XB5332B

One Cell Lithium-ion/Polymer Battery Protection IC

GENERAL DESCRIPTION

The XB5332B product is a high integration solution for lithium-ion/polymer battery protection. XB5332B contains advanced power MOSFET, high-accuracy voltage detection circuits and delay circuits. XB5332B is put into an ultra-small SOT23-5 package and only one external component makes it an ideal solution in limited space of battery pack.

XB5332B has all the protection functions required in the battery application including overcharging, overdischarging, overcurrent and load short circuiting protection etc. The accurate overcharging detection voltage en-sures safe and full utilization charging. The low standby current drains little current from the cell while in storage.

The device is not only targeted for digital cellular phones, but also for any other Li-Ion and Li-Poly battery-powered information appliances requiring long-term battery life.

FEATURES

- Protection of Charger Reverse Connec-tion
- Protection of Battery Cell Reverse Con-nection without external load

- Integrated Advanced Power MOSFET with Equivalent of $62\,m\Omega$ $R_{SS(ON)}$
- Ultra-small SOT23-5 Package
- Only One External Capacitor Required
- Over-temperature Protection
- Overcharge Current Protection
- Two-step Overcurrent Detection
  -Overdischarge Current 1
  -Load Short Circuiting
- Low Current Consumption
  -Operation Mode: 2.8µA typ
  -Power-down Mode: 1.5µA typ
- Charger Detection Function
- 0V Battery Charging Function
- Delay Times are generated inside
- High-accuracy Voltage Detection
- RoHS Compliant and Lead (Pb) Free

APPLICATIONS

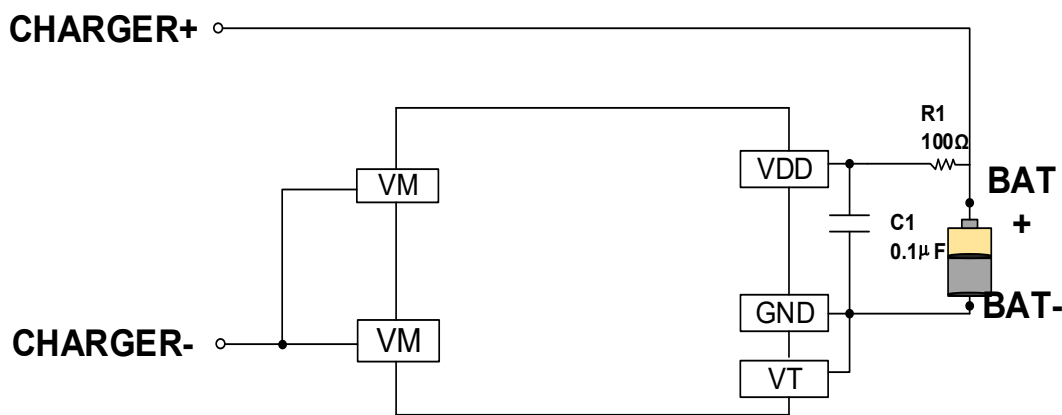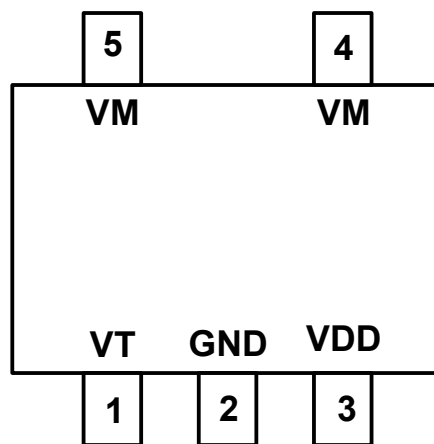One-Cell Lithium-ion Battery Pack
Lithium-Polymer Battery Pack

Figure 1. Typical Application Circuit

ORDERING INFORMATION

PART NUMBER	OCV [VCU] (V)	OCRV [VCL] (V)	ODV [VDL] (V)	ODRV [VDR] (V)	TOP MARK
XB5332B	4.30±50mV	4.10±50mV	2.9±100mV	3.0±100mV	5332BYW(note)

Note: "YW" is manufacture date code, "Y" means the year, "W" means the week.

