GENERAL DESCRIPTION

The PT4101 is a step-up DC/DC converter designed for driving up to 8 white LEDs in series from a single cell Lithium Ion battery with constant current. Because it directly regulates output current, the PT4101 is ideal for driving light emitting diodes (LEDs) whose light intensity is proportional to the current passing through them, not the voltage across their terminals. A single external resistor sets LED current between 5mA and 20mA, which can then be easily adjusted using either a DC voltage or a pulse width modulated (PWM) signal. Its low 104mV feedback voltage reduces power loss and improves efficiency. The OV pin monitors the output voltage and turns off the converter if an over-voltage condition is present due to an open circuit condition. The PT4101 is available in SOT23-6 and QFN8 packages.

FEATURES

- Drives Up to 5 Series White LEDs from 2.5V
- Drives Up to 8 Series White LEDs from 3.6V
- Up to 87% Efficiency
- 1.2MHz Fixed Switching Frequency
- Low 104mV Feedback Voltage
- Open Load Shutdown
- Soft Start/PWM Dimming
- SOT23-6 and QFN-8 Packages

APPLICATIONS

- Cell Phones
- Handheld Computers and PDAs
- Digital Cameras
- Small LCD Displays

TYPICAL APPLICATIONS

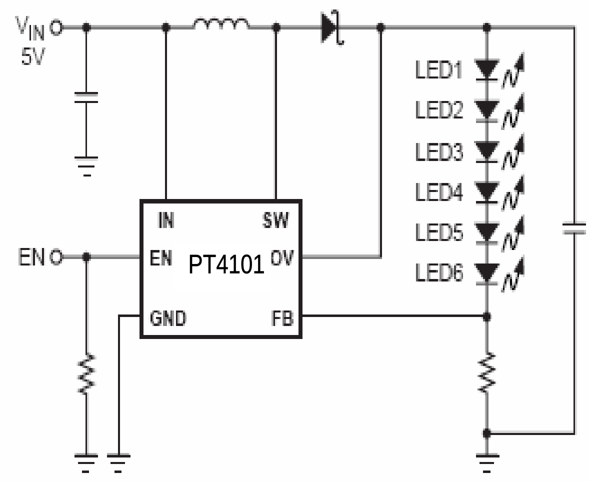


Figure 1. Li-Ion Driver for Six White LEDs

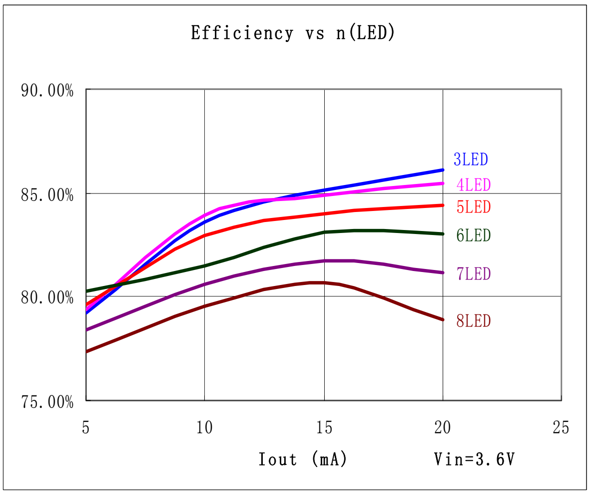
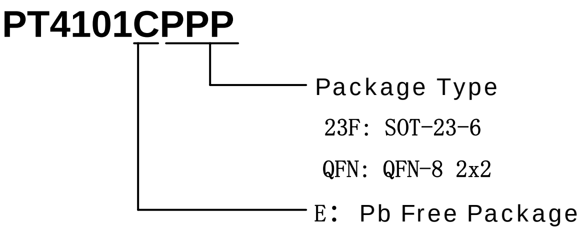
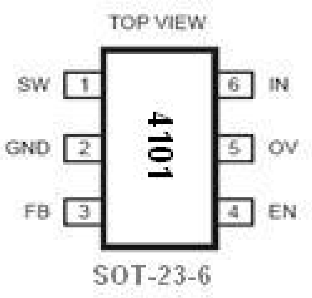


