DATASHEET

V0.1 May.13 2015

AXP176

Enhanced single Cell Li-Battery and Power System Management IC

Revision History

Revision	Date	Description
V 0.1	2015.05.13	Initial Version

Declaration

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Catalogue

1. Summary

AXP176 is a highly integrated power management IC(PMIC) targeted 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 complex and accurate requirements of power control.

AXP176 contains an USB-Compatible charger, 1 Buck DC-DC converter, 3 low dropout linear regulator(LDOs), multi- channel 12-bit ADC including voltage/current/temperature monitoring. To ensure the security and stability of the power system, AXP176 also provides self-protection circuits such as over-voltage protection(OVP)、under-voltage protection(UVP)、over-current protection(OCP) and over-temperature protection(OTP).

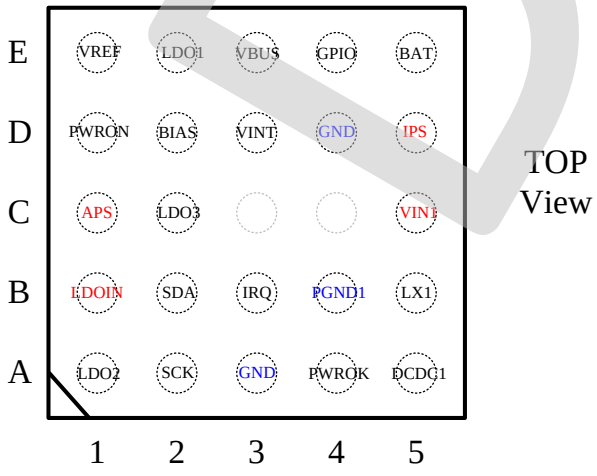
The "Intelligent Power Select"(IPS)™ circuit of AXP176 distributes power safely and transparently among the USB, Li-Battery and the application system. It also allows application system to work normally when only running at the external input voltage and not the battery.

AXP176 has two input sources, including USB VBUS input and battery. AXP176 provides TWSI(Two Wire Serial Interface) to communicate with the application processor. Through the interface, processor can enable or disable the outputs, and set the output voltage, as well as get the power status and "fuel gauge" data, High-accuracy ADC makes it convenient for consumer real-time control and know the system power dissipation, which brings them wonderful experience of device electricity usage that never had before.

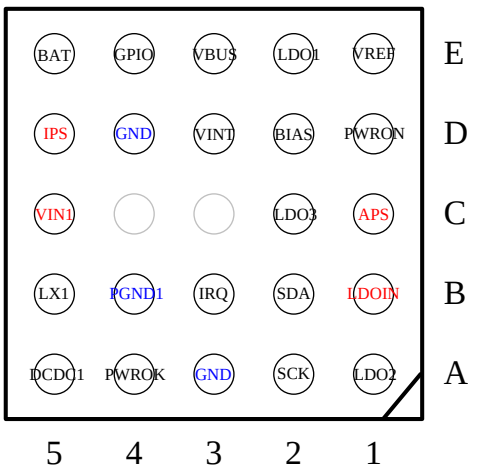
AXP176 is available in a 23-ball 2.61mm x 2.56mm WLCSP package.

AXP176 has a very tiny package, so it is well to use on wearable device such as smart watch, smart cup, and so on.

