

DESCRIPTION

The MP2674 is a high-performance single cell Li-Ion/Li-Polymer battery charger protection circuit. By integrating high voltage input protection into the IC, the MP2674 can tolerate an input surge up to +30V.

The device features input over voltage protection (OVP), battery over voltage protection (BOVP) and over charge current protection (OCP). The device also provides fault indications to the system when any of the protection events happens.

For guaranteed safe operation, the MP2674 monitors its own internal temperature and turns off the MOSFET bridging VIN and OUT when the die temperature exceeds 150°C.

The MP2674 is available in an 8-pin 2mmx2mm QFN package.

FEATURES

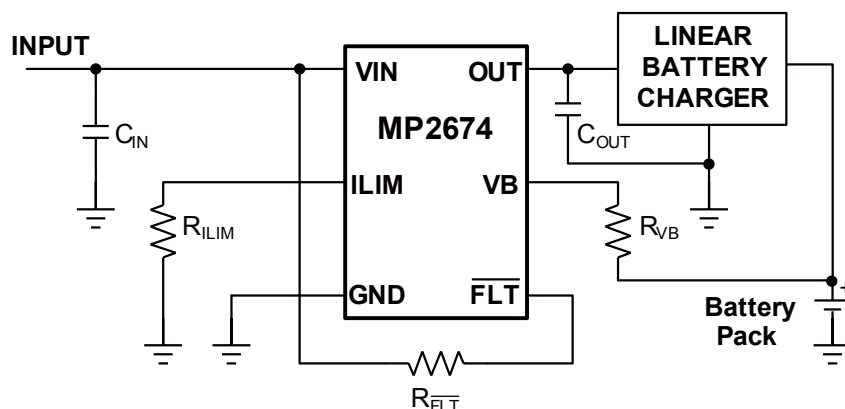
- Input Surge up to 30V
- Input Over voltage protection in 1µs.
- Proprietary Battery Over-Voltage Protection
- Programmable Charge Current Protection Limit Value.
- Temperature Monitoring and Protection
- Fault Indication
- 2mmx2mm QFN Package

APPLICATIONS

- Cell Phones
- MP3 Players
- Smart Phones
- PDA
- Digital Cameras
- Desktop Chargers

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TYPICAL APPLICATION



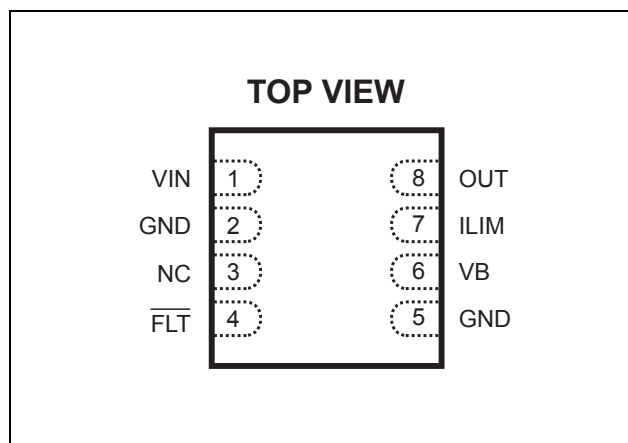
ORDERING INFORMATION

Part Number*	Package	Top Marking	Free Air Temperature (T _A)
MP2674EG	QFN8 (2mm x 2mm)	2Q	-20°C to +85°C

*For Tape & Reel, add suffix -Z (e.g. MP2674EG-Z):

For RoHS compliant packaging, add suffix -LF (e.g. MP2674EG-LF-Z).

