# XB4908AJL

## One Cell Lithium-ion/Polymer Battery Protection IC

## GENERAL DESCRIPTION

The XB4908AJL product is a high integration solution for lithium-ion/polymer battery protection. XB4908AJL contains advanced power MOSFET, high-accuracy voltage detection circuits and delay circuits. XB4908AJL put into an ultra-small ESN4 package with simple components makes it an ideal solution in limited space of battery pack.

XB4908AJL has all the protection functions required in the battery application including overcharging, over-discharging, overcurrent and load short circuiting protection etc. The accurate overcharging detection voltage ensures 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 Connection
- Protection of Battery Cell Reverse Connection Without External load
- Integrated Advanced Power MOSFET with Equivalent of 15.5 mΩ $R_{SS(ON)}$
- Ultra-small ESN4 Package
- Only One External Capacitor Required
- Over-temperature Protection
- Overcharge Current Protection
- Two-step Overcurrent Detection
  - -Over-discharge Current
  - -Load Short Circuiting
- Low Current Consumption
  - -Operation Mode: 3.9μA typ.
  - -Power-down Mode:2.2μA typ.
- Charger Detection Function
- 0V Battery Charging Function
- Delay Times are generated inside
- High-accuracy Voltage Detection
- Over-Discharge Self-recovery
- RoHS Compliant and Lead (Pb) Free
- ESD HBM:2KV

## APPLICATIONS

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

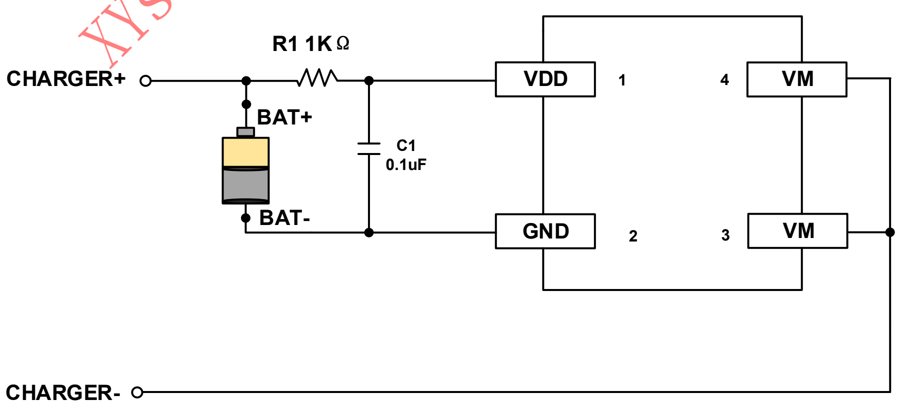


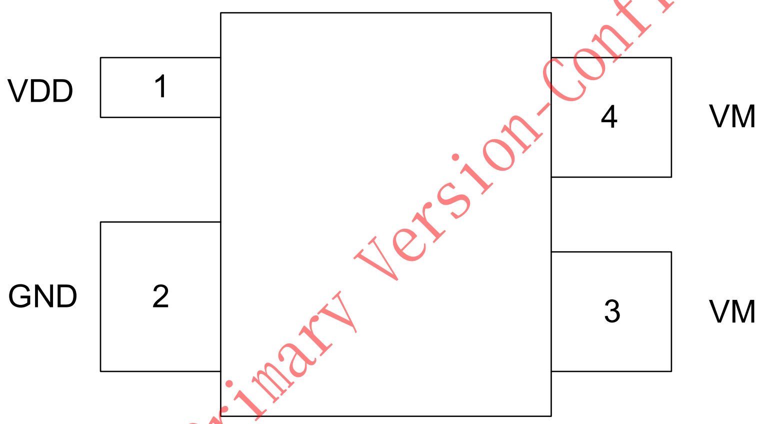

**Figure 1. Typical Application Circuit**

## ORDERING INFORMATION

| PART NUMBER | OCV [VCU] (V) | OCRV [VCL] (V) | ODV [VDL] (V) | ODRV [VDR] (V) | TOP MARK |
|---|---|---|---|---|---|
| XB4908AJL | 4.30±50mV | 4.10±50mV | 2.4±100mV | 3.0±100mV | YWXXX (note) |

Note: “YWXXX” is manufacture date code, “Y” means the year, “W” means the week.
“XXX” is internal product code of XySemi.