Figure 2. Efficiency vs Number of LEDs

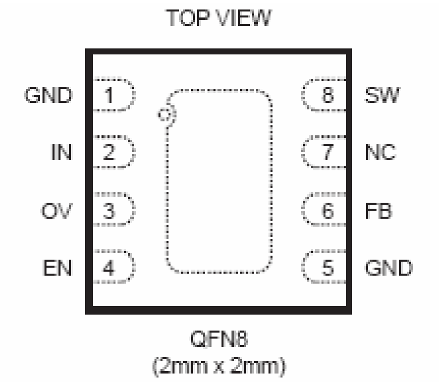
ORDERING INFORMATION



PACKAGES



Note: Pin 1 at the bottom-left corner of the digit "4"



PIN DESCRIPTION

SOT Pin No.	QFN Pin No.	Pin Names	Description
1	8	SW	Power Switch Output. Connect the inductor and the blocking Schottky diode to SW.
2	1,5	GND	Ground
3	6	FB	Feedback input pin. The reference voltage at this pin is 104mV. Connect the cathode of the lowest LED to FB and a current sense resistor between FB and GND.
4	4	EN	Enable pin. A high input at EN enables the device and a low input disables the devices. When not used, connect EN to the input source for automatic startup.
5	3	OV	Over Voltage Input. OV measures the output voltage for open circuit protection. Connect OV to the output at the top of the LED string.
6	2	IN	Input Supply Pin. Must be locally bypassed.
	7	NC	Not Connected

ABSOLUTE MAXIMUM RATINGS (Note 1)

SYMBOL	ITEMS	VALUE	UNIT
V_{IN}	Input Voltage	-0.3～6	V
V_{SW}	Voltage at SW Pin	-0.5～35	V
V_{IO}	All Other I/O Pins	GND-0.3 to VDD+0.3	V
P_{TR1}	Thermal Resistance，SOT-23-6 Θ_{JA} Θ_{JC}	 220 110	℃/W
P_{TR2}	Thermal Resistance，QFN-8 (2mm x 2mm) Θ_{JA} Θ_{JC}	 80 16	℃/W
Tstg	Storage Temperature	-55 to 150	℃
Tsolder	Package Lead Soldering Temperature	260℃, 10s	

RECOMMANDED OPERATING RANGE (Note 2)

SYMBOL	ITEMS	VALUE	UNIT
V_{IN}	V_{IN} Supply Voltage	2.5 to +6	V
V_{SW}	Output Voltage	V_{IN} to 28	V
T_{OPT}	Operating Temperature	-40 to +85	℃

ELECTRICAL CHARACTERISTICS

V_{IN}=V_{EN}=3V, Topt=25℃ unless specified otherwise.

SYMBOL	ITEMS	CONDITIONS	Min.	Typ.	Max.	UNIT
V_{IN}	Input Voltage		2. 5		6	V
Feedback						
V_{FB}	FB Pin Voltage	Driving 4xLED @15mA	94	104	114	mV
Ibias	FB Pin Input Bias Current			0. 05	1	μA
Operating Current						
Ioff	Operating Current（Shutdown）	V_{SW-ON} =0V		0. 1	1	μA
Isby	Operating Current（Quiescent）	V_{FB}=0.3V		100	350	μA
Fsw	Switching Frequency		1. 0	1. 25	1. 5	MHz
Dmax	Maximum Duty Cycle	V_{FB}=0V	85	90		%
Chip Enable						
V_{EN_H}	EN Minimum High Level		1. 5			V
V_{EN_L}	EN Maximum Low Level				0. 4	V
V_{HYS}	EN Hysteresis			90		mV
	EN Input Bias Current	V_{SW-ON} =0V, 5V			1	μA

ELECTRICAL CHARACTERISTICS(contd.)