Pin Description



TOP View

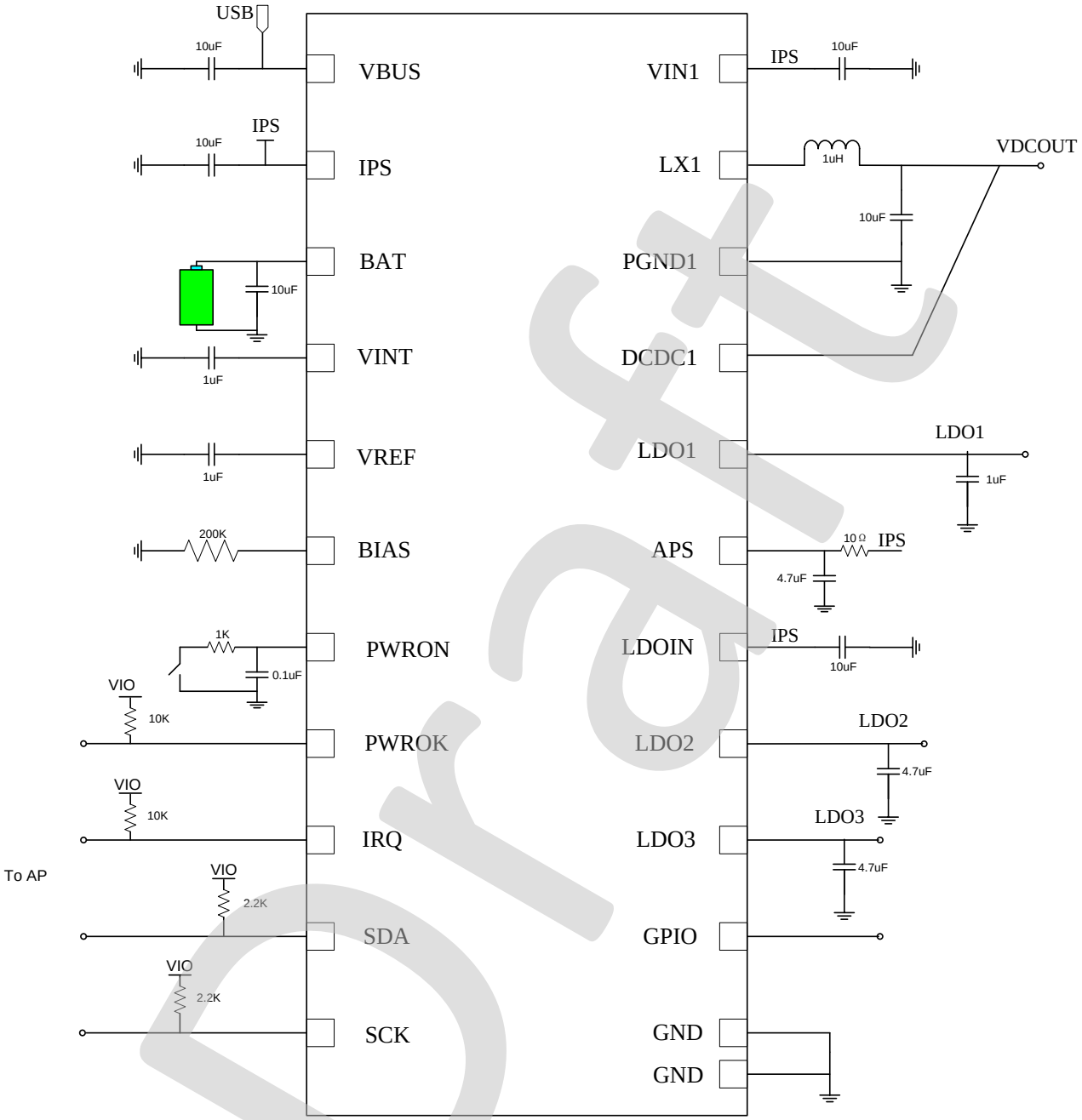


Bottom View

2. Feature

- **Battery Management**
  - Operation Voltage: 2.9V~6.3V (AMR：-0.3V~11V)
  - Configurable Intelligent Power Select system
  - Adaptive USB adaptor voltage/current limit
- **Full-integrated Charger**
  - 1.4A charge current with built-in MOSFET
  - USB-Compatible charger
  - High precision as 1%
  - Support 4.1V/4.15V/4.2V/4.36V battery
  - Charging process control automatically
  - Auto adjust the charging current according to the system load
- **1 Synchronous Step-Down Converters**
  - DC-DC1: can be adjusted between 0.7V~3.5V 25mV/step, load capability up to 1.2A
- **3 LDOs**
  - LDO1:30mA,always on
  - LDO2:low noise LDO, 1.8V~3.3V adjustable, 100mV/step, load capability up to 200mA
  - LDO3:low noise LDO, 1.8V~3.3V adjustable, 100mV/step, load capability up to 200mA
- **Signal Capture**
  - Integrated multi-channel 12 bit ADC
  - High accuracy coulomb counter and fuel-gauge system
  - Provide the rich power management information including instantaneous power consumption(mA or mW),remaining power(% or mA),charge status(%),remaining battery life and charge time, etc.
  - Low power warning and protection
  - Provide die temperature information
- **Host Interface**
  - Two Wire Serial Interface(TWSI) for communication between the processor and PMIC
  - Configurable interrupt management
  - Integrated timer
  - 4 groups registers for the data storage when system shutdown
- **System Management**
  - Soft reset or hardware reset
  - Support soft shutdown or hardware shutdown, and external wakeup
  - Monitoring output voltage, self-diagnostic function
  - Support PWROK for system reset
  - External power source detect ion (insert/remove/lack of driving capacity)
  - Self-protection: OVP,UVP,OCP,OTP
  - Support OTG VBUS power state setting/monitoring

3. Typical Application



4. Absolute Maximum Ratings

Symbol	Description	Value	Units
VBUS	Input Voltage	-0.3 to 11	V
T_J	Operating Virtual Junction 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(HBM)	>2000	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
VBUS						
V_{IN}	VBUS Input Voltage		3.8		6.3	V
I_{OUT}	V_{OUT} Current Available Before Loading BAT	400mV Voltage Drop		500	900	mA
V_{UVLO}	VBUS Under Voltage Lockout			3.8		V
V_{OUT}	IPS Output Voltage		2.9		5.0	V
R_{VBUS}	Internal Ideal Diode On Resistance	PIN to PIN, VBUS to IPSOUT			300	mΩ
Battery Charger						
V_{TRGT}	BAT Charge Target Voltage		-0.5%	4.2	+0.5%	V
I_{CHRG}	Charge Current			780	1320	mA
I_{TRKL}	Trickle Charge Current			10%		I_{CHRG} mA
V_{TRKL}	Trickle Charge Threshold Voltage			3.0		V
ΔV_{RECHG}	Recharge Battery Threshold Voltage	Threshold Voltage Relative to V_{TARGET}		-100		mV
T_{TIMER1}	Charger Safety Timer Termination Time	Trickle Mode		40		Min
T_{TIMER2}	Charger Safety Timer Termination Time	CC Mode		480		Min
I_{END}	End of Charge Indication Current Ratio	CV Mode		10%	15%	I_{CHRG} mA
Ideal Diode						
$R_{ds(on)}$	Internal Ideal Diode On Resistance(BAT to IPSOUT)				100	mΩ

SYMBOL	DESCRIPTION	CONDITIONS	MIN	TYP	MAX	UNITS
Off Mode Current						
I_{BATOFF}	OFF Mode Current	BAT=3.8V		27		μA
Logic						
V_{IL}	Logic Low Input Voltage			0.3		V
V_{IH}	Logic High Input Voltage			2		V
TWSI						
V_{CC}	Input Supply Voltage			3.3		V
ADDRESS	TWSI Address			0x68		
f_{SCK}	Clock Operating Frequency			400	1200	kHZ
t_f	Clock Data Fall Time	2.2Kohm Pull High		60		ns
t_r	Clock Data Rise Time	2.2Kohm Pull High		100		ns

DCDC						
f_{OSC}	Oscillator Frequency	Default		1.5		MHz
DCDC1						
I_{VIN1}	Input Current	PFM Mode I_{DC1OUT} =0		26		μA
I_{LIM1}	PMOS Switch Current Limit	PWM Mode		1600		mA
I_{DC1OUT}	Available Output Current	PWM Mode		1200		mA
V_{DC1OUT}	Output Voltage	Default	0.7	3.3	3.5	V