PACKAGE REFERENCE



ABSOLUTE MAXIMUM RATINGS ⁽¹⁾

V _{IN} to GND.....	-0.3V to 30V
OUT and VB to GND.....	-0.3V to 7V
Other Pins (ILIM, FLT).....	-0.3V to 5.5V
Continuous Power Dissipation...(T _A = +25°C) ⁽²⁾	1.25W
Junction Temperature.....	150°C
Lead Temperature (Solder).....	260°C
Storage Temperature.....	-65°C to +150°C

Recommended Operating Conditions ⁽³⁾

Supply Voltage V _{IN}	4.3V to 5.5V
Operating Current Range.....	0A to 1.5A
Operating Junct. Temp (T _J).....	-20°C to +125°C

Thermal Resistance ⁽⁴⁾	θ_{JA}	θ_{JC}
QFN8 (2mm x 2mm).....	100	55... °C/W

Notes:

- Exceeding these ratings may damage the device.
- The maximum allowable power dissipation is a function of the maximum junction temperature T_J (MAX), the junction-to-ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D (MAX) = (T_J (MAX)-T_A)/θ_{JA}. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
- The device is not guaranteed to function outside of its operating conditions.
- Measured on JESD51-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

$V_{IN} = 5V$, $T_A = +25^{\circ}C$, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
Power-On Reset						
Rising VIN Threshold	V _{POR}		2.35	2.43	2.50	V
POR Hysteresis				110		mV
VIN Bias Current	I _{VIN}	When enabled		0.6		mA
		When disabled		25		μA
Protection						
Input Over-voltage Protection (OVP)	V _{OVP}		5.6	5.80	6.0	V
Input OVP Hysteresis				50		mV
Input OVP Falling Threshold			5.45			V
Input OVP Propagation Delay					1	μs
Over-current Protection	I _{OCP}	V _{VB} = 3V, R _{ILIM} = 25kΩ	0.78	0.90	1.10	A
Overcurrent Protection Blanking Time	BT _{OCP}			170		μs
Battery Over-voltage Protection Threshold	V _{BOVP}		4.29	4.37	4.475	V
Battery OVP Threshold Hysteresis				55		mV
Battery OVP Falling Threshold			4.225			V
Battery OVP Blanking Time	BT _{BOVP}			180		μs
VB Pin Leakage Current		V _{VB} = 4.34V			20	nA
Over Temperature Protection Rising Threshold				150		°C
Over Temperature Protection Falling Threshold				110		°C
Logic						
FLT [−] Output Logic Low		Sink 5mA current		0.25	0.8	V
FLT [−] Parasitic Series Resistor				60		Ω
FLT [−] Output Logic High Leakage Current					1.5	μA
Power MOSFET						
On Resistance	R _{DS(ON)}	Measured at 200mA,		200	300	mΩ

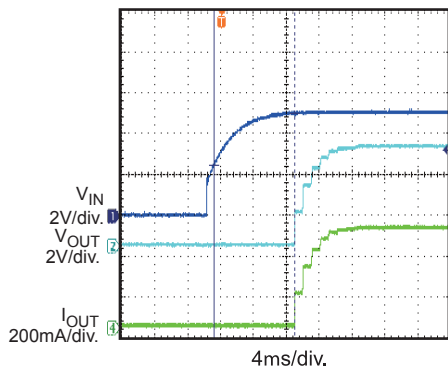
PIN FUNCTIONS

8-pin QFN	Name	Description
1	VIN	Input Power Source. VIN can withstand 30V input.
2, 5	GND	System Ground.
3	NC	No Connect. Keep it floating.
4	$\overline{\text{FLT}}$	Open-Drain Logic Output. This pin turns LOW when any protection event occurs. Connect a pull-up resistor to VIN pin. Higher than 10k Ω is recommended.
6	VB	Battery Voltage Monitoring Input. Connect this pin to the battery pack positive terminal via an isolation resistor.
7	ILIM	Over-current Protection Threshold Setting. Connect a resistor between this pin and GND to set the OCP threshold.
8	OUT	Output pin and input pin of the protected charger.