## PIN CONFIGURATION




TOP View

**Figure 2. PIN Configuration**



## PIN DESCRIPTION

| XB4908AJL PIN NUMBER | PIN NAME | PIN DESCRIPTION |
|---|---|---|
| 1 | VDD | Power Supply. |
| 2 | GND | Ground, connect the negative terminal of the battery to this pin. |
| 3,4 | VM | The negative terminal of the battery pack. The internal FET switch connects this terminal to GND Please Connect these pins with mass metal. |

## 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 RELIABILITY.)

| 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 | 150 | °C |
| Storage Temperature | -55 to 150 | °C |
| Lead Temperature ( Soldering, 10 sec) | 300 | °C |
| Power Dissipation at T=25°C | 0.3 | W |
| Package Thermal Resistance (Junction to Ambient) $\theta_{JA}$ | 150 | °C/W |
| Package Thermal Resistance (Junction to Case) $\theta_{JC}$ | 100 | °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 Voltage** | | | | | | |
| Discharge over-current release Voltage | VRIOV1 | | 300 | 500 | 700 | mV |
| **Detection Current** | | | | | | |
| Over-discharge Current Detection | *IIOV1 | VDD=3.6V | 5.5 | 7.5 | 9.5 | A |
| Overcharge Current Detection | *ICHOC | VDD=3.6V | 4. 0 | 6.0 | 8.0 | A |
| Load Short-Circuiting Detection | *ISHORT | VDD=3.6V | 20.0 | 40.0 | 60.0 | A |
| Current Consumption | | | | | | |
| Current Consumption in Normal Operation | IOPE | VDD=3.6V VM pin floating | | 3.9 | 6 | μA |
| Current Consumption in Power Down | IPD | VDD=2.0V VM pin floating | | 2.2 | 4 | μA |
| **VM Internal Resistance** | | | | | | |
| Internal Resistance between VM and VDD | *RVMD | VDD=3.6V VM=1.0V | 200 | 300 | 400 | kΩ |
| Internal Resistance between VM and GND | *RVMS | VDD=3.6V VM pin floating | 15 | 25 | 35 | kΩ |
| **FET on Resistance** | | | | | | |
| Equivalent FET on Resistance | *RSS(ON) | VDD=3.6V IVM =1.0A | | 15.5 | 18.5 | mΩ |
| **Over Temperature Protection** | | | | | | |
| Over Temperature Protection | *TSHD+ | | | 150 | | ˚C |
| Over Temperature Recovery Degree | *TSHD- | | | 110 | | ˚C |
| **Detection Delay Time** | | | | | | |
| Overcharge Voltage Detection Delay-Time | tCU | | 80 | 130 | 180 | mS |
| Over-discharge Voltage Detection Delay Time | tDL | | 20 | 40 | 60 | mS |
| Over-discharge Current1 Detection Delay Time | tIOV1 | VDD=3.6V | 5 | 10 | 20 | mS |
| Overcharge Current Detection Delay Time | *tCHOC | VDD=3.6V | 5 | 10 | 20 | mS |
| Load Short-Circuiting Detection Delay Time | *tSHORT | VDD=3.6V | 50 | 200 | 600 | μS |

