AXP259 Datasheet

2 Cells Battery Management IC

Revision 1.4

Jul.6, 2017

1. FEATURES

- 6V~14V Input Operating Range and Support 2 Cells Battery
- <50uA Off-State Battery Discharge Current
- IPS (Intelligent Power Select) with External NMOS for ACIN Path, with External PMOS for BAT Path
- Support TWSI (Two Wire Serial Interface), slave address: 0x6C(W)/ 0x6D(R)
- High Accuracy E-Gauge™
- 1MHz Up to 4A 5V Buck DCDC
- Protection
- Input Over-Voltage Protection Voltage
- Short Protect for PMOS in BAT Path
- Battery Thermistor Sense Hot/Cold Charge Suspend
- Programmable Safety Timer for Charger
- Charge Over-Current Protection
- Die Thermal Balance for Charger
- Thermal Shutdown
- 56 pin, 7×7 mm^2 QFN Package

2. APPLICATIONS

- POS, WI-FI Audio Box
- Tablet PC, Ultrabook, Industrial and Medical Equipment
- UMPC-like, Student Computer

3. DESCRIPTION

AXP259 is a highly integrated BMU targeting at 2 cells Li-battery (Li-ion or Li-polymer) applications. It provides an easy and flexible battery management solution for large current charge and system power supply.

AXP259 comes with a high voltage input Charger that supports up to 3A charge current. It also supports a 4A BUCK for system power supply.

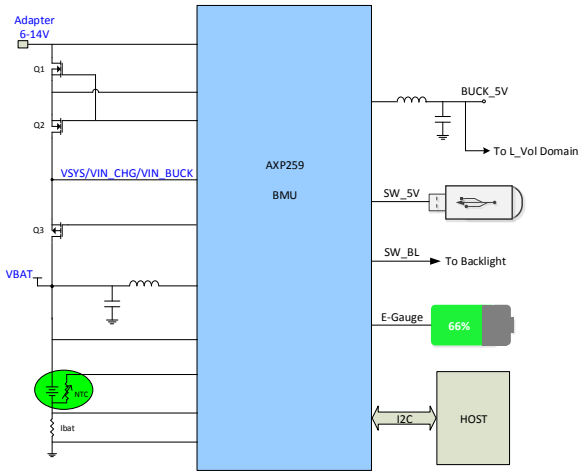
To ensure the security and stability of the power system, AXP259 provides multiple channels 12-bit ADC for voltage/ current / temperature monitor and it also integrates protection circuits such as OVP, UVP, OTP, and OCP. Moreover, AXP259 features a unique E-Gauge™(Fuel Gauge) system, making power gauge easy and exact.

In addition, AXP259 embraces a fast interface for the system to dynamically adjust charge current and buck output voltage so that the battery charge time could be saved and battery life can be extended to the largest extent.

Besides, AXP259 features an IPS™ (Intelligent Power Select) circuit to transparently select power path among adapter and Li-battery to system load.

AXP259 is available in 7mm x 7mm 56-pin QFN package, and the package is Pb free.

Simplified Application Diagram



REVISION HISTORY

Revision	Date	Description
V1.0	Oct.21,2016	Initial internal release
V1.1	Dec.04,2016	Delete register list
V1.2	Apr.18,2017	Revise clerical mistake and add parameter description
V1.3	Jun.16,2017	Change ACIN/BAT voltage range for 2-3 cells application
V1.4	Jul.5,2017	Delete 3 cells application and add charger CV accuracy; Max ACIN operation voltage change from 15V to 14V

DECLARATION

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4. PIN MAP

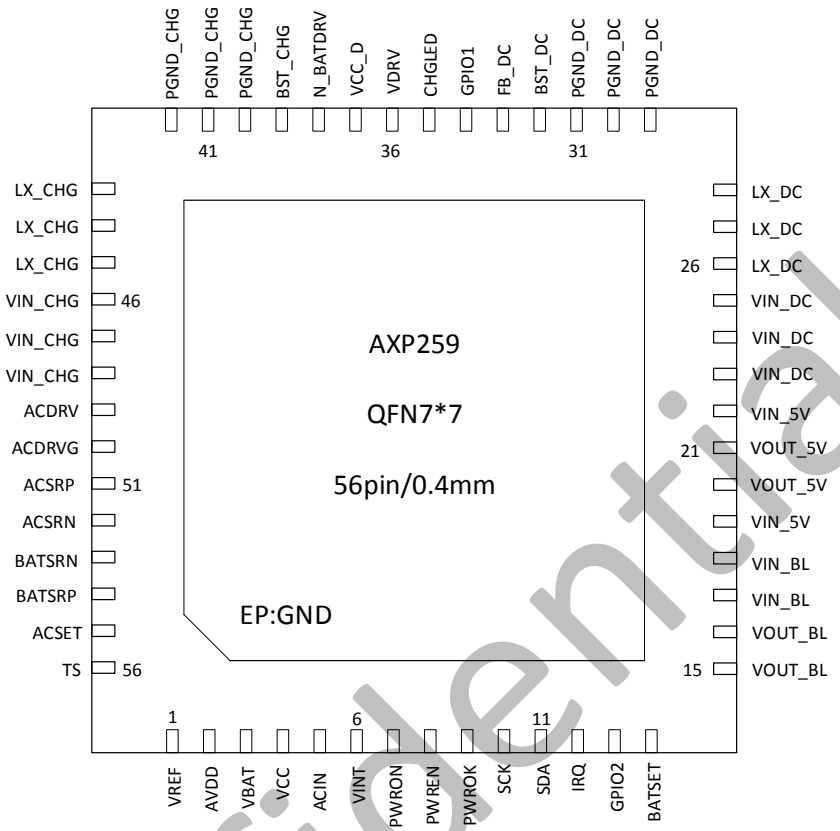

Figure 1. AXP259 Pin Configuration

5. PIN DESCRIPTION

Pin	Name	Type	Function Description
1	VREF	AIO	Internal reference voltage. The pin need connect capacitor.
2	AVDD	PIO	Internal analog circuit power supply, also as RTC power. The pin need connect capacitor.
3	VBAT	PI	Battery power input
4	VCC	PIO	Chip internal power. The pin need connect capacitor.
5	ACIN	PI	Adapter power input
6	VINT	PIO	Internal digital part power and RTC power. The pin need connect capacitor.
7	PWRON	DI	Power on key input. The pin can go high internally to VINT
8	PWREN	DO	PMIC enable signal output
9	PWROK	DO	The indication of power on completed for power system
10	SCK	DI	Serial interface clock input signal
11	SDA	DIO	Serial interface data signal
12	IRQ	DIO	Interrupt signal, also as receive power-on signal
13	GPIO2	DO	GPIO, also as EXTEN signal output
14	BATSET	AI	Battery serial number setting, supports 2 cells with BATSET connecting to GND,not allowed pull up to high or floating
15,16	VOUT_BL	PO	High voltage power switch output
17,18	VIN_BL	PI	High voltage power switch input
19,22	VIN_5V	PI	Low voltage power switch input
20,21	VOUT_5V	PO	Low voltage power switch output
23~25	VIN_DC	PI	BUCK power supply input
26~28	LX_DC	PIO	BUCK power output, external connect inductance and capacitor
29~31	PGND_DC	PG	BUCK power ground
32	BST_DC	PIO	BUCK power drive boot strap, external connect capacitor to LX_DC
33	FB_DC	AI	BUCK feedback
34	GPIO1	DO	GPIO, also as wakeup signal output
35	CHGLED	DO	Charger status indicator
36	VDRV	PIO	Internal power supply, need external capacitor
37	VCC_D	PI	Internal power supply, connect external capacitor from VCC_D to gnd
38	N_BATDRV	AO	Battery power switch drive, connect to P-type switch grid
39	BST_CHG	PIO	Charger power drive boot strap, connect external capacitor from N_BATDRV to LX_CHG
40~42	PGND_CHG	PG	Charger power ground
43~45	LX_CHG	PIO	Charger power output, external connect inductance and capacitor
46~48	VIN_CHG	PI	Charger power supply input
49	ACDRV	AO	Adapter input switch drive, connect to N-type switch grid
50	ACDRVG	AI	Adapter input switch drive, connect to N-type switch source
51	ACSRP	AI	Adapter RSNS positive input

52	ACSRN	AI	Adapter RSNS negative input
53	BATSRN	AI	Battery RSNS negative input, connect to battery negative end
54	BATSRP	AI	Battery RSNS positive input, connect to PCB ground
55	ACSET	AI	ACIN input current-limit setting, external connect resistance
56	TS	AIO	Battery temperature detection or external ADC input
EP	EP	G	Exposed PAD. Internal analog and control circuit connect to GND

6. BLOCK DIAGRAM

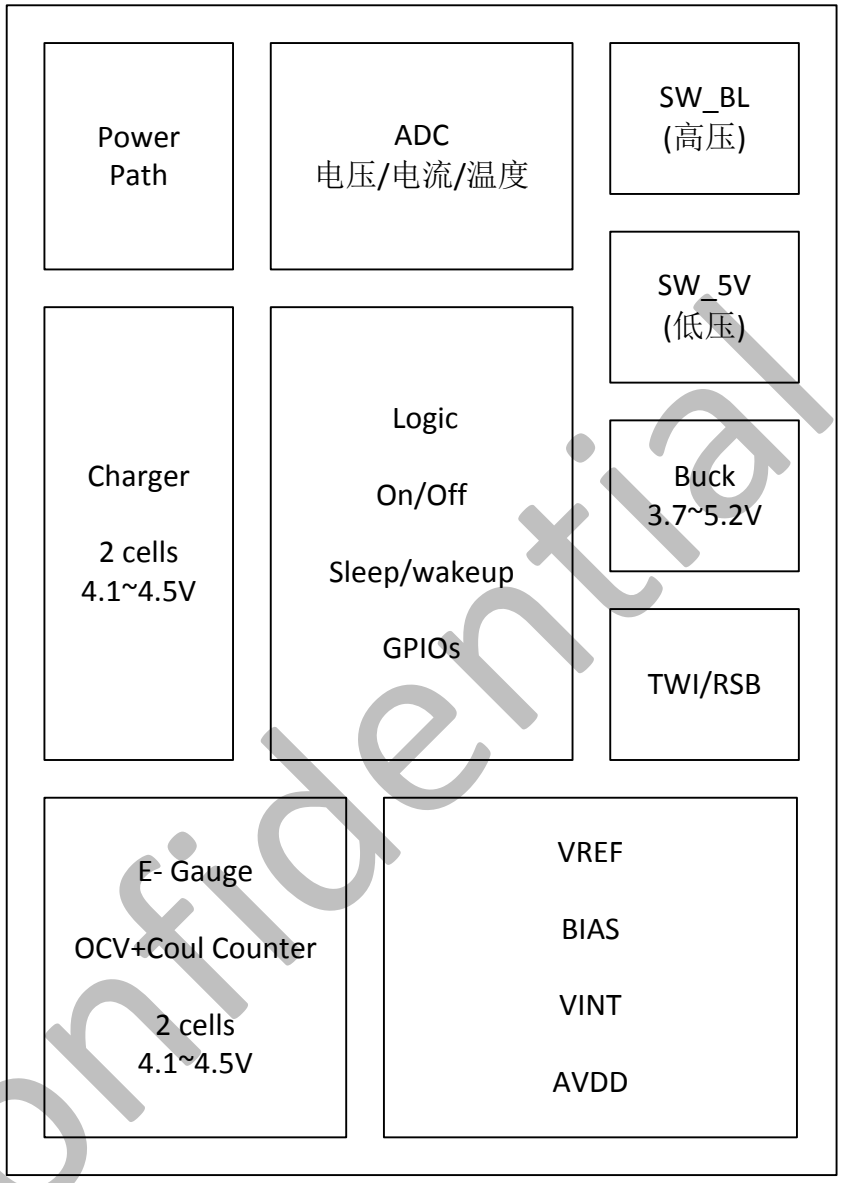

Figure 2. Block Diagram

7. ABSOLUTE MAXIMUM RATINGS

Symbol	Description	Value	Unit
ACIN	Input voltage range	-0.3 to 20	V
VBAT	Input voltage range	-0.3 to 20	V
V_{RIO1}	Voltage range on pin PWROK	-0.3 to 5.5	V
V_{RIO2}	Voltage range on pins SCK, SDA, IRQ, GPIO1, GPIO2, TS	-0.3 to 3.6	V
V_{RIO3}	Voltage range on pins PWRON, PWREN, BATSET, ACSET	-0.3 to 2.1	V
T_J	Junction temperature range	-40 to 150	℃
T_{STG}	Storage temperature range	-40 to 150	℃
T_{LEAD}	Maximum soldering temperature (at leads，10sec)	260	℃