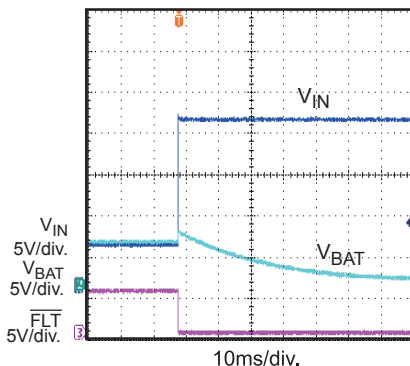
TYPICAL PERFORMANCE CHARACTERISTICS

$V_{IN}=5V$, $R_{ILIM}=24.9k\Omega$, $R_{VB}=200k\Omega$, $R_{FLT}=100k\Omega$, $T_A=25^\circ C$, unless otherwise noted.

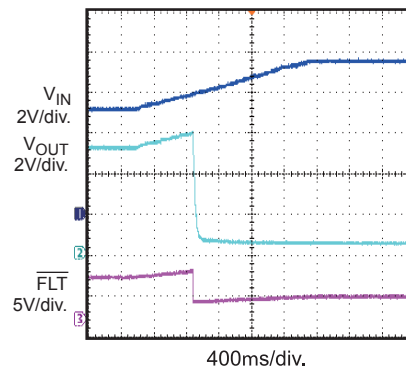
Power Up through V_{IN}
10 Ω Load



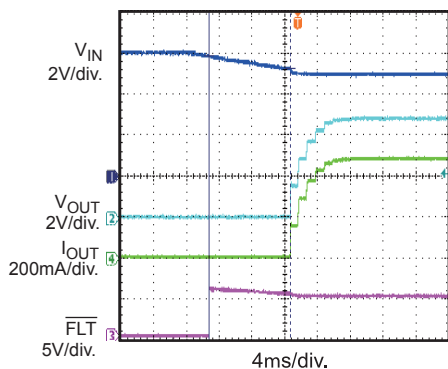
Input OVP
 V_{IN} Steps from 5V to 20V
without Load



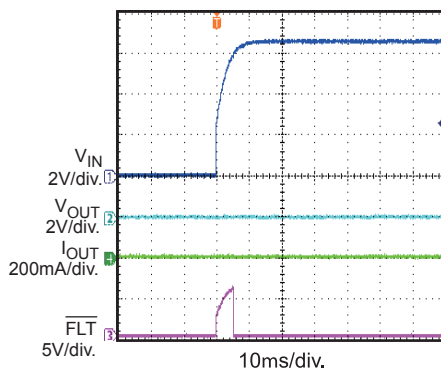
Input OVP
Ramp Up V_{IN} Slowly
without Load



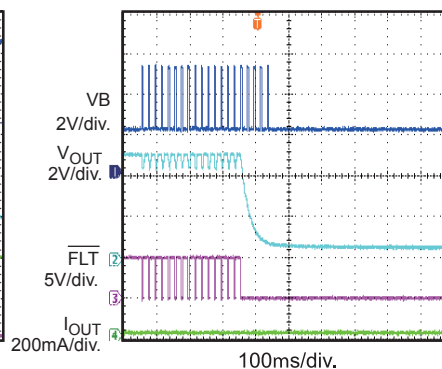
Input OVP Removal
Ramp Down V_{IN} Slowly with 10 Ω Load



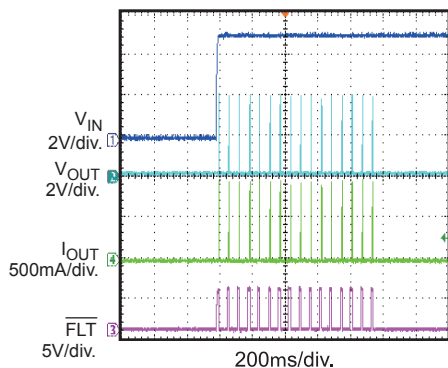
Input OVP Start Up
Ramp Up V_{IN} Slowly from 0V to 6.6V
without Load