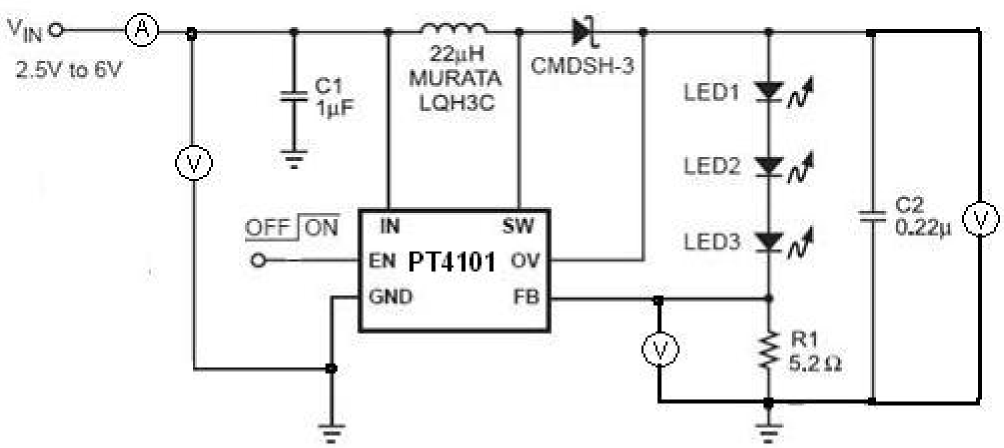
$V_{IN}=V_{EN}=3V$, Topt=25℃ unless specified otherwise.

SYMBOL	ITEMS	CONDITIONS	Min.	Typ.	Max.	UNIT
Output Switch						
R_{ON}	SW On Resistance (Note 3)			0. 5		Ω
I_{LIMIT}	SW Current Limit			400		mA
I_{LEAK}	SW Leakage Current	Vsw＝5V		0. 01	1	μA
Open Circuit Protection						
V_{OV}	Open Circuit Shutdown Threshold	V_{OV} Rising		30		V
Soft Start						
tss	Soft Start Time (Note 3)	V_{IN} Power On		160		μS

Notes:

1. Exceeding these ratings may damage the device
2. The device is not guaranteed to function outside of its operating rating.
3. Guaranteed by design.

TESTING CIRCUIT



TYPICAL PERFORMANCE CHARACTERISTICS

1. Driving Capability

Vin	I_{LED}=15mA	I_{LED}=20mA
2.5V	5 x LED	4 x LED
3.0V	6 x LED	5 x LED
3.6V	8 x LED	8 x LED

2.Efficiency

Figure 3. Efficiency vs Vin and I_{LED}

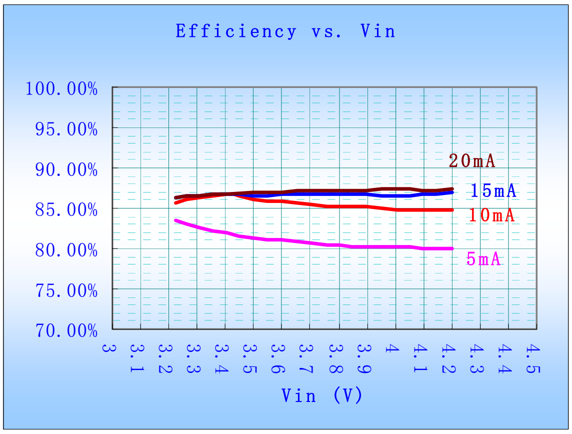
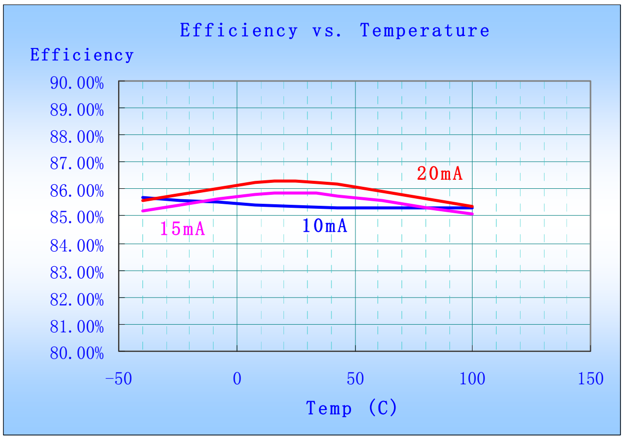
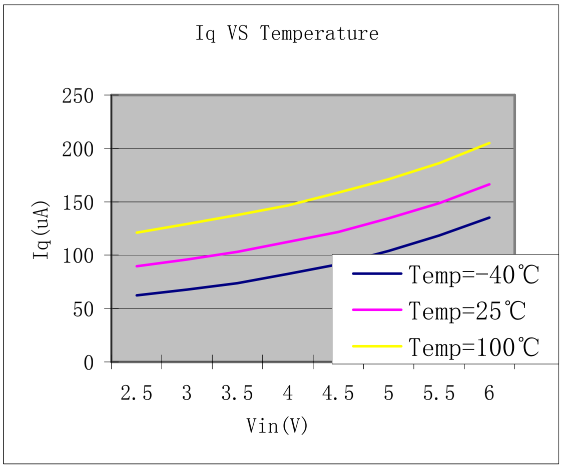


