XB5307H

Single-cell lithium-ion/lithium-polymer rechargeable battery pack protection chip

Overview

The XB5307H product is a highly integrated solution for single-cell lithium-ion/lithium polymer rechargeable battery pack protection. XB5307H includes advanced power MOSFET, high-precision voltage detection circuit and delay circuit.

XB5307H uses SOT23-6 package and has only one

External components minimize the battery protection circuit space. This makes the device ideal for rechargeable battery pack applications where space is very limited.

XB5307H has all required battery protection functions such as overcharge, over-discharge, over-current, over-temperature and short circuit, and its power consumption is very low

during operation. The chip isn't just designed for phones;
It is suitable for all kinds of information products that require long-term power supply from lithium-ion or lithium-polymer rechargeable batteries, such as smart bracelets, watches, Bluetooth headsets and other products.

Features •

Charger reverse connection protection •

Battery reverse connection protection

• Integrated 40mÿ equivalent advanced power MOSFET • SOT23-6 package •

Only one external capacitor

• Over-temperature protection •

Overcharge current

protection • 2-stage over-

current protection - Over-

discharge current 1 -

Load short-circuit current •

Charger detection function • 0V

battery charging function • Delay

time internal setting • High-precision

voltage detection • Low static

current consumption

Working state: 2.8uA Typical value.. In over-discharge mode:

1.5uA typical. •Compatible with

RoHS and lead-free standards·

Application

of single-cell lithium-ion battery

Lithium polymer battery

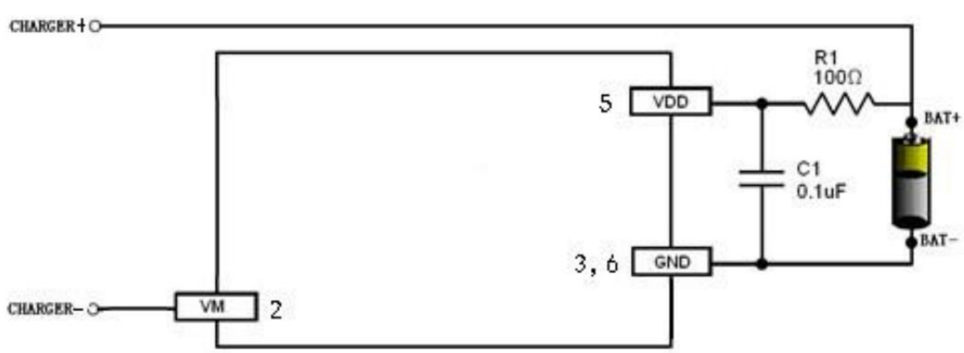


Figure 1. Typical application circuit

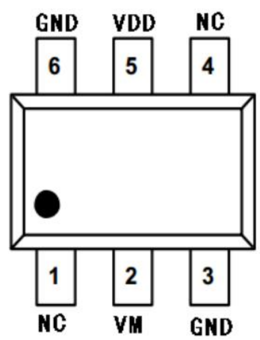
Ordering information

Product model	package	Overcharge voltage [VCU] (V)	Overcharge recovery press [VCL] (V)	Over discharge voltage [VDL] (V)	Over-discharge recovery voltage [VDR] (V)	Overcurrent detection current [IOV1] (A)	silk screen
XB5307H	SOT23-6	4.425	4.25	2.90	3.0	5.0	5307HYW(note)