8. THERMAL INFORMATION

Symbol	Description	Value	Unit
Θ_{JA}	Junction-to-ambient thermal resistance	23	℃/W
P_D	Internal power dissipation Test condition: Demo PCB Board AXP259 Demo dimension: 122mm x 102mm x1.6mm Four layers and with thermal Vias, Θ_{JA}=23℃ /W, T_A=25℃	3500	mW

9. RECOMMENDED OPERATING CONDITIONS

Symbol	Description	Min	Max	Unit
ACIN	Input voltage range	6	14	V
VBAT	Input voltage range	6	14	V
V_{RIO1}	Voltage range on pin PWROK		5	V
T_J	Junction temperature range	-25	125	℃
T_A	Operating temperature range	-25	75	℃
ESD Ratings	**Description**		**Value**	**Unit**
	ESD stress voltage(HBM)		±4000	V
	ESD stress voltage(CDM)		±750	V

10. ELECTRICAL CHARACTERISTICS

Minimum and maximum values are at ACIN = 6 V to 14V V and T_J = -40°C to 125°C. Typical values are at ACIN = 12 V and T_J =25°C

Parameter	Description	Test Conditions	Min	Typ	Max	Unit
Power Supply						
ACIN	Adapter Input Supply		6.0	12	14	V
ACIN_UVLO	Under Voltage Lockout(UVLO) Threshold	Rising Voltage	6.0			V
		Falling Voltage			5.8	V
ACIN_HYS	AICN UVLO Hysteresis			200		mV
VSYS	System Voltage Range		5.8	12	14	V
VBAT	Battery Voltage Range		5.8	7.4	14	V
VCC	Internal Circuit Power Supply		3.1		14	V
VDRV	Internal Drive Voltage		4.2	5.0		V
AVDD	Internal Power Supply for Analog Circuit		2.8	3.3		V
VINT	Internal Power Supply for Logic Circuit		1.4	1.8		V
VREF	Reference Voltage for Internal Circuit			1.25		V
ΔVREF	VREF Accuracy	T_A = -40°C to 125°C	-3%		+3%	
Battery Charger						
Charge F_{OSC}	Charger Oscillator Frequency	Default		1.5		MHz
L1	Charger Inductor Value	2-Cell Charging		2.2		uH
V_{TGRT}	Battery Charge Target Voltage range		4.1	4.2	4.5	V
V_{TGRT}	Single Cell 4.2V@T_A=25℃		-0.5%		+0.5%	
I_{CHRG}	Constant Charge Current		400	1200	3000	mA
I_{TRKL}	Trickle Charge Current	REG 22[0]=0	200	10%*I_{CHRG}		mA
ΔV_{RECHG}	Recharge Battery Threshold Voltage	Threshold Voltage Relative to V_{TRGT}		-100		mV
T_{TIMER1}	Charger Safety Timer Termination Time	TC Mode, REG 20[3:2]=01	40	50	70	min
T_{TIMER2}	Charger Safety Timer Termination Time	CC Mode, REG20 [1:0]=01	6	8	12	hour
I_{END}	End Of Charge Indication Current Ratio to I_{CHRG}	CV Mode		10%	20%	
TS						

$V_{LTF-work}$	Cold Temperature Fault Threshold Voltage for Battery Work		0	3.226	3.264	V
$V_{HTF-work}$	Hot Temperature Fault Threshold Voltage for Battery Work		0	0.282	3.264	V
$V_{LTF-charge}$	Cold Temperature Fault Threshold Voltage for Battery Charge		0	2.112	3.264	V
$V_{HTF-charge}$	Hot Temperature Fault Threshold Voltage for Battery Charge		0	0.397	3.264	V
Power OFF Current						
I_{BATOFF}	Power OFF Mode Current	BAT=8.0V		45		uA
Buck						
V_{IN_Buck}	Input Voltage Range		5.8	12	14	V
V_{REG}	Buck Regulator Output Voltage Range	VSYS=12V	4.0	5.0	5.5	V
IQ	Input Current With Null Load	VSYS=12V, Enable Buck		200		uA
V_{REG} Accuracy		Forced PWM at Light Load	-1		+1	%
Buck F_{OSC}	Buck Oscillator Frequency	I_{load}=1.0A		1.0		MHz
L2	Buck Inductor Value			2.2		uH
T_{SS}	Soft Start Time			1		ms
I_{limit_peak}	Peak Current Limit		6.0			A
V_{OVP}	Over Output Voltage Protection	Enable Buck OVP, V_{OVP}=115%*V_{REG}	4.6	5.75	6.325	V
V_{UVP}	Under Output Voltage Protection	Enable Buck UVP, V_{UVP}=85%*V_{REG}	3.4	4.25	4.675	V
R_{DIS}	Discharge Resistor	Enable Discharge Function		340		Ω
Switch_5V						
V_{IN_5V}	Input Voltage for Switch_5V	V_{IN_5V} Connect With the Output Of Buck		5.0		V
I_{LMT}	Current Limit		0.5	0.5	5.0	A
$R_{ds(ON)}$	Internal MOSFET ON Resistor			100		mΩ
Switch_BL						
V_{IN_BL}	Input Voltage for Switch BL	V_{IN_BL} Connect With the System Side		12	14	V

$R_{ds(ON)}$	Internal MOSFET ON Resistor			70		mΩ
GPIO1						
V_{IL}	Logic Low Voltage			0.5		V
V_{IH}	Logic High Voltage			1.3		V
V_{IL}	Logic Low Voltage	REG18[2:0]=010, Drive Low			0.3	V
V_{IH}	Logic High Voltage	REG18[2:0]=011, Drive High	0.7	1.8		V
GPIO2						
V_{IL}	Logic Low Voltage			0.5		V
V_{IH}	Logic High Voltage			1.3		V
V_{IL}	Logic Low Voltage	REG19[2:0]=010, Drive Low			0.3	V
V_{IH}	Logic High Voltage	REG19[2:0]=011, Drive High	0.7	1.8		V

11. TYPICAL CHARACTERISTICS

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2 Cells Battery Charger Efficiency vs. Charger Current (ACIN=9V)	Figure 3
2 cells Battery Charger Efficiency vs. Charger Current (ACIN=12V)	Figure 4
BUCK Enable	Figure 5
BUCK Disable	Figure 6
System Power-On Sequence(No battery)	Figure 7, Figure 8 Figure 9, Figure 10
System Power-Off Sequence from PWRON	Figure 11, Figure 12
Load Transient	Figure 13

Table 1. Typical Characteristics

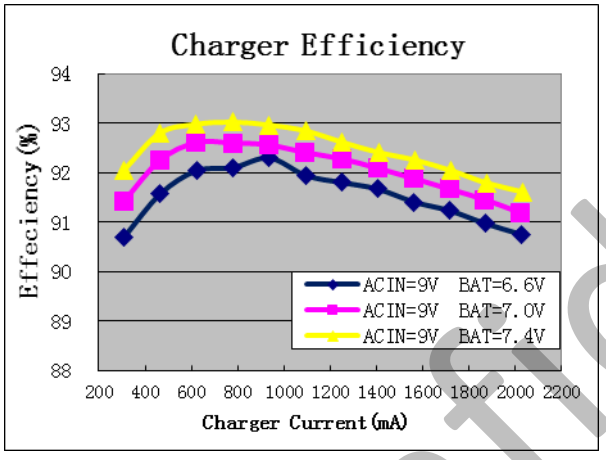


Figure 3. 2 Cells Battery Charger Efficiency vs. Charger Current (ACIN=9V)

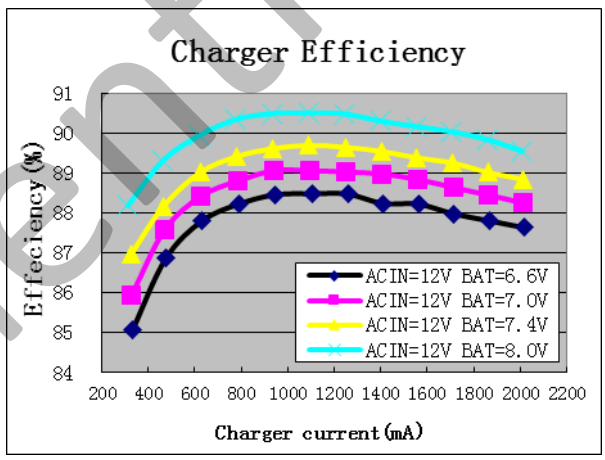
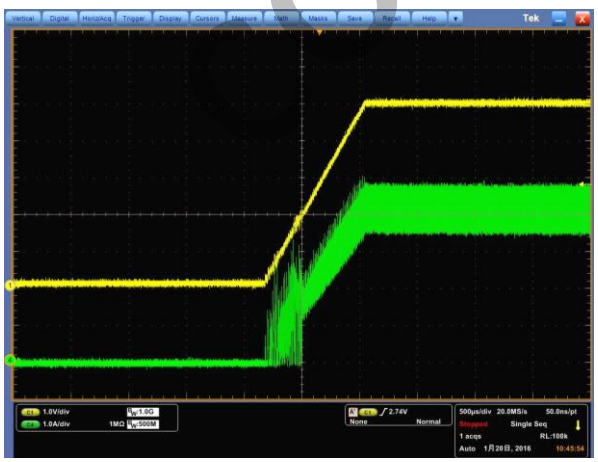
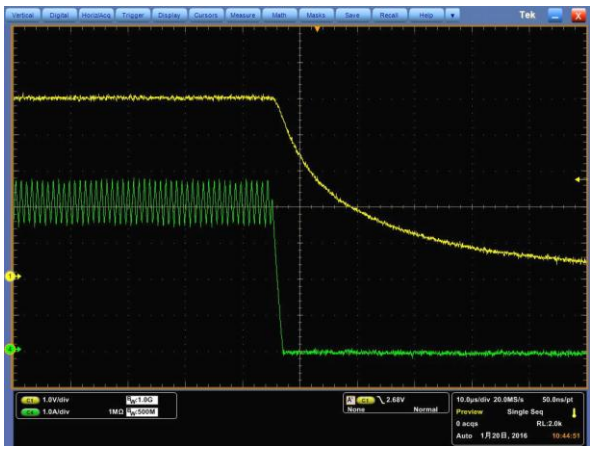


Figure 4. 2 Cells Battery Charger Efficiency vs. Charger Current (ACIN=12V)



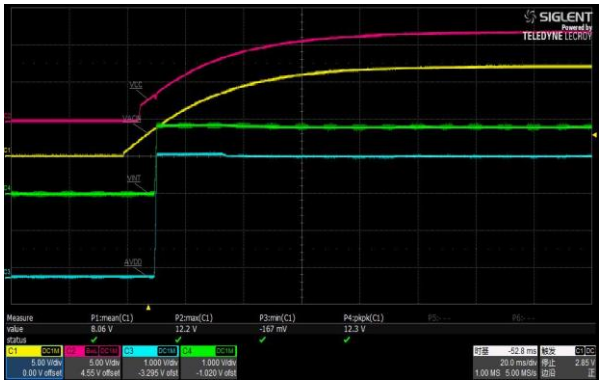
ACIN = 12V, load current = 4.0A;CH1: Vout, 1.0V/div; CH4: I_L, 1.0A/div

