

PMIC Optimized For Multi-Core High-Performance System

AXP228

Datasheet

Revision 1.1

2013.01.06

Version history

Version	Modify Time	Author	Description
Revision 1.0	2012.12.12		Initial version
Revision 1.1	2013.01.06		

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Overview

Description

AXP228 is a highly integrated PMIC targeting at single cell Li-battery(Li-ion or Li-polymer)applications that require multi-channel power conversion outputs. It provides an easy and flexible power management solution for multi-core processors to meet the increasingly complex and accurate requirements on power control.

AXP228 comes with an adaptive USB3.0-compatible Flash Charger that supports up to 94% efficiency and 2.2A charge current. It also supports 21 channels power outputs (including 5-CH DCDC, with efficiency up to 95%). To ensure the security and stability of the power system, AXP228 provides multiple channels 12-bit ADC for voltage/current/temperature monitor and integrates protection circuits such as OVP,UVP,OTP,OCP. Moreover, AXP228s features a unique E-Gauge™ system, making power gauge easy and exact.

In addition, AXP228 embraces a fast interface for the system to dynaically adjust output voltage and enable work mode switch so that the battery life can be extended to the largest extent.

Besides, AXP228 features an IPS™ (Intelligent Power Select) circuit to transparently select power path among USB, external adaptor, Li-battery, and system load, making it possible for the system to work normally when only external input power but no battery is available.

Lastly, AXP228 is available in 8mm x 8mm x0.75mm 68-pin QFN package.

Applications

- Tablet, Smartphone, DVR
- UMPC-like, Student Computer

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Feature

Features

- IPS™

- Input voltage range: 2.9V~6.3V (AMR: 0.3V~11V)
- Configurable IPS™ system
- Adaptive USB/AC adaptor voltage/current limit (4.4V/900mA/500mA)

- Flash Charger

- Integrated MOSFET charge current up to 2.2A
- Battery temperature monitor
- Fully support USB charge
- High charge accuracy, $\pm 0.5\%$ accuracy
- Support 4.1V/4.2V/4.22V/4.24V battery
- Automatic charge control
- Support LED to indicate charge status
- Automatic charge current adjustment based on system load

- Buck DC-DC Converters (5-CH)

- DC-DC1: 1.6V~3.4V adjustable, 100mV/step, load current up to 1.4A
- DC-DC2: 0.6V~1.54V adjustable, 20mV/step, load current up to 2.5A, support VRC (Voltage Ramp Control)
- DC-DC3: 0.6V~1.86V adjustable, 20mV/step, load current up to 2.5A
- DC-DC4: 0.6V~1.54V adjustable, 20mV/step, load current up to 0.6A
- DC-DC5: 1.0V~2.55V adjustable, 50mV/step, load current up to 2A

- LDOs (14-CH)

- RTC_VCC: 30mA, always alive
- ALDO1/2: low noise LDO, 0.7V~3.3V adjustable, 100mV/step, load current up to 300mA
- ALDO3: low noise LDO, 0.7V~3.3V adjustable, 100mV/step, load current up to 200mA
- LDOIO0/LDOIO1: low noise LDO, 0.7V~3.3V adjustable, 100mV/step, load current up to 100mA
- DLDO1/ ELDO1: 0.7~3.3V adjustable, 100mV/step, load current up to 400mA
- DLDO2/ DLDO3/ ELDO2/ ELDO3: 0.7~3.3V adjustable, 100mV/step, load current up to 200mA
- DLDO4: 0.7V~3.3V adjustable, 100mV/step, load current up to 100mA
- DC5LDO: 0.7V~1.4V adjustable, 100mV/step, load current up to 200mA

- Switch(2-CH)

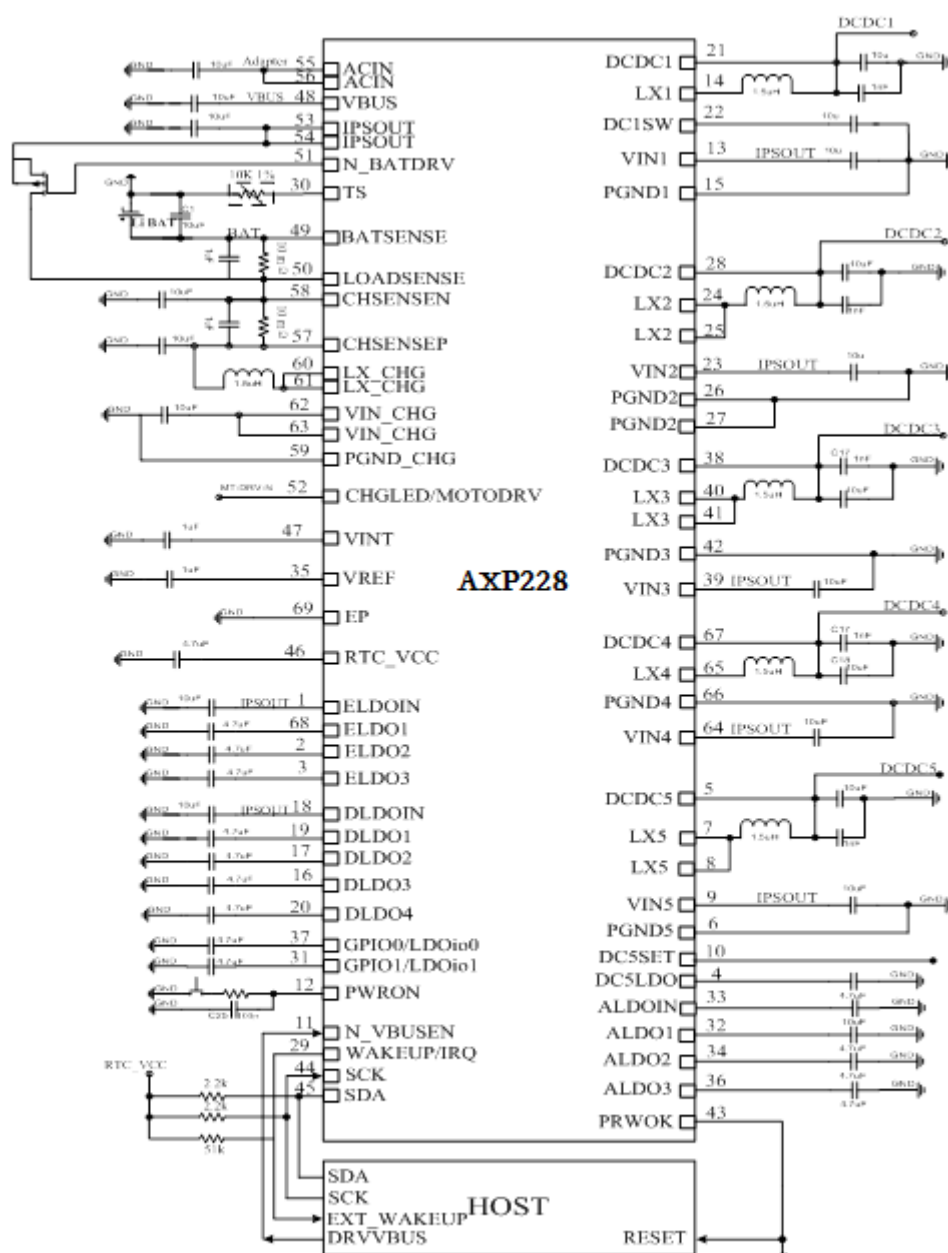
- DC1SW: internal resistance 100mOhm, power sourced from DCDC1
- CHGLED: 100mA sink strength, can be used to drive the motor and charging LED 

- Host Interface

- P2WI(Push-Pull Two Wire Interface) for host communication
- Configurable interrupt management
- Flexible pin function configuration: 2 GPIOs can be set as IO or LDO, etc
- Integrated timer