Note: "YW" is the production date, "Y" is the year, "W" is the week number

Pin diagram

TOP VIEW



Pin description

XB5307H pin number	pin name	Pin description
1 ,4	NC	empty foot
2	VM	Negative terminal of the battery pack. Internal FET switch connected to GND
3,6	GND	ground terminal, connected to the negative pole of the battery cell
5	VDD	IC power supply terminal

absolute maximum ratings

(Note: To protect the device, the following maximum ratings are not allowed to be exceeded. Working under maximum ratings for a long time may affect the reliability of the product)

parameter	numerical value	unit
VDD input voltage	-0.3 to 6	IN
VM input voltage	-6 to 10	IN
Working temperature	-40 to 85	°C

maximum junction temperature	125	°C
Storage temperature	-55 to 150	°C
Pin temperature (soldering, 10 seconds)	300	°C
Power consumption at 25°C ambient temperature	0.625	IN
Package thermal limit (junction temperature)	250	°C/W
ÿJA Package thermal resistance (junction to ambient) ÿJA	130	°C/W
ESD	2000	IN

Electrical characteristics

Unless otherwise stated, all specifications are at T=25°C.

parameter	logo	Test Conditions	Minimum value	Typical value	Maximum value	Unit
Detection voltage						
Overcharge detection voltage	VCU		4.40	4.425	4.45	IN
Overcharge recovery voltage	VCL		4.2	4.25	4.3	IN
Over discharge detection voltage	VDL		2.85	2.9	2.95	IN
Over-discharge recovery voltage	VDR		2.95	3.0	3.05	IN
Detect current						
Overdischarge current 1 detection current	*IIOV1	VDD=3.6		5		A
Load short circuit detection current	*ISHORT	VDD=3.6		20		A
Current power consumption						
Normal operating power consumption	IOPE	VDD=3.6 VM =0V		2.8	6	ÿA
Shutdown power consumption	IPDN	VDD=2.0V VM pin floating		1.5	3	ÿA
VM terminal resistance						
Internal resistance between VM and VDD	*RVMD	VDD=2.0V VM pin floating		320		kÿ
Internal resistance between VM and GND	*RVMS	VDD=3.6V VM=1.0V		100		kÿ

FET **on-resistance**						
FET equivalent on-resistance	*RSS(ON)	VDD=3.6V IVM =1.0A		40		mÿ
Over temperature protection						
Over temperature protection temperature	*TSHD+			120		°C
Over-temperature protection recovery temperature	*TSHD-			100		
Detection delay						
Overcharge detection delay	tCU			130	200	mS
Over discharge detection delay	tDL			40	60	mS
Overcurrent detection delay	*tIOV	VDD=3.6		10	20	mS
Short circuit detection delay	*tSHORT	VDD=3.6		75	150	uS

Note: *—This parameter is guaranteed by design and may not be subject to testing.

