not be changed		
5-4	VBUS valid voltage setting 00: 4.0V; 01: 4.15V; 10: 4.45V; 11: 4.55V	RW	00
3	VBUS Valid Detection feature: 0:Disable,1:Enable	RW	0
2	VBUS Session Detection feature: 0:Disable, 1:Enable	RW	0
1	Discharge VBUS discharge function setting 0: to disable the VBUS discharge resistance；1: to enable the VBUS discharge resistance	RW	0

0	Charge VBUS charge function setting 0: disable the VBUS charge resistance；1: enable the VBUS charge resistance and charge the VBUS	RW	0

10.34 REG 8FH:Over-temperature shutdown feature set

The default value: 21H

Bit	Description	R / W	Default value
7-3	Reserved, can not be changed	RW	0
2	AXP209 Internal over-temperature shutdown feature set 0:Not shut down; 1:Shutdown	RW	0
1-0	Reserved, can not be changed		

10.35 REG 90H: GPIO0 function settings

The default value: 07H

Bit	Description		R / W	Default value
7	GPIO0 Rising edge IRQ Or Wakeup Function	0:disable	RW	0
6	GPIO0 Falling edge IRQ Or Wakeup Function	1:enable	RW	0
5-3	Reserved, can not be changed		RW	0
2	GPIO0 Pin feature set Bit 2-0	000:Output Low 001:Output High (3.3V) 010:Universal input function 011:Low Noise LDO5 100: ADC Input 1XX:Floating	RW	1
1			RW	1
0			RW	1

10.36 REG 91H: LDO5 Output voltage and EXTEN / GPIO high level settings

The default value: A5H

Bit	Description	R / W	Default value
7-4	LDO5 The output voltage is set Vout = [1.8 + (Bit7-4)* 0.1] V; default = 1.8 + 10 * 0.1 = 2.8V	RW	1010
3	Reserved, can not be changed		
2-0	EXTEN and GPIO [1: 0] output high level setting 000: 1.8V; 001: 2.5V; 010: 2.8V; 011: 3.0V; 100: 3.1V; 101: 3.3V; 110: 3.4V; 111: 3.5V	RW	101

10.37 REG 92H: GPIO1 Feature setttings

The default value: 07H

Bit	Description		R / W	Default value
7	GPIO1 Rising edge IRQ Or Wakeup Function	0:disable	RW	0
6	GPIO1 Rising edge IRQ Or Wakeup Function	1:enable	RW	0
5-3	Reserved, can not be changed		RW	0
2-0	GPIO1 Pin feature set	000:Output Low 001:Output High (3.3V) 010:Universal input function 011:Low Noise LDO 100: ADC Input 1XX:Floating	RW	111

10.38 REG 93H: GPIO2 Feature set

The default value: 07H

Bit	Description		R / W	Default value
7	GPIO2 Rising edge IRQ Or Wakeup Function	0:disable	RW	0
6	GPIO2 Falling edge IRQ Or Wakeup Function	1:enable	RW	0
5-3	Reserved, can not be changed		RW	0
2-0	GPIO2 Pin feature set	000:Output Low 001:Floating 010:Universal input function XXX:Floating	RW	111

10.39 REG 94H: GPIO [2: 0]Setting and monitoring of signal status

The default value: 00H

Bit	Description		R / W	The default value
7	Reserved, can not be changed		R	
6	GPIO2 Input Status	0:Input low level 1:Input high level	R	
5	GPIO1 Input Status		R	
4	GPIO0 Input Status		R	
3-0	Reserved, can not be changed			

10.40 REG 95H: GPIO3 Settings

The default value: 00H

Bit	Description		R / W	Default value
7	GPIO3 Rising edge IRQ Or Wakeup Function	0:disable	RW	0
6	GPIO3 Falling edge IRQ Or Wakeup Function	1:enable	RW	0
5-3	Reserved, can not be changed			
2	GPIO3 Feature set	0:NMOS Open Drain Output 1: Digital Input Function	RW	0
1	GPIO3 Output Settings	0:Output low,NMOS Turn on 1:Float,NMOS Shut down	RW	1
0	GPIO3 Input Status	0: Input High 1: Input Low	R	