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Typical Application



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PIN

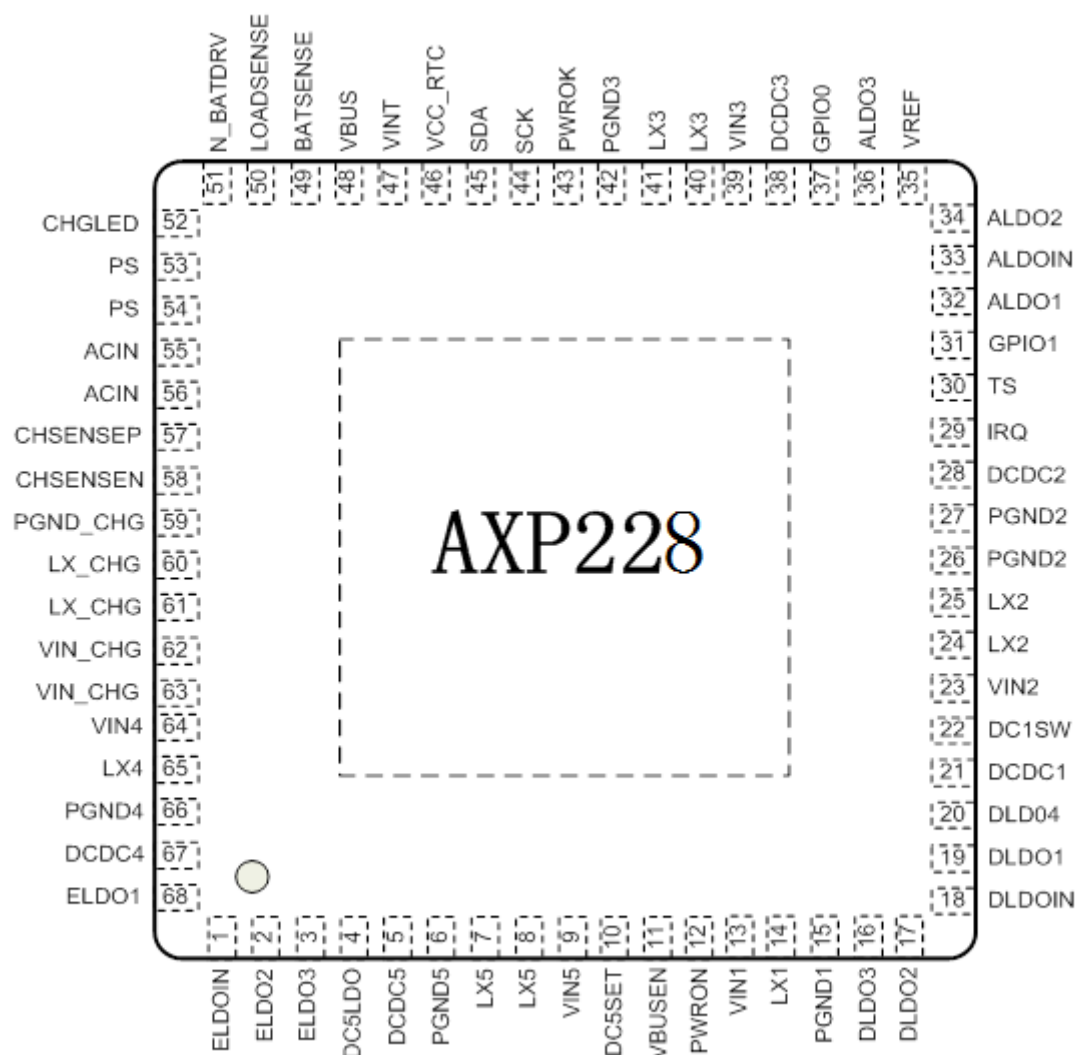


Figure 4-1. AXP228 PIN

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Pin List

Num	Name	Type	Condition	Description
1	ELDOIN	PI		ELDO Input source
2	ELDO2	O		Output Pin of ELDO2
3	ELDO3	O		Output Pin of ELDO3
4	DC5LDO	O		Output Pin of DC5LDO
5	DCDC5	I		DC-DC5 feedback pin
6	PGND5	G		NMOS Ground for DCDC5
7,8	LX5	IO		Inductor Pin for DCDC5
9	VIN5	PI		DCDC5 input source
10	DC5SET	I		Setting DCDC5 Output Voltage
11	N_VBUSEN	IO	Input	VBUS to IPSOUT Selection GND: IPSOUT selects VBUS High: IPSOUT does not select VBUS
			Output	VBUS to IPSOUT Selection IPSOUT selects VBUS : GND IPSOUT does not select VBUS: High
12	PWRON	I		Power On-Off key input, Internal 100k pull high to APS
13	VIN1	PI		DCDC1 Input Source
14	LX1	IO		Inductor Pin for DCDC1
15	PGND1	G		NMOS GND for DCDC1
16	DLDO3	O		Output Pin of DLDO3
17	DLDO2	O		Output Pin of DLDO2
18	DLDOIN	PI		DLDO Input Source
19	DLDO1	O		Output Pin of DLDO1
20	DLDO4	O		Output Pin of DLDO4
21	DCDC1	I		DC-DC1 feedback pin
22	DC1SW	O		DCDC1 Switch Output Pin
23	VIN2	PI		DCDC2 Input Source
24,25	LX2	IO		Inductor Pin for DCDC2
26, 27	PGND2	G		NMOS Ground for DCDC2
28	DCDC2	I		DC-DC2 Feedback Pin
29	IRQ/WAKEUP	IO		IRQ Output or Wakeup
30	TS	I		Battery Temperature Sensor Input or an External ADC Input
31	GPIO1/PWREN	IO	REG 92H[2:0]	GPIO1 or Low noise LDO
				PWREN function set by internal program

Num	Name	Type	Condition	Description
				memory
32	ALDO1	O		Output Pin of ALDO1
33	DLDOIN	PI		ALDO Input Source
34	ALDO2	O		Output Pin of ALDO2
35	VREF	O		Internal reference voltage
36	ALDO3	O		Output pin of ALDO3
37	GPIO0	IO	REG 90H[2:0]	GPIO0
				Low noise LDO
38	DCDC3	I		DC-DC3 feedback pin
39	VIN3	PI		DCDC3 Input Source
40, 41	LX3	IO		Inductor Pin for DCDC3
42	PGND2	G		NMOS Ground for DCDC2
43	PWROK	O		Power Good Indication Output
44	SCK	I		Clock pin for serial interface. Normally, it connects a 2.2K resistor to 3.3V I/O power
45	SDA	IO		Data pin for serial interface. Normally, it connects a 2.2K resistor to 3.3V I/O power
46	VCC_RTC	O		Output Pin of VCC_RTC
47	VINT	PO		Internal logic power, 1.8V
48	VBUS	PI		VBUS input
49	BATSENSE	I		PWM Charger Current Sense Resistance Positive Input
50	LOADSENSE	I		PWM Charger Current Sense Resistance Negative Input
51	N_BATDRV	O		BAT to PS extern PMOS driver
52	CHGLED	O		charger status indication
53,54	IPSOUT	PO		System power source
55, 56	ACIN	PI		Adapter input
57	CHSENSEP	I		PWM Charger Current Limit Sense Resistance Positive Input
58	CHSENSEN	I		PWM Charger Current Limit Sense Resistance Negative Input
59	PGND_CHG	G		NMOS Ground for PWM Charger
60,61	LX_CHG	IO		Inductor Pin for PWM Charger
62,63	VIN_CHG	I		Charger Input source
64	VIN4	I		DCDC4 input source
65	LX4	IO		Inductor Pin for DCDC4
66	PGND4	G		NMOS Ground for DCDC4
67	DCDC4	I		Feed back to DCDC4
68	ELDO1	O		Output Pin of ELDO1
69	EP	G		Exposed Pad, need to be connected to system ground

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Block Diagram

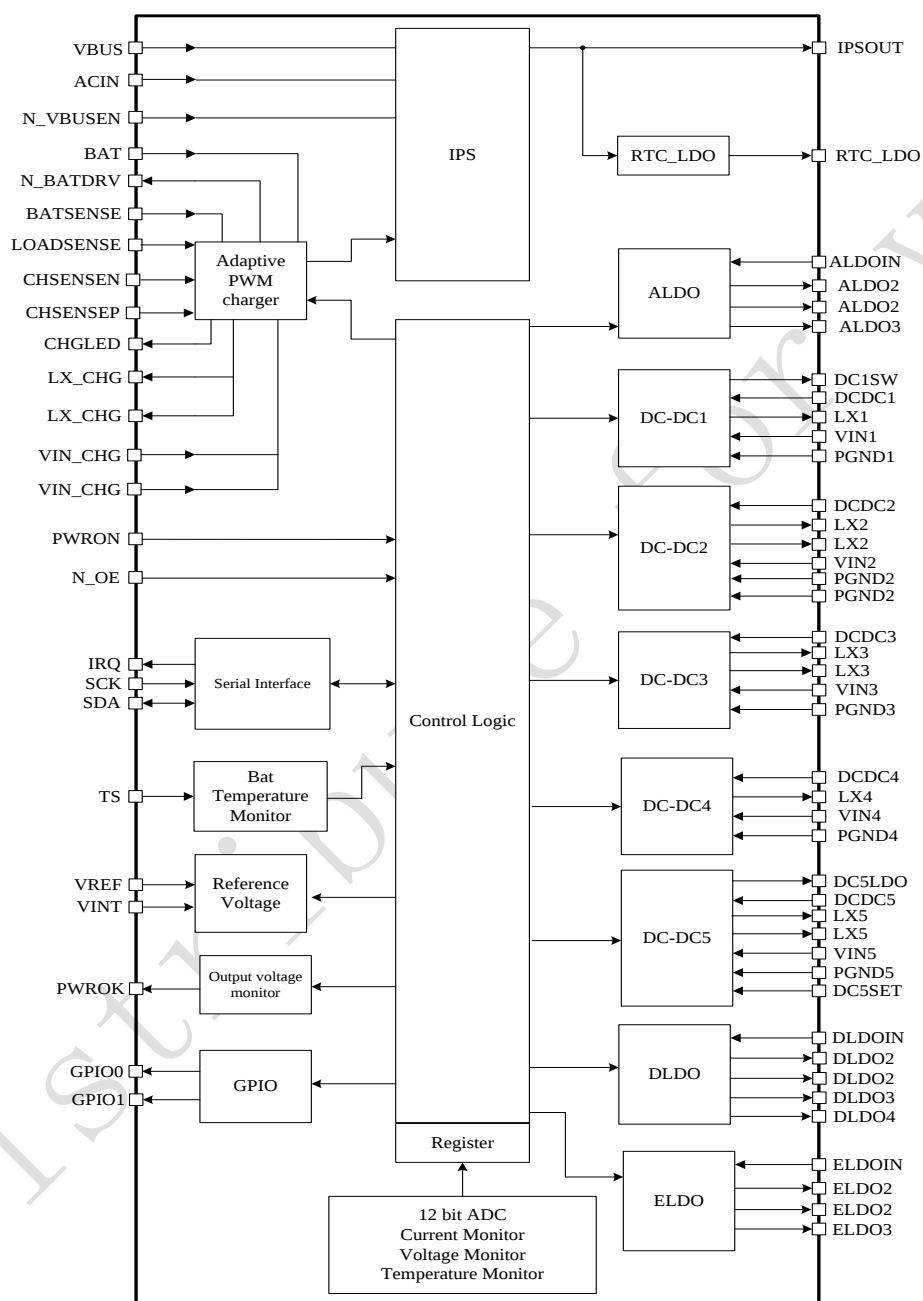


Figure 6-1. Block Diagram

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Absolute Maximum Ratings

SYMBOL	DESCRIPTION	VALUE	UNITS
ACIN	Input Voltage	-0.3 ~ 11	V
VBUS	Input Voltage	-0.3 ~ 11	V
T _J	Operating Temperature Range	-40 ~ 130	°C
T _S	Storage Temperature Range	-40 ~150	°C
T _{LEAD}	Maximum Soldering Temperature (at leads, 10sec)	300	°C
V _{ESD}	Maximum ESD stress voltage, Human Body Model	>4000	V
P _D	Internal Power Dissipation	2700	mW

Figure 0-1. Absolute ratings

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Electrical Characteristics

 $V_{IN} = 5V$, $BAT = 3.8V$, $T_A = 25^\circ C$

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		3500		mA
V_{UVLO}	ACIN Under Voltage Lockout			3.8		V
V_{OUT}	IPS Output Voltage		2.9		5.0	V
R_{ACIN}	Internal Ideal Resistance	PIN to PIN, ACIN to IPSOUT			120	m Ω
VBUS						
V_{IN}	VBUS Input Voltage		3.8		6.3	V
I_{OUT}	V_{OUT} Current Available Before Loading BAT			1500	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 Resistance	PIN to PIN, VBUS to IPSOUT			160	m Ω
Battery Charger						
V_{TRGT}	BAT Charge Target Voltage		-0.5%	4.2	+0.5%	V
I_{CHRG}	Charge Current			1200	2200	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		50		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
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	Falling Threshold		0.2		V

	Voltage	Hysteresis				
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SYMBOL	DESCRIPTION	CONDITIONS	MIN	TYP	MAX	UNITS
Off Mode Current						
I _{BATOFF}	OFF Mode Current	BAT=3.8V		40		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			1.2		V
TWSI						
V _{CC}	Input Supply Voltage		1.8		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		3		MHz
DCDC1						
I _{VIN1}	Input Current	PFM Mode I _{DC1OUT} =0		50		μA
I _{LIM1}	PMOS Switch Current Limit	PWM Mode		2200		mA
I _{DC1OUT}	Available Output Current	PWM Mode		1400		mA
V _{DC1OUT}	Output Voltage	Default	1.6	3.0	3.4	V
DCDC2						
I _{VIN2}	Input Current	PFM Mode I _{DC2OUT} =0		50		μA
I _{LIM2}	PMOS Switch Current Limit	PWM Mode		3000		mA
I _{DC2OUT}	Available Output Current	PWM Mode		2500		mA
V _{DC2OUT}	Output Voltage Range		0.6	1.1	1.54	V
DCDC3						
I _{VIN3}	Input Current	PFM Mode I _{DC3OUT} =0		50		μA
I _{LIM3}	PMOS Switch Current Limit	PWM Mode		3000		mA
I _{DC3OUT}	Available Output Current	PWM Mode		2500		mA
V _{DC3OUT}	Output Voltage Range		0.6	1.1	1.86	V
DCDC4						
I _{VIN3}	Input Current	PFM Mode I _{DC3OUT} =0		42		μA