PIN CONFIGURATION

TOP View
Figure 2. PIN Configuration

PIN DESCRIPTION

XB5332B PIN NUMBER	PIN NAME	PIN DESCRIPTION
1	VT	Test pin；only for vendor not used by application
2	GND	Ground,connect the negative terminal of the battery to this pin
3	VDD	Power Supply
4,5	VM	The negative terminal of the battery pack. The internal FET switch connects this terminal to GND

ABSOLUTE MAXIMUM RATINGS

(NOTE: DO NOT EXCEED THESE LIMITS TO PREVENT DAMAGE TO THE DEVICE. EXPOSURE TO ABSOLUTE MAXIMUM RATING CONDITIONS FOR LONG PERIODS MAY AFFECT DEVICE RELIABIL-ITY.)

PARAMETER	VALUE	UNIT
VDD input pin voltage	-0.3 to 6	V
VM input pin voltage	-6 to 10	V
Operating Ambient Temperature	-40 to 85	°C
Maximum Junction Temperature	125	°C
Storage Temperature	-55 to 150	°C
Lead Temperature (Soldering, 10 sec)	300	°C
Power Dissipation at T=25°C	0.4	W
Package Thermal Resistance (Junction to Ambient) θ$_{JA}$	250	° C/W
Package Thermal Resistance (Junction to Case) θ$_{JC}$	130	° C/W
HBM ESD	2000	V

ELECTRICAL CHARACTERISTICS

Typical and limits appearing in normal type apply for TA = 25°C, unless otherwise specified.

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Detection Current						
Overdischarge Current Detection	*I$_{IOV1}$	V$_{DD}$=3.6V	2.5	3.3	4.1	A
Overcharge Current Detection	*I$_{CHOC}$	V$_{DD}$=3.6V	2.5	3.3	4.1	A
Load Short-Circuiting Detection	*I$_{SHORT}$	V$_{DD}$=3.6V	10	20	30	A
Current Consumption						
Current Consumption in Normal Operation	I$_{OPE}$	VDD=3.6V VM pin floating		2.8	6	μA
Current Consumption in Power Down	I$_{PD}$	VDD=2.0V VM pin floating		1.5	3	μA
VM Internal Resistance						
Internal Resistance between VM and V$_{DD}$	R$_{VMD}$	VDD =3.6V VM=1.0V	200	300	400	kΩ
Internal Resistance between VM and GND	R$_{VMS}$	VDD=3.6V VM pin floating	10	20	30	kΩ
FET on Resistance						
Equivalent FET on Resistance	*R$_{SS(ON)}$	V$_{DD}$=3.6V I$_{VM}$=1.0A		62	74	mΩ
Over Temperature Protection						
Over Temperature Protection	*T$_{SHD+}$			150		°C
Over Temperature Recovery Degree	*T$_{SHD-}$			110		°C
Detection Delay Time						
Overcharge Voltage Detection Delay-Time	t$_{CU}$		80	130	180	mS
Overdischarge Voltage Detection Delay Time	t$_{DL}$		20	40	60	mS
Overdischarge Current1 Detection Delay Time	t$_{IOV1}$	V$_{DD}$=3.6V	4	7.5	16	mS
Load Short-Circuiting Detection Delay Time	*t$_{SHORT}$	V$_{DD}$=3.6V	80	180	300	μS

Note1: *---The parameter is guaranteed by design.