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

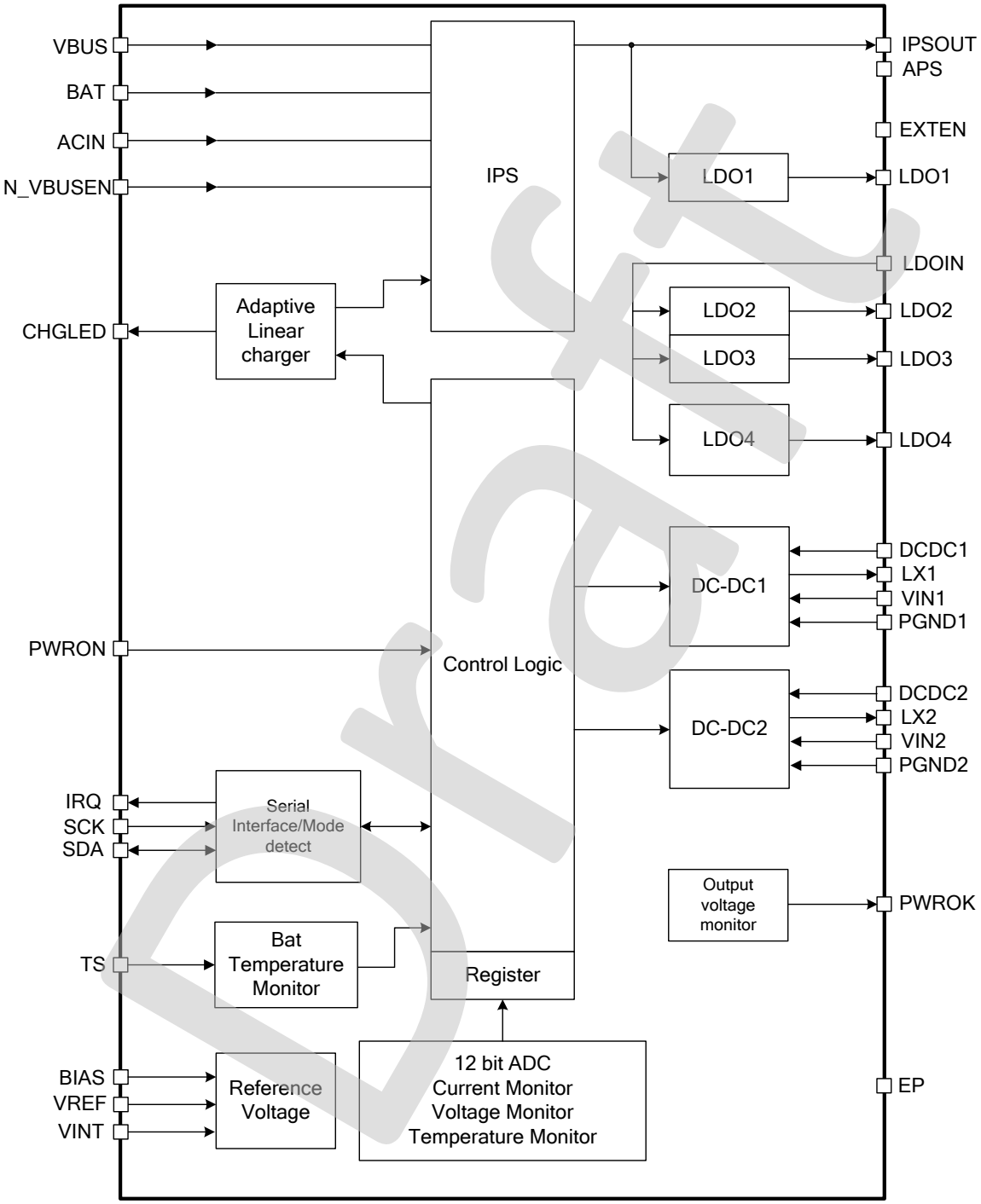
6. Typical Characteristics

To be updated

7. Pin Description

Num	Name	Type	Function Description
A1	LDO2	O	Output Pin of LDO2
A2	SCK	I	TWSI Clock Signal,pull high to 3.3V IO Power through an 2.2K Resistor
A3	GND	G	ground
A4	PWROK	O	Power good indication
A5	DCDC1	I	DCDC1 feedback pin
B1	LDOIN	PI	Input to LDO2 and LDO3
B2	SDA	IO	TWSI Data Signal,pull high to 3.3V IO Power through an 2.2K Resistor
B3	IRQ	O	IRQ output
B4	PGND1	G	NMOS Ground for DCDC1
B5	LX1	IO	Inductor Pin for DCDC1
C1	APS	PI	Internal Power Input
C2	LDO3	O	Output Pin of LDO3
C5	VIN1	PI	DCDC1 input source
D1	PWRON	I	Power On-Off key input，Internal 100k pull high to APS
D2	BIAS	IO	External 200Kohm 1% resistor
D3	VINT	PO	Internal logic power, 2.5V
D4	GND	G	ground
D5	IPSOUT	PO	System power source
E1	VREF	O	Internal reference voltage
E2	LDO1	O	LDO1 output，for Host RTC block
E3	VBUS	PI	USB VBUS input
E4	GPIO	IO	GPIO
E5	BAT	IO	Main Battery

8. Functional Block Diagram



9. Control and Operating

When AXP176 is working, the TWSI interface, SCK/SDA pin is pulled up to the system IO power, the Host can adjust and monitor the status of AXP176 through this interface.
Note1: "Host" refers to the processor of the application system
Note2: The following "external power" is VBUS

9.1. On/Off and Reset

PEK

A key can be connected between the pin PWRON and GND, which act as an independent switch key, called Power Enable Key (PEK). AXP176 can automatically identify that either the key-press is "long press" or "short press" and make the appropriate response.

Power on trigger Source

1.VBUS and the battery access.
2.PEK.

Power On

When VBUS or battery connect in, AXP176 will startup automatically by customized.
AXP176 can be started up by PEK (the time of pushing the key must be more than "ONLEVEL") . In practice, the timer (Alarm) timeout signal of the system can be connected to PWRON-and be parallel with PEK, low level signals is the equivalent of PEK press, also can cause AXP176 to be started up.

Power Off

When the time of PEK "long-press" longer than IRQLEVEL , through the interrupt service program in PEK, Host can write "1" to the "register REG32H [7]" to inform AXP176 to shutdown, it will turn off all the output except LDO1.

In the following cases, AXP176 will automatically shut down:
1. the input voltage is too low, low power protection;
2. the output voltage is too low, overload protection;
3. the input voltage is too high, over-voltage protection (details in the "power-path management" section);
4. when PEK is longer than OFFLEVEL (default 6S) ,the system automatically disable all output except LDO1;

The mechanism of AXP176 automatic protection, can avoid un-recovery damage to the device when application exception occurs to protect the entire system.