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

## FUNCTIONAL BLOCK DIAGRAM

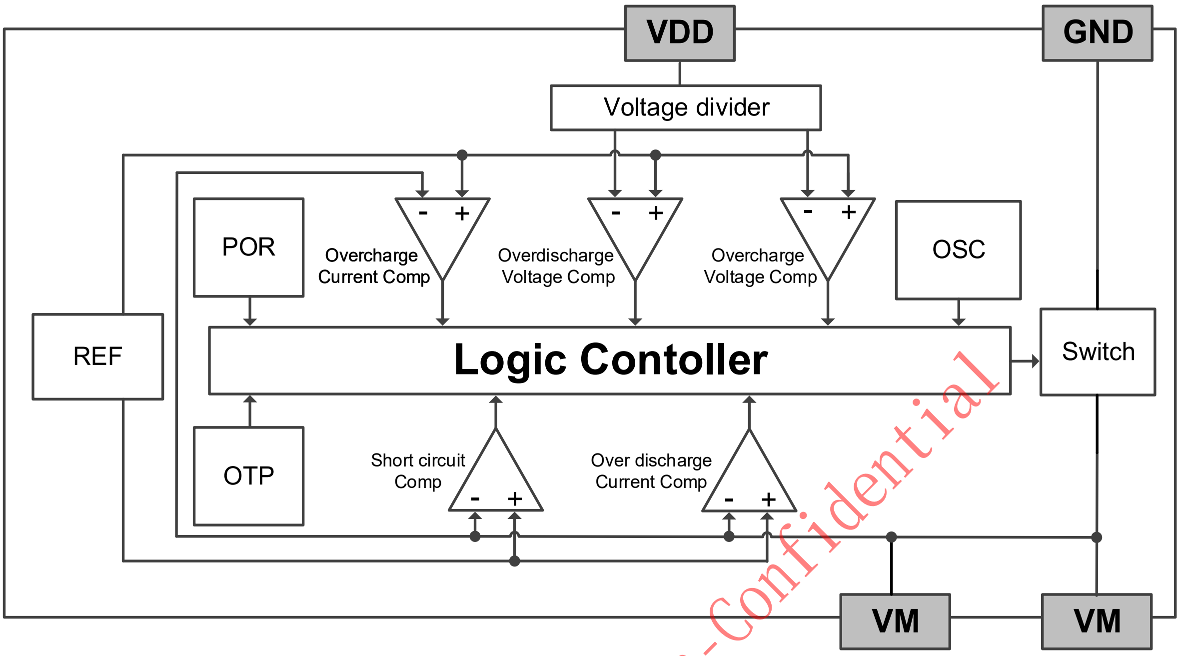



Figure 3. Functional Block Diagram



## FUNCTIONAL DESCRIPTION

The XB4908AJL monitors the voltage and current of a battery and protects it from being damaged due to overcharge voltage, over-discharge voltage, over-discharge 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 $R_{SS(ON)}$ is as low as 15.5 mΩ typical.

### Normal 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 ($V_{CU}$) during charging under normal condition and the state continues for the overcharge detection delay time ($t_{CU}$) or longer, the XB4908AJL 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 ($V_{CL}$), the XB4908AJL turns the charging control FET on and returns to the normal condition.
2. When a load is connected and discharging starts, the XB4908AJL 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 XB4908AJL 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 ($V_{CU}$), the XB4908AJL 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 b

elow 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 the overcharge detection voltage ($V_{CU}$) and the battery voltage does not drops below the overcharge detection voltage ($V_{CU}$) 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 ($V_{CU}$). Since an actual battery has, however, an 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.

## Over-discharge Condition

When the battery voltage drops below the over-discharge detection voltage ($V_{DL}$) during discharging under normal condition and it continues for the over-discharge detection delay time ($t_{DL}$) or longer, the XB4908AJL turns the discharging control FET off and stops discharging. This condition is called over-discharge condition. After the discharging control FET is turned off, the VM pin is pulled up by the $R_{VMD}$ resistor between VM and VDD in XB4908AJL. Meanwhile when VM is bigger than 1.5V (typ.) (the load short-circuiting detection voltage), the current of the chip is reduced to the power-down current ($I_{PDN}$). This condition is called power-down condition. The VM and VDD pins are shorted by the $R_{VMD}$ resistor in the IC under the over-discharge 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 over-discharge detection voltage (VDL) or higher (see note), the XB4908AJL turns the FET on and changes to the normal condition from the over-discharge condition.

**Remark**

If the VM pin voltage is no less than the charger detection voltage ($V_{CHA}$), when the battery under over-discharge condition is connected to a charger, the over-discharge condition is released (the discharging control FET is turned on) as usual, provided that the battery voltage reaches the over-discharge voltage ($V_{DL}$) 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 XB4908AJL 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 $R_{VMS}$ 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 re-coverable impedance. When the load is removed, the VM pin goes back to the GND potential since the VM pin is shorted the GND pin with the $R_{VMS}$ resistor. Detecting that the VM pin potential is lower than the overcurrent detection voltage ($V_{IOV}$), the IC returns 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 XB4908AJL 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 over-discharge condition, the XB4908AJL consequently turns the charging control FET off and stops charging after the battery voltage becomes the over-discharge 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 XB4908AJL 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 over-discharge current 2 and load short-circuiting starts when over-discharge current 1 is detected. As soon as over-discharge current 2 or load short-circuiting is detected over detection delay time for over-discharge current 2 or load short-circuiting, the XB4908AJL stops discharging. When battery voltage falls below over-discharge detection voltage due to over-discharge current, the XB4908AJL stop discharging by over-discharge current detection. In this case the recovery of battery voltage is so slow that if battery voltage after over-discharge voltage detection delay time is still lower than over-discharge detection voltage, the XB4908AJL 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 over-discharge release voltage ($V_{DR}$), 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.