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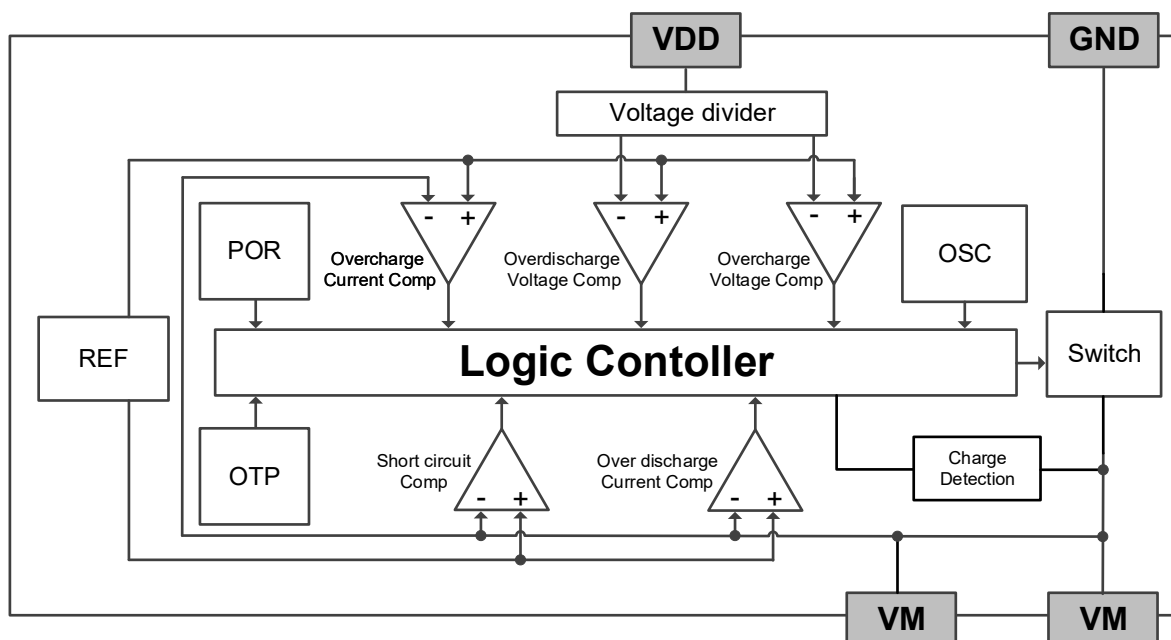**Rev0.2**

FUNCTIONAL BLOCK DIAGRAM

Figure 3. Functional Block Diagram

FUNCTIONAL DESCRIPTION

The XB5332B monitors the voltage and current of a battery and protects it from bei -ng damaged due to overcharge voltage, ov -erdischarge voltage, overdischarge curren -t, and short circuit conditions by disconnec -ting the battery from the load or charger. T -hese functions are required in order to ope -rate the battery cell within specified limits. The device requires only one external capa citor. The MOSFET is integrated and its R $_{SS(ON)}$ is as low as 62 mΩ typical.

Normal Mode

If no exception condition is detected, ch- arging and discharging can be carried out freely. This condition is called the normal o -perating mode.

Overcharge Condition

When the battery voltage becomes highe -r than the overcharge detection voltage (V $_{CU}$) during charging under normal condition

and the state continues for the overcharge detection delay time (t$_{CU}$) or longer, the XB5 332B turns the charging control FET off to stop charging. This condition is called the o -vercharge condition. The overcharge cond -ition is released in the following two cases:

1. When the battery voltage drops below the overcharge release voltage (V$_{CL}$), the X B5332B turns the charging control FET on and returns to the normal condition.

2. When a load is connected and dischar -ging starts, the XB5332B turns the chargi- ng control FET on and returns to the norma -l condition. The release mechanism is as f -ollows: the discharging current flows throu -gh an internal parasitic diode of the chargi -ng FET immediately after a load is connec -ted and discharging starts, and the VM pin voltage increases about 0.7 V (forward volt -age of the diode) from the GND pin voltag- e momentarily. The XB5332B detects this v oltage and releases the overcharge conditi on. Consequently, in the case that the batt- ery voltage is equal to or lower than the ov-

ercharge detection voltage (V$_{CU}$), the XB53 32B returns to the normal condition immediately, but in the case the battery voltage is higher than the overcharge detection voltage (V$_{CU}$),the chip does not return to the normal condition until the battery voltage drops below the overcharge detection voltage (V$_{CU}$) 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 t -he overcharge detection voltage (V$_{CU}$) and the battery voltage does not drops below the overcharge de -tection voltage (V$_{CU}$) even when a heavy load, which causes an overcurrent, is connected, the overcurr -ent 1 and overcurrent 2 do not work until the batter -y voltage drops below the overcharge detection vol -tage (V$_{CU}$). Since an actual battery has, however, a -n internal impedance of several dozens of mΩ, 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 th -e overdischarge detection voltage (V$_{DL}$) du -ring discharging under normal condition a -nd it continues for the overdischarge detect -ion delay time (t$_{DL}$) or longer, the XB5332B turns the discharging control FET off and st ops discharging. This condition is called ov erdischarge condition. After the dischargin -g control FET is turned off, the VM pin is p -ulled up by the R$_{VMD}$ resistor between VM a -nd VDD in XB5332B. Meanwhile when VM is bigger than 1.5V (typ.) (the load short-cir cuiting detection voltage), the current of th e chip is reduced to the power-down curren t (I$_{PDN}$). This condition is called power-down condition. The VM and VDD pins are short ed by the R$_{VMD}$ resistor in the IC under the o -verdischarge and power-down conditions.