10.41 REG 40H And 48H: IRQ Enable 1 And IRQ Status 1

IRQ Enable 1,REG40H: Default: D8H

Bit	Description	R / W	Default value
7	ACIN Over-voltage IRQ Enable	RW	1
6	ACIN Connection IRQ Enable	RW	1
5	ACIN Disconnection IRQ Enable	RW	0
4	VBUS Over-voltage IRQ Enable	RW	1
3	VBUS Connection IRQ Enable	RW	1
2	VBUS Disconnection IRQ Enable	RW	0
1	VBUS Available but less than V_{HOLD}IRQ Enable	RW	0
0	Reserved, can not be changed	RW	0

IRQ State 1,REG48H: Default: 00H

Bit	Description	R / W	Default value
7-0	The description of each status bit respectively matches each bit of 40H above; For example:Bit7 Is ACIN Over-voltage IRQ Status bit	RW	0

10.42 REG 41H And 49H: IRQ Enable 2 And IRQ Status 2

IRQ Enable 2,REG41H: Default: FFH

Bit	Description	R / W	Default value
7	Battery connected IRQ Enable	RW	1
6	Battery is removed IRQ Enable	RW	1
5	Battery in activation charge mode IRQ Enable	RW	1
4	Exit battery activation mode IRQ Enable	RW	1
3	Charging IRQ Enable	RW	1
2	Charging complete IRQ Enable	RW	1
1	Battery over-temperature IRQ Enable	RW	1
0	Battery low temperature IRQ Enable	RW	1

IRQ State 2,REG49H: Default: 00H

Bit	Description	R / W	The default value
7-0	Meaning of the status bits correspond to each bit of 41H listed above	RW	0

10.43 REG 42H And 4AH: IRQ Enable 3 And IRQ Status 3

IRQ Enable 3,REG42H: Default: 03H

Bit	Description	R / W	Default value
7	AXP209 Internal over-temperature IRQ Enable	RW	0
6	Charging current is less than the set current IRQ Enable	RW	0
5	Reserved, can not be changed		
4	DC-DC2 The output voltage is less than the set value IRQ Enable	RW	0
3	DC-DC3 The output voltage is less than the set value IRQ Enable	RW	0
2	LDO3 The output voltage is less than the set value IRQ Enable		
1	PEK Short press IRQ Enable	RW	1
0	PEK Long press IRQ Enable	RW	1

IRQ State 3,REG4AH: Default: 00H

Bit	Description	R / W	Default value
7-0	Meaning of the status bits correspond to each bit of 42H above	RW	0

10.44 REG 43H And 4BH: IRQ Enable 4 And IRQ Status 4

IRQ Enable 4,REG43H: Default: 01H

Bit	Description	R / W	Default value
7	N_OE startup IRQ Enable	RW	0
6	N_OE Shutdown IRQ Enable	RW	0
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	APS Low voltage IRQ Enable (LEVEL1)	RW	0
0	APS Low voltage IRQ Enable (LEVEL2)	RW	1

IRQ State 4,REG4BH: Default: 00H

Bit	Description	R / W	Default value
7-0	Meaning of the status bits correspond to each bit of 43H above	RW	0

10.45 REG 44H And 4C: IRQ Enable 5 And IRQ Status 5

IRQ Enable 5,REG44HThe default value: 00H;

Bit	Description	R / W	Default value
7	Timer expires IRQ Enable	RW	0
6	PEK Button on the rising edge IRQ Enable	RW	0
5	PEK Button on the falling edge IRQ Enable	RW	0
4	Reserved, can not be changed	RW	0
3	GPIO3 Edge trigger input IRQ Enable	RW	0
2	GPIO2 Edge trigger input IRQ Enable	RW	0
1	GPIO1 input edge-trigger or ADC Input IRQ Enable	RW	0
0	GPIO0 Edge trigger input IRQ Enable	RW	0

IRQ State 5,REG4CH: Default: 00H

Bit	Description	R / W	Default value
7-0	Meaning of the status bits corresponds to each bit 44H above	RW	0

Note: Writing 1 to all IRQ status register bits will clear corresponding status.