PWROK

The PWROK of AXP176 can be used as the reset signal of the application system. During startup time, PWROK is low, after the output voltage of all channels stability, PWROK will be pulled up in order to assert a power-on reset to the system.

During the application system work as normal, AXP176 monitors the output voltage and load all the time, if in

the overload or under voltage situation, PWROK immediately changes to be low, resets application system and then power off to protect the system.

9.2. IPS

AXP176's power input can come from lithium battery BAT, or USB VBUS input, according to the status of the external power and lithium battery, IPS selects the appropriate source.

- only lithium battery exist and no external power input, use lithium battery power to supply;
- access to an external power source , use external power to supply in priority;
- the battery is connected, when external power supply removed, immediately switch to lithium battery power supply;
- If the external power can't supply for charger and system , AXP176 will reduce the charge current until 0, and then switch on the battery path to work together.

when VBUS load capacity is insufficient, IPSOUT voltage drops, BAT will been change it status from being charged to discharging, provides current for system load with VBUS together.

Through TWSI, Host can access AXP176 internal register to set the parameters of IPS and read the status.

Voltage / Current limit mode and direct mode

In order to avoid influencing the USB communications, VBUS default works in "VBUS voltage-limiting mode." In this mode, AXP176 will hold VBUS voltage above at a reference voltage VHOLD to meet the USB specification. VHOLD is 4.4V at default, can be adjust at register Reg30H [5:3] .

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

If the system only uses the USB-powered and does not care USB communication, or use the USB-port power adapter, you can set AXP176 to "VBUS direct mode" through modify the register REG30H [6] , then AXP176 will give priority to meet electricity demand for applications. if the USB Host drive capacities is too weak or Power Consumption is too strong, VBUS power system voltage will be less than VHOLD, AXP176 will assert IRQ, tell the Host that VBUS power supply capacity is weak and the USB communication may be invalid, the follow-up actions can be decided by the Host software.

The reaction when the AXP176 is inserted by external power

AXP176 can automatically detect whether the external power inserted or not. After the external power is valid, it will automatically determine whether the external power supply is available to use or not, and the results will be set in the corresponding register, at the same time assert IRQ.

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

REG00H[5]	Indication the existence of an external power VBUS
REG00H[4]	Indication the available to use or not of an external power VBUS
REG00H[3]	When VBUS insert, whether VBUS voltage is above VHOLD or not
REG00H[0]	Whether the startup is triggered by VBUS or not

When Host receives IRQ7(mean VBUS is weak),together with the status REG00H[3],it will determine whether

VBUS low voltage status is because of system load or VBUS is lower than V_{HOLD} at the time insert. That make the host decide the system work on voltage limit mode or change to direct mode.

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

AXP176 has two stage of low voltage warning and automatically power off (V_{OFF}) which is compared with APS. Once APS is lower than $V_{WARNING}$， AXP176 sends out IRQ30. If APS is lower than V_{OFF}， AXP176 gets into power off mode, disable all output except LDO1.

$V_{WARNING}$ can be set into LEVEL1/LEVEL2，when APS is lower than LEVEL2, AXP176 sends out IRQ30，after APS is higher than LEVEL1, clear this IRQ automatically.

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

Over-voltage protection

When external power supply voltage higher than 6.2V, AXP176 sends out IRQ1 or IRQ4, which means external power supply is over-voltage. If higher than 7V, AXP176 is powered off automatically.

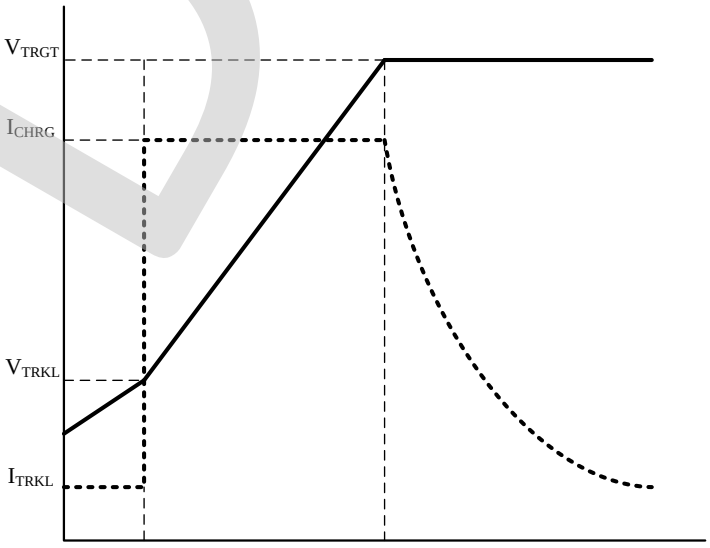
9.3. Adaptive Charger

AXP176 has integrated a constant current/voltage charger, which can automatically control charge period, internal safety clock can stop charging without CPU. This charger can adjust charge current based on the power dissipation of the system , fuel gauge, small current charge and active mode. Internal temperature detect circuit can decrease charge current when in over/under temperature.

Startup adaptive charge

The charge function is default enable(register disable, see “REG33H”).After insert external power source, AXP176 judges whether external power source can be used for charge or not, when it’s available, and charge function is enabled, AXP176 gets into charge mode automatically, and sends IRQ to Host, which indicates the charge process start. Meanwhile, CHGLED was set to low to drive external light-emitting diode indicate AXP176 is in charge mode.

Charge voltage current diagram



Two indicate voltage

V_{TRGT}， charge target voltage. V_{TRGT} can be set by register, 4.2V by default (see REG33H[6:5]). Meanwhile, when external power source is lower than 4.2V, AXP176 will adjust V_{TRGT} by itself.

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

Charge current

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

Charge flow

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

Once battery is higher than 3.0V, charger goes into constant current mode. If charge current is lower than 65% of the set value, the system sends out IRQ17, which informs “External power source is weak, charge current doesn’t reach the target value, so the charge time will be longer, if you want to reduce the charge time, you should insert a more powerful source or disable the system load”.