I_{LIM3}	PMOS Switch Current Limit	PWM Mode		1200		mA
I_{DC3OUT}	Available Output Current	PWM Mode		600		mA
V_{DC3OUT}	Output Voltage Range		0.6	1.1	1.54	V
DCDC5						
I_{VIN3}	Input Current	PFM Mode $I_{DC3OUT} = 0$		45		uA
I_{LIM3}	PMOS Switch Current Limit	PWM Mode		2600		mA
I_{DC3OUT}	Available Output Current	PWM Mode		2000		mA
V_{DC3OUT}	Output Voltage Range		1.0	1.5	2.55	V

SYMBOL	DESCRIPTION	CONDITIONS	MIN	TYP	MAX	UNITS
RTC_VCC						
V_{RTC_VCC}	Output Voltage	$I_{RTC_VCC}=1mA$	-1%	1.2	1%	V
I_{RTC_VCC}	Output Current			100		mA
ALDO1						
V_{ALDO1}	Output Voltage	$I_{ALDO1}=1mA$	-1%	0.7	1%	V
I_{ALDO1}	Output Current			300		mA
I_Q	Quiescent Current			67		μA
PSRR	Power Supply Rejection Ratio	$I_{ALDO1}=60mA$, 1KHz		TBD		dB
e_N	Output Noise,20-80KHz	$V_O=3.3V$, $I_O=20mA$		31		μV _{RMS}
ALDO2						
V_{ALDO2}	Output Voltage	$I_{ALDO2}=1mA$	-1%	1.8	1%	V
I_{ALDO2}	Output Current			300		mA
I_Q	Quiescent Current			67		μA
PSRR	Power Supply Rejection Ratio	$I_{ALDO2}=10mA$,1KHz		TBD		dB
e_N	Output Noise,20-80KHz	$V_O=3.3V$, $I_O=20mA$		31		μV _{RMS}
ALDO3						
V_{ALDO3}	Output Voltage	$I_{ALDO3}=1mA$	-1%	3.0	1%	V
I_{ALDO3}	Output Current			200		mA
I_Q	Quiescent Current			67		μA
PSRR	Power Supply Rejection Ratio	$I_{ALDO3}=10mA$, 1KHz		TBD		dB
e_N	Output Noise,20-80KHz	$V_O=3.3V$, $I_O=20mA$		43		μV _{RMS}
DLDO1						
V_{DLDO1}	Output Voltage	$I_{DLDO1}=1mA$	-1%	0.7	1%	V
I_{DLDO1}	Output Current			400		mA
I_Q	Quiescent Current			60		μA
PSRR	Power Supply Rejection Ratio	$I_{DLDO1}=10mA$, 1KHz		TBD		dB
e_N	Output Noise,20-80KHz	$V_O=3.3V$, $I_O=20mA$		100		μV _{RMS}
DLDO2						
V_{DLDO2}	Output Voltage	$I_{DLDO2}=1mA$	-1%	0.7	1%	V
I_{DLDO2}	Output Current			200		mA
I_Q	Quiescent Current			60		μA
PSRR	Power Supply Rejection Ratio	$I_{DLDO2}=10mA$, 1KHz		TBD		dB

e_N	Output Noise,20-80KHz	$V_O=3.3V, I_O=20mA$		100		μV_{RMS}
DLDO3						
V_{DLDO3}	Output Voltage	$I_{DLDO3}=1mA$	-1%	3.0	1%	V
I_{DLDO3}	Output Current			200		mA
I_Q	Quiescent Current			60		μA
PSRR	Power Supply Rejection Ratio	$I_{DLDO3}=10mA, 1KHz$		TBD		dB
e_N	Output Noise,20-80KHz	$V_O=3.3V, I_O=20mA$		100		μV_{RMS}
DLDO4						
V_{DLDO4}	Output Voltage	$I_{DLDO4}=1mA$	-1%	3.0	1%	V
I_{DLDO4}	Output Current			100		mA
I_Q	Quiescent Current			60		μA
PSRR	Power Supply Rejection Ratio	$I_{DLDO4}=10mA, 1KHz$		TBD		dB
e_N	Output Noise,20-80KHz	$V_O=3.3V, I_O=20mA$		100		μV_{RMS}
ELDO1						
V_{ELDO1}	Output Voltage	$I_{ELDO1}=1mA$	-1%	0.7	1%	V
I_{ELDO1}	Output Current			400		mA
I_Q	Quiescent Current			60		μA
PSRR	Power Supply Rejection Ratio	$I_{ELDO1}=10mA, 1KHz$		TBD		dB
e_N	Output Noise,20-80KHz	$V_O=3.3V, I_O=20mA$		100		μV_{RMS}
ELDO2						
V_{ELDO2}	Output Voltage	$I_{ELDO2}=1mA$	-1%	0.7	1%	V
I_{ELDO2}	Output Current			200		mA
I_Q	Quiescent Current			60		μA
PSRR	Power Supply Rejection Ratio	$I_{ELDO2}=10mA, 1KHz$		TBD		dB
e_N	Output Noise,20-80KHz	$V_O=3.3V, I_O=20mA$		100		μV_{RMS}
DLDO3						
V_{ELDO3}	Output Voltage	$I_{ELDO3}=1mA$	-1%	0.7	1%	V
I_{ELDO3}	Output Current			200		mA
I_Q	Quiescent Current			60		μA
PSRR	Power Supply Rejection Ratio	$I_{ELDO3}=10mA, 1KHz$		TBD		dB
e_N	Output Noise,20-80KHz	$V_O=3.3V, I_O=20mA$		100		μV_{RMS}
DC5LDO						
V_{DC5LDO}	Output Voltage	$I_{DC5LDO}=1mA$	-1%	0.7	1%	V
I_{DC5LDO}	Output Current			200		mA
I_Q	Quiescent Current			60		μA
PSRR	Power Supply Rejection Ratio	$I_{DC5LDO}=10mA, 1KHz$		TBD		dB
e_N	Output Noise,20-80KHz	$V_O=3.3V, I_O=20mA$		100		μV_{RMS}
LDOio0						
V_{LDOio0}	Output Voltage	$I_{LDOio0}=1mA$	-1%	3.3	1%	V
I_{LDOio0}	Output Current			100		mA
I_Q	Quiescent Current			40		μA
PSRR	Power Supply Rejection Ratio	$I_{LDOio0}=10mA, 1KHz$		TBD		dB
e_N	Output Noise,20-80KHz	$V_O=3.3V, I_O=20mA$		40		μV_{RMS}

LDOio1						
V_{LDOio1}	Output Voltage	$I_{LDOio1}=1mA$	-1%	3.3	1%	V
I_{LDOio1}	Output Current			100		mA
I_Q	Quiescent Current			40		μA
PSRR	Power Supply Rejection Ratio	$I_{LDOio1}=10mA$, 1KHz		TBD		dB
e_N	Output Noise, 20-80KHz	$V_O=3.3V$, $I_O=20mA$		40		μV_{RMS}
DC1SW						
R_{DC1SW}	Internal Ideal Resistance	PIN to PIN, DCDC1 同 DC1SW		156		m Ω
I_Q	Quiescent Current			40		μA
CHGLED						
R_{DC1SW}	Internal Ideal Resistance	$V_{in}=0.3V$		2000		m Ω

9 Control and Operation

Once AXP228 is powered on, SCK/SDA pin of TWI will be pulled up to IO Power and then Host can adjust and monitor AXP228 with rich feedback information.

Remarks: “Host” here refers to system processor.

Remarks: “External Power” below includes ACIN and VBUS input.

9.1 Power On/Off & Reset

Power Enable Key (PEK)

The Power Key (PEK) can be connected between PWRON pin and GND of AXP228. AXP228 can automatically identify the four status (Long-press ,Short-press ,Key Down ,Key Up) and then correspond respectively.

Power on Source

1. ACIN、VBUS Insert
2. PEK

Power On

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

1. If a valid power source has plugged in (ACIN or VBUS>3.8V), AXP228 will be turned on or not by the default the configure module configuration.
2. Press PEK can power on AXP228.

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

Power Off



When you push-and-hold PEK longer than IRQLEVEL, HOST can write “1” into “REG32H [7]” to inform AXP228 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(DCDC) 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. 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)

Remarks: With the automatic protection mechanism, AXP228 can protect whole system by preventing components from damage due to system abnormality.

Sleep and wakeup

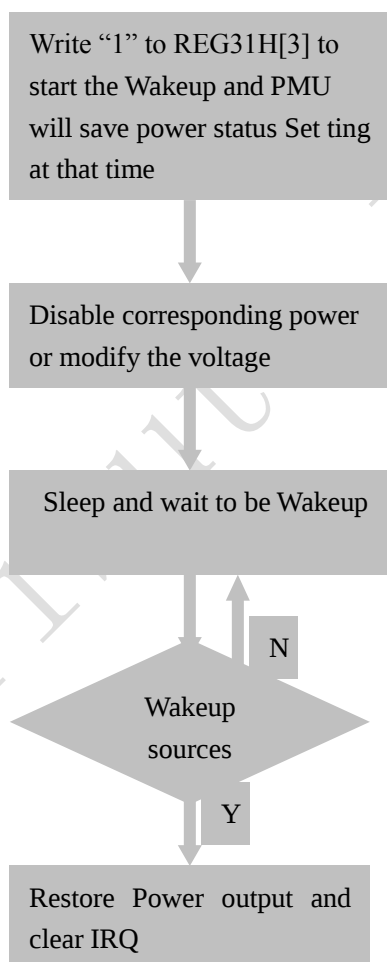
When the running system needs to enter Sleep mode, Maybe one or several power outputs should be disabled or change to other voltage. Wakeup can be initiated by the following sources:

- 1.,ACIN/VBUS insert/remove
- 2,PEK short/long press
- 3,PEK nedge
- 4,Low power warning level1/2
- 5,GPIO[1:0] Posedg or negedge
- 6,Software wakeup by Set the REG31H[5]
- 7,IRQ from high go low



These sources will make the PMU wakeup and all power outputs resume to default voltage in default power on timing sequence.

See control process under sleep and wakeup modes as below:



System Reset and Output Monitoring (PWROK)



The PWROK pin can be used as the reset signal of application system. During AXP228 startup, PWROK outputs low level, which will then be pulled high to startup the system after output voltage reaches the regulated value.

When application system works normally, AXP228 will be always monitoring the voltage and load status. If overload or under-voltage occurs, the PWROK will instantly output low level to reset the system and prevent

malfunction or data errors.