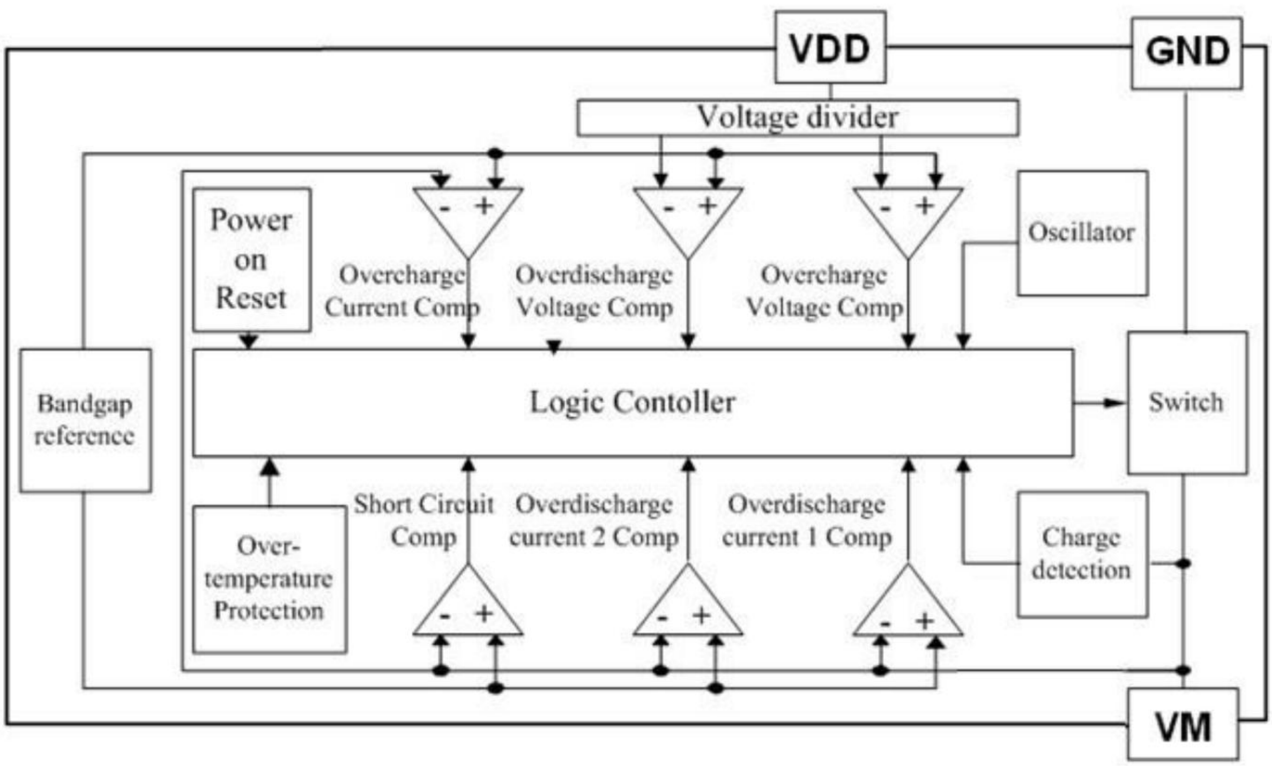


Figure 3. Functional Block Diagram

FUNCTIONAL DESCRIPTION

The XB5307H monitors the voltage and current of a battery and protects it from being damaged due to overcharge voltage, overdischarge voltage, overdischarge current, and short circuit conditions by disconnecting the battery from the load or charger. These functions are required in order to operate the battery cell within specified limits.
The device requires only one external capacitor.
The MOSFET is integrated and its RSS(ON) is as low as 40mÿ typical.

Normal operating mode

If no exception condition is detected, charging and discharging can be carried out freely. This condition is called the normal operating mode.

Overcharge Condition

When the battery voltage becomes higher than the overcharge detection voltage (VCU) during charging under normal conditionand the state continues for the overcharge detection delay time (tCU) or longer, the XB5307H turns the charging control FET off to stop charging. This condition is called

the overcharge condition. The overcharge condition is released in the following two cases:

1, When the battery voltage drops below the overcharge release voltage (VCL), the XB5307H turns the charging control FET on and returns to the normal condition.

2, When a load is connected and discharging starts, the XB5307H turns the charging control FET on and returns to the normal condition. The release mechanism is as follows: the discharging current flows through an internal parasitic diode of the charging FET immediately after a load is connected and discharging starts, and the VM pin voltage increases about 0.7 V (forward voltage of the diode) from the GND pin voltage momentarily. The XB5307H detects this voltage and releases the overcharge condition. Consequently, in the case that the battery voltage is equal to or lower than the overcharge detection voltage (VCU), the XB5307Hreturns to the normal condition immediately, but in the case the battery voltage is higher than the overcharge detection voltage (VCU),the chip does not return to the normal condition until

the battery voltage drops below the overcharge detection voltage (VCU) even if the load is connected. In addition, if the VM pin voltage is equal to or lower than the overcurrent 1 detection voltage when a load is connected and discharging starts, the chip does not return to the normal condition.

Remark If the battery is charged to a voltage higher than the overcharge detection voltage (VCU) and the battery voltage does not drops below the overcharge detection voltage (VCU) even when a heavy load, which causes an overcurrent, is connected, the overcurrent 1 and overcurrent 2 do not work until the battery voltage drops below the overcharge detection voltage (VCU). Since an actual battery has, however, an internal impedance of several dozens of mÿ and the battery voltage drops immediately after a heavy load which causes an overcurrent is connected, the overcurrent 1 and overcurrent 2 work. Detection of load short-circuiting works regardless of the battery voltage.