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

In constant voltage mode, When charge current is lower than 10% or 15% of the set value(which can be set by REG33H), charge period is over, AXP176 sends out IRQ13, CHGLED indicate stop status. When battery voltage is lower than V_{RCH} again, AXP176 can recharge automatically, and sends out IRQ12.

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

Battery active mode

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

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

AXP176 uses REG01H to indicate charger is in battery active mode or not.

Battery detect

AXP176 can check battery is presence or not, and set in register(see REG01H) and sends out IRQ13、IRQ14. Battery detect function can be enable or disable by Host(see REG32H).

9.4. Multi-Outputs

AXP176’s multi-output is showed as follows:

Output	Type	Application example	Drive ability

DCDC1	BUCK	2.5V I/O	1200 mA
LDO1	LDO	RTC	30 mA
LDO2	LDO	Analog/FM	200 mA
LDO3	LDO	1.8V HDMI	200 mA

AXP176 has integrated 1 Buck DC-DC converters, 3 low dropout linear regulator, multi-startup time sequence and control mode. DC-DC switch frequency is 1.5MHz, using small inductance and capacitance.

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

Recommend inductance and capacitance is showed as follows:

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

LDO1

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

LDO2/3

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

Soft Start

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

Self-diagnose: load control and current limit protection

All DC-DC converters and LDO's have the function of load control and current limit protection. When load current is over than its ability, output voltage will drop. When one of the DC-DC's output voltages is lower than 85% of the set value, AXP176 is powered off automatically. Meanwhile the system can record which power rail makes system powered off(see REG46H[5:2]),and sends out IRQ.

All DC-DC don't need Scotty diode and the feed back resistance circuit. If the application circuits don't use any

DC-DC, just floating LX pin, but the VIN and PGND should connect as normal.

9.5. Default Voltage/Timing Setting

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

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

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

9.6. Signal Capture

The multi channel 12-bit ADC of AXP176 not only measure the cell voltage but also measure the cell current and external power source voltage and current, meanwhile internally integrates with the batteries' charge-discharge coulomb-counter. According to these data, Host can calculate accurately the battery power , what's more , can get the rich batteries' information like the real-time power consumption, the remaining battery power, the progress of charging, the remaining time to work and the remaining time to charge completely and etc.

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

Channel	000H	STEP	FFFH
Battery Voltage	0mV	1.1mV	4.5045V
Bat discharge current	0mA	0.5mA	4.095A
Bat charge current	0mA	0.5mA	4.095A
VBUS voltage	0mV	1.7mV	6.9615V
VBUS current	0mA	0.375mA	1.5356A
Internal temperature	-144.7℃	0.1℃	264.8℃
APS voltage	0mV	1.4mV	5.733V

9.7. Timer

AXP176 includes an internal timer, which can change the timer through setting register REG8AH[6:0] whose LSB is one Minute, reset the timer after timeout.