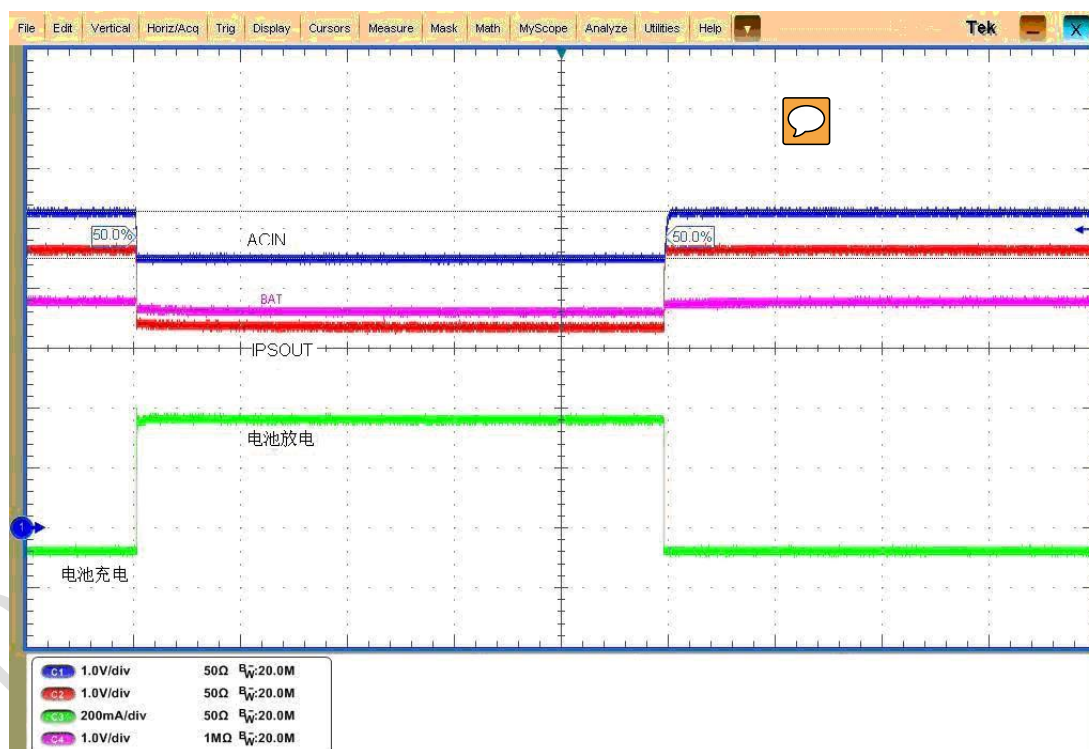
9.2 Power Path Management (IPS)

The input sources of AXP228 include Li- Battery, external power ACIN (such as AC adapter or USB VBUS input). IPS can select proper power allotting method according to external power and Li- Battery status.

- If only Li- Battery is available, and no external power input, Li- Battery is used for power input;
- If external power is available (VBUS or ACIN), it is preferred in power supply
- If Li- Battery is available, it will “Seamlessly” switch to Li- Battery once external power is removed
- When both VBUS and ACIN are available, ACIN will be applied to supply power in priority, and Li- Battery will be charged.
- If the current of ACIN path is not enough, VBUS will be enabled to achieve ACIN/VBUS common power supply
- If the current is still insufficient, charge current will be reduced to zero, and Battery is used for one of power sources

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 status to discharge to supply load current together with ACIN.

Host can set IPS parameters and read the feedback by visiting internal registers in AXP228 via TWSI.

Voltage-Limit/ Current-Limit Mode and Direct Mode

In order not to affect the USB communication, VBUS is always working under VBUS Voltage-Limit mode by

default. In this mode, AXP228 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 need to limit the current obtained from USB VBUS, a current-limit mode is provided (See REG30H [1] register), with 900mA/500mA (Reg30H [1:0]) selectable.

If the system just utilizes the USB for power supply rather than communication, or the USB power adapter is utilized, AXP228 can be Set to “VBUS Direct Mode” by modifying register REG30H[6], and then AXP228 will give priority to the application power demand. When the drive ability of USB Host is insufficient or system power consumption is large so that the VBUS voltage is lower than VHOLD, AXP228 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.

AXP228's Reaction to External Power Supply Plugin

AXP228 can automatically detect the plug-in of external powers and judge whether the power is usable or not. The result will be set in corresponding registers, and IRQ will be released to inform the Host at the same time.

The following table has listed the status bits and meanings of external power registers.

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

The status bit of “indicating whether the VBUS voltage is above V_{HOLD} or not when used” enables 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 power supply.



REG30_[7]	REG8F_[4]	N_VBUSEN	REG30H[2]	是否选用
0	0	High	0	No
0	0	Low	1	Yes
0	1	High	X	No
0	1	Low	X	Yes
1	X	X	X	Yes

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

With AXP228, the value of V_{WARNING} (low-power warning voltage) and V_{OFF} (automatic shutdown voltage) can be Set . If the Battery level is found to be lower than V_{WARNING} , IRQ20/IRQ21 will be released. If ALDOIN is lower than V_{OFF} , AXP228 will automatically enter Shutdown Mode, and disable all other outputs except LDO1. 

The two 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.

Over-Voltage Protection

If the external power voltage exceeds 6.3V, AXP228 will release IRQ1/4 for indication. If the external power voltage exceeds 7V, AXP228 will automatically shutdown the system.

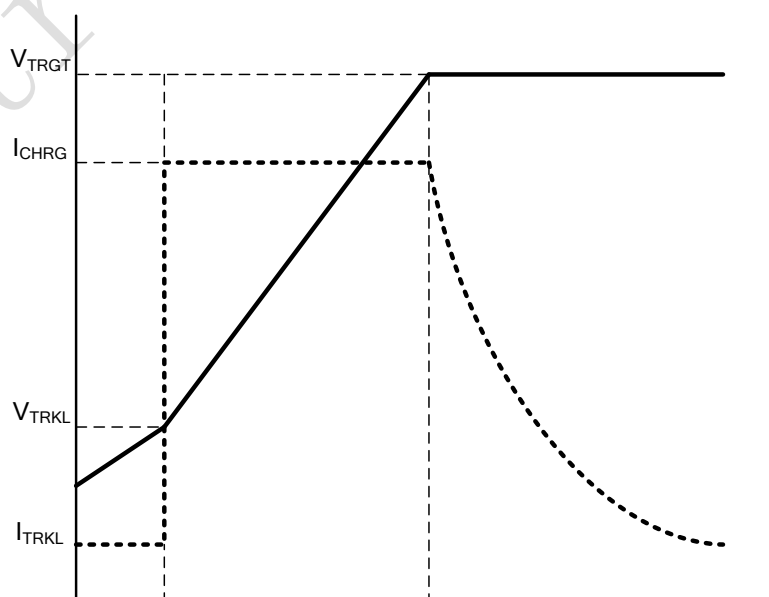
9.3 Adaptive Flash Charger

AXP228 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 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 stop the charge current when the temperature is too high or too low.

Adaptive Charge Startup

The default state of the charger is “Enable”. (It can be programmed via registers. Refer to register REG33H.) When external power is plugged in, AXP228 will automatically start the charge, and send IRQ to Host for indication. At the same time, CHGLED pin will output low level to drive external LED to indicate the charging state.

Charge Voltage/Current



Two Symbolic Voltages

V_{TRGT} =charge target voltage. The V_{TRGT} is 4.2V by default, which can be Set by register (Refer to“REG33H[6:5]”) . At the same time, AXP228 will automatically adjust the charge target voltage when external power voltage is low.

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

Charge Current

The charge current is 450mA or 1200mA by default, which can be Set by REG33H [3:0].

Charge Process

If the Battery voltage is lower than 3.0V, the charger will automatically enter the pre-charge mode, with charge current be 1/10 of the preset value. If the Battery voltage is still below 3.0V 40 minutes later (adjustable, see “REG34H”), 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 release IRQ17 to indicate that “drive ability of external power is insufficient, as a result, the charge current is lower than the pre-set value, which may lead to longer charge time, so stronger power is preferred, or the 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 fall.

When the charge current is lower than 10% or 15% (adjustable, see register “REG33H”) of the preset value, a charge cycle ends, and AXP228 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 released.

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 Activate Mode

At the entering the Battery activate mode from either pre-charge mode or constant current mod (the timer expires), AXP228 will release IRQ10 in both cases to indicate that the Battery may be damaged.

In Battery activate mode, the charger always inputs relatively low current to batteries. AXP228 will exit activate mode and release IRQ11 only if the Battery voltage has reached V_{RCH} .

AXP228 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.

类型 A

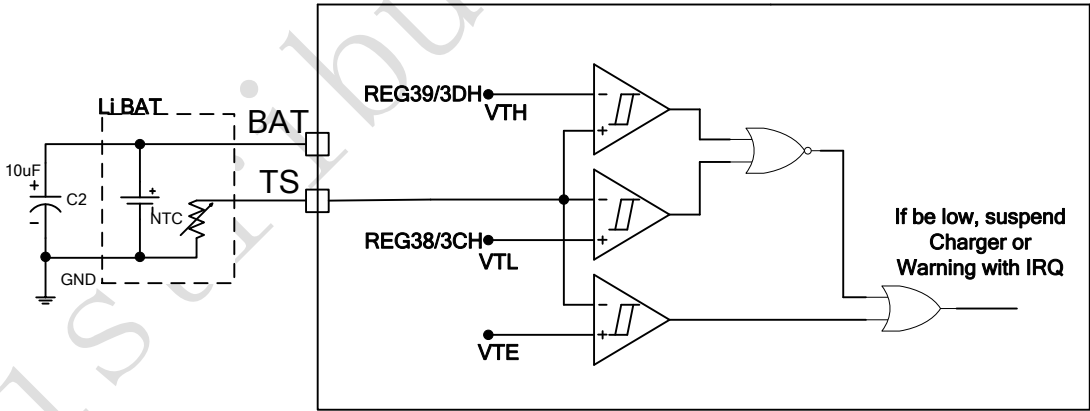
Status	表现	注释
正在 Charge	低电平	
不在 Charge	高阻	
Battery 异常	25% duty 1Hz 跳变	Charge 器进入 Battery 激活模式, 或者 Battery 温度过高、过低
过压	25% duty 4Hz 跳变	外部 Power 输入 Voltage 过高

类型 B

Status	表现	注释
正在 Charge	25% duty 1Hz 跳变	
不在 Charge	高阻	
Battery 异常及输入过压	25% duty 1Hz 跳变	Charge 器进入 Battery 激活模式, 或者 Battery 温度过高、过低以及 Output Voltage 过高
无 Battery	低电平	无 Battery 接入

Battery Temperature Detection

AXP228 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 refer 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 is suggested to choose the NTC temperature-sensitive resistor, which is 10Kohm and 1% accuracy at 25°C. AXP228 will send constant current via TS pin, and the current can be Set as 20uA、40uA、60uA、and 80uA (See register REG84H) to adapt to different NTC resistors. When the current goes through the temperature-sensitive resistor, a test 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 serial or parallel connected to expand the detect extent.

If the Battery is free from temperature-sensitive resistor, TS pin can be linked to the ground, and in that case, AXP228 will automatically disable the Battery temperature monitoring function. 

Battery Detection

AXP228 will automatically detect the Battery presence, record the result in registers (refer to REG01H) and release IRQ8, IRQ9.

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

9.4 Multi-Power Outputs

The following table has listed the multi-power outputs and their functions of AXP228.