Figure 5. BUCK Enable



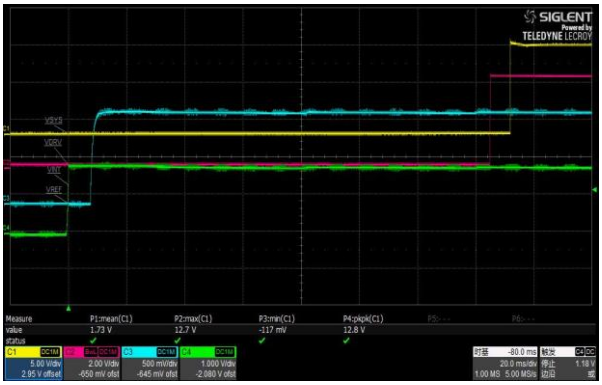
ACIN = 12V, load current = 4.0A;CH1: Vout, 1.0V/div; CH4: I_L, 1.0A/div

Figure 6. BUCK Disable



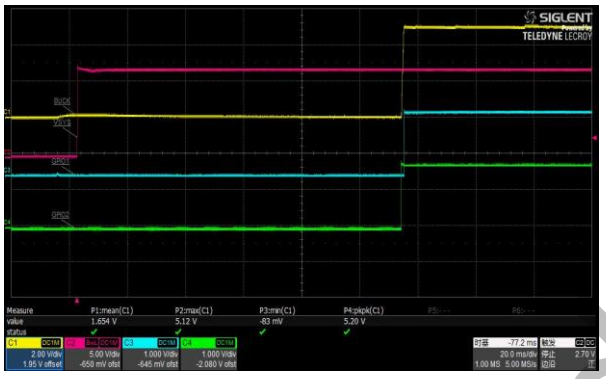
CH1: ACIN, 5V/div; CH2: VCC, 5V/div; CH3: AVDD, 1V/div; CH4: VINT, 1V/div

Figure 7. Power-On Sequence with ACIN



CH1: VSYS,5V/div; CH2: VDRV,2V/div; CH3: VREF, 500mV/div; CH4: VINT, 1V/div

Figure 8. Power-On Sequence with VREF

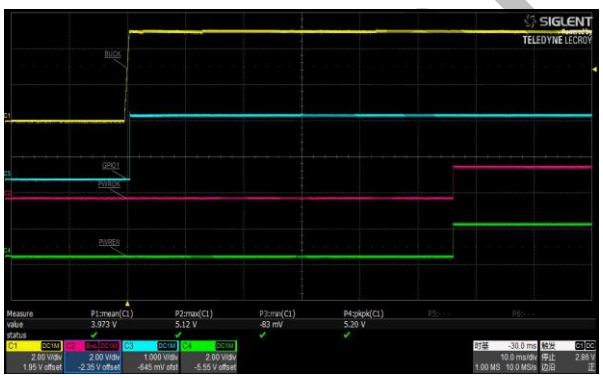


CH1: BUCK,2V/div; CH2: VSYS,5V/div; CH3: GPIO1, 1V/div; CH4: GPIO2, 1V/div

Figure 9. Power-On Sequence with GPIO1/2

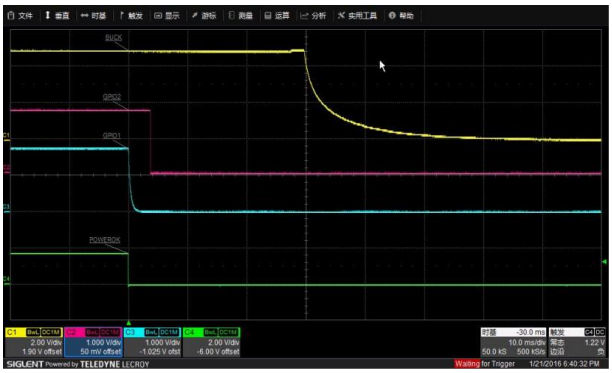
CH1: BUCK, 2V/div; CH2: PWREN, 1V/div; CH3: GPIO1, 1V/div; CH4: POWEROK, 2V/div

Figure 10. Power-Off Sequence with PWREN



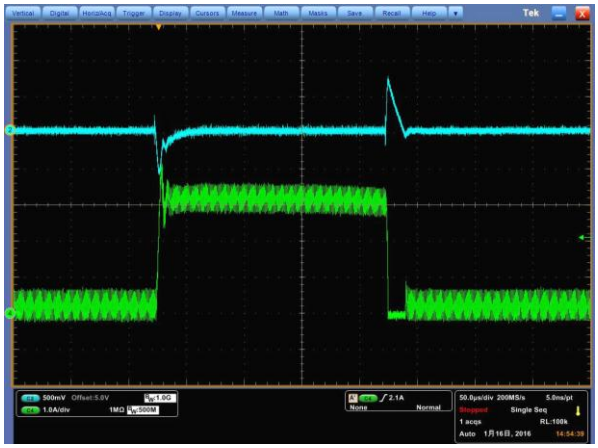
CH1:BUCK,2V/div; CH2: PWROK,2V/div; CH3: GPIO1, 1V/div; CH4: PWREN, 2V/div

Figure 11. Power-On Sequence with PWROK



CH1: BUCK, 2V/div; CH2: GPIO2, 1V/div; CH3: GPIO1, 1V/div; CH4: POWEROK, 2V/div

Figure 12. Power-off Sequence with GPIO2



ACIN= 8.4V, I_L = 0.4A~4.0A; CH2: Vout, 500mV/div;
CH4:I_L, 1.0A/div

Figure 13. Load Transient

11.1 Serial Interface Communication

AXP259 supports TWI protocol, and performs only as a TWI slave device with address 0x6C/0x6D. Note that the other registers can be accessed only if the high 4 bits of REGFFH are the same as the high 4 bits of REGFEH.

11.2 IPS

AXP259 owns Intelligent Power Select (IPS) to select the optimal sources from battery and adapter to power the system (VSYS).

(1). Only if ACIN pin is above 4.5V , ACIN is decided from low to high, after 256ms delay, the power path of ACIN to VSYS is opened.

(2). After ACIN has accessed to the system or powered on, the system will start the internal VDRV_LDO firstly and produce VDRV. ACIN or BAT power path selection will follow below: If the ACIN works availably, then ACDRV is pulled high to select power path of ACIN to VSYS, or the N_BATDRV is pulled low to select the BAT power path. During power off and no ACIN access,BAT power path is available..

(3). If ACIN has accessed and VACIN is above (VBAT + 500 mV),(If the BAT power path has selected, N_BATDRV need be pulled high to disable the power path of BAT to VSYS and delay 10 us), ACDRV is pulled high to select the power path of ACIN to VSYS. After selected ACIN power path, if VACIN is less than (VBAT + 100 mV), then the internal pull-down on BAT need be opened. If VBAT is pulled down and does not meet the condition that ACIN < VBAT +100 mV, then ACIN power path is not turned off and ACIN continues to provide power; if VBAT is pulled down and meets the condition that ACIN < VBAT +100 mV, then ACIN power path is turned off automatically, but BAT power path is not opened automatically.

(4). If the battery has accessed and VBAT is above (VSYS + 50 mV),(If ACIN power supply path is selected, firstly ACDRV need be pulled low to disable the power path of ACIN to VSYS and delay 10 us) N_BATDRV need be pulled low to select the power path of BAT to VSYS. After selected the BAT power path, if VBAT is less than (VSYS + 20mV) , BAT power path is turned off automatically, but ACIN power path is not opened automatically at this moment. AXP259 will not select ACIN power path until meet the condition that VACIN > VBAT + 500 mV.

(5). At ACIN and BAT power supply switch process, for example power consumption output larger, VSYS could appear larger pull-down, BAT supply the system through the body diode.

(6). When ACIN exists and charger is charging, Battery OVP will happens after AXP259 detect the single BAT voltage is above Vtarget + 100mv. If this happens, ACDRV will pull to be low to shut ACIN power path.

(7). AXP259 has a ACSET pin, which is used to set current-limit of ACIN path. When ACIN input current is closed to the current limit setting by ACSET, AXP259 will reduce the charging current to make the ACIN input current not exceed the current limit value. When ACIN accesses, the relationship between the current-limit and the external resistor value is:

$$I_{ACLMT}=20uA*R_{ACSET}/(20*R_{ACSENS}).$$

11.3 Power On/Off

BMU has two states: power-off and power-on. Except VCC, VINT, AVDD and Charger, all the power rails will be shut down in the power-off mode, in this mode if the BMU is powered by BAT, the current consumption is less than 50uA.

11.3.1 Power On

4 Power on sources:

- ACIN is inserted and available
- BAT is inserted and single cell voltage is above 3.0V
- PWRON pressed time is more than ONLEVEL;
- IRQ is pulled low(REG26[6]=1)

After power on sources are available, AXP259 PWROK pin will output high to indicate that the buck_5v is good.

11.3.2 Power Off

Normal power-off sources:

(1). The pressed time of PWRON is above OFFLEVEL (This function can be configured by setting REG27[3], AXP259 can power off automatically by setting REG27[2] after 512ms)

(2). Software power-off command from Host.

After power off, the buck_5v is shutdown and POWOK pin is to be low.

11.3.3 Reset

In power-on state, there are three methods to perform a reset:

(1). Set REG28H[7] to “1”.

(2). PWROK pin is pulled low and delays a debounce time of 128us (An external RESET key can be connected to this pin). After the reset source is detected by the BMU, it will perform the power-off procedure and then perform the power-on procedure after a delay of 512ms.

(3). If the width of POK pulse is longer than 16s,the BMU will be forced to be shutdown, delay 2s after the

shutdown procedure completed, the BMU will perform Power on Reset and power on automatically (This function can be configured by Reg29H[2] and not enabled in default state)

11.4 Charger

11.4.1 Basic Characteristics

(1). Supports input voltage 6V~14V adapter, PWM charge, inductor<3.3uH, switch frequency 1.5MHz, and 2.2uH inductor value is recommend.

(2). Constant charge current Ichgset is set by REG21[3:0] (0.4A~3A, 200mA/step, default 1200mA) .

(3). Supports 2 cells Li-battery. When BMU power on (after VSYSOK signal sent) , the system checks battery cell numbers through BATSET PIN connect status, and calculates single cell battery voltage through VBAT voltage and number of battery in series. GND means two cells in series, floating and pull-up status is not allowed. Battery number information stores in REG01[1:0], during work process of the chip, if detected battery access, charger will check and calculate battery cell number again and update result to the register.

(4). Single cell charge target voltage Vtarget is configurable, the default value is 4.2V. (Set by REG21[7:5], support 4.10V,4.15V,4.2V,4.25V,4.35V,4.4V,4.45V,4.50V).

11.4.2 Charging Process

(1). Charging Condition

When system meets the following all conditions, battery will be charged.

- Charger enable (REG20[7]=1);
- ACIN not OVP;
- ACIN exists and is available, ACIN > VBAT+0.5V (lag VBAT+0.1V);
- System judges battery exist (REG00[4]=1), the battery is insufficient when external power connect; or single cell battery voltage reduces to lower than re-charge limit *Vrchg*;
- VINT,AVDD power on normally, VSYSOK is sent and delays 32ms;
- AXP259 die temperature is lower than warning level 1;
- When TS pin is used to detect battery temperature, the temperature is within the range of charge;
- Charge time does not run out on each stage (Charge safety timer, REG00[3]=0);
- ACIN power supply is sufficient, and greater than power supplies of the system other modules;
- BAT power supply path external MOS normal (REG01[2]=0).

Either of above charging condition is not met, or battery charge completed, BMU internally will automatically shut down the charger.

(2). Pre-Charge

When single cell battery voltage is lower than 3.0V, charger is under Pre-charge mode, the charge current is one tenths that of constant current *Ichgset*. REG22[0] is used to set the minimum charge current of trickle charge (default 200mA, minimum setting 100mA).

(3). Constant Current Charge

When single cell battery voltage is above 3.0V and lower than Vtarget, charger is under constant current charge and charges through PWM mode, constant current charge Ichgset is set through REG21[3:0].

BMU will ensure power supply output as a priority when charging the battery. If ACIN power supply is unsufficient, ACIN and VSYS voltage ramp down, then AXP259 will reduce charge current to maintain VSYS voltage on Vhold (VBAT+0.5V). How to do: add voltage-limit loop in charger, when VSYS voltage drops to closer to Vhold, charge current decreases automatically until charge current is 0. If power supply output demands decrease or adapter power supply becomes stronger, charge will automatically increase charge current to the setting charge current.