Overdischarge Condition

When the battery voltage drops below the overdischarge detection voltage (VDL) during discharging under normal condition and it continues for the overdischarge

detection delay time (tDL) or longer, the XB5307H turns the discharging controlFET off and stops discharging. This condition is called overdischarge condition. After the discharging control FET is turned off, the VM pin is pulled up by the RVMD resistor between VM and VDD in XB5307H.

Meanwhile when VM is bigger than 1.5 V (typ.) (the load short-circuiting detection voltage), the current of the chip is reduced to the power-down current (IPDN). This condition is called power-down condition.

The VM and VDD pins are shorted by the RVMD resistor in the IC under the overdischarge and power-down conditions.

The power-down condition is released when a charger is connected and the potential difference between VM and VDD becomes 1.3 V (typ.) or higher (load short-circuiting detection voltage). At this time, the FET is still off. When the battery voltage becomes the overdischarge detection voltage (VDL) or higher (see note), the XB5307H turns the FET on and changes to the normal condition from the overdischarge condition.

Remark If the VM pin voltage is no less than the charger detection voltage (VCHA), when the battery under overdischarge condition is connected to a charger, the overdischarge condition is released (the discharging control FET is turned on) as usual, provided that the battery voltage reaches the overdischarge release voltage (VDU) or higher.

Overcurrent Condition

When the discharging current becomes equal to or higher than a specified value (the VM pin voltage is equal to or higher than the overcurrent detection voltage) during discharging under normal condition and the state continues for the overcurrent detection delay time or longer, the XB5307H turns off the discharging control FET to stop discharging.

This condition is called overcurrent condition. (The overcurrent

includes overcurrent, or load short-circuiting.)

The VM and GND pins are shorted internally by the RVMS resistor under the overcurrent condition. When a load is connected, the VM pin voltage equals the VDD voltage due to the load.

The overcurrent condition returns to the normal condition when the load is released and the impedance between the B+ and B-pins becomes higher than the automatic recoverable impedance.

When the load is removed, the VM pin goes back to theGND potential since the VM pin is shorted the GND pin with the RVMS resistor. Detecting that the VM pin potential is lower than the overcurrent detection voltage (VIOV1), the IC returns to the normal condition.

Abnormal Charge Current Detection If the VM pin voltage drops below the charger detection voltage (VCHA) during charging under the normal condition and it continues for the overcharge detection delay time (tCU) or longer, the XB5307H turns the charging control FET off and stops charging. This action is called abnormal charge current detection.

Abnormal charge current detection works when the discharging control FET is on and the VM pin voltage drops below the charger detection voltage (VCHA). When an abnormal charge current flows into a battery in the overdischarge condition, the XB5307H consequently turns the charging control FET off and stops charging after the battery voltage becomes the overdischarge detection voltage and the overcharge detection delay time (tCU) elapses.

Abnormal charge current detection is released when the voltage difference between VM pin and GND pin becomes lower than the charger detection voltage (VCHA) by separating the charger. Since the 0 V battery charging function has higher priority than the abnormal charge current detection function, abnormal charge current may not be detected by the product with the 0 V battery charging function while the battery voltage is low.

Load Short-circuiting condition

If voltage of VM pin is equal or below short circuiting protection voltage (VSHORT), the XB5307H will stop discharging and battery is disconnected from load. The maximum delay time to switch current off is tSHORT. This status is released when voltage of VM pin is higher than short protection voltage (VSHORT), such as when disconnecting the load.