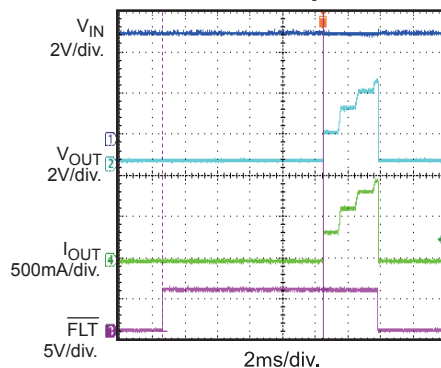
Battery OVP
No Load, Shut Dwon Permanently
after 16 Times



OCP Before Start Up
Shut Dwon Permanently after 16 Times

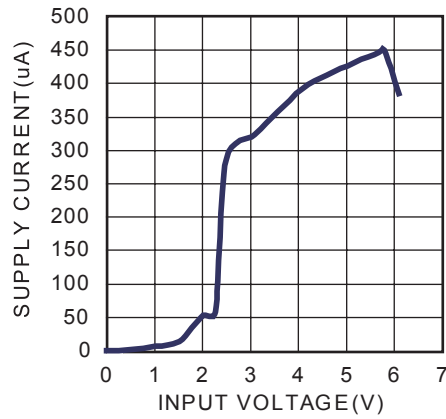
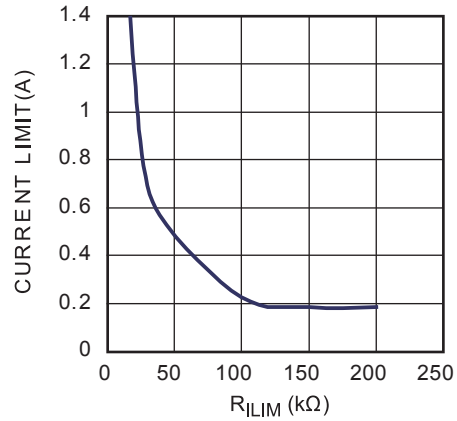


**Zoom In of OCP
Before Start Up**



TYPICAL PERFORMANCE CHARACTERISTICS *(Continued)*

$V_{IN}=5V$, $R_{ILIM}=24.9k\Omega$, $R_{VB}=200k\Omega$, $R_{FLT}=100k\Omega$, $T_A=25^\circ C$, unless otherwise noted.

Supply Current vs. V_{IN} **Limit Current vs. R_{ILIM}** 

The schematic diagram illustrates a linear battery charger with an integrated protection circuit. The system is divided into two main sections: a protection circuit (enclosed in a dashed box) and the battery charger itself.

Protection Circuit (Dashed Box):

- Input:** The circuit starts with an **INPUT** terminal connected to V_{IN} .
- Reference and Logic:** A voltage divider consisting of resistors $R1$ and $R2$ is connected to V_{IN} . The midpoint of this divider is connected to the non-inverting input (+) of comparator **CP1**. The inverting input (-) of **CP1** is connected to a **1.2V** reference voltage. The output of **CP1** is connected to the **POR PRE-REG REF** block and the **LOGIC** block.
- Logic and Drivers:** The **LOGIC** block is a central control unit. It receives inputs from **CP1**, the **POR PRE-REG REF** block, and the **FLT** (fault) signal. It provides control signals to the **FET DRIVER** and comparator **CP3**.
- FET Driver and Transistors:** The **FET DRIVER** block controls two MOSFETs, **Q1** and **Q2**. **Q1** is a PMOS transistor with its source connected to V_{IN} and its gate controlled by the **FET DRIVER**. **Q2** is an NMOS transistor with its source connected to ground and its gate controlled by the **FET DRIVER**. The drain of **Q2** is connected to the gate of **Q1**.
- Current Limiting:** The output of the **Q1**/**Q2** pair is connected to the non-inverting input (+) of comparator **CP2**. The inverting input (-) of **CP2** is connected to the output of **CP3**. The output of **CP2** is connected to the **EA** (Error Amplifier) block. The output of the **EA** is connected to the gate of MOSFET **Q3**. The source of **Q3** is connected to ground, and its drain is connected to the output of the protection circuit, labeled **ILIM**.
- Output and Feedback:** The **ILIM** signal is connected to a resistor R_{ILIM} and then to ground. The output of the protection circuit is also connected to the **OUT** terminal of the **LINEAR BATTERY CHARGER** block. The **OUT** terminal is connected to the positive terminal of the battery being charged. The negative terminal of the battery is connected to ground. A feedback resistor R_{VB} is connected between the battery's positive terminal and the **VB** (Voltage Feedback) input of the **LINEAR BATTERY CHARGER** block.