When ACIN input current is closed to ACSET setting current limit, then the system reduces charging current until charging current is 0, which ensures ACIN input current not to exceed the current-limit value.

(4). Constant Voltage Charge

When single cell battery voltage reaches target voltage, charger accesses constant voltage charge, charger outputs voltage constantly to step down charging current, in order to completely charge battery.

When single cell battery voltage is above Vrchg, and charge current reduces under the charge threshold, AXP259 reports charge done, and stop charging (charger enable bit still is 1), charge current threshold can be set through REG20[6:4].

(5). Re-Charge

When charge done, battery voltage decreases under re-charge limit Vrchg, BMU will automatically enable charger, there is no need to re-plug adapter. The function defines as 'Re-charge'.

(6). Battery Detect

As long as AC adapter is present and usable, battery detect will be enabled to determine whether battery is connected. Battery detect function is enabled by default, and can shut down through REG22[7], when shut down this function, BMU considers that battery always connected (REG00[4]=1).

(7). Inductor Selection

Inductor selection trades off between cost, size, efficiency and output capacitor; AXP259 will achieve smaller inductor because of owing 1.5M switching frequency; An inductor must not saturate under the worst case condition, and 2.2uH inductor value is suggested to adopt.

11.4.3 Charge Protection Function

(1). Charge Timeout Safety

Once started Pre-charge mode, BMU will enable timer1, if BMU can not enter from pre-charge to constant current within 50mins (set through REG20[3:2]), then BMU will enter battery safe mode, and send out IRQ, which indicates battery could damage.

When charger enters into constant current, BMU will enable timer2, if BMU can not finish whole charge cycle within 8 hours (set through REG20[1:0]),then BMU will enter battery safe mode, and send out IRQ, which indicates battery could damage.

Time speed of Timer1 or timer2 is relevant with actual charge current, the smaller the actual charge current, the slower time speed is.

In battery safe mode, charger always charges with 5mA current. BMU has one readable register bit, REG00[3], named 'battery safe mode indication', which indicates whether BMU is in battery safe mode, '1' indicates that BMU is in activation mode, '0' indicates that BMU is not in activation mode. In battery safe mode, if:

- VBAT > Vrchg; or
- External power ACIN gone; or
- Charger enable register bit of REG20[7] is written as 0; or
- Charger safety timer of REG22[6] is written as 0,

Then charger will quit battery safe mode, and send the corresponding IRQ.

When charge starts, REG22[6] is 0, then charger safety timer will not be opened, charge time is limited for each stage, charger will not enter charger safe mode (REG00[3]=0).

(2). BMU Die Temperature Protection

BMU has built-in temperature protection function through ADC monitor internal temperature. AXP259 has 3 level temperature protection, warning level 1 is set through REG23[2:0] (default 85℃), warning level 2/3 is set through REGF3[1:0] (linkage, default 111.6/125.3℃),hysteresis threshold is about 27.2℃ lower than the corresponding warning level. For typical application, warning level 2/3 setting value is higher than warning level 1 setting value.

Charger has built-in constant temperature loop, when IC inside temperature closes to warning level 1, BMU will automatically reduce charge current, in order to make die temperature not higher than warning level 1. If die temperature is higher than warning level 1, charger will not charge. If die temperature goes down, charge current will automatically recover.

If IC inside temperature is higher than warning level2, BMU will send out IRQ (this IRQ default as disable), and indicate through CHGLED(see more details in Charging Indication), over temperature status can read through REG00[7].

If IC inside temperature is higher than warning level 3, BMU can automatically shut down (setting through REGF3[3]).

(3). Battery Temperature Protection

BMU can monitor battery temperature, when REG25[2] is 0, TS pin is used to detect battery temperature and parallel with charger. The battery temperature sensitive resistance is connected between TS pin and GND, suggesting the resistance is 10kohm when temperature is 25℃.BMU can output constant current through TS pin, the current is adjustable as 20uA, 40uA, 60uA, 80uA (default as 60uA) to adapt different NTC resistance, when NTC resistance chooses 10kΩ type, the current need be set to 60uA. Current enable mode is set through REG25[1:0]. When current passes temperature sensitive resistance, BMU gets a detect voltage, and uses ADC to calculate battery temperature data. Take TH11-3H103 temperature sensitive resistance of Mitsubishi for example, with 60uA constant current, the relationship for temperature, equivalent resistance, detection voltage, and ADC data is as follows.

Temperature	Equivalent Resistance	Detection Voltage	ADC 12bit Data
About -16~-17℃	54.60Kohm	3.276V	FFFH
-15℃	50.15Hohm	3.009V	EB1H
-10℃	40.26Kohm	2.416V	BCCH
-5℃	32.55Kohm	1.953V	989H
0℃	26.49Kohm	1.481V	73BH
5℃	21.68Kohm	1.301V	65AH
10℃	17.78Kohm	1.067V	42AH
25℃	10.00Kohm	0.600V	2EEH
40℃	5.839Kohm	0.350V	1B5H
45℃	4.924Kohm	0.295V	170H
50℃	4.171Kohm	0.250V	138H
55℃	3.549Kohm	0.213V	10AH
60℃	3.032Kohm	0.182V	0E3H

During battery charging process, if TS Pin voltage is lower than VHTF-charge or above VLTF-charge (VLTF-charge or VHTF-charge can set through REG38 and REG39, the default value of VLTF-charge need be set around 0℃, VHTF-charge around 45℃), indicating battery temperature is too high or too low, then the charger is paused, and IRQ is sent out to notify the system. When temperature is back to normal range, charger will automatically recovery.

During normal working process, if TS pin voltage is lower than VHTF-work or above VLTF-work, (VLTF-work and VHTF-work can set through REG 3C and REG 3D, the default value of VLTF-work need be set around -10℃, VHTF-work around 55℃), indicating battery temperature is too high or too low, now IRQ is sent out to notify system. The typical application is system will shut down after received the two IRQ.

High temperature protection threshold hysteresis for VHTF-charge and VHTF-work can set through REG37 (default 51.2mV, ADC data 40H), low temperature protection threshold hysteresis for VLTF-charge and VLTF-work can set through REG36 (default 307.2mV, ADC data 180H). Adding one extra resistance on TS pin can larger temperature detection range.

Some battery may have no temperature sensitive resistance, then TS pin need be set as ADC's external input through register.

Use TS pin current source and get TS pin data scenario as below.

Working Scenario	Setting
User does not need detect battery temperature	REG25[2] = 1
User only need detect battery temperature and protect battery during charging process, and no detection when no charging	REG25[2] = 0 REG25[1:0] = 01
User need detect battery temperature and protect battery during charging, and also detect battery temperature and notify system when no	REG25[2] = 0 REG25[1:0] = 10

charging	
User use TS pin current source to drive other device	REG25[2] = 1 REG25[1:0]=11 when need current source, REG25[1:0] = 00 when no need

11.4.4 Charging Indication

CHGLED pin uses open-drain push-pull output, internal pull up to VDRV, output drive capability is above 10mA. Detail function register control list is as follows.

REG90[2:0]= 000 (Type A CHGLED) Open Drain	High Resistance	No charging (condition is not met or battery charged). REG00[6]=0.
	25% 1Hz pull low/high resistance jump	Charger internal abnormal alarm (including timer out, die temperature over warning level 2, battery temperature is above charging range)
	25% 4Hz pull low/ high resistance jump	External power overvoltage, ACOV happens
	Pull low	Charging
REG90[2:0]= 001 (Type B CHGLED) Open Drain	High resistance	No condition charging, and power supply by battery
	25% 1Hz pull low/high resistance jump	Charging
	25% 4Hz pull low/high resistance jump	Alarm, including external power ACOV happens, charger internal abnormal
	Pull low	ACIN supplies power when no battery, charging over or full battery capability
REG90[2:0]= 010 (Breath CHGLED) Open Drain	High resistance	Battery supplies power when no ACIN
	Breath LED output(*note1)	Charging
	Pull low	ACIN is present but not in charging status
REG90[2:0]= 011 (Breath Lamp) Open Drain	Breath LED output，enable REG90[6] Breath frequency and luminance are controlled by REG91~REG9A	
REG90[2:0]= 100 (Tri-state CHGLED) Push Pull	High resistance	Battery supplies power when no ACIN
	Pull high	Charging
	Pull low	ACIN is present but not in charging status
REG90[2:0]= 101 (PWM function) Push Pull	PWM output, enable REG90[6] The frequency and duty-cycle are controlled by REG95~REG99	
REG90[2:0]=110/111 (GPO) Push Pull	The output status is controlled by REG90[5:3]	

Note: LED is on when CHGLED is low.

11.5 BUCK

AXP259 integrates a high voltage BUCK converter which is used to convert high voltage VSYS to 5V supply for power supply system output.

(1). Input range is from 6V to 14V, and output range is from 4.0V to 5.5V (controlled by REG11[3:0], the default value is 5.0V)

(2). Enabled by REG10[0], open by default when start

(3). Maximum output current : 4A

(4). Switching frequency : 1MHz

(5). Internal output voltage detection, with power on OK signal indication, output OVP/UVP message (REG01[5:4]), whether shut down or not depends on REG12[7:6]

(6). Internal soft start (1ms)

(7). Internal discharge feature, use about 300Ω discharging resistor when disable the function (The feature is controlled by REG12[3])

(8). Integrated MOSFET

(9). Integrated peak current-limit protection.

11.6 Power Switch

AXP259 integrates two power switches: SW_BL and SW_5V. SW_BL can withstand voltage 14V and SW_5V can withstand over 5.5V.

SW_5V supports current-limit function, and the current is controlled by REG12[5:4] (default 500mA).

11.7 VREF/Interrupt/VINT and Others

BMU internally integrates two high precision reference voltages.

IRQ pin in the BMU, is used to indicate whether interrupt happen in AXP259 (refer to REG4X for details). If there is interrupt and related enable bit is high, IRQ is pulled down to ground and then report the status to host. If REG26[4] is 1, IRQ is used as power on source. IRQ will be internally pulled up slightly to VINT after IC shut down. BMU can power on automatically, if IRQ is externally pulled down to “0” and has a 32ms debounce delay.

VINT LDO(1.8V) is used for RTC. VINT LDO is set to 1.76V in power-on state and 1.8V in power-off state.
GPIO1 is used as Wakeup OUT by default, and GPIO2 is used as EXTEN by default. Refer to REG18/19 for details.

11.8 ADC

BMU has a low speed 12-bit SAR ADC for measuring BAT voltage (VBAT), BAT charge current and BAT discharge current, adapter current and voltage, TS, and die temperature. No IRQ for ADCs. The ADC's sampling frequency can be changed to 800/400/200/100. Channel 2 is 25Hz.

No	Channel function	000H	001H	002H	…	FFFH
0	Single cell Battery voltage	0mV	1.2mV	2.4mV	…	4.914V
1	Reserved					
2	Die temperature	-267.7	+0.10625*xxxH (℃)			167.4℃
3	BAT charge current	0mA	1mA	2mA	…	4.095A
4	BAT discharge current	0mA	1mA	2mA	…	4.095A
5	Adapter discharge current	0mA	1mA	2mA	…	4.095A
6	TS pin input	0mV	0.8mV	1.6mV	…	3.276V
7	ACIN voltage	0mV	8mV	16mV	…	32.760V

Note: ADC data is 12-bit, and TWSI must read twice to get the complete data, with the condition of high 8 bits reading firstly and then low 4 bits.

11.9 E-gauge

The Fuel Gauge comprises 3 modules – Rdc calculation module; OCV (Open Circuit Voltage) and Coulomb counter module; and calibration module. The Fuel Gauge system is able to export information about battery to application such as Battery capacity percentage (REGB9H), Battery Voltage (REG78H, REG79H), Battery charging current (REG7AH, REG7BH), Battery discharge current (REG 7CH, REG 7DH), Battery maximum capacity (REGE0H, REG 1H), Battery Rdc value (REGBAH, REGBBH). The Fuel Gauge can be enabled or disabled via REGB8H. The Battery low warning can be set in REGE6H, and IRQ (REG4BH) will be sent out to alert the platform when the battery capacity percentage is lower than the warning level by REGE6H.