Delay Circuits

The detection delay time for overdischarge current 2 and load short-circuiting starts when overdischarge current 1 is detected. As soon as overdischarge current 2 or load short-circuiting is detected over detection delay time for overdischarge current 2 or load short- circuiting, the XB5307H stops discharging. When battery voltage falls below overdischarge detection voltage due to overdischarge current, the XB5307H stop discharging by overdischarge current detection. In this case the recovery of battery voltage is so slow that if battery voltage after overdischarge voltage detection delay time is still lower than overdischarge detection voltage, the XB5307H shifts to power-down.

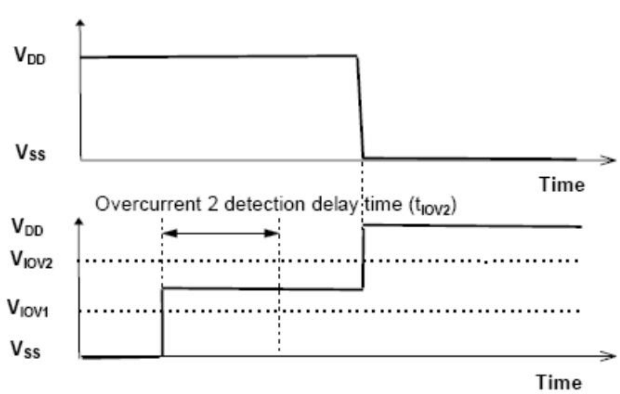


Figure 4. Overcurrent delay time

0V Battery Charging Function (1) (2) (3)

This function enables the charging of a connected battery whose voltage is 0 V by self-discharge. When a charger having 0 V battery start charging charger voltage (V0CHA) or higher is connected between B+ and B- pins, the charging control FET gate is fixed to VDD potential. When the voltage between the gate and the source of the charging control FET becomes equal to or higher than the turn-on voltage by the charger voltage, the charging control FET is turned on to start charging. At this time, the discharging control FET is off and the charging current flows through the internal parasitic diode in the discharging control FET. If the battery voltage becomes equal to or higher than the overdischarge release voltage (VDU), the normal condition returns.

Note

(1) Some battery providers do not recommend charging of completely discharged batteries. Please refer to battery providers before the selection of 0 V battery charging function.
(2) The 0V battery charging function has higher priority than the abnormal charge current detection function. Consequently, a product with the 0 V battery charging function charges a battery and abnormal charge current cannot be detected during the battery voltage is low (at most 1.8 V or lower).
(3) When a battery is connected to the IC for the first time, the IC may not enter the normal condition in which discharging is possible. In this case, set the VM pin voltage equal to the GND voltage (short the VM and GND pins or connect a charger) to enter the normal condition.