Output Path	类型	默认 Voltage	启动步骤	应用举例	最大驱动能力
DCDC1	BUCK	3.3V	1	3.3V I/O	1400 mA
DCDC2	BUCK	1.1V	1	1.1V CPU	2500 mA
DCDC3	BUCK	1.1V	1	1.1V GPU	2500 mA
DCDC4	BUCK	1.1V	1	1.1V Core	600mA
DCDC5	BUCK	1.5V/DC5SET 设定	1	1.5V DDR	2000mA
RTC-LDO	LDO	3.0V	1	RTC	30 mA
ALDO1	LDO	OFF	OFF	N/A	300 mA
ALDO2	LDO	1.8V	1	N/A	300 mA
ALDO3	LDO	3.0V	1	N/A	200mA
LDO _{IO0}	LDO	OFF	OFF	N/A	100 mA
LDO _{IO1}	LDO	OFF	OFF	N/A	100 mA
DLDO1	LDO	OFF	OFF	N/A	400 mA
DLDO2	LDO	OFF	OFF	N/A	200 mA
DLDO3	LDO	OFF	OFF	N/A	200mA
DLDO4	LDO	OFF	OFF	N/A	200 mA
ELDO1	LDO	OFF	OFF	N/A	400 mA
ELDO2	LDO	OFF	OFF	N/A	200 mA
ELDO3	LDO	OFF	OFF	N/A	200mA
DC5LDO	LDO	1.1V	1	N/A	200mA
DC1SW	Switch	OFF	OFF	N/A	400mA

AXP228 includes five synchronous step-down DC-DCs, fourteen LDOs, two switches, as well as multiple timing and controlling configuration. The work frequency of DC-DC is 3MHz 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 fixed PWM mode or auto mode (automatically switchable according to the load). See register REG80H.

DC-DC1/2/3/4/5

DCDC3 output voltage ranges from 0.6 V to 1.86V, and output voltage of DCDC2 is ranged from 0.6-1.54V, which can be programmed via registers.(refer to “ register REG23H 27H”).

The output capacitor is recommended to use small ESR ceramic capacitors, for example 10uF X7R. The saturation current of inductors used must 50% higher than the output current.

**LDO 1**

LDO1 is always on and can be used to supply continuous power for application RTC with 30mA drive ability 30mA.

ALDO1/2/3

Low noise LDO, output current is 300mA/300mA/200mA

LDOio0/LDOio1

Low noise LDO, output current is 100mA

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.

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

9.5 Default Voltage/Timing Set ting

The default voltage and power on/off sequence of each power can be Set by AXP228.

Power on Timing includes eight levels, and the interval between each level can be Set as 1、2、4、16 and 32mS.

Default voltage Set ting: each DC-DC/LDO Set ting ranges from the lowest voltage to the highest voltage.

DC3SET PIN is used to Set the default voltage of DC-DC3:

DC3SET	DC3SETGND	DC3SETto OAPS	DC3SET floating
DC-DC3 voltage	1.8V	3.3V/2.5V	1.2V/1.5V

9.6 E-Gauge system

Ordinary Battery monitor is to estimate the Battery energy by measuring the Battery voltage. However, the multiple 12-bit ADCs in AXP228 can measure Battery voltage, as well as Battery current. It also integrates the gauge algorithm. According to these data, Host can get the remaining percentage 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 Enable state controlling and sampling rate of each ADC can be Set via register 84H. The sampling results will be saved in corresponding registers, 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	1mA	4.095A
Bat charge current	0mA	1mA	4.095A
Internal temperature	-267.7°C	0.1°C	165.8°C
TS pin input	0mV	0.8mV	3.276V

9.7 Multi-Function Pin Description

GPIO[1:0]

Can be defined as GPIO[1:0], or LDO, etc. Please refer to REG90H-92H Instruction for details

CHGLED

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

9.8 Timer

AXP228 features a 7-bit internal timer, whose values can be programmed via register REG8AH[6:0]. The minimum time step of timer is one minute, and the timing range is 1~127 minutes.

9.9 TWSI and IRQ

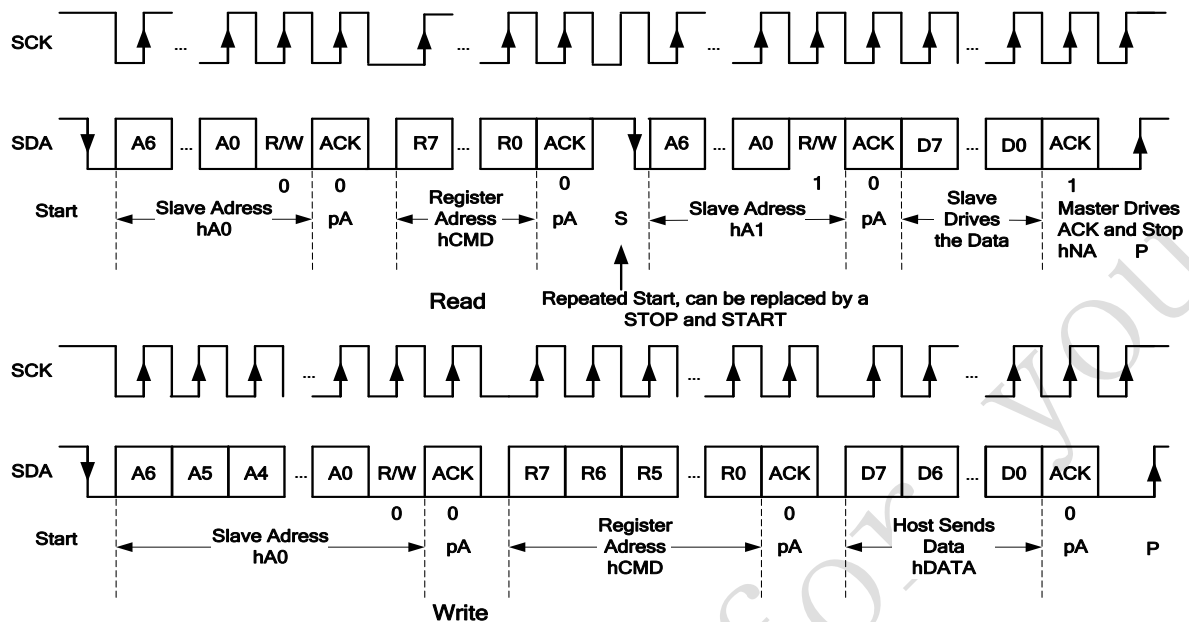


Figure9-1: Single Read and Write

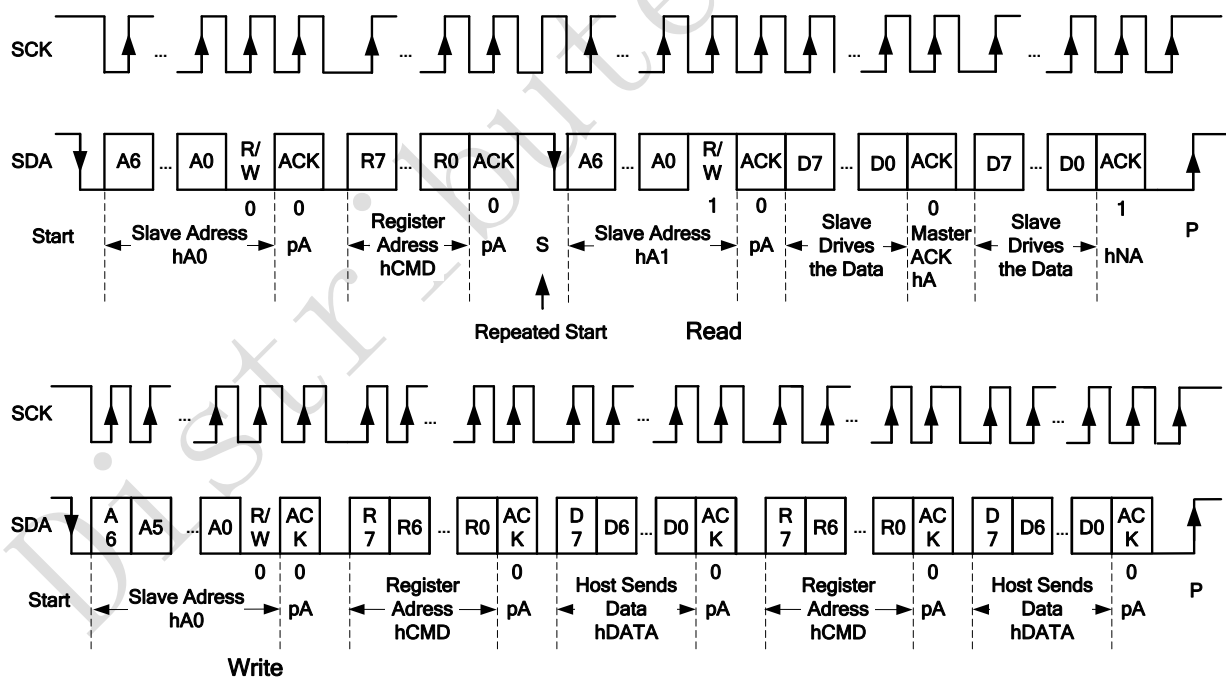


Figure 9-2. Multi Read and Write

Host can communication with AXP228 registers via the TWSI interface, and the operation timing is listed 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, AXP228 will inform Host by pulling down to the IRQ interrupt mechanism, and the interrupt state will be reserved 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 (51K resistance higher through the external). Each interrupt can be masked via interrupt control registers (Refer to registers REG40H, REG41H, REG42H, REG43H, and REG44H).

Bit	IRQ	DESCRIPTION	Bit	IRQ	DESCRIPTION
REG48_[7]	IRQ1	ACIN over voltage	REG4B_[7]	Reserved	
REG48_[6]	IRQ2	ACIN insert	REG4B_[6]		
REG48_[5]	IRQ3	ACIN remove	REG4B_[5]		
REG48_[4]	IRQ4	VBUS over voltage	REG4B_[4]		
REG48_[3]	IRQ5	VBUS insert	REG4B_[3]		
REG48_[2]	IRQ6	VBUS remove	REG4B_[2]		
REG48_[1]	IRQ7	VBUS lower than V _{HOLD}	REG4B_[1]	IRQ20	Battery low level warning1
REG48_[0]	reversed		REG4B_[0]	IRQ21	Battery low level warning2
REG49_[7]	IRQ8	Battery present	REG4C_[7]	IRQ22	Timer timeout
REG49_[6]	IRQ9	Battery remove	REG4C_[6]	IRQ23	PEK posedge
REG49_[5]	IRQ10	Battery active mode	REG4C_[5]	IRQ24	PEK negedge
REG49_[4]	IRQ11	Exit Battery active mode	REG4C_[4]	Reserved	
REG49_[3]	IRQ12	Charging	REG4C_[3]		
REG49_[2]	IRQ13	Charge finish	REG4C_[2]		
REG49_[1]	IRQ14	Battery over temperature	REG4C_[1]	IRQ25	GPIO1 edge trigger
REG49_[0]	IRQ15	Battery under temperature	REG4C_[0]	IRQ26	GPIO0 edge trigger
REG4A_[7]	IRQ16	IC over temperature			
REG4A_[6]	IRQ17	Charge current not enough			
REG4A_[5]	Reserved				
REG4A_[4]					
REG4A_[3]					
REG4A_[2]					
REG4A_[1]	IRQ18	PEK short press			
REG4A_[0]	IRQ19	PEK long press			