Once a default battery is selected for a particular design, it is highly recommended to calibrate the battery to achieve better Fuel Gauge accuracy using dedicated hardware and software. Once the calibration data are available, user can write the calibration information to REGC0H~REGDFH (OCV percentage table) on each boot. Or user can choose not to do the calibration and use the default OCV percentage value. Additionally, the Fuel Gauge system is capable to learn the battery characteristic on each Full charge cycle. Information such as Battery Maximum capacity (REGE0H, REGE1H) and Rdc (REGBAH, REGBBH) will be updated automatically over time.

12. TYPICAL APPLICATION

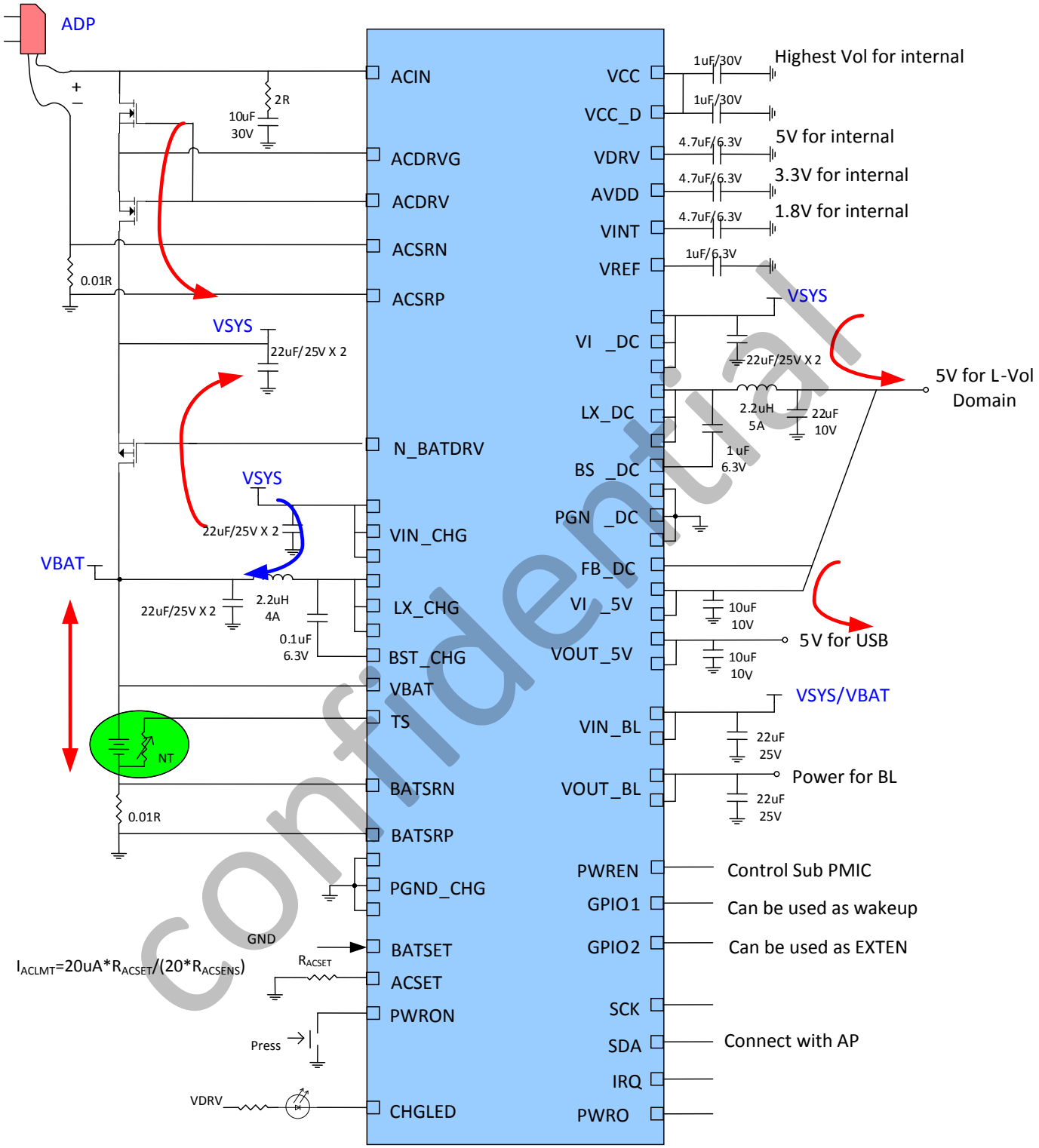
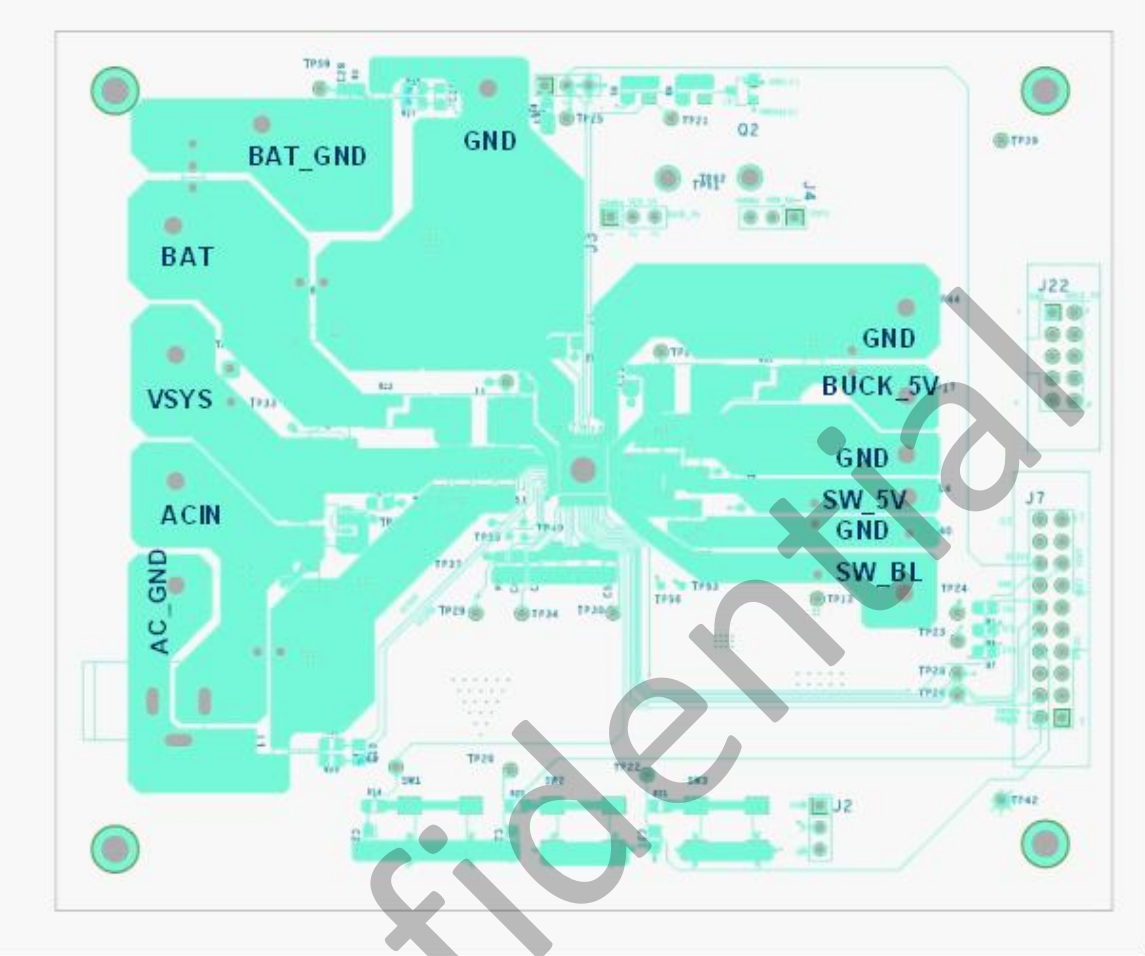


Figure 14. AXP259 typical application

13. PCB REFERENCE



14. REGISTER DESCRIPTION

REG 00: Power Source Status

Reset: power on reset

Bit	Description	R/W
7	Indication AXP259 over temperature(warning level 2) or not 0: Not over temperature 1: Over temperature	R
6	Charging indication 0: Charger is not charging or charging is done 1: Charger is charging	R
5	Indication battery current direction 0: Battery discharge 1: Charging battery	R
4	Battery presence indication 0: Battery is not connected 1: Battery is connected	R
3	Indicate battery safe mode 0: Charger is not in battery safe mode 1: Charger is in battery safe mode	R
2	BMU has detected battery status 0: Has not detected 1: Has detected	R
1	Reserved	R
0	ACIN presence indication 0: ACIN not present 1: ACIN present	R

REG 01: BMU Status Indication 1

Reset: power on reset

Bit	Description	R/W
7	Buck output is 15% higher than the set value 0: No 1: Yes Writing 1 will clear it	R/W
6	BUCK output voltage is 15% lower than the set value 0: No 1: Yes Writing 1 will clear it	R/W
5	The BMU has calibrated the OCV- percentage curve. 0 : Has not calibrated 1 : Has calibrated	R

4	The BMU has calibrated the total battery capacity. 0 : Has not calibrated 1 : has calibrated	R
3	BUCK inductor & FB detect result 0: Inductor not present or FB is not connected 1: Inductor is present and FB is connected	R
2	The source and drain of PMOS in BAT Path is short or not 0: Not shorted 1: Shorted	R
1-0	Battery cells number 00: 2 (BATSET=GND) 01: reserved 10: reserved 11: 2 cells	R/W

REG 02: BMU Startup Source

Reset: system reset

Bit	Description	R/W
7	Reserved	R
6	BMU power on by PWROK 16s restart.	R
5	Startup by VBAT low go high	R
4	Startup by ACIN low go high	R
3	Startup by PWRON press	R
2	Reserved	R
1	Startup by restart event	R
0	Startup by IRQ be drive low when REG26[6]=1	R

Note: If more than one sources trigger at the same time, all will be set high.

REG 03: IC Type No.

Bit	Description	R/W
5-4	Reserved	R
7-6 & 3-0	IC Type No. 00_0100: IC is AXP259	R

REG 05~0F: Data Buffer

Default: 00H

Reset: power on reset

Bit	Description	R/W	Default
7-0	Data buffer	RW	00H

REG 10: Power Rails Enable

Default: 09H

Reset: System reset

Bit	Description		R/W	Default
7-4	Reserved		RW	0
3	EXTEN enable bit Note: when GPIO2 outputs as EXTEN, this bit is available.	0: Disable 1: Enable	RW	1
2	SW_BL enable bit		RW	0
1	SW_5V enable bit		RW	0
0	5V BUCK enable bit		RW	1

Note: REG10 has buffer register. When RFG1F[6] is 0, 0x10H addressing points to REG10; when REG1F[6] is set to 1, the value of REG10 will be exported to buffer register, 0x10H addressing points to buffer register and the value of REG10 is the same; when REG3F[6] is set to 1, the value of buffer register is exported to REG10, after completed, REG1F[6] and REG3F[6] will be set to 0 automatically, 0x10H addressing point s to REG10.