9.8. TWSI and IRQ

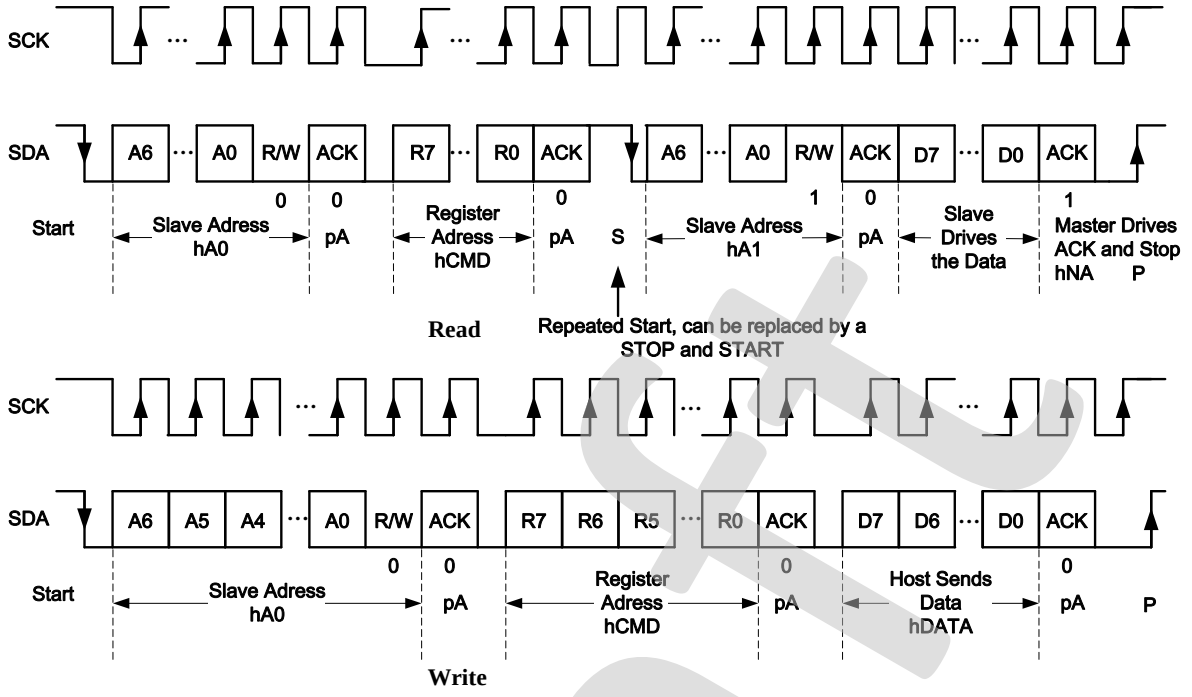


Figure 9-1. Single Read and Write

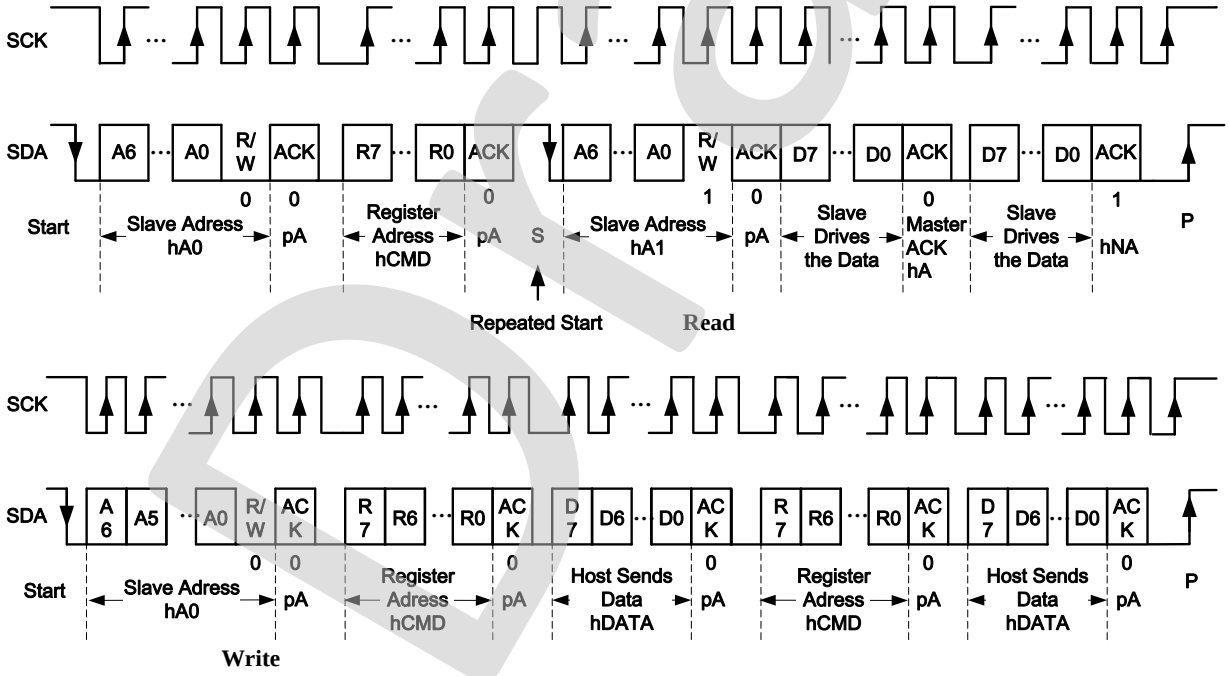


Figure 9-2. Multi Read and Write

Host can access registers through TWSI, its time sequence is as illustrated in shown picture, support standard 100KHz or 400KHz , and the maximum speed is up to 1.2MHz, while it supports read and write operation, that device address 69H is to read and 68H to write. In certain cases, AXP176 reminds Host through pulling down the interrupt mechanism of IRQ, and puts the IRQ status into corresponding register(refer to register REG44H, register REG45H, register REG47H), and cancel the interruption by adding 1 to the appropriate register. IRQ

output raise(increase its resistance by 51k from outside), when there are no events of interruption. Each IRQ can be blocked through IRQ register(refer to register REG40H, register REG41H, register REG42H, REG43H).

Location	IRQ	Description	Location	IRQ	Description
REG44H[7]	IRQ1	Reserved	REG 46H[7]	IRQ16	IC internal over temperature
REG44H[6]	IRQ2	Reserved	REG 46H[6]	IRQ17	Charge current not enough
REG 44H[5]	IRQ3	Reserved	REG 46H[5]	IRQ18	DCDC1 under voltage
REG 44H[4]	IRQ4	VBUS overvoltage	REG 46H[4]	IRQ19	Reserved
REG 44H[3]	IRQ5	VBUS insert	REG 46H[3]	IRQ20	Reserved
REG 44H[2]	IRQ6	VBUS remove	REG 46H[2]	Reserved	
REG 44H[1]	IRQ7	VBUS valid but lower than V_{HOLD}	REG 46H[1]	IRQ22	Short time key press
REG 44H[0]	Reserved		REG 46H[0]	IRQ23	Long time key press
REG 45H[7]	IRQ8	Battery is present	REG 47H[7]	IRQ24	Reserved
REG 45H[6]	IRQ9	Battery not present	REG 47H[6]	IRQ25	Reserved
REG 45H[5]	IRQ10	Into battery active mode	REG 47H[5]	IRQ26	VBUS valid
REG 45H[4]	IRQ11	Quit battery active mode	REG 47H[4]	IRQ27	VBUS invalid
REG 45H[3]	IRQ12	Charging	REG 47H[3]	IRQ28	VBUS Session Valid
REG 45H[2]	IRQ13	Charge finished	REG 47H[2]	IRQ29	VBUS Session End
REG 45H[1]	IRQ14	Reserved	REG 47H[1]	Reserved	
REG 45H[0]	IRQ15	Reserved	REG 47H[0]	IRQ30	Under voltage warning

9.9. Registers

9.9.1. power supply control class

Location	Description	R/W	Default
00	Power supply status register	R	
01	Power supply mode/charging status register	R	
04	OTG VBUS status register	R	
06-09	Data buffer register	R/W	F0/0F/00/FF
12	DC-DC1 & LDO2/3switch register	R/W	XFH
26	DC-DC1voltage set register	R/W	68H
28	LDO2/3 voltage set register	R/W	CFH
30	VBUS-IPSOUT access set register	R/W	60H
31	V_{OFF} power off voltage set register	R/W	X3H
32	Power off control register	R/W	46H
33	Charging control register1	R/W	C8H
34	Charging control register2	R/W	41H
35	Backup battery charging control register	R/W	22H

36	PEK parameter set register	R/W	5DH
3A	APS under voltage Level1 set register	R/W	68H
3B	APS under voltage Level2 set register	R/W	5FH
82	ADC enable set register 1	R/W	83H
83	ADC enable set register 2	R/W	80H
84	ADC sample frequency set	R/W	32H
8A	Timer control register	R/W	00H
8F	Over temperature power off control register	R/W	01H

9.9.2. IRQ control class

Location	Description	R/W	Default
40	IRQ enable control register 1	R/W	D8H
41	IRQ enable control register 2	R/W	FFH
42	IRQ enable control register 3	R/W	3BH
43	IRQ enable control register 4	R/W	C1H
44	IRQ status register 1	R/W	00H
45	IRQ status register 2	R/W	00H
46	IRQ status register 3	R/W	00H
47	IRQ status register 4	R/W	00H