10.51 REG B8H:Coulomb Counter Control

The default value: 00H

Bit	Description	R / W	Default value
7	Coulomb gauge enable/disable	RW	0
6	Coulomb counter suspend control. Writing “1” to this bit will suspend the Coulomb counter, and this bit will be automatically cleared to 0 as well	RW	0
5	Coulomb counter clear control. Writing “1” to this bit will clear the coulomb counter, and this bit will automatically be cleared to 0.	RW	0
4-2	Reserved, can not be changed	RW	0
1-0	Decrypt the start bit. Automatically clear to 0 after the decryption.	RW	0
0	Decryption is complete: 0: Not finished 1: Finished	RW	0

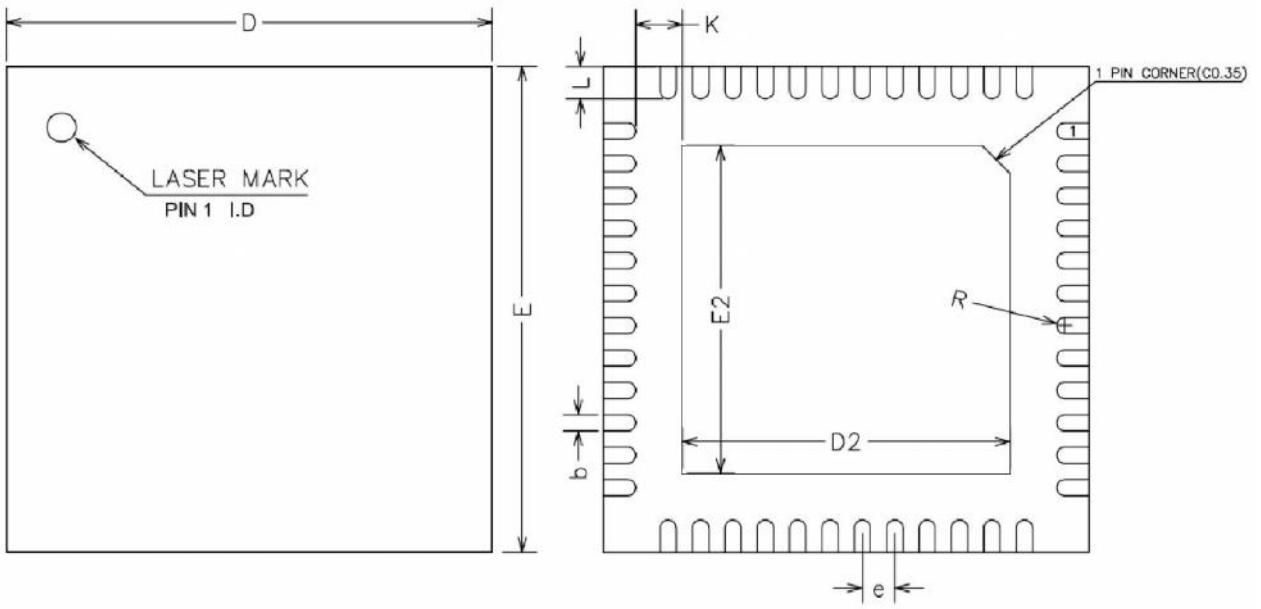
10.52 REG B9H:Fuel Gauge

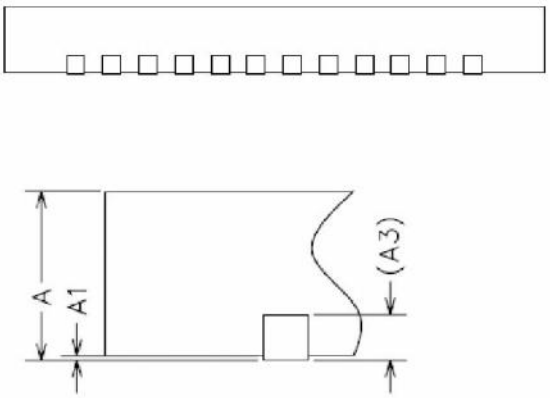
The default value: 7FH

Bit	Description	R / W	Default value
7	Fuel Gauge Control 0: Normal operating mode 1: Suspended	RW	0
6-0	Fuel gauge percentage	R	7F

11. Package

AXP209：QFN48





COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0	0.02	0.05
A3		0.20REF	
b	0.15	0.20	0.25
D	5.90	6.00	6.10
E	5.90	6.00	6.10
D2	3.95	4.05	4.15
E2	3.95	4.05	4.15
e	0.35	0.40	0.45
K	0.20	–	–
L	0.35	0.40	0.45
R	0.09	–	–