10

REGISTER

Control Register List

Address	Description	R/W	Default
00	Status REG	R	
01	Mode and charge status REG	R	
04-0F	Data bugger REG	R/W	00H
10	DCDC1/2/3/4/5&ALDO1/2&DC5LDO Control REG	R/W	BFH
12	ELDO1/2/3&DLDO1/2/3/4&DC1SW Control REG	R/W	00H
13	ADLDO1/2/3 woke mode REG	R/W	81H
15	DLDO1 Voltage Set REG	R/W	00H
16	DLDO2 Voltage Set REG	R/W	00H
17	DLDO3 Voltage Set REG	R/W	00H
18	DLDO4 Voltage Set REG	R/W	00H
19	ELDO1 Voltage Set REG	R/W	00H
1A	ELDO2 Voltage Set REG	R/W	00H
1B	ELDO3 Voltage Set REG	R/W	00H
1C	DC5LDO Voltage Set REG	R/W	04H
21	DC-DC1 Voltage Set REG	R/W	11H
22	DC-DC2 Voltage Set REG	R/W	19H
23	DC-DC3 Voltage Set REG	R/W	19H
24	DC-DC4 Voltage Set REG	R/W	19H
25	DC-DC5 Voltage Set REG	R/W	0AH
27	DC-DC2/3 Ramp control REG	R/W	00H
28	ALDO1 Voltage Set REG	R/W	00H
29	ALDO2 Voltage Set REG	R/W	0BH
2A	ALDO3 Voltage Set REG	R/W	17H
30	VBUS-IPSOUT Path control REG	R/W	60H
31	Sleep/wakeup and power off control REG	R/W	03H
32	Power off and Battery detection REG	R/W	43H
33	Charge control REG1	R/W	C6H
34	Charge control REG2	R/W	45H
35	Charge control REG3	R/W	0EH
36	PEK parameter Set REG	R/W	5DH
37	DCDC converter work frequency REG	R/W	08H
38	Battery under temperature Set REG when charging	R/W	A5H
39	Battery over temperature Set REG when charging	R/W	1FH
3C	Battery under temperature Set REG when discharging	R/W	FCH
3D	Battery over temperature Set REG when	R/W	16H

Address	Description	R/W	Default
	discharging		
80	DCDC work mode Set REG	R/W	E0H
82	ADC Enable Set REG1	R/W	E0H
84	ADC Sample rate, TS pin Control REG	R/W	32H
85	TS ADC sample rate Set REG	R/W	00H
8A	Timer Set REG	R/W	00H
8C/8D	PWREN Set REG	R/W	00H
8F	Over temperature operation Set REG	R/W	01H

GPIO Set Register List

Address	Description	R/W	Default
90	GPIO0 Set REG	R/W	07H
91	GPIO0 LDO mode output voltage Set REG	R/W	1FH
92	GPIO1 control REG	R/W	07H
93	GPIO1 LDO mode output voltage Set REG	R/W	1FH
94	GPIO[1:0] signal REG	R/W	00H
97	GPIO[1:0] pull down Set REG	R/W	00H

Interrupt Register List

Address	Description	R/W	Default
40	IRQ enable Set REG1	R/W	D8H
41	IRQ enable Set REG2	R/W	FFH
42	IRQ enable Set REG3	R/W	03H
43	IRQ enable Set REG4	R/W	03H
44	IRQ enable Set REG5	R/W	00H
48	IRQ status REG1	R/W	00H
49	IRQ status REG2	R/W	00H
4A	IRQ status REG3	R/W	00H
4B	IRQ status REG4	R/W	00H
4C	IRQ status REG5	R/W	00H

ADC Data Register List

Address	Description	R/W
56	AXP228 internal temperature monitor ADC Data highest 8 bit	R
57	AXP228 internal temperature monitor ADC Data lowest 4 bit	R
58	TS ADC Data highest 8 bit, Battery temperature	R
59	TS ADC Data lowest 4 bit, Battery temperature	R
78	Battery voltage highest 8 bit	R

79	Battery voltage lowest 4 bit	R
7A	Charge current highest 8 bit	R
7B	Charge current lowest 5 bit	R
7C	Discharge current highest 8 bit	R
7D	Discharge current lowest 5 bit	R

Address	Description	R/W	Default
B8	Coulomb counter control REG	R/W	00H
B9	Gauge result (%)	R	64H
E0	Battery full capacity bit[14:8]	R/W	00H
E1	Battery full capacity bit[7:0]	R/W	00H
E6	Battery low level warning Set REG	R/W	A0H

Note: Battery full capacity unit :1.456mAH

Register Description

REG 00H: Power Input Status

Bit	Description	R/W
7	ACIN presence indication 0:ACIN not exist; 1:ACIN exists	R
6	Indicating whether ACIN is usable	R
5	VBUS presence indication 0:VBUS not exist; 1:VBUS exists	R
4	Indicating whether VBUS is usable	R
3	Indicating whether the VBUS voltage is above VHOLD before used.	R
2	Indicating the Battery current direction 0: the Battery is 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

REG 01H: Power Working Mode and Charge Status Indication

Bit	Description	R/W
7	Indicating whether AXP202 is over-temperature 0: not over-temperature; 1: over-temperature	R
6	Charge indication 0:not charge or charge finished; 1: in charging	R
5	Battery existence indication 0:no Battery connected to AXP202; 1: Battery already connected to AXP202	R

4	Reserved and unchangeable	R
3	Indicating whether the Battery enters the activate mode 0: not enter the activate mode; 1: already entered the activate mode	R
2-0	Reserved and unchangeable	R

REG 04-0FH: Data Buffer

Note: As long as one of the external powers, batteries or backup batteries exists, this data will be reserved and free from the startup and shutdown influence.

REG 10H: DCDC1/2/3/4/5&ALDO1/2&DC5LDO Enable Set

Default: XXH

Bit	Description	R/W	Default
7	ALDO2 Enable Set	RW	X
6	ALDO1 Enable Set	RW	X
5	DC-DC5 Enable Set	RW	X
4	DC-DC4 Enable Set	RW	X
3	DC-DC3 Enable Set	RW	X
2	DC-DC2 Enable Set	RW	X
1	DC-DC1 Enable Set	RW	X
0	DC5LDO Enable Set	RW	X

Note: X means that decided by the internal memory Set

REG 12H: Power Output Control

Default: XXH

Bit	Description	R/W	Default
7	DC1SW Enable Set	RW	0
6	DLDO4 Enable Set	RW	0
5	DLDO3 Enable Set	RW	0
4	DLDO2 Enable Set	RW	0
3	DLDO1 Enable Set	RW	X
2	ELDO3 Enable Set	RW	0
1	ELDO2 Enable Set	RW	0
0	ELDO1 Enable Set	RW	X

REG 13H:Power Output Control

Default:01H

Bit	Description		R/W	Default
7	ALDO3 Enable Set	0:Off; 1:On	RW	0
6-0	Reserved and unchangeable		RW	0

REG 15H:DLDO1 Output Voltage Set

Default: 00H

Bit	Description		R/W	Default
7-5	Reserved and unchangeable			
4	DLDO1 Output Voltage Set Bit4	0.7-3.3V,100mV/step	RW	0
3	DLDO1 Output Voltage Set Bit3		RW	0
2	DLDO1 Output Voltage Set Bit2		RW	0
1	DLDO1 Output Voltage Set Bit1		RW	0
0	DLDO1 Output Voltage Set Bit0		RW	0

REG 16H:DLDO2 Output Voltage Set

Default: 00H

Bit	Description		R/W	Default
7-5	Reserved and unchangeable			
4	DLDO2 Output Voltage Set Bit4	0.7-3.3V,100mV/step	RW	0
3	DLDO2 Output Voltage Set Bit3		RW	0
2	DLDO2 Output Voltage Set Bit2		RW	0
1	DLDO2 Output Voltage Set Bit1		RW	0
0	DLDO2 Output Voltage Set Bit0		RW	0

REG 17H:DLDO3 Output Voltage Set

Default: 00H

Bit	Description		R/W	Default
7-5	Reserved and unchangeable			
4	DLDO3 Output Voltage Set Bit4	0.7-3.3V,100mV/step	RW	0
3	DLDO3 Output Voltage Set Bit3		RW	0
2	DLDO3 Output Voltage Set Bit2		RW	0
1	DLDO3 Output Voltage Set Bit1		RW	0

0	DLDO3 Output Voltage Set Bit0		RW	0
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REG 18H: DLD04 Output Voltage Set

Default: 00H

Bit	Description		R/W	Default
7-5	Reserved and unchangeable			
4	DLDO4 Output Voltage Set Bit4	0.7-3.3V,100mV/step	RW	0
3	DLDO4 Output Voltage Set Bit3		RW	0
2	DLDO4 Output Voltage Set Bit2		RW	0
1	DLDO4 Output Voltage Set Bit1		RW	0
0	DLDO4 Output Voltage Set Bit0		RW	0

REG 19H: ELDO1 Output Voltage Set

Default: 00H

Bit	Description		R/W	Default
7-5	Reserved and unchangeable			
4	ELDO1 Output Voltage Set Bit4	0.7-3.3V,100mV/step	RW	0
3	ELDO1 Output Voltage Set Bit3		RW	0
2	ELDO1 Output Voltage Set Bit2		RW	0
1	ELDO1 Output Voltage Set Bit1		RW	0
0	ELDO1 Output Voltage Set Bit0		RW	0

REG 1AH:ELD02 Output Voltage Set

Default: 00H

Bit	Description		R/W	Default
7-5	Reserved and unchangeable			
4	ELDO2 Output Voltage Set Bit4	0.7-3.3V,100mV/step	RW	0
3	ELDO2 Output Voltage Set Bit3		RW	0
2	ELDO2 Output Voltage Set Bit2		RW	0
1	ELDO2 Output Voltage Set Bit1		RW	0
0	ELDO2 Output Voltage Set Bit0		RW	0

REG 1BH:ELD03 Output Voltage Set

Default: 00H

Bit	Description	R/W	Default
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7-5	Reserved and unchangeable			
4	ELDO3 Output Voltage Set Bit4	0.7-3.3V,100mV/step	RW	0
3	ELDO3 Output Voltage Set Bit3		RW	0
2	ELDO3 Output Voltage Set Bit2		RW	0
1	ELDO3 Output Voltage Set Bit1		RW	0
0	ELDO3 Output Voltage Set Bit0		RW	0

REG 1CH:DC5LDO Output Voltage Set

Default: 04H

Bit	Description		R/W	Default
7-3	Reserved and unchangeable			
2	DC5LDO Output Voltage Set Bit2	0.7-1.4V,100mV/step	RW	1
1	DC5LDO Output Voltage Set Bit1		RW	0
0	DC5LDO Output Voltage Set Bit0		RW	0