9.9.3. ADC data class

Location	Description	R/W
56	ACIN voltage ADC data high 8 bit	R
57	ACIN voltage ADC data low 4 bit	R
58	ACIN current ADC data high 8 bit	R
59	ACIN current ADC data low 4 bit	R
5A	VBUS voltage ADC data high 8 bit	R
5B	VBUS voltage ADC data low 4 bit	R
5C	VBUS current ADC data high 8 bit	R
5D	VBUS current ADC data low 4 bit	R
5E	AXP176 internal temperature monitor ADC data High 8 bit	R
5F	AXP176 internal temperature monitor ADC data low 4 bit	R
62	TS input ADC data High 8 bit，monitor battery temperature by default	R
63	TS input ADC data low 4 bit，monitor battery temperature by default	R
70	Battery instantaneous power high 8 bit	R
71	Battery instantaneous power middle 8 bit	R
72	Battery instantaneous power low 8 bit	R
78	Battery voltage high 8 bit	R
79	Battery voltage low 4 bit	R
7A	Battery charging current high 8 bit	R
7B	Battery charging current low 5 bit	R
7C	Battery discharging current high 8 bit	R

7D	Battery discharging current low 5 bit	R
7E	APS voltage high 8 bit	R
7F	APS voltage low 4 bit	R

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

9.9.4. REG 00H: power supply status

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

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

Bit	Description	R/W
7	Indicate whether AXP176 is over temperature or not 0: not over temperature; 1: over temperature	R
6	Charging indicate 0: not be charging or charge finished; 1:charging	R
5	Battery present status indicator 0: no battery connects to AXP176; 1:battery has connected to AXP176	R
4	Reserved	R
3	Indicate whether battery goes into active mode or not 0:not in battery active mode; 1:in battery active mode	R
2	Indicate whether charging current is less than expected current 0: actual charging current equal to expected current; 1: actual charging current less than	R

	expected current	
1-0	Reserved	R

9.9.6. REG 04H:USB OTG VBUS status indicator

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

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

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

9.9.8. REG 12H:DC-DC1 & LDO2/3/4 output control

Default: XFH

Bit	Description		R/W	Default
7-4	Reserved			
3	LDO3 switch control	0:disable; 1:enable	RW	X
2	LDO2 switch control		RW	X
1	Reserved		RW	X
0	DC-DC1 switch control		RW	X

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

Default: 68H

Bit	Description		R/W	Default
7	Reserved			
6	DC-DC1 output voltage Bit6	0.7-3.5V，25mV/step	RW	X
5	DC-DC1 output voltage Bit5		RW	X
4	DC-DC1 output voltage Bit4		RW	X
3	DC-DC1 output voltage Bit3		RW	X
2	DC-DC1 output voltage Bit2		RW	X
1	DC-DC1 output voltage Bit1		RW	X
0	DC-DC1 output voltage Bit0		RW	X

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

Default: CFH

Bit	Description		R/W	Default
7	LDO2 output voltage Bit3	1.8-3.3V， 100mV/step	RW	X

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

9.9.11. REG 30H:VBUS-IPSOUT access management

Default:6XH

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

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

Default:X3H

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

9.9.13. REG 32H:power off control

Default:46H

Bit	Description	R/W	Default
7	Power off control 1: close AXP176 output	RW	0
6	Reserved	RW	0x46

9.9.14. REG 33H: charging control 1

Default: C8H

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

9.9.15. REG 34H: charging control 2

Default:41H

Bit	Description		R/W	Default
7	Pre-charge overtime Bit1	00: 30 min； 01: 40min； 10: 50min； 11: 60min	RW	0
6	Pre-charge overtime Bit0		RW	1
5-2	Reserved			
1	In constant current mode overtime Bit1	00: 7Hours； 01: 8Hours； 10: 9Hours； 11: 10Hours	RW	0
0	In constant current mode overtime Bit0		RW	1

9.9.16. REG 36H:PEK press key parameter set

Default: 5DH

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

9.9.17. REG 3AH:APS low voltage level 1

Default:68H

Bit	Description	R/W	Default

7-0	APS low voltage level 1	RW	68H

9.9.18. REG 3BH:APS low voltage level 2

Default:5FH

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

REG3AH、REG3BH corresponding APS voltage is:(suppose register value is n):

Vwarning = 2.8672 + 1.4mV * n * 4

9.9.19. REG 82H:ADC enable 1

Default:83H

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

9.9.20. REG 83H:ADC enable 2

Default:80H

Bit	Description		R/W	Default
7	AXP176 internal temperature monitor ADC enable	0:disable; 1:enable	RW	1
6-0	Reserved			

9.9.21. REG 84H: ADC sample rate set

Default:32H

Bit	Description		R/W	Default
7	ADC sample rate Bit 1	25×2^n	RW	0
6	ADC sample rate Bit 0	Sample rate: 25， 50， 100， 200Hz	RW	0
5-0	Reserved		RW	0x32

9.9.22. REG 8AH: timer control

Default:00H

Bit	Description	R/W	Default
7	Timer timeout Set 1 clear this status	RW	0

6-0	Set time, unit is minute 0000000:close this timer	RW	0000000

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

Default:01H

Bit	Description	R/W	Default
7-3	Reserved	RW	0
2	AXP176 internal over temperature power off function set 0:not power off; 1:power off	RW	0
1-0	Reserved		

9.9.24. REG 40H:IRQ enable 1

Default:D8H

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

9.9.25. REG 41H:IRQ enable 2

Default: FFH

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

9.9.26. REG 42H:IRQ enable 3

Default:3BH

Bit	Description	R/W	Default
7	AXP176 internal over temperature IRQ enable	RW	0
6	Charge current not enough IRQ enable	RW	0

5	DC-DC1 under voltage IRQ enable	RW	1
4	Reserved	RW	1
3	Reserved	RW	1
2	Reserved		
1	Short time key press IRQ enable	RW	1
0	Long time key press IRQ enable	RW	1

9.9.27. REG 43H:IRQ enable 4

Default:C1H

Bit	Description	R/W	Default
7	Reserved	RW	1
6	Reserved	RW	1
5	VBUS valid IRQ enable	RW	0
4	VBUS invalid IRQ enable	RW	0
3	Reserved	RW	0
2	Reserved	RW	0
1	Reserved	RW	1
0	APS under voltage IRQ enable	RW	1