External Components:

- LINEAR BATTERY CHARGER:** A block representing the main charging circuit, which receives V_{IN} and provides the **OUT** terminal.
- FLT (Fault):** A fault signal input to the **LOGIC** block.
- GND:** Ground connection points for the **FLT** signal, the **EA** output, the R_{ILIM} resistor, and the battery's negative terminal.

Figure 1—Function Block Diagram

OPERATION

The MP2674 is designed to provide a redundant safety protection to a Li-Ion battery from failures of the charging system. The IC continuously monitors the input voltage, the battery voltage, and the charge current. When any of the above three parameters exceeds its limit, the IC turns off an internal N-channel MOSFET to remove the power from the charging system. The threshold of charge current protection is user-programmable. Additionally, the IC also monitors its own die temperature and turns off the N-channel MOSFET if the temperature exceeds 150°C. Together with the battery charging IC and the protection module in a battery pack, the charging system has triple-level protection from over-charging the Li-Ion battery and is two-fault tolerant. The MP2674 protects up to 30V input voltage.

Power Up

The MP2674 has a power-on reset (POR) threshold of 2.43V with a built-in hysteresis of 110mV. When the input voltage is below the POR threshold, the internal power FET is off. The IC resets itself and waits for approximately 10ms after the input voltage exceeds the POR threshold, then, if the input voltage and battery voltage are safe, the IC begins to soft-start the internal power FET. The 10ms delay allows any transient at the input during a hot insertion of the power supply to settle down before the IC starts to operate. The soft-start slowly turns on the power FET to reduce the inrush current as well as the input voltage drop during the transition.

Input Over-voltage Protection (OVP)

The input voltage is continuously monitored by the comparator CP1 in the Block Diagram (Figure 1). The OVP threshold is set by a resistive divider consisting of R1 and R2 and an accurate reference generated by the IC itself. The protection threshold is set to 5.8V. When the input voltage exceeds the threshold, the CP1 outputs a logic signal to turn off the power FET within 1μs to prevent the high input voltage from damaging the electronics in the handheld system. The hysteresis for the input OVP threshold is given in the Electrical Specification.

When the input over-voltage condition is removed, the power FET is turned on again by running through the soft-start. Because of the 10ms second delay before the soft-start, the output is never enabled if the input rises above the OVP threshold quickly.

Over-current Protection (OCP)

The current in the power FET is limited to prevent charging the battery with an excessive current. The current is sensed using the voltage drop across the power FET after the FET is turned on. The reference of the OCP is generated using a sensing FET Q2, as shown in Figure 1. The current in the sensing FET is forced to a value which can be programmed by an external resistor connected to the ILIM pin. The size of the power FET Q1 is 31,250 times the size of the sensing FET Q2. Therefore, when the current in the power FET is 31,250 times the current in the sensing FET, the drain voltage of the power FET falls below that of the sensing FET. The comparator CP2 then outputs a signal to turn off the power FET. The OCP threshold can be programmed using the following formula:

$$I_{LIM} = \frac{0.8V}{R_{ILIM}} \cdot 31250 = \frac{25000}{R_{ILIM}}$$

The OCP comparator CP2 has a built-in 170μs delay to prevent false triggering by transient signals. When OCP happened, Vo shuts down for about 40ms and take 10ms delay to soft start as the OCP condition is removed. The OCP function also has a 4-bit binary counter that accumulates during an OCP event. When the total count reaches 16, the power PFET is turned off permanently unless the input power is recycled.