The power-down condition is released w -hen a charger is connected and the potenti -al difference between VM and VDD beco -mes 1.3 V (typ.) or higher (load short-circui -ting detection voltage). At this time, the FE T is still off. When the battery voltage beco -mes the overdischarge detection voltage(V $_{DL}$) or higher (see note), the XB5332B turns the FET on and changes to the normal con -dition from the overdischarge condition.

Remark

If the VM pin voltage is no less than the charger d -etection voltage (V$_{CHA}$), when the battery under ove -rdischarge condition is connected to a charger, the overdischarge condition is released (the dischargin -g control FET is turned on) as usual, provided that t -he battery voltage reaches the overdischarge relea -se voltage (V$_{DU}$) or higher.

Overcurrent Condition

When the discharging current becomes equal to or higher than a specified value (th -e VM pin voltage is equal to or higher than the overcurrent detection voltage) during di -scharging under normal condition and the state continues for the overcurrent detectio -n delay time or longer, the XB5332B turns off the discharging control FET to stop disc -harging. This condition is called overcurre -nt condition. (The overcurrent includes ove -rcurrent, or load short-circuiting.)

The VM and GND pins are shorted intern -ally by the R$_{VMS}$ resistor under the overcurr -ent condition. When a load is connected, t -he 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 re -coverable impedance. When the load is re -moved, the VM pin goes back to the GND potential since the VM pin is shorted the G ND pin with the R$_{VMS}$ resistor. Detecting that the VM pin potential is lower than the overc -urrent detection voltage (V$_{IOV}$), the IC retur- ns to the normal condition.

Abnormal Charge Current Detection

If the VM pin voltage drops below the charger detection voltage (V_{CHA}) during charging under the normal condition and it continues for the overcharge detection delay time (t_{CU}) or longer, the XB5332B 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 (V_{CHA}). When an abnormal charge current flows into a battery in the overdischarge condition, the XB5332B 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 (t_{CU}) elapses.

Abnormal charge current detection is released when the voltage difference between VM pin and GND pin becomes lower than the charger detection voltage (V_{CHA}) 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 (V_{SHORT}), the XB5332B will stop discharging and battery is disconnected from load. The maximum delay time to switch current off is t_{SHORT}. This status is released when voltage of VM pin is higher than short protection voltage (V_{SHORT}), 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 XB5332B stops discharging. When battery voltage falls below overdischarge detection voltage due to overdischarge current, the XB5332B 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 XB5332B shifts to power-down.

0V Battery Charging Function [1] [2] [3]

This function enables the charging of a connected battery whose voltage is 0V by self-discharge. When a charger having 0V battery start charging charger voltage (V_{0CHA}) 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 (V_{DU}), 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.

TYPICAL APPLICATION

As shown in Figure 5, the current path and must be kept as short & heavy as possibl -e. C1 is a filter decoupling circuit and should be as close as possible to VCC pin of XB53 32B.
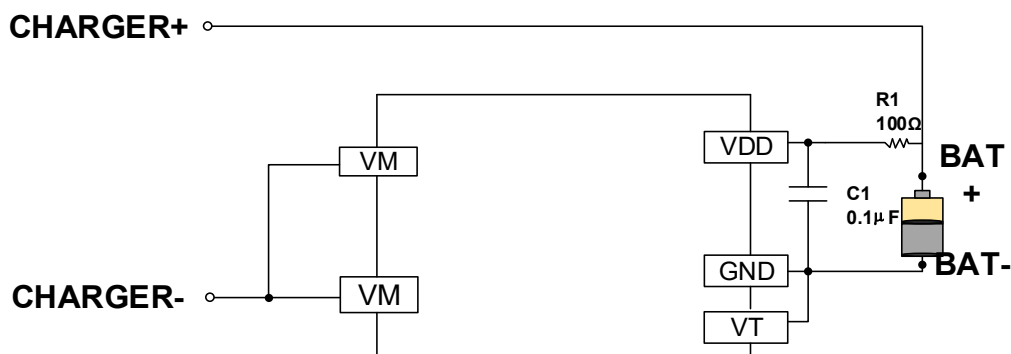

Figure 5 XB5332B in a Typical Battery Protection Circuit

| Symbol	Typ	Value range	Unit
C1	0.1	0.1~2.2	μF
R1	0.1	0.1~1	KΩ

Remark:
1.The above parameters may be changed without notice;
2.The schematic diagram and parameters of the IC are not used as the basis to ensure the operation of the circuit. Please conduct full measurement on the actual application circuit before setting the parameters.