TIMING CHART

1ÿ Overcharge and overdischarge detection

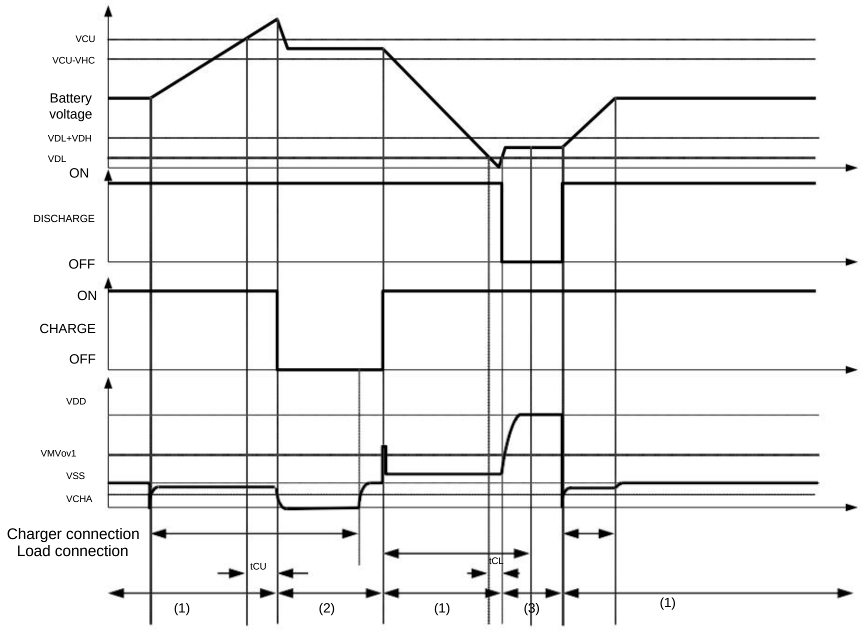


Figure5-1 Overcharge and Overdischarge Voltage Detection

2ÿ Overdischarge current detection

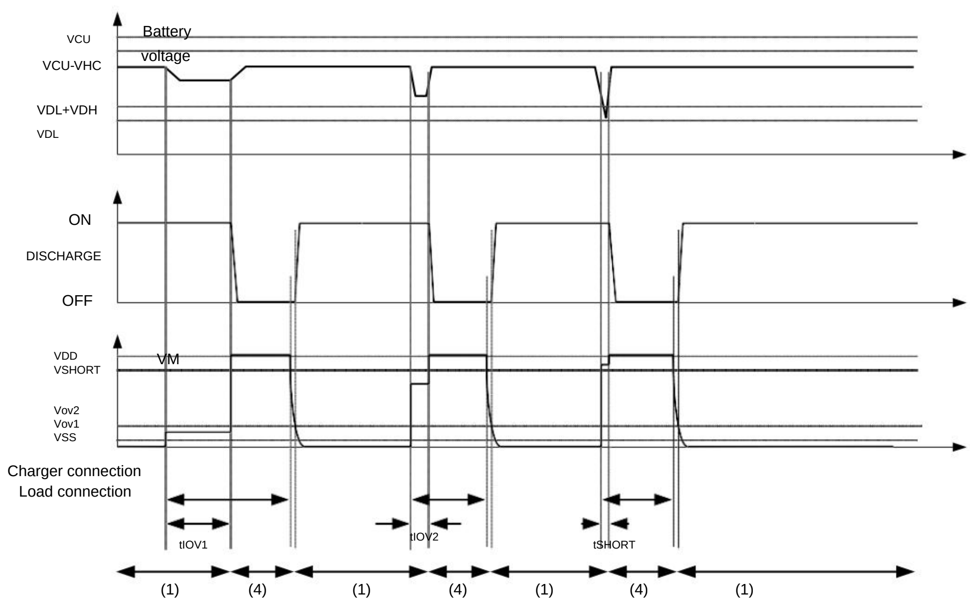


Figure5-2 Overdischarge Current Detection

Remark: (1) Normal condition (2) Overcharge voltage condition (3) Overdischarge voltage condition (4) Overcurrent condition