REG 21H: DC-DC1 Output Voltage Set

Default: 11H

Bit	Description		R/W	Default
7-5	Reserved and unchangeable			
4	DC-DC1 Output Voltage Set Bit4	1.6-3.4V, 100mV/step	RW	1
3	DC-DC1 Output Voltage Set Bit3		RW	0
2	DC-DC2 Output Voltage Set Bit2		RW	0
1	DC-DC2 Output Voltage Set Bit1		RW	0
0	DC-DC2 Output Voltage Set Bit0		RW	1

REG 22H: DC-DC2 Output Voltage Set

Default:19H

Bit	Description		R/W	Default
7-6	Reserved and unchangeable			
5	DC-DC2 Output Voltage Set Bit5	0.6-1.54V, 20mV/step	RW	0
4	DC-DC2 Output Voltage Set Bit4		RW	1
3	DC-DC2 Output Voltage Set Bit3		RW	1
2	DC-DC2 Output Voltage Set Bit2		RW	0
1	DC-DC2 Output Voltage Set Bit1		RW	0
0	DC-DC2 Output Voltage Set Bit0		RW	1

REG 23H: DC-DC3 Output Voltage Set

Default: 19H

Bit	Description	R/W	Default
7-6	Reserved and unchangeable		
5	DC-DC3 Output Voltage Set Bit5	RW	0
4	DC-DC3 Output Voltage Set Bit4	RW	1
3	DC-DC3 Output Voltage Set Bit3	RW	1
2	DC-DC3 Output Voltage Set Bit2	RW	0
1	DC-DC3 Output Voltage Set Bit1	RW	0
0	DC-DC3 Output Voltage Set Bit0	RW	1

REG 24H: DC-DC4 Output Voltage Set

Default: 19H

Bit	Description	R/W	Default
7-6	Reserved and unchangeable		
5	DC-DC4 Output Voltage Set Bit5	RW	0
4	DC-DC4 Output Voltage Set Bit4	RW	1
3	DC-DC4 Output Voltage Set Bit3	RW	1
2	DC-DC4 Output Voltage Set Bit2	RW	0
1	DC-DC4 Output Voltage Set Bit1	RW	0
0	DC-DC4 Output Voltage Set Bit0	RW	1

REG 25H: DC-DC5 Output Voltage Set

Default: 0AH

Bit	Description	R/W	Default
7-5	Reserved and unchangeable		
4	DC-DC5 Output Voltage Set Bit4	RW	0
3	DC-DC5 Output Voltage Set Bit3	RW	1
2	DC-DC5 Output Voltage Set Bit2	RW	0
1	DC-DC5 Output Voltage Set Bit1	RW	1
0	DC-DC5 Output Voltage Set Bit0	RW	0

REG 27H: DC-DC2/3 Dynamic Voltage Scaling Parameter Set

Default: 00H

Bit	Description	R/W	Default
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7-4	Reserved and unchangeable			
3	DC-DC3 VRC Enable Control 0:On; 1:Off		RW	0
2	DC-DC2 VRC Enable Control 0:On; 1:Off		RW	0
1	DC-DC3 VRC Voltage ramp Control	0: 20mV/15.625us=1.6mV/us 1: 20mV/31.250us=0.8mV/us	RW	0
0	DC-DC2 VRC Voltage ramp Control	0: 20mV/15.625us=1.6mV/us 1: 20mV/31.250us=0.8mV/us	RW	0

REG 28H: ALDO1 Output Voltage Set

Default: 00H

Bit	Description		R/W	Default
7-5	Reserved and unchangeable			
4	ALDO1 Output Voltage Set Bit4	0.7-3.3V,100mV/step	RW	0
3	ALDO1 Output Voltage Set Bit3		RW	0
2	ALDO1 Output Voltage Set Bit2		RW	0
1	ALDO1 Output Voltage Set Bit1		RW	0
0	ALDO1 Output Voltage Set Bit0		RW	0

REG 29H: ALDO2 Output Voltage Set

Default: 0BH

Bit	Description		R/W	Default
7-5	Reserved and unchangeable			
4	ALDO2 Output Voltage Set Bit4	0.7-3.3V,100mV/step	RW	0
3	ALDO2 Output Voltage Set Bit3		RW	1
2	ALDO2 Output Voltage Set Bit2		RW	0
1	ALDO2 Output Voltage Set Bit1		RW	1
0	ALDO2 Output Voltage Set Bit0		RW	1

REG 2AH:ALDO3 Output Voltage Set

Default: 17H

Bit	Description		R/W	Default
7-5	Reserved and unchangeable			
4	ALDO3 Output Voltage Set Bit4	0.7-3.3V,100mV/step	RW	1

3	ALDO3 Output Voltage Set Bit3		RW	0
2	ALDO3 Output Voltage Set Bit2		RW	1
1	ALDO3 Output Voltage Set Bit1		RW	1
0	ALDO3 Output Voltage Set Bit0		RW	1

REG 30H: VBUS-IPSOUT Path set

Default: 6XH

Bit	Description		R/W	Default
7	VBUS-IPSOUT Path select Control when VBUS valid 0:decided by N_VBUSEN pin, N_VBUSEN=0,the path is on 1:VBUS-IPSOUT Path is On		RW	0
6	VBUS V _{HOLD} voltage limit set 0:not limited; 1:limited		RW	1
5	V _{HOLD} Set Bit 2	000: 4.0V; 001: 4.1V; 010: 4.2V	RW	1
4	V _{HOLD} Set Bit 1	011: 4.3V; 100: 4.4V; 101: 4.5V	RW	0
3	V _{HOLD} Set Bit 0	110: 4.6V; 111: 4.7V	RW	0
2	DRIVEVBUS as GPO, Output Control 0: Output Low 1: Output High (IPSOUT)		RW	0
1:0	VBUS current limit Control Set 00 -900mA; 01-500mA; 1x-no current limit		RW	X

REG 31H: Wakeup Control and Voff Voltage Set

Default:X3H

Bit	Description		R/W	Default
7	PWROK status when Wakeup 0: do not output low 1: output low		RW	0
6	Soft re-startup Control, write 1 to re-startup, then it self-clear		RW	0
5	Software Wakeup Control, write 1 to restore the output voltage, then it self-clear		RW	0
4	When Wakeup function Enabled, IRQ triggered PMU Wakeup and IRQ masked or not when Wakeup 0: IRQ triggered Wakeup, When Wakeup, all IRQ masked 1: IRQ work normal, but not triggered Wakeup			
3	Wakeup Function Enable Set when Sleep 0: Wakeup function Off 1: Wakeup function On It self-clear after write 1			
2	V _{OFF} Set Bit2	000-2.6V; 001-2.7V; 010-2.8V;	RW	0
1	V _{OFF} Set Bit1	011-2.9V; 100-3.0V; 101-3.1V;	RW	1

0	V _{OFF} Set Bit0	110-3.2V; 111-3.3V	RW	1
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REG 32H: Power off Set 、 Battery detection and CHGLED Control

Default:43H

Bit	Description		R/W	Default
7	Power off Control Write 1 to power off all output except LDO1 		RW	0
6	Battery detection Set : 0:Off; 1:On		RW	1
5-4	CHGLED PIN Set	00: High-Z 01: 25% 0.5Hz toggle 10: 25% 2Hz toggle 11: Output Low	RW	00
3	CHGLED PIN Control Set	0: REGREG 32HBit[5:4] Control 1: Controlled by charge module	RW	0
2	Sequence when Power Output Off 0: All Power Output Off at the same time 1: Reverse to the power on sequence		RW	0
1-0	PWROK delay after Power Output ready	00: 8ms; 01: 16ms; 10: 32ms; 11:64ms	RW	10

REG 33H: Charge Control1

Default: CXH

Bit	Description		R/W	Default
7	Charge Enable Control 0:Off, 1:On		RW	1
6:5	Charge Voltage Set 00:4.1V; 01:4.22V; 10:4.2V; 11:4.24V		RW	10
4	Charge end current Set 0: 10% 1: 15%		RW	0
3-0	Charge current Set 	0000:300mA; 0001:450mA; 0010:600mA; 0011:750mA; 0100:900mA; 0101:1050mA; 0110:1200mA; 0111:1350mA; 1000:1500mA; 1001:1650mA; 1010:1800mA; 1011:1950mA; 1100:2100mA; 1101:2250mA; 1110:2400mA; 1111:2550mA	RW	X

REG 34H: Charge Control12

Default: 45H

Bit	Description	R/W	Default
7	Pre-Charge timeout Set Bit1	RW	0
6	Pre-Charge timeout Set Bit0		
5	Charge Output Off or On when charge finished 0: Off; 1: On	RW	000
4	CHGLED function type 0: A 1: B		0
3	Reserved and unchangeable		0
2	Charge target voltage follow with the charge current or not 0: On 1: Off		0
2	Charge external Path Enable Set 0:Off; 1:On	RW	0
1	Constant Current timeout set Bit1	RW	0
0	Constant Current timeout set Bit0		

REG 35H: Charge Control13

Default: 22H

Bit	Description	R/W	Default
7: 4	Reserved and unchangeable		
3:0	Charge loop current limit Set  0000:300mA; 0001:450mA; 0010:600mA; 0011:750mA; 0100:900mA; 0101:1050mA; 0110:1200mA; 0111:1350mA; 1000:1500mA; 1001:1650mA; 1010:1800mA; 1011:1950mA; 1100:2100mA; 1101:2250mA; 1110:2400mA; 1111:2550mA	RW	1110

REG 36H:PEK Parameter Set

Default:5DH

Bit	Description	R/W	Default
7	Power on Time Set Bit1	RW	0
6	Power on Time Set Bit0		
5	Long key Time Set Bit1	RW	0
4	Long key Time Set Bit0		
3	Hardwar Power off function Set when key down time longer than Power off Time 0:Off; 1:On	RW	1

2	Re-startup or not after hardware power off 0:no; 1:yes		RW	1
1	Power off time Set Bit1	00: 4S; 01: 6S;	RW	0
0	Power off time Set Bit0	10: 8S; 11: 10S	RW	1

REG 37H:DC-DC work frequency Set

Default: 08H

Bit	Description	R/W	Default
7	DC-DC and charger frequency-spread Set 0: Off 1: On		0
6	DC-DC and charger spread frequency Set 0: 50KHz 1: 100KHz		0
5	Reserved and unchangeable		
4	DC-DC 2&3 Poly-phase Function Set 0: Off 1: On		X
3	DC-DCSwitch frequency Set Bit 3	RW	1
2	DC-DCSwitch frequency Set Bit 2		
1	DC-DCSwitch frequency Set Bit 1		
0	DC-DCSwitch frequency Set Bit 0		

REG 38H:VLTF-charge Battery Charge under temperature Set

Default:A5H

Bit	Description	R/W	Default
7-0	Battery under temperature Set when charge, M	RW	A5H

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

REG 39H:VHTF-charge Battery Charge over temperature Set

Default:1FH

Bit	Description	R/W	Default
7-0	Battery over temperature Set when charge, N	RW	1FH

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

REG 3CH:VLTF-discharge Battery under temperature Set

Default: FCH

Bit	Description		R/W	Default
7-0	Battery under temperature Set when discharge, M	M*10H M=FCH:3.226V Range:0V~3.264V	RW	FCH