### Discharge Over-current /Short Self-recovery

The recovery condition of short circuit/ discharge overcurrent is that the VM voltage is less than $V_{RIOV1}$.

# TIMING CHART

## 1. Overcharge and Over-discharge voltage detection

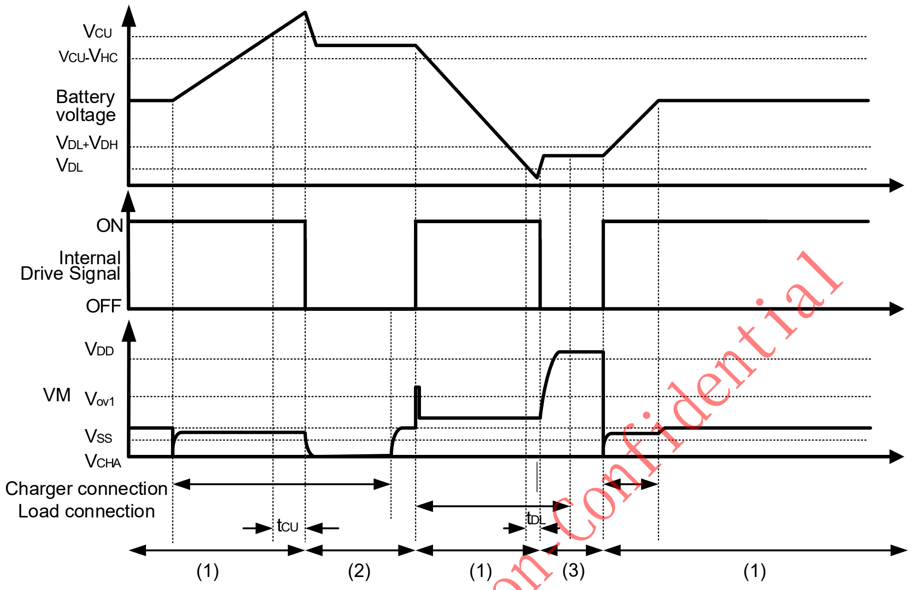



**Figure4-1 Overcharge and Over-discharge Voltage Detection**

Remark: (1) Normal condition (2) Overcharge voltage condition (3) Over-discharge voltage condition