REG 11: BUCK Voltage Control

Default: 0AH

Reset: System reset

Bit	Description	R/W	Default
7-4	Reserved	RW	0
3-0	BUCK voltage control bit 3:0 4.0~5.5V, 0.1V/step, default 5V	RW	AH

REG 12: BUCK Control

Default: C2H

Reset: Power on reset

Bit	Description	R/W	Default
7	Buck output voltage is 15% higher than the setting value, auto power off enable 0: Disable 1: Enable	RW	1
6	Buck output voltage is 15% lower than the setting value, auto power off enable 0: Disable 1: Enable	RW	1
5-4	SW_5V current limit setting 00: 500mA 01: 1000mA 10: 1500mA 11: 5A	RW	0
3	Buck/SW_BL/SW_5V disable, internal quick discharge resistance enable 0: Enable 1: Disable	RW	0

2	BUCK light load mode control 0:PFM/PWM auto switch 1: Force PWM	RW	0
1-0	Reserved	RW	10

REG 13: DCDC Frequency Setting

Default: 08H

Reset: Power on reset

Bit	Description	R/W	Default
7-6	Reserved	RW	0
5	Charger continuous conduction mode control 0: Enable 1: Disable	RW	0
4	DCDC Comp parameter set 0: 2.2uH 1: 3.3uH	RW	0
3-0	DCDC and charger PWM frequency setting bit 3:0 DCDC frequency range: 0.68MHz~1.28MHz，default 1MHz Charger frequency range: 1.02MHz~1.92MHz, default 1.5MHz	RW	1000

REG 18: GPIO1 Control

Default: 00H

Reset: System reset

Bit	Description	R/W	Default
7-4	Reserved	RW	0000
3	Wakeup effective signal 0: Low level 1: High level	RW	0
2-0	Pin function setting bit[2:0] 000: Wakeup IN 001: Wakeup OUT(high means VINT) 010: Drive low 011: Drive high(VINT) 1xx: Floating Note: The default value of bit2 can be customized by customer, output high impedance state when power off.	RW	001

REG 19: GPIO2 Control

Default: 00H

Reset: System reset

Bit	Description	R/W	Default

7-3	Reserved	RW	0
2-0	Pin function setting bit[2:0] 000: EXTEN (The output is controlled by REG10[3],high level means VINT) 001: Floating 010: Drive low 011: Drive high(VINT) 1xx: Floating Note: The default value of bit2 can be customized by customer. After PWROK pin pull low 4ms, the bit reset.	RW	000

REG 1A: GPIO1 Signal Bit

Default: 00H

Reset: System reset

Bit	Description	R/W	Default
7-1	Reserved	R	0
0	This bit reflects the logic level of the GPIO1 pin when configured as digital input	R	0

REG 1E: BMU Abnormal Shut Down Control

Default: 0FH

Reset: Power on reset

Bit	Description	R/W	Default
7-4	Reserved	RW	0
3	ACOV happens, power off enable 0 : Disable 1 : Enable	RW	1
2	VSYSOV happens ,power off enable 0 : Disable 1 : Enable	RW	1
1	VSYS is lower than 5.8V, power off control enable 0 : Disable 1 : Enable	RW	1
0	Reserved	RW	1

REG 1F: Register Buffer Control

Default: 00H

Reset: bit [1:0] is Power on reset, others is system reset

Bit	Description	R/W	Default
7	Reserved	RW	0
6	Register address 0x10 control 0: REG10 1: REG10 (the corresponding bugger register) This bit will be reset in the following two conditions:	RW	0

	(1).Wakeup, clear 0 when buffer register need no export to REG10 (2).REG3F[6] is written to 1, clear 0 after buffer register exports to REG10 .		
5-0	Reserved	RW	0

REG 20: Charger Control 1

Default: X5H

Reset: Bit [7] reset is system reset, Bit [6:0] reset is power on reset

Bit	Description		R/W	Default
7	Charger enable control 0: Disable 1: Enable		RW	1
6-4	Current for charger end condition setting 000 : when charge current is lower than 10% , charge is done 001 : when charge current is lower than 20% , charge is done 010 - 111 : when charge current is lower than 100*(n-1) mA , charge is done		RW	000
3	Pre-charge Timer length setting 1	00: 40 minutes	RW	0
2	Pre-charge Timer length setting 0	01: 50 minutes 10: 60 minutes 11: 70 minutes	RW	1
1	Fast charge maximum time setting 1	00: 6 hours	RW	0
0	Fast charge maximum time setting 0	01: 8 hours 10: 10 hours 11: 12 hours.	RW	1

REG 21: Charger Control 2

Default: 54H

Reset: Power on reset

Bit	Description	R/W	Default
7-5	Charge voltage setting 000: 4.10V 001: 4.15V 010: 4.20V 011: 4.25V 100: 4.35V 101: 4.40V 110: 4.45V 111: 4.50V	RW	010
4	Reserved	RW	1
3-0	Charge current setting: 400mA-3.4A, 200mA/step, default is 1.2A	RW	0100

REG 22: Charger Control 3

Default: E6H

Reset: Power on reset (bit 2 is System reset)

Bit	Description	R/W	Default
7	Battery detection function control 0: Disable 1: Enable	RW	1
6	charger safety timer enable 0: Disable 1: Enable	RW	1
5-4	Ts ADC speed setting 00 : 25Hz 01 : 50Hz 10 : 100Hz 11: 200Hz	RW	10
3	Reserved	RW	0
2	Select ACIN for power supply 0: Disable 1: Enable	RW	1
1	BAT Path MOSFET short protect enable 0: Disable 1: Enable	RW	1
0	Pre-charge current min value set 0: 200mA 1: 100mA	RW	0

REG 23: Charger Control 4

Default: 04H

Reset: Power on reset

Bit	Description	R/W	Default
7-3	Reserved	RW	00H
2-0	Die temperature warning level 1 setting bit 2~0: Level 1: 45+N*10 ℃	RW	100

REG 24: ADC Control

Default: F9H

Reset: Power on reset

Bit	Description		R/W	Default
7	VBAT voltage ADC enable	0: off 1: on	RW	1
6	BAT current ADC enable		RW	1
5	ACIN voltage ADC enable		RW	1
4	Adapter current ADC enable		RW	1

3	Die temperature ADC enable		RW	1
2-1	Reserved		RW	00
0	TS PIN input ADC enable		RW	1

REG 25: TS Pin Control

Default: 80H

Reset: Power on reset

Bit	Description	R/W	Default
7-6	Current source to TS PIN setting 00:20uA 01:40uA 10:60uA 11:80uA	RW	10
5	Reserved	RW	0
4-3	ADC speed setting 100×2n, So Fs=100, 200, 400, 800Hz	RW	00
2	TS PIN function select: 0: TS pin is the battery temperature sensor input and will affect the charger 1: TS pin is the external input for ADC and doesn't affect the charger	RW	0
10	TS current source on/off enable bit[1:0] 00: Off 01: Always on when TS input ADC is enable, not affected by ADC phase or charger 10: On in the ADC phase and off when the ADC phase is off, for power saving 11: Always on	RW	01

REG 26: On/off/sleep Setting

Default: 00H

Reset: Bit 3 is System reset, others are Power on reset

Bit	Description	R/W	Default
7	PWROK drive low or not when power wake up and the REG26[3] is 1. 0 : Not drive low 1 : Drive low when wake up	RW	0
6	IRQ pin power on or wake up BMU enable control. 0 : Disable 1 : Enable	RW	0
5	Soft power wake up, write 1 to this bit, the output power will wake up, after then this bit will clear itself.	RW	0
4	Control bit for wake up trigger source and IRQ output during wake up period. 0: IRQs can wake up BMU and IRQ pin will masked 1: IRQs can not wake up BMU and IRQ pin will not masked	RW	0
3	BMU sleep control bit. When set this bit to 1, the BMU will enter to sleep status, and when wake up by REG26[5], IRQ pin or IRQs , this bit will clear itself.	RW	0
2-0	Reserved	RW	000

REG 27: POK Setting

Default: 59H

Reset: bit 3 is System reset, others are Power on reset

Bit	Description	R/W	Default
7-6	ONLEVEL setting 1-0 00:128ms 01: 1s 10: 2s 11: 3s	RW	01
5-4	IRQLEVEL setting 1-0 00: 1s 01: 1.5s 10: 2s 11: 2.5s	RW	01
3	Enable bit for the function which will shut down the BMU when POK is larger than OFFLEVEL 0: Disable 1: Enable	RW	1
2	The BMU auto turn on or not when it shut down after OFFLEVEL POK 0: Not turn on 1: Auto turn on	RW	0
1-0	OFFLEVEL setting 1-0 00: 4s 01: 6s 10: 8s 11: 10s	RW	01

REG 28: Restart and Power off Delay Control

Default: 00H

Reset: bit 7:6 is System reset, others are Power on reset

Bit	Description	R/W	Default
7	HOST restart the BMU control bit Write 1 to this bit, the BMU will restart and then clear this bit by self	RW	0
6	Host powers off the BMU, writing 1 to this bit will power off the BMU.	RW	0
5	DCDC voltage setting to default value or not when wake up. 0: Not setting to default value. 1: Setting to default value.	RW	0
4-3	Reserved	RW	0
2-0	Power off delay when PWRON press down over offlevel time. 000 : 0s 001 : 10s 010 : 20s	RW	000

	011 : 30s 100 : 40s 101 : 50s 110 : 60s 111 : 70s		

REG 29: Force Power on Reset and Buck Voltage Debounce

Default: 59H

Reset: Power on reset

Bit	Description	R/W	Default
7	Reserved	RW	0
6-5	The time delay from buck start up to PWROK/PWREN go high setting 00 : 8ms 01 : 32ms 10 : 64ms 11 : 128ms	RW	10
4	PWROK pin press down restart BMU function control bit. 0 : Disable 1 : Enable	RW	1
3	Control bit for the PWROK input still remains low when the internal PWROK pad driver go high over the setting time will shut down BMU. 0 : Disable 1 : Enable	RW	1
2	Control bit for the PWRON pin low 16s in power on status will trigger BMU power off 2s and then restart. 0 : Disable 1 : Enable	RW	0
1-0	The buck output voltage monitor debounce time setting. 00 : 62us 01 : 124us 10 : 186us 11 : 248us	RW	01

REG 36: The Hysteresis Set for Ts Low Temperature Go to Normal

Default: 18H

Reset: Power on reset

Bit	Description	R/W	Default
7-6	The hysteresis set for Ts from low temperature go to normal. Thys = M*10, default 307.2mV, ADC data 180H	RW	18H

REG 37: The Hysteresis Set for Ts High Temperature Go to Normal

Default: 04H

Reset: Power on reset

Bit	Description	R/W	Default
7-6	The hysteresis set for Ts from high temperature go to normal. Thys = M*10, default 51.2mV, ADC data 40H	RW	04H

REG 38: VLTF-Charge Setting

Default: 74H

Reset: Power on reset

Bit	Description	R/W	Default
7-0	VLTF setting M * 10 h, when M = 74 h corresponds to 1.485 V (about 0 ℃) Voltage rang is from 0 V to 3.264 V	RW	74H

REG 39: VHTF-Charge Setting

Default: 17H

Reset: Power on reset

Bit	Description	R/W	Default
7-0	VHTF setting, N N * 10 h, when N = 17H, corresponds to 0.294 V (about 45 ℃) Voltage range is from 0 V to 3.264 V	RW	17H

REG 3C: VLTF-Work Setting

Default: BDH

Reset: Power on reset

Bit	Description	R/W	Default
7-0	VLTF setting M * 10 h, when M = BDH, corresponds to 2.419 V (about - 10 ℃) Voltage range is from 0 V to 3.264 V	RW	BDH

REG 3D: VHTF-Work Setting

Default: 11H

Reset: Power on reset

Bit	Description	R/W	Default
7-0	VHTF setting, N N * 10 h, when N = 11 H, corresponding to the 0.218 V (55 ℃) Voltage range is from 0 V to 3.264 V	RW	11H

REG 3F: Special Control Register

Default: 00H

Reset: System reset

Bit	Description	R/W	Default
7	Reserved	RW	0
6	After writing 1, if REG1F [6] = 1, buffer register will export to REG 10. Export after the completion of the automatic emptying, at the same time will REG1F [6] set to 0.	RW	0
4-0	Reserved	RW	00H

REG 40: IRQ Enable 1

Default: FDH

Reset: Power on reset

Bit	Description	R/W	Default
7	ACIN over voltage IRQ enable	RW	1
6	ACIN over current IRQ enable	RW	1
5	ACIN low go high IRQ enable	RW	1
4	ACIN high go low IRQ enable	RW	1
3	Enable when BUCK output voltage is 15% higher than target value	RW	1
2	Enable when BUCK output voltage is 15% lower than target value	RW	1
1	The external PMOS short enable	RW	0
0	IC Temperature over the warning level 2 IRQ (OTIRQ) enable	RW	1