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

REG 3DH:VHTF-discharge Battery over temperature Set

Default:16H

Bit	Description		R/W	Default
7-0	Battery over temperature Set when discharge, N	N*10H N=16H:0.282V Range:0V~3.264V	RW	16H

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

REG 80H:DC-DC Work mode

Default:80H

Bit	Description		R/W	Default
7-5	Reserved and unchangeable			
4	DC-DC5 Work mode Control	0:PFM/PWM auto switch 1:fixed PWM	RW	0
3	DC-DC4 Work mode Control		RW	0
2	DC-DC3 Work mode Control		RW	0
1	DC-DC2 Work mode Control		RW	0
0	DC-DC1 Work mode Control		RW	0

REG 82H:ADC Enable

Default:83H

Bit	Description		R/W	Default
7	Battery Voltage ADC Enable	0:Off, 1:On	RW	1
6	Battery Current ADC Enable		RW	0
5	Internal temperature ADC Enable		RW	0
4-1	Reserved and unchangeable			
0	TS Pin ADC Enable	0:Off, 1:On	RW	1

REG 84H:ADC Sample rate Set , TS Pin Control

Default:32H

Bit	Description		R/W	Default
7	ADC Sample rate Set Bit 1	10×2 ⁿ Sample rate: 100, 200, 400, 800Hz	RW	0
6	ADC Sample rate Set Bit 0		RW	0
5-4	TS Pin Output Current Set : 00:20uA; 01:40uA; 10:60uA; 11:80uA		RW	11
3	Reserved and unchangeable			
2	TS Pin function 0: Battery temperature detection, 1:ADC Input		RW	0
1-0	TS Pin Current Output Set	00:Off	RW	1
		01: Output Current when charging 10:Output Current when ADC sample 11: always On	RW	0

REG 85H:TS ADC Sample rate set

Default:X0H

Bit	Description		R/W	Default
7	TS ADC Sample rate Set 1	10×2 ⁿ Sample rate 分别为100，200，400，800Hz	RW	0
6	TS ADC Sample rate Set 0		RW	0
5-0	Reserved and unchangeable			

REG 8AH:Timer Control

Default:00H

Bit	Description	R/W	Default
7	Timer Timeout status: 1:timeout Write 1 to clear this bit	RW	0
6-0	Timer set, 1min/step Write 0 to disable the timer	RW	0000000

REG 8CH:PWRENControl Set 1

Default:00H

Bit	Description	R/W	Default
7	DC-DC1 controlled by PWREN	RW	0
6	DC-DC2 controlled by PWREN	RW	0
5	DC-DC3 controlled by PWREN	RW	0
4	DC-DC4 controlled by PWREN	RW	0
3	DC-DC5 controlled by PWREN	RW	0
2	ALDO1 controlled by PWREN	RW	0
1	ALDO2 controlled by PWREN	RW	0
0	ALDO3 controlled by PWREN	RW	0

REG 8DH:PWRENControl Set 2

Default:00H

Bit	Description	R/W	Default
7	DLDO1 controlled by PWREN	RW	0
6	DLDO2 controlled by PWREN	RW	0
5	DLDO3 controlled by PWREN	RW	0
4	DLDO4 controlled by PWREN	RW	0
3	ELDO1 controlled by PWREN	RW	0
2	ELDO2 controlled by PWREN	RW	0
1	ELDO3 controlled by PWREN	RW	0
0	DC5LDO controlled by PWREN	RW	0

REG 8FH:IC over temperature Power off function Set

Default:01H

Bit	Description	R/W	Default
7	IRQ PIN triggered Power on or Wakeup function Set 0: Off 1: On	RW	0
6	ACIN/VBUS In-short function Set 0: auto detection 1: set by REG8F_[5]	RW	0
5	ACIN/VBUS In-short status and Set 0: not In-short 1: In-short	RW	0
4	N_VBUSEN PIN function Control 0: Output Pin , as DRIVEVBUS function (Output to enable the OTG 5V Boost module) 1: Input Pin , Control VBUS Path	RW	X
3	Reserved and unchangeable		
2	AXP228 internal over temperature Power off function Set 0:do not Power off ; 1: Power off	RW	0
1-0	Reserved and unchangeable	RW	01

REG 90H:GPIO0 function Set

Default:07H

Bit	Description		R/W	Default
7	GPIO0 posedge triggered IRQ/wakeup or not when as input 0: no 1: yes		RW	0
6	GPIO0 negedge triggered IRQ/wakeup or not when as input 0: no 1: yes		RW	0
5-3	Reserved and unchangeable			
2	GPIO0 Pin Function Set Bit 2	000: Output low 001: Output High 010:input Function	RW	1
1	GPIO0 Pin Function Set Bit 1	011: low noise LDO Function On 100:low noise LDO Function Off	RW	1
0	GPIO0 Pin Function Set Bit 0	101-111: floating	RW	1

REG 91H:GPIO0 work as LDO mode and Output voltage Set

Default:1FH

Bit	Description		R/W	Default
7-5	Reserved and unchangeable			
4	GPIO0 LDO Output Voltage Set Bit4	0.7-3.3V,100mV/step	RW	0
3	GPIO0 LDO Output Voltage Set Bit3		RW	0
2	GPIO0 LDO Output Voltage Set Bit2		RW	0
1	GPIO0 LDO Output Voltage Set Bit1		RW	0
0	GPIO0 LDO Output Voltage Set Bit0		RW	0

REG 92H:GPIO1 Function Set

Default:07H

Bit	Description		R/W	Default
7	GPIO1 posedge triggered IRQ/wakeup or not when as input 0: no 1: yes		RW	0
6	GPIO1 negedge triggered IRQ/wakeup or not when as input 0: no 1: yes		RW	0

5-3	Reserved and unchangeable			
2	GPIO1 Pin Function Set Bit 2	000: Output low 001: Output High 010: input Function 011: low noise LDO Function On 100:low noise LDO Function Off 101-111: floating	RW	1
1	GPIO1 Pin Function Set Bit 1		RW	1
0	GPIO1 Pin Function Set Bit 0		RW	1

REG 93H:GPIO1 work as LDO mode and Output voltage Set

Default:1FH

Bit	Description		R/W	Default
7-5	Reserved and unchangeable			
4	GPIO1 LDO Output Voltage Set Bit4	0.7-3.3V,100mV/step	RW	0
3	GPIO1 LDO Output Voltage Set Bit3		RW	0
2	GPIO1 LDO Output Voltage Set Bit2		RW	0
1	GPIO1 LDO Output Voltage Set Bit1		RW	0
0	GPIO1 LDO Output Voltage Set Bit0		RW	0

REG 94H:GPIO[1:0] input status

Default:00H

Bit	Description		R/W	Default
7-2				
1	GPIO1 input status	0:Low	R	
0	GPIO0input status	1:High	R	

REG 97H:GPIO[1:0] pull down resister Set

Default:00H

Bit	Description		R/W	Default
7-2	Reserved and unchangeable			
1	GPIO1 pull down Control when work as input	0:pull down resistor off 1:pull down resistor on	RW	0

0	GPIO0 pull down Control when work as input		RW	0
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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 and unchangeable	RW	0

REG 41H:IRQ Enable 2

Default:FFH

Bit	Description	R/W	Default
7	Battery present IRQ Enable	RW	1
6	Battery remove IRQ Enable	RW	1
5	Battery enter active mode IRQ Enable	RW	1
4	Exit 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

REG 42H:IRQ Enable 3

Default:3BH

Bit	Description	R/W	Default
7	AXP228 internal over temperature IRQ Enable	RW	0
6-2	Reserved and unchangeable		
1	Short key IRQ Enable	RW	1
0	Long key IRQ Enable	RW	1

REG 43H:IRQ Enable 4

Default:C1H

Bit	Description	R/W	Default
7-2	Reserved and unchangeable		
1	Battery energy low warning level 1 IRQ Enable(information)	RW	1
0	Battery energy low warning level 2 IRQ Enable(need to Power off)	RW	1

REG 44H:IRQ Enable 5

Default:00H

Bit	Description	R/W	Default
7	Timer Timeout IRQ Enable	RW	0
6	PEK posedge IRQ Enable	RW	0
5	PEK negedge IRQ Enable	RW	0
4-2	Reserved and unchangeable		
1	GPIO1 edge IRQ Enable	RW	0
0	GPIO0 edge IRQ Enable	RW	0

REG 48H:IRQ Status 1

Default:00H

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

REG 49H:IRQ Status 2

Default:00H

Bit	Description	R/W	Default
7	Battery present IRQ	RW	0
6	Battery remove IRQ	RW	0
5	Battery enter active mode IRQ	RW	0

4	Exit Battery active mode IRQ	RW	0
3	Charging IRQ	RW	0
2	Charge finished IRQ	RW	0
1	Battery over temperature IRQ	RW	0
0	Battery under temperature IRQ	RW	0

REG 4AH:IRQ Status 3

Default:00H

Bit	Description	R/W	Default
7	AXP228 internal over temperature IRQ	RW	0
6-2	Reserved and unchangeable		
1	Short key IRQ	RW	0
0	Long key IRQ	RW	0

REG 4BH:IRQ Status 4

Default:00H

Bit	Description	R/W	Default
7-2	Reserved and unchangeable		
1	Battery energy low warning level 1 IRQ (information)	RW	0
0	Battery energy low warning level 2 IRQ (need to Power off)	RW	0

REG 4CH:IRQ Status 5

Default:00H

Bit	Description	R/W	Default
7	Timer Timeout IRQ	RW	0
6	PEK posedge IRQ	RW	0
5	PEK negedge IRQ	RW	0
4-2	Reserved and unchangeable		
1	GPIO1 edge IRQ	RW	0
0	GPIO0 edge IRQ	RW	0

Note:Write 1 to these bit will clear the IRQ status

REG B8H:E-Gauge Control

Default:C0H

Bit	Description	R/W	Default
7	Gauge system Enable Control  0: Off 1: On	RW	1
6	Coulomb counter Enable Control 0: Off 1: On	RW	1
5	Battery full capacity calibration Function Enable 0: Off 1: On	RW	1
4	Battery capacity calibration Status 0: do not at calibration status 1: calibrating now	RW	0
3-0	Reserved and unchangeable	RW	0

REG B9H: Battery Gauge result

Default:64H

Bit	Description	R/W	Default
7	Battery result indication 0: be calculated yet 1: calculating now	R	0
6-0	Battery gauge result	R	0~100%

REG E0H: Battery full design capacity Set 1

Default:00H

Bit	Description	R/W	Default
7	Battery full design capacity configured or not 0: not be configured 1:has been configured	RW	0
6-0	Battery full design capacity bit[14:8]	RW	

Battery full design capacity = Value * 1.456mAh

REG E1H: Battery full design capacity Set 2

Default:00H

Bit	Description	R/W	Default
7-0	Battery full design capacity bit[7:0]	RW	

REG E6H: Battery low power warning level Set

Default:A0H

Bit	Description	R/W	Default
7:4	Battery low power warning level 1 Set 	RW	1010

	0000-1111: 5%-20%		
6-0	Battery low power warning level 2 Set 0000-1111: 0%-15%	RW	0000

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PACKAGE