Precautions

• Pay attention to the operating conditions for input/output voltage and load current so that the power loss in XB5332B does not exceed the power dissipation of the package.
• Do not apply an electrostatic discharge to this XB5332B that exceeds the performance ratings of the built-in electrostatic protection circuit.

PACKAGE OUTLINE(SOT23-5)
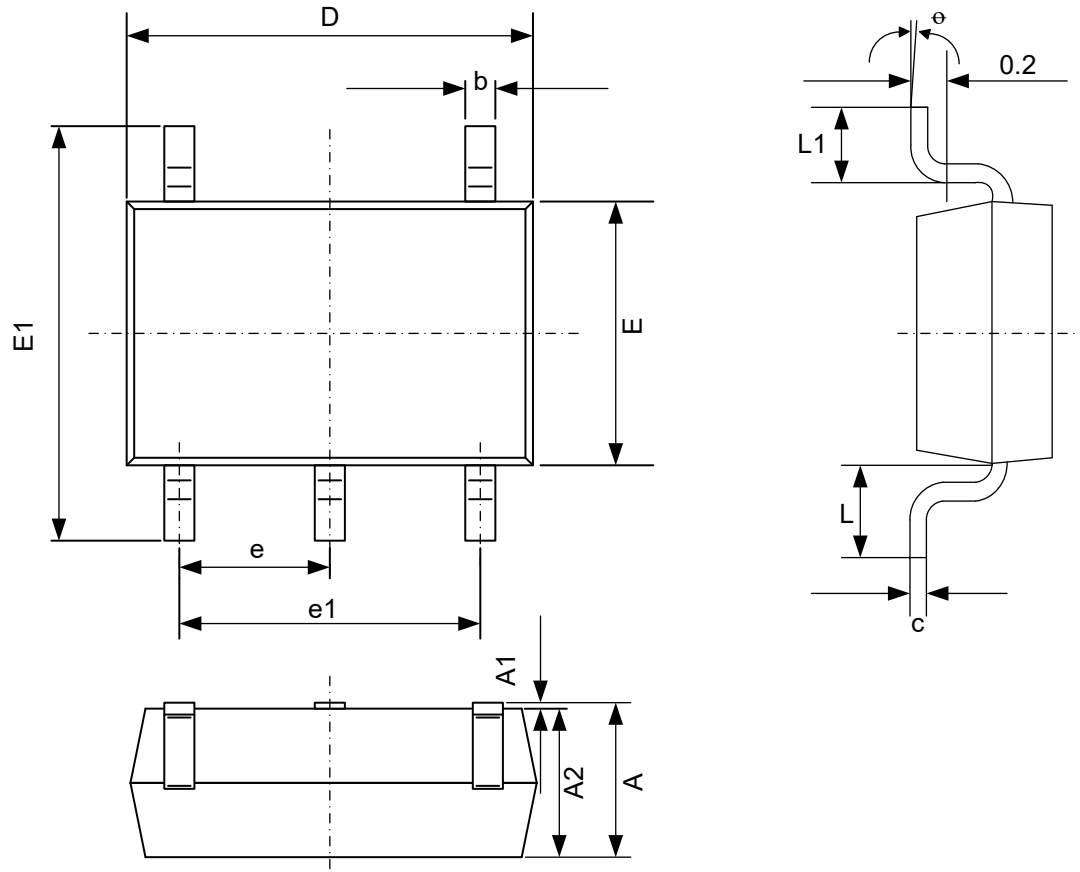
Symbol	Dimensions In Millimetres		Dimensions In Inches	
	Min	Max	Min	Max
A	0.950	1.250	0.038	0.049
A1	0.000	0.100	0.000	0.004
A2	0.900	1.150	0.036	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.700REF		0.037REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

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