Battery Over-voltage Protection (BOVP)

The battery voltage OVP threshold is internally set to 4.37V. The threshold has 55mV built-in hysteresis. The comparator CP3, as shown in Figure 1, monitors the VB pin and issues an over-voltage signal to turn off the internal power FET when the battery voltage exceeds the battery OVP threshold. The comparator CP3 has a built-in 180μs blanking time to prevent any transient voltage from triggering the OVP. If the OVP situation still exists after the blanking

time, the power FET is turned off. There is an internal 4-bit binary counter monitoring the occurrence of the battery over-voltage event. If the battery over-voltage occurs 16 times, the power FET is turned off permanently. Recycling the input power will reset the counter and restart the MP2674.

The resistor between the VB pin and the battery, R_{VB} , as shown in the Typical Applications circuit, is an important component. This resistor provides a current limit in case the VB pin is shorted to the input voltage under a failure mode. The VB pin leakage current under normal operation is negligible to allow a resistance of 200k Ω to 1M Ω being used.

Thermal Protection

The MP2674 monitors its own die temperature to prevent thermal failures. When the internal temperature reaches 150°C, the internal N-channel power MOSFET is turned off. The IC does not resume operation until the internal temperature drops below 110°C.

Warning Indication Output

The $\overline{\text{FLT}}$ pin is an open-drain output that indicates a LOW signal when any of the four protection events happens.

1. Input over voltage
2. Battery over voltage
3. Output over current
4. Thermal protection

To pull the $\overline{\text{FLT}}$ pin voltage low when fault, a recommended 10k Ω to 200k Ω resistor should be used as the pull up resistor.

APPLICATION INFORMATION

For safe and effective charging, some strict requirements have to be satisfied during charging Li-Ion batteries such as high precise power source for charging ($4.2V \pm 50mV$), the accuracy should be higher than 1%. For highly used capacity, the voltage of the battery should be charged to the value (4.2V) as possible as could. Otherwise, the performance and the life of the battery suffers overcharge. Additionally, the pre-charge for depleted batteries, charging voltage, charging current, as well as the temperature detection and protection, are required for linear battery chargers. The output of most MPS linear chargers has a typical I-V curve and provides overcharge, input over voltage, over temperature protection. The function of the MP2674 is to add a redundant protection layer such that, under any fault condition, the charging system output does not exceed the I-V limits that the battery required. Additionally, MP2674 provides full protection for these chargers whose protection function is not so complete especially those without input surge voltage sustain. MP2674 guarantees the safety of the charge system with its perfect 4 protection functions: OVP, BOVP, OCP and OTP

The MP2674 is a simple device that requires few external components, in addition to the linear charger circuit as shown in the Typical Application Circuit. The selection of MP2674's external components is shown as follow, and the selection of the current limit resistor R_{ILIM} has been introduced in the Over-current Protection section.

C_{IN} and C_{OUT} Selection

The input capacitor (C_{IN}) is for decoupling. Higher value of C_{IN} reduces the voltage drop or the over shoot during transients. The AC adapter is inserted live (hot insertion) and sudden step down of the current in the power FET will cause the input voltage overshoot.

During an input OVP, the FET is turned off in less than $1\mu s$ and can lead to significant over shoot. Higher capacitance of C_{IN} reduces this type of over shoot. However, the over shoot caused by a hot insertion is not very dependent on the decoupling capacitance value. Usually,

the input decoupling capacitor is recommended to use a dielectric ceramic capacitor with a value between $1\mu F$ to $4.7\mu F$.