## 2. Over-discharge Current and Load Short detection

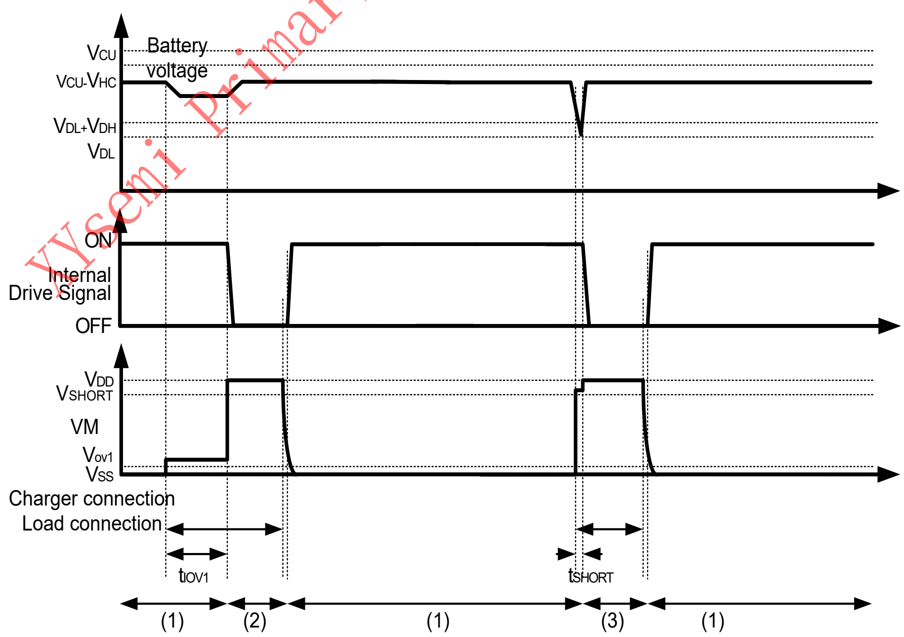



**Figure4-2 Over-discharge Current and Short Detection**

Remark: (1) Normal condition (2) Overcharge voltage condition (3) Over-discharge voltage condition

## 3. Abnormal Charger Detection

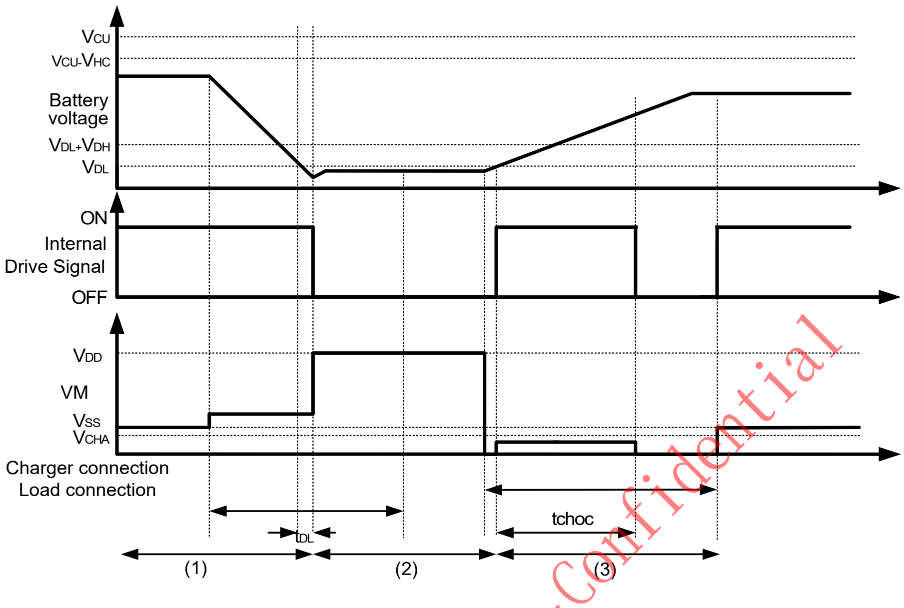



**Figure4-3 Abnormal Charger Detection**

Remark: (1) Normal condition (2) Over-discharge voltage condition (3) Overcharge voltage condition

# TYPICAL APPLICATION

As shown in Figure 5, the current path which must be kept as short as possible. For thermal management, ensure that these trace widths are adequate. C is a decoupling ca pacitor which should be placed as close as possible to XB4908AJL.

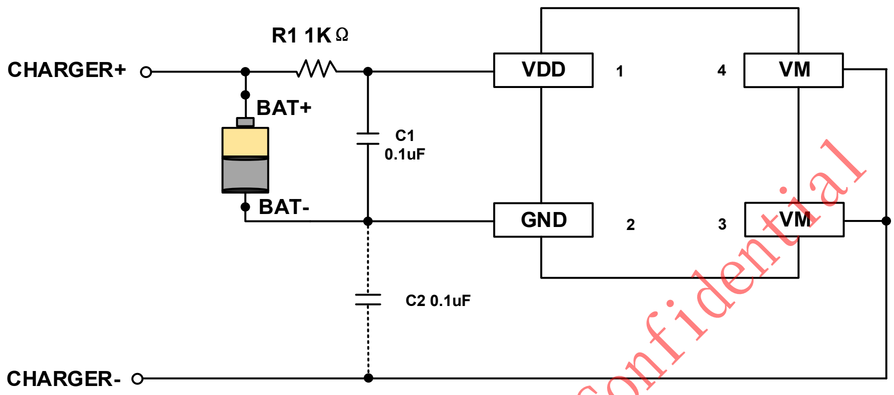



**Figure 5 XB4908AJL in a Typical Battery Protection Circuit**

| Symbol | Typ | Value range | Unit |
|---|---|---|---|
| C1 | 0.1 | 0.1~2.2 | μF |
| C2 | 0.1 | - | μF |
| R1 | 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.
3.If the resistance value is large , the overcharging voltage will be correspondingly larger by several mV.