9.9.28. REG 44H:IRQ status1

Default:00H

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

9.9.29. REG 45H:IRQ status2

Default:00H

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

0	battery under temperature IRQ status	RW	0

9.9.30. REG 46H:IRQ status3

Default:00H

Bit	Description	R/W	Default
7	AXP176 internal over temperature IRQ status	RW	0
6	Charge current not enough IRQ status	RW	0
5	DC-DC1 under voltage IRQ status	RW	0
4	Reserved	RW	0
3	Reserved	RW	0
2	Reserved	RW	0
1	Short time key press IRQ status	RW	0
0	Long time key press IRQ status	RW	0

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

9.9.31. REG 47H:IRQ status4

Default:00H

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

9.9.32. REG B8H: Coulomb counter control

Default:00H

Bit	Description	R/W	Default
7	Coulomb counter open/close	RW	0
6	Coulomb counter pause, 1: pause, then clear itself	RW	0
5	Clear coulomb counter control, 1:clear coulomb counter, then clear itself	RW	0
4-0	Reserved	RW	0

10. Package Information

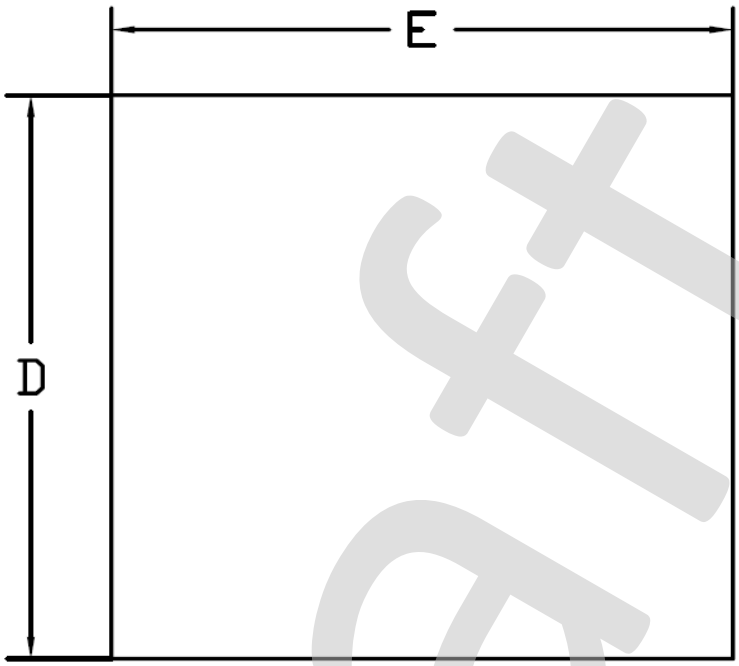


Figure 10-1. AXP176 Package Top View

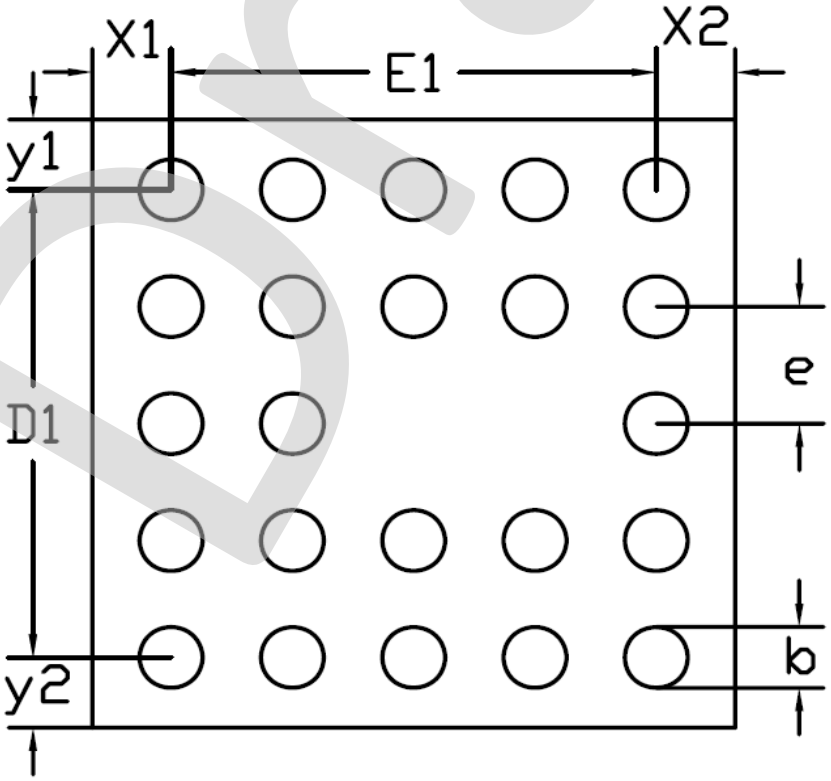


Figure 10-2. AXP176 Package Bottom View

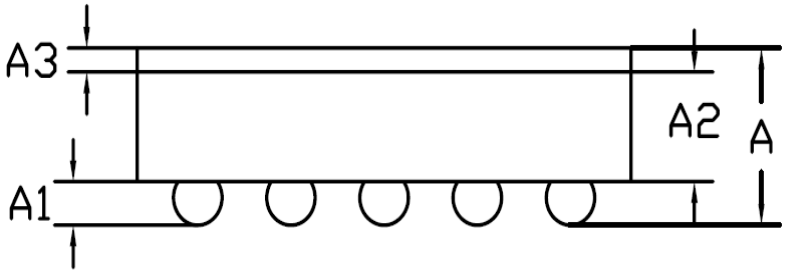


Figure 10-3. AXP176 Package Side View

COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	0.590	0.620	0.650
A1	0.185	0.210	0.235
A2	0.360	0.380	0.400
A3	0.020	0.030	0.040
D	2.570	2.600	2.630
D1		2.000BSC	
E	2.620	2.650	2.680
E1		2.000BSC	
b	0.235	0.260	0.285
e		0.500 BSC	
x1		0.3250 REF	
x2		0.3250 REF	
y1		0.3000 REF	
y2		0.3000 REF	

Figure 10-4. AXP176 Package Dimension