3ÿ Charger Detection

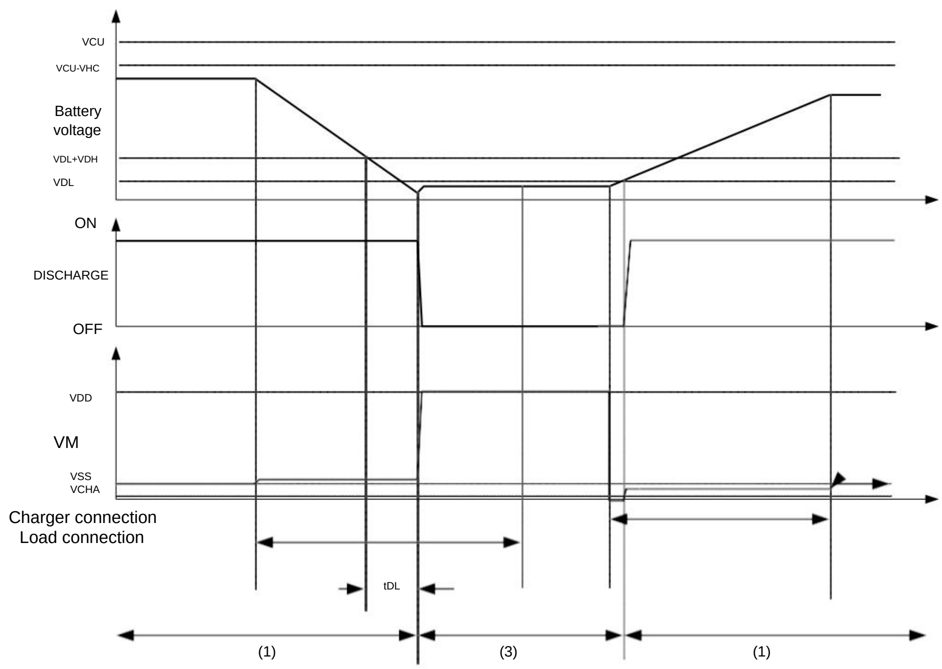


Figure5-3 Charger Detection

4ÿ Abnormal Charger Detection

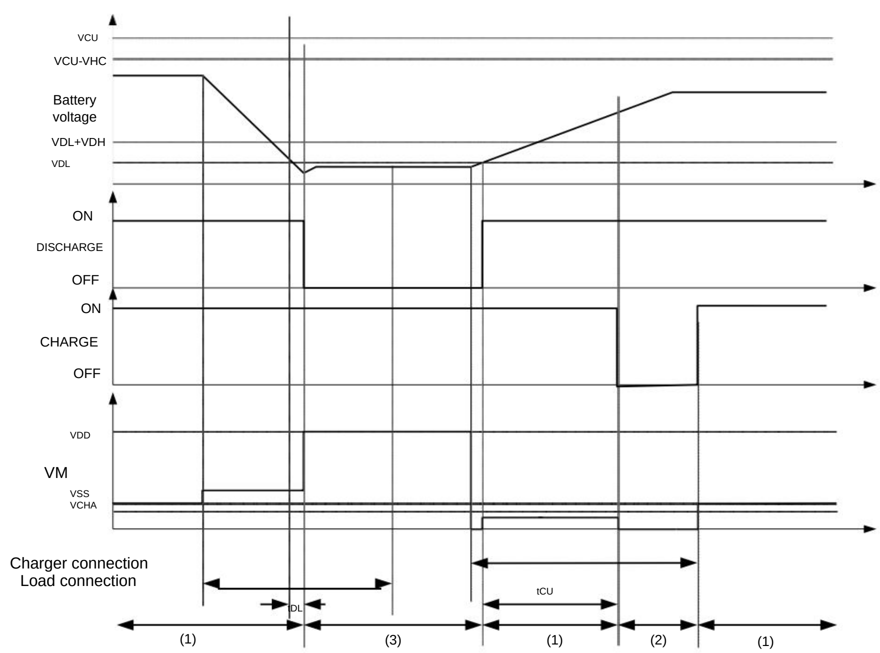


Figure5-4 Abnormal Charger Detection

Remark: (1) Normal condition (2) Overcharge voltage condition (3) Overdischarge voltage condition (4) Overcurrent condition

TYPICAL APPLICATION

As shown in Figure 6, the bold line is the high density current path which must be kept as short as possible. For thermal management, ensure that these trace widths are adequate. C1 is a decoupling capacitor which should be placed as close as possible to XB5307H. Pin3 and Pin6 must be connected with heavy lines together outside.