## Precautions

• Pay attention to the operating conditions for input/output voltage and load current so that the power loss in XB4908AJL does not exceed the power dissipation of the package.
• Do not apply an electrostatic discharge to this XB4908AJL that exceeds the performance ratings of the built-in electrostatic protection circuit.

# APPLIED MEASUREMENT METHOD

## (1).Overcharge characteristic test method:

a. According to the figure6-1, connect the power supply DC1 to the B + and GND pins of the system board and set the voltage to about 3.6V. Connect the power supply from GND to VM to DC2 power supply and set 100mV current limiting 10mA. Observe the waveform.

b. Adjust the power supply voltage V1 and increase it by 0.001V until the output level of VM pin changes from 0 to negative (-100mV). Record the overcharge protection voltage and measure the protection delay.

c. Adjust the power supply voltage V1 to decrease by 0.001V until the output voltage of VM pin is recovered from negative (-100mV) to 0 level, and record the overcharge recovery voltage.

## (2).Over discharge characteristic test method:

a. According to the figure6-2, connect the power supply DC1 to the B + and GND pins of the system board and set the voltage to about 3.6V. Connect the DC2 power supply from VM to GND, set the 100mV current limiting 10mA, and observe the waveform.

b. Adjust the power supply voltage V1 and decrease it by 0.001V until the output level of VM pin changes from 0 to positive (100mV). Record the over-discharge protection voltage and measure the protection delay.

c. Adjust the power supply voltage V1 to increase by 0.001 V until the output voltage of VM pin is restored from positive (100 mV) to 0 level, and record the over-discharge recovery voltage.

## (3).Discharge over current test method:

a. According to the figure6-3, connect the DC1 power supply to the B + and GND pins of the system board and set the voltage to about 3.0V/3.6V/4.2V. Connect the electronic load from B + to VM and observe the waveform.

b. Adjust the electronic load increase it by 1mA step, detect that the current from B + to VM is turned off and meet the delay standard (about 10ms), and record the discharge delay time.

## (4).Charging over current test method:

a. According to the figure6-4, connect the DC1 power supply to the B + and GND pins of the system board and set the voltage to about 3.0V/3.6V/4.2V, and load DC2 power supply from GND to VM.

b. Adjust the current limiting value of DC2 power supply to increase by 1mA step, detect that the current from GND to VM is turned off and meet the delay standard (about 10ms), and record the charging over-current delay time.

## (5).Iq test method:

a. As shown in the figure6-5, connect the positive pole of DC1 to B +, and the negative pole to GND, and set the voltage to 3.6V;

b. VM grounding, record the current passing through DC1 (Iq).

## (6).Isd test method:

a. As shown in the figure6-6, connect the positive pole of DC1 to B + and the negative pole to GND, and set the voltage to 2V;

b. VM is suspended and the current passing through DC1 is recorded as Isd.