The output of the MP2674 and the input of the charging circuit typically share one decoupling capacitor. The selection of that capacitor is mainly determined by the requirement of the charging circuit. When using the MP2602 family chargers, a $1\mu F$ to $4.7\mu F$ ceramic capacitor is recommended.

R_{VB} Selection

R_{VB} limits the current from the VB pin to the battery terminal in case the MP2674 fails. The recommended value is between $200k\Omega$ to $1M\Omega$. With $200k\Omega$ resistance, during the failure operation, assuming the VB pin voltage is 30V and the battery voltage is 4.2V. The worst case the current flowing from the VB pin to the charger output is,

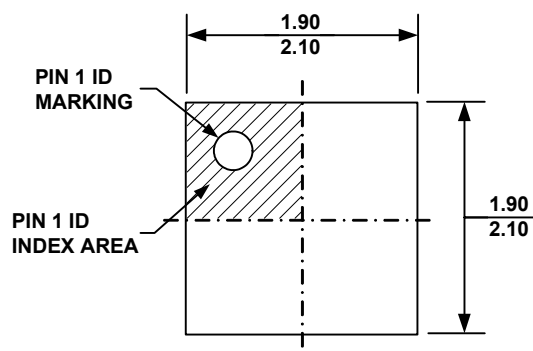
$$(30V - 4.2V)/200k\Omega = 130\mu A,$$

Such small current can be easily absorbed by the bias current of other components. Increasing the R_{VB} value reduces the worst case current, but at the same time increases the error for the 4.37V battery OVP threshold.

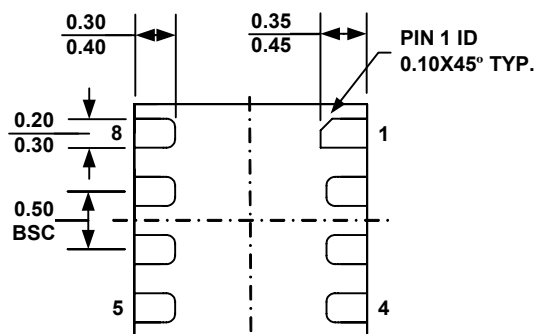
As the typical VB pin leakage current is 20nA, the error of the battery OVP threshold can be calculated as $4.37V + 20nA \times R_{VB}$. With the $200k\Omega$ resistor, the worst-case additional error is 4mV and with a $1M\Omega$ resistor, the worst-case additional error is 20mV.

PACKAGE INFORMATION

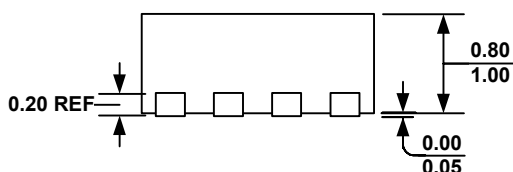
QFN8 (2mmx2mm)



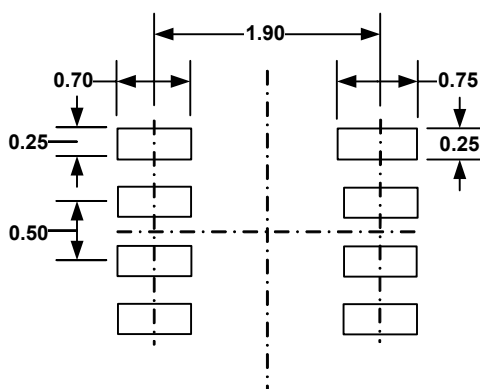
TOP VIEW



BOTTOM VIEW



SIDE VIEW



RECOMMENDED LAND PATTERN

NOTE:

- 1) ALL DIMENSIONS ARE IN MILLIMETERS.
- 2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
- 3) LEAD COPLANARITY SHALL BE 0.10 MILLIMETER MAX.
- 4) JEDEC REFERENCE IS MO-220, VARIATION VCCD.
- 5) DRAWING IS NOT TO SCALE.

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