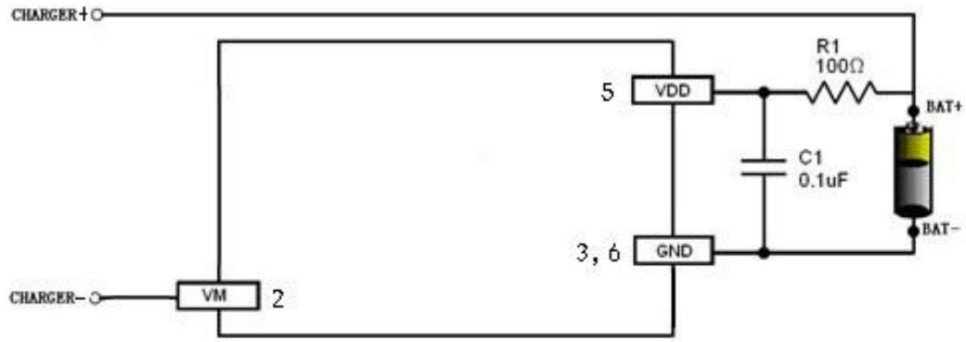


Fig 6 XB5307H in a Typical Battery Protection Circuit

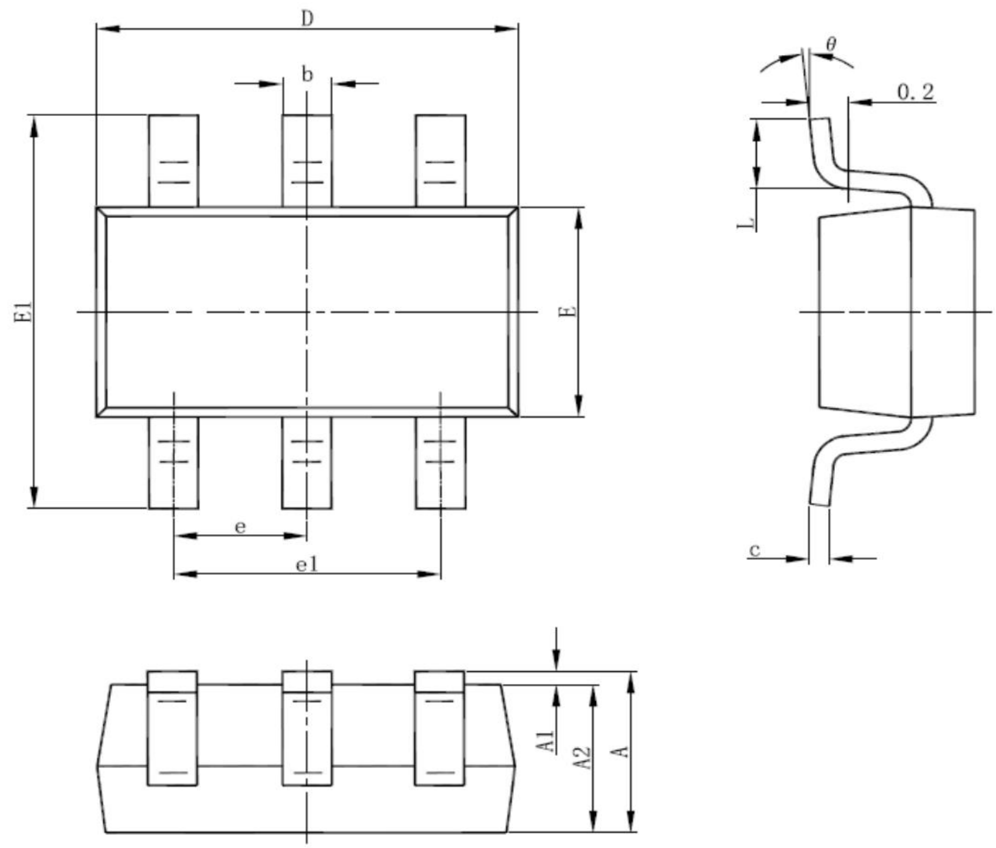
Precautions

• Pay attention to the operating conditions for input/output voltage and load current so that the power loss in XB5307H does not exceed the power dissipation of the package.

• Do not apply an electrostatic discharge to this XB5307H that exceeds the performance ratings of the built-in electrostatic protection circuit.

PACKAGE OUTLINE

SOT-23-6L PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

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