## SCHEMATIC DIAGRAM OF TEST METHOD

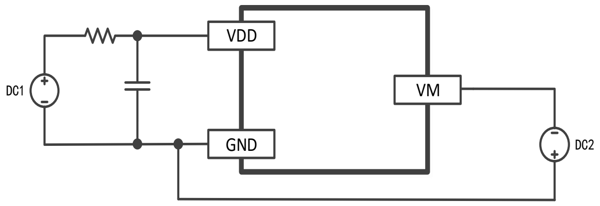



Figure6-1

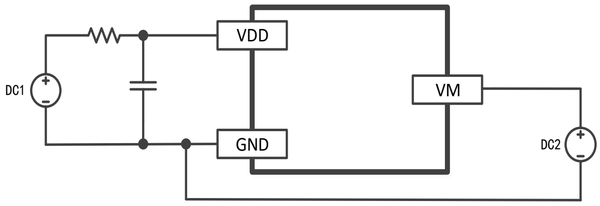



Figure6-2

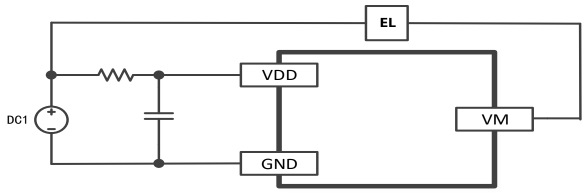



Figure6-3

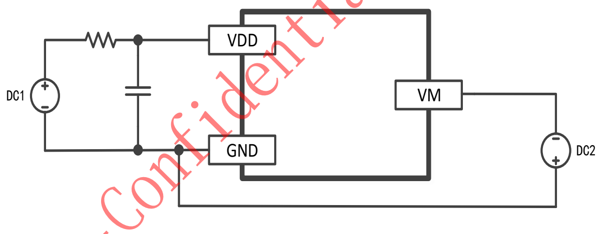



Figure6-4

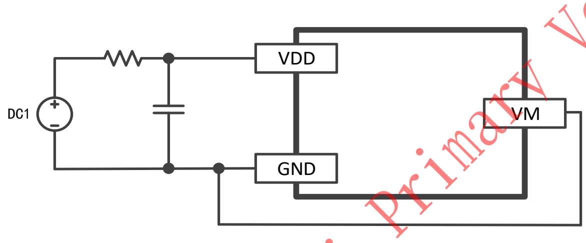



Figure6-5

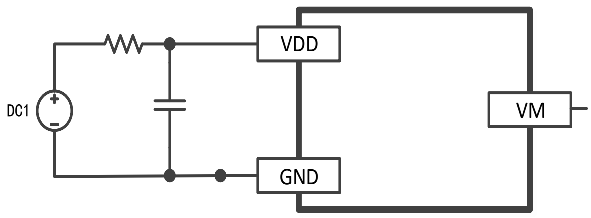
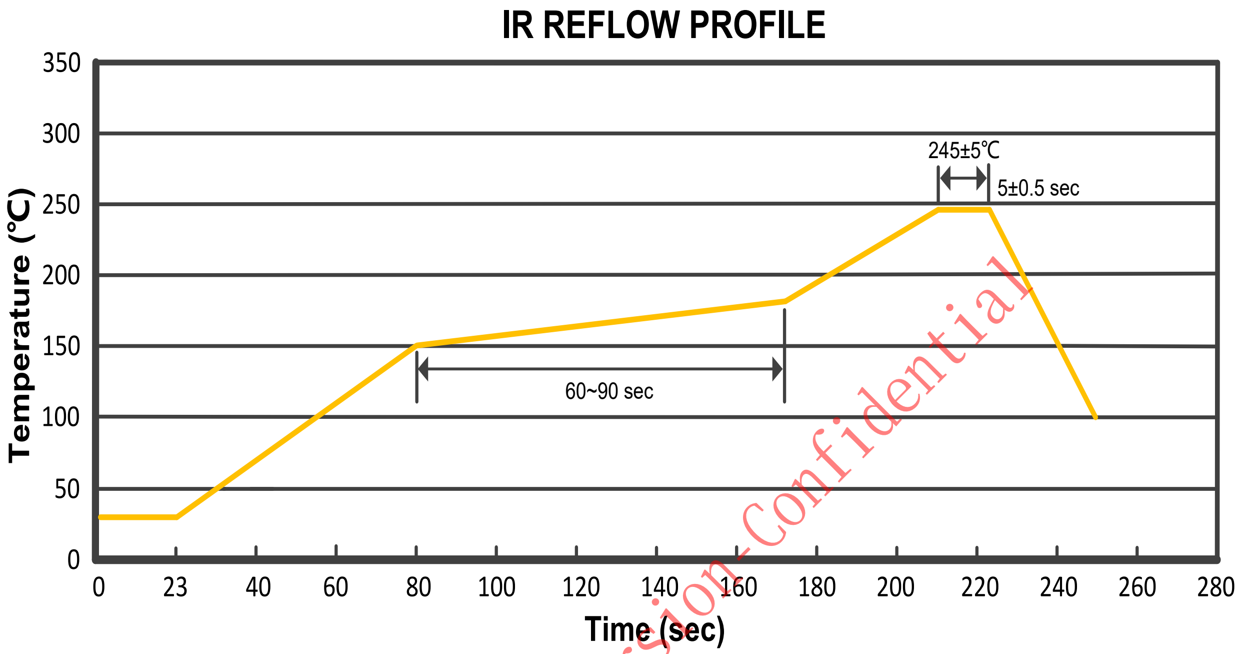