REG 41: IRQ Enable 2

Default: FFH

Reset: Power on reset

Bit	Description	R/W	Default
7	Battery append IRQ enable	RW	1
6	Battery absent IRQ enable	RW	1
5	Enter battery safe mode IRQ enable	RW	1
4	Quit battery safe mode IRQ enable	RW	1
3	Charger begin charging IRQ enable	RW	1
2	Battery charge done IRQ enable	RW	1
1	Battery capacity percentage drop to warning level 1 IRQ(WL1IRQ) enable	RW	1
0	Battery capacity percentage drop to warning level 2 IRQ(WL2IRQ) enable	RW	1

REG 42: IRQ Enable 3

Default: FFH

Reset: Power on reset

Bit	Description	R/W	Default
7	Battery over temperature in charge mode IRQ (BCOTIRQ) enable	RW	1
6	Quit Battery over temperature in charge mode IRQ (QBCOTIRQ) enable	RW	1
5	Battery under temperature in charge mode IRQ (BCUTIRQ) enable	RW	1
4	Quit Battery under temperature in charge mode IRQ (QBCUTIRQ) enable	RW	1
3	Battery over temperature in work mode IRQ (BWOTIRQ) enable	RW	1

2	Quit Battery over temperature in work mode IRQ (QBWOTIRQ) enable	RW	1
1	Battery under temperature in work mode IRQ (BWUTIRQ) enable	RW	1
0	Quit Battery under temperature in work mode IRQ (QBWUTIRQ) enable	RW	1

REG 43: IRQ Enable 4

Default: 7CH

Reset: Power on reset

Bit	Description	R/W	Default
7	Reserved	RW	0
6	POK positive edge IRQ (POKPIRQ) enable	RW	1
5	POK negative edge IRQ (POKNIRQ) enable	RW	1
4	POK short time active IRQ (POKSIRQ) enable	RW	1
3	POK long time active IRQ (POKLIRQ) enable	RW	1
2	POK off time active IRQ (POKOIRQ) enable	RW	1
1	The battery percentage change IRQ enable, not used as wakeup source	RW	0
0	GPIO0 edge IRQ enable.	RW	0

REG 44: IRQ Enable 5

Default: 01H

Reset: Power on reset

Bit	Description	R/W	Default
7-1	Reserved	RW	00H
0	ACIN is poor power(mismatch with application need) IRQ enable	RW	1

REG 48: IRQ Status 1

Default: 00H

Reset: bit [3:2] system reset, others power on reset

Bit	Description	R/W	Default
7	ACIN over voltage IRQ Writing 1 to it or ACIN dropping to normal will clear it.	RW	0
6	ACIN over current IRQ Writing 1 to it or ACIN current dropping to normal will clear it.	RW	0
5	ACIN low go high IRQ Writing 1 to it or ACIN high go low will clear it.	RW	0
4	ACIN high go low IRQ Writing 1 to it or ACIN low go high will clear it.	RW	0
3	Buck voltage output higher than 15% setting value IRQ Writing 1 to it or voltage return to normal will clear it.	RW	0
2	Buck voltage output lower than set 15% setting value IRQ Writing 1 to it or voltage return to normal will clear it.	RW	0
1	The external PMOS short status Writing 1 to it or going to normal will clear it	RW	0

0	OTIRQ Writing 1 to it or IC temperature dropping to normal will clear it.	RW	0

REG 49: IRQ Status 2

Default: 00H

Reset: Power on reset

Bit	Description	R/W	Default
7	Battery append IRQ Writing 1 to it or battery removal will clear it.	RW	0
6	Battery removal IRQ Writing 1 to it or battery append will clear it.	RW	0
5	Enter battery safe mode IRQ Writing 1 to it or quitting battery active mode will clear it.	RW	0
4	Quit battery safe mode IRQ Writing 1 to it or entering battery active mode will clear it.	RW	0
3	Charger begin charging IRQ Writing 1 to it or charging stop will clear it.	RW	0
2	Battery charge done IRQ Writing 1 to it or charger restart charging will clear it.	RW	0
1	WL1IRQ Writing 1 to it or battery capacity percentage rising up to warning level 1 or charger begin charging will clear it. This IRQ is disabled when there is no battery.	RW	0
0	WL2IRQ Writing 1 to it or battery capacity percentage rising up to warning level 2 or charger begin charging will clear it. This IRQ is disabled when there is no battery.	RW	0

REG 4A: IRQ Status 3

Default: 00H

Reset: Power on reset

Bit	Description	R/W	Default
7	BCOTIRQ Writing 1 to it or battery temperature dropping to normal in work will clear it.	RW	0
6	QBCOTIRQ Writing 1 to it or battery temperature rising over temperature in charge will clear it.	RW	0
5	BCUTIRQ Writing 1 to it or battery temperature rising to normal in work will clear it.	RW	0
4	QBCUTIRQ Writing 1 to it or battery temperature dropping under temperature in charge will clear it.	RW	0
3	BWOTIRQ Writing 1 to it or battery temperature dropping to normal in work will clear it.	RW	0
2	QBWOTIRQ	RW	0

	Writing 1 to it or battery temperature rising over temperature in work will clear it.		
1	BWUTIRQ Writing 1 to it or battery temperature rising to normal in work will clear it.	RW	0
0	QBWUTIRQ Writing 1 to it or battery temperature dropping under temperature in work will clear it.	RW	0

REG 4B: IRQ Status 4

Default: 00H

Reset: Bit[1] is Power on reset, and others is System reset

Bit	Description	R/W	Default
7	Reserved		
6	POKPIRQ Writing 1 to it will clear it.	RW	0
5	POKNIRQ Writing 1 to it will clear it.	RW	0
4	POKSIRQ Writing 1 to it will clear it.	RW	0
3	POKLIRQ Writing 1 to it will clear it.	RW	0
2	POKOIRQ Writing 1 to it will clear it.	RW	0
1	The battery percentage change Writing 1 to it will clear it. It is not used as wakeup source	RW	0
0	GPIO0 edge IRQ Writing 1 to it will clear it.	RW	0

REG 4C: IRQ Status 5

Default: 00H

Reset: Bit[1] is System reset, others is Power on reset

Bit	Description	R/W	Default
7-1	Reserved	RW	00H
0	ACIN is poor power (mismatch with application need) IRQ status. Writing 1 to it or ACIN power path disable or ACIN<4.5V will clear it.	RW	0

REG 90: CHGLED Pin Function Setting

Default: 00H

Reset: Bit[6:3] is System reset, others is Power on reset.

Bit	Description	R/W	Default
7	Reserved	RW	0
6	Breath and PWM function enable control when REG90[2:0] is set to 011 or 101 0 : Disable	RW	0

	1 : Enable		
5-3	CHGLED pin output when reg90[2:0] is set to 110-111 000 : High impedance 001 : High level 25% duty 1Hz 010 : High level 25% duty 4Hz 011 : Drive low 100 : Drive high 101-111 : High impedance	RW	000
2-0	CHGLED pin display function setting 000 : Display with type A function, Open-Drain 001 : Display with type B function, Open-Drain 010 : Display with breath function controlled by charger, Open-Drain 011 : Display with breath function not controlled by charger, Open-Drain 100 : Display with three state(low/high/High impedance) controlled by charger, Push-Pull 101 : Display with PWM function, Push-Pull 110-111: Output controlled by REG90[5:3], Push-Pull.	RW	000

REG B8: E-Gauge Control

Default: C0H

Reset: Power on reset

Bit	Description	R/W	Default
7	Fuel gauge enable control(including OCV and coulombmeter) 0: Disable 1: Enable	RW	1
6	Coulombmeter enable control 0: Disable 1: Enable	RW	1
5	Battery maximum capacity calibration enable control 0: Disable 1: Enable	RW	0
4	Battery maximum capacity calibration status 0: Not calibrating 1: Is calibrating	R	0
3-2	Reserved	RW	0
1	Old coulombmeter enable control 0: Disable 1: Enable	RW	0
0	Old coulombmeter clear control 0: Write 0 to this bit will do nothing 1: Write 1 to this bit will clear old coulombmeter and then this bit will be cleared automatically	RW	0

REG B9: Battery Capacity Percentage for Indication

Default: 64H

Reset: Power on reset

Bit	Description	R/W	Default
7	Indicating if battery capacity percentage for indication is valid 0: Not valid 1: Valid	R	0
6-0	Battery capacity percentage for indication	R	64H

REG BA: RDC 1

Default: 80H

Reset: Bit [7] & [4-0] reset is power on reset

Bit	Description	R/W	Default
7	RDC calculation control 0: Disable 1: Enable	RW	1
6	Flag bit [5:0] and A2 [7:0] is as the pre-testing correct RDC values or not 1 : Yes 0 : No	R	0
5	Flag whether already tested right RDC value. 1 : Yes 0 : No	R	0
4-0	Single battery equivalent RDC high 5 bits	RW	00000

REG BB: RDC0

Default: 55H

Reset: Power on reset

Bit	Description	R/W	Default
7-0	Single battery corresponding RDC values low 8 bits	RW	55H

REG BC: OCV1

Default: 64H

Reset: Power on reset

Bit	Description	R/W	Default
7-0	Equivalent single battery OCV high 8 bits	R	00

REG BD: OCV0

Default: 00H

Reset: Power on reset

Bit	Description	R/W	Default

7-4	Not design		
3-0	Single battery equivalent OCV low 4 bits	R	0

REG C0~DF: OCV-Percentage Table

Default: 00H

Reset: Power on reset

Bit	Description	R/W	Default
7	Reserved		
6-0	OCV Voltage corresponding to the percentage value	RW	00H

REG E0: Battery Maximum Capacity

Default: 00H

Reset: Power on reset

Bit	Description	R/W	Default
7	Indicating if battery maximum capacity is valid 0: Not valid 1: Valid	R/W	0
6-0	battery maximum capacity bit[14:8]	RW	0

REG E1: Battery Maximum Capacity

Default: 00H

Reset: Power on reset

Bit	Description	R/W	Default
7-0	Battery maximum capacity bit[7:0](Unit: 1.456mAh)	RW	0

REG E2: Coulombmeter Counter

Default: 00H

Reset: Power on reset

Bit	Description	R/W	Default
7	Indicating if coulombmeter counter is valid: 0: Not valid 1: Valid	RW	0
6-0	Coulombmeter counter[14:8]	RW	0

REG E3: Coulombmeter Counter

Default: 00H

Reset: Power on reset

Bit	Description	R/W	Default
7-0	Coulombmeter counter[7:0] (Unit: 1.456mAh)	RW	0

REG E4: OCV Percentage of Battery Capacity

Default: 64H

Reset: Power on reset

Bit	Description	R/W	Default
7	Indicating if OCV percentage of battery capacity is valid 0: Not valid 1: Valid	R	0
6-0	OCV percentage of battery capacity	R	64H

REG E5: Coulombmeter Percentage of Battery Capacity

Default: 64H

Reset: Power on reset

Bit	Description	R/W	Default
7	Indicating if coulombmeter percentage of battery capacity is valid 0: Not valid 1: Valid	R	0
6-0	Coulombmeter percentage of battery capacity	R	64H

REG E6: Battery Capacity Percentage Warning Level

Default: A0H

Reset: Power on reset

Bit	Description	R/W	Default
7-4	Warning level 1: Warning threshold, 5-20%, 1% per step	RW	A
3-0	Warning level 2: Shutting down threshold, 0-15%, 1% per step	RW	0

REG E7: External PMOS Short Detect and E-gauge Work Mode Set

Default: 01H

Reset: Power on reset

Bit	Description	R/W	Default
7	E-Gauge work status setting in power off state 0 : Don't work in BMU off mode 1 : Continue work in BMU off mode	RW	0
6	Reserved	RW	0
5	The BMU shut down event will trigger the total battery capacity and the ocv-per curve calibration process to completely when the battery charge percent calculation by ocv less the threshold which set by REGEA[3] 0 : Disable 1 : Enable	RW	0
4	The battery voltage limit control bit in the battery internal resistor calculation stop charge status. 0 : No limit	RW	0

	1 : Limit as the charge status(setting in REGEC[4:3])		
3	The current abnormal condition on external pmos short detect will clear at the charger status change (on or off) control bit 0 : Don't clear when charger status change 1 : Clear when charger status change	RW	0
2-0	Reserved	RW	001