Figure6-6

## Solderability Curve of Lead-Free Reflow Soldering (applicable to SMT tube)

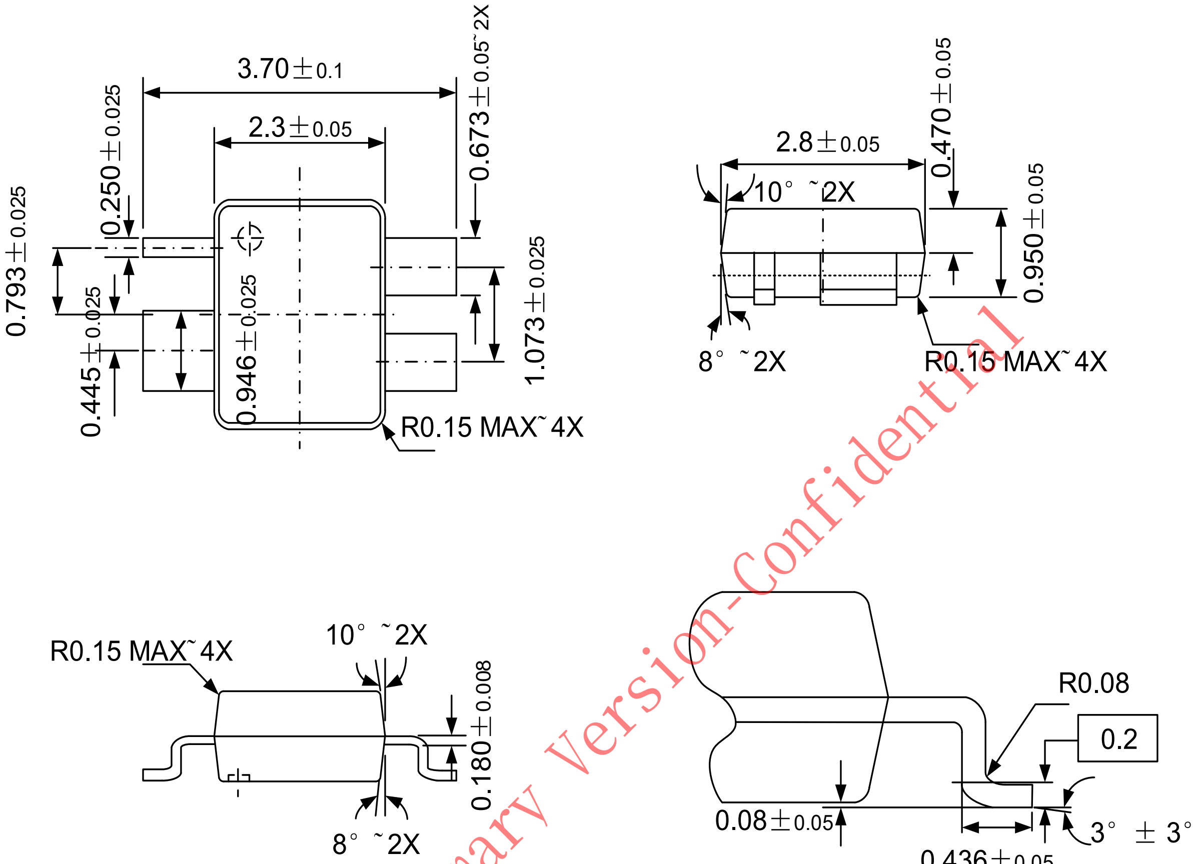



Explain:
1.Preheating temperature 25~150℃, duration 60~90sec;
2.Peak temperature 245 ± 5 ℃, duration 5 ± 0.5sec;
3.Cooling rate of welding process is 2~10℃/sec.

### Resistance to welding heat conditions

Temperature: 270±5℃; Time:10±1sec

## PACKAGE OUTLINE(ESN4)



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