REG E8: Fuel Gauge Tuning Control 0

Default: 00H

Reset: Power on reset

Bit	Description	R/W	Default
7	When the available signal of the external power supply is changed or not, reset ADC filter or not 0: Yes, reset the ADC filter 1: No	RW	0
6	When the charging circuit on or off, reset ADC filter or not 0: Yes, reset the ADC filter 1: No	RW	0
5	When the battery voltage ADC channels open or closed, reset ADC filter or not 0: Yes, reset the ADC filter 1: No	RW	0
4	When the battery rechargeable battery ADC channels open or closed, reset ADC filter or not 0: Yes, reset the ADC filter 1: No	RW	0
3	When the battery discharge current ADC channels open or closed, reset ADC filter or not 0: Yes, reset the ADC filter 1: No	RW	0
2-0	Battery capacity percentage for indication update mini time interval 000: 30s 001: 60s 010: 120s 011: 164s 100: No minimal time interval, only update the percentage 101: 5s 110: 10s 111: 20s	RW	0

REG E9: Fuel Gauge Tuning Control 1

Default: 00H

Reset: Power on reset

Bit	Description	R/W	Default

7-6	Maximum time interval of calibrating coulometer Percentage (Coulombmeter Percentage of' capacity) by the OCV Percentage (OCV Percentage of battery capacity)in the head and tail ends 00: 60s 01: 120s 10: 15s 11: 30s	RW	00
5-3	Minimum time when calculating the RDC and waiting for charging data stability 000: 180s 001: 240s 010: 300s 011: 600s 100: 30s 101: 60s 110: 90s 111: 120s	RW	000
2-0	Minimum time when calculating RDC and waiting for discharging data stability 000: 180s 001: 240s 010: 300s 011: 600s 100: 30s 101: 60s 110: 90s 111: 120s	RW	000

REG EA: Fuel Gauge Tuning Control 2

Default: 00H

Reset: Power on reset

Bit	Description	R/W	Default
7-6	OCV Percentage (OCV Percentage of battery capacity) Debounce setting Only N consecutive OCV percentages are changed larger or smaller, then OCV Percentage is considered that it has changed a stage steadily in the direction, where N is set as follows. 00: 4 01: 8 10: 1 11: 2	RW	0
5-4	Coulometer Percentage (Coulombmeter Percentage of 'capacity) Debounce setting Only N consecutive OCV percentages are changed larger or smaller, then OCV Percentage is considered that it has changed a stage steadily in the direction, where N is set as follows. 00: 4 01: 8	RW	0

	10: 1 11: 2		
3	Starting condition of battery maximum capacity calibration 0: OCV percentage < (REG E6_[3:0] + 3) 1: OCV percentage < (REG E6_[3:0] + 6)	RW	0
2	End condition0 of the battery maximum capacity calibration 0: OCV percentage ≥ 95% 1: OCV percentage = 100%	RW	0
1	End condition1 of the battery maximum capacity calibration 0: Need to detect whether real charging complete 1: Don't need to detect whether real charging complete	RW	0
0	End condition2 of the battery maximum capacity calibration When real charge completed, charge status (REG01[6]) is changed from 1 to 0 ,after 64ms, the Charger should send out charge complete instruction signal. So checking the method of charge completed is: the charge status (REG 01[6]) is changed from 1 to 0, and charge complete instruction signal can receive or not within N ms. N sets as follows. 0: 68ms 1: 120ms	RW	0

REG EB: Fuel Gauge Tuning Control 3

Default: 00H

Reset: Power on reset

Bit	Description	R/W	Default
7	Charging status (REG 01[6]) is 1, control whether reduce the percentage 0: Decrease 1: Non-decrease	RW	0
6-4	Charging status (REG 01 [6]) is 1, decrease percentage (BCP) delay setting 000: 4% 001: 5% 010: 6% 011: 7% 100: 0% 101: 1% 110: 2% 111: 3% Decrease BCP condition: PCT<(BCP-N), PCT means OCV or coulombmeter	RW	0
3	Charging current set when counting and calibration RDC 0: ≥300mA 1: ≥150mA	RW	0
2-0	Before and After charging OCV percentage jump threshold(N) set when calibrating RDC 000: 4% 001: 5%	RW	0

	010: 6% 011: 7% 100: 0% 101: 1% 110: 2% 111: 3% Calibration condition: ΔOCVPCT > N, OCVPC means OCV percentage		

REG EC: Fuel Gauge Tuning Control 4

Default: 00H

Reset: Power on reset

Bit	Description	R/W	Default
7	Control whether ADC current data subtract Offse0 0: Enable 1: Disable	RW	0
6	ADC current data offset0 smooth management control 0: Enable 1: Disable	RW	0
5	Enable whether re-counting RDC after BMU on/off control 0: Disable 1: Enable	RW	0
4-3	Single battery voltage lower threshold of RDC detection 00: 3.5V 01: 3.6V 10: 3.7V 11: 3.4V	RW	00
2-0	Choose calibration threshold of coulombmeter, conlombmeter combines with REGE6[3:0] 000: REG E6[3:0]+7(default) 001: REG E6[3:0]+8 010: REG E6[3:0]+9 011: REG E6[3:0]+10 100: REG E6[3:0]+3 101: REG E6[3:0]+4 110: REG E6[3:0]+5 111: REG E6[3:0]+6 In default status, when OCV percentage is less or equal than REG[3:0]+7, start to calibrate coulombmeter.	RW	000

REG ED: Fuel Gauge Tuning Control 5

Default: 00H

Reset: Power on reset

Bit	Description	R/W	Default

7	OCV update time enable control by the charging and discharging rate 0: Disable 1: Enable	RW	0
6	OCV update time setting when the charging and discharging rate is more than 0.5C 0: 30s 1: 15s	RW	0
5-4	OCV update time setting when the charging and discharging rate is more than 0.125C and less than 0.5C 00: 60s 01: 75s 10: 30s 11: 45s	RW	00
3-2	OCV update time setting when the charging and discharging rate is less than 0.125C 00: 120s 01: 180s 10: 240s 11: 60s	RW	00
1-0	Fixed OCV update time setting 00: 30s 01: 45s 10: 60s 11: 15s	RW	00

REG EE: Fuel Gauge Tuning Control 6

Default: 21H

Reset: Power on reset

Bit	Description	R/W	Default
7	OCV capacity curve and battery capacity calibration control in charge or discharge status 0: Charging-calibration 1: Discharging-calibration	RW	0
6	Battery current coefficient correction options 0: Set the OTP coefficient, but switch to the correction coefficient after external resistor calibration completed 1: Fixed select the setting coefficient of external resistance correction register	RW	0
5	Reserved	RW	1
4	The debounce number of battery OCV reached 0. 0: 3 1: 4	RW	0
3	Whether hold charge accumulation or regressive when Coulometer value in 100% or OCV in 0%, or OCV curve in calibration period 0: Normal accumulation or regressive 1: Hold, do not accumulate or regressive	RW	0

2	OCVPCT update control. 0: Old ocvpct update which not depend on charge ratio 1: New ocvpct update which depend on charge ratio	RW	0
1-0	The ocv debounce time setting at every ocv level during the BMU doing ocv percent curve calibration. 00: 2s 01: 4s 10: 6s 11: 8s	RW	01

REG EF: Fuel Gauge Tuning Control 7

Default: 00H

Reset: Power on reset

Bit	Description	R/W	Default
7	The OCV percent curve and battery capacity calibration in BMU power status will enable ADC and fuel-gauge control bit 0 : Don't enable ADC and fuel-gauge 1 : Enable ADC and fuel- gauge	RW	0
6	In the charging state, the smooth OCV-percentage less than coulomb calibration threshold and the instantaneous OCV-percentage equal 0%, then it will clear the coulomb counter or not. 0 : Clear the coulomb 1 : Not clear the coulomb	R/W	0
5	The battery total calibration has completed and the OCV percent calibration has not completed, the OCV percent calibration processing will stop or not. 0 : Stop 1 : Don't stop	R/W	0
4	The indication of battery charge percentage can go to 100% or not before charge done 0 : Disable 1 : Enable	R/W	0
3	The BMU power off will stop the discharge OCV percent curve and battery capacity calibration setting. 0 : Stop the calibration; 1 : Don't stopping the calibration.	RW	0
2	The battery charge percent for OCV percent curve calibration selection. 0 : The instantaneous charge percent; 1 : The smooth charge percent.	RW	0
1	The battery charge percent for battery capacity calibration selection. 0 : The instantaneous charge percent; 1 : The smooth charge percent.	RW	0
0	The battery charge percent for the battery discharge ocv percent curve and capacity calibration start. 0 : Must equal 100%;	RW	0

	1 : No limit.		

REG F3: Temperature Warning Level 2/3 Setting

Default: 03H

Reset: Power on reset

Bit	Description	R/W	Default
7-4	Reserved	/	/
3	Die temperature over level3 shut down BMU enable control 0 : Disable 1 : Enable	R/W	0
2- 0	Die temperature warning level 2 setting, and level 3 = level 2 + 13.6(TWO options)℃ 000 : 91.2℃ 001 : 97.9℃ 010 : 104.7℃ 011 : 111.6℃ 100 : 118.4℃ 101 : 125.3℃ 110 : 132.2℃ 111 : 139℃	R/W	011

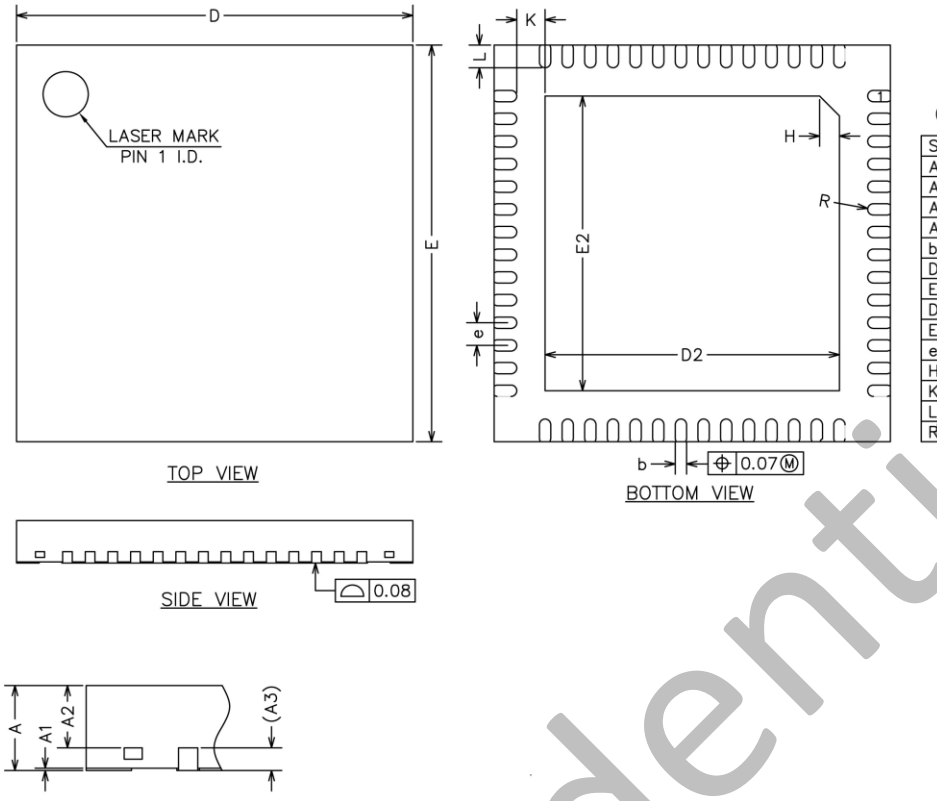
REG XFF: Register Address Extension

Default: 00H

Reset: system reset

Bit	Description	R/W	Default
7-4	Extended address dynamic value. The chip can be read and written when Reg xFF is written 0x40	RW	0000
3-0	Reserved	RW	0000

15. PACKAGE



COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0	0.02	0.05
A2	0.50	0.55	0.60
A3		0.20REF	
b	0.15	0.20	0.25
D	6.90	7.00	7.10
E	6.90	7.00	7.10
D2	5.10	5.20	5.30
E2	5.10	5.20	5.30
e	0.30	0.40	0.50
H		0.35REF	
K		0.50REF	
L	0.35	0.40	0.45
R	0.09	–	–