Figure 4. Efficiency vs Temperature



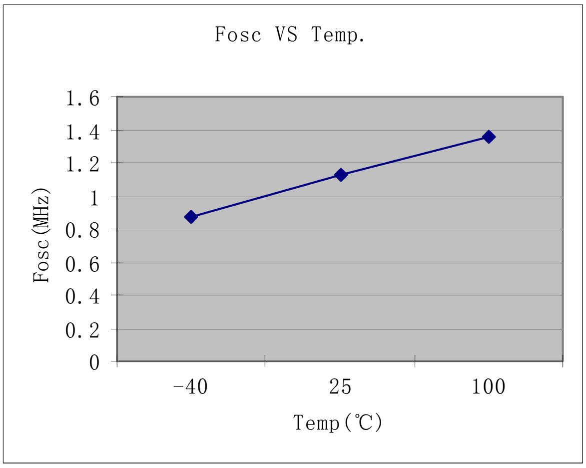
3. Quiescent Current vs VIN and Temperature

Figure 5. Iq vs. Temperature



4.Switching Frequency vs Temperature

Figure 6. Fosc vs. Temperature



OPERATION

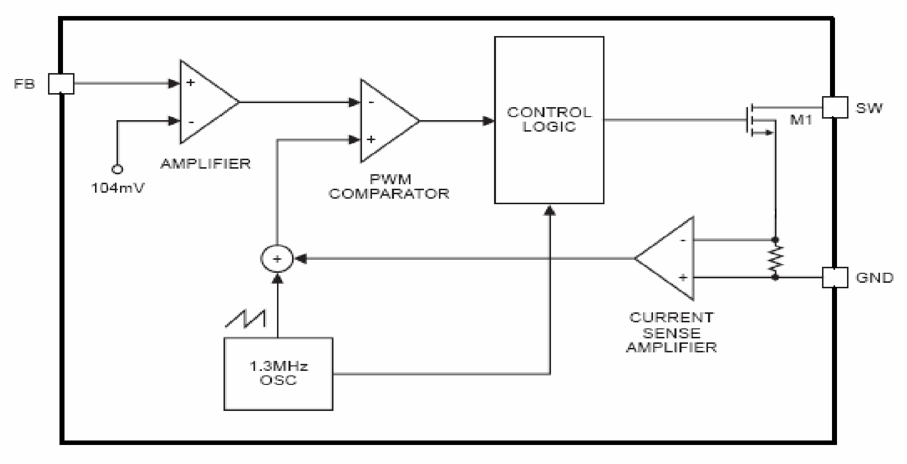


Figure 7. Simplified Block Diagram of the PT4101

The PT4101 uses a constant frequency, peak current mode boost regulator architecture to regulate the series string of white LEDs. The operation of the PT4101 can be understood by referring to the simplified block diagram shown above in Figure 7. At the start of each oscillator cycle, the control logic turns on the power switch M1. The signal at the non-inverting input of the PWM comparator is proportional to the switch current, summed together with a portion of the oscillator ramp. When this signal reaches the level set by the output of error amplifier, the PWM comparator resets the latch in the control logic and turns off the power switch. In this manner, error amplifier sets the correct peak current level to keep the LED current in regulation. If the feedback voltage starts to drop, the output of the error amplifier increases. This results in more current to flow through M1, hence increasing the power delivered to the output.

APPLICATION INFORMATION

■ Inductor Selections

For most of the applications of the PT4101, it is recommended to use an inductor of 22uH. Although small size is one of the major factors in selecting an inductor, the smaller and thinner inductors give higher core losses at 1.25MHz and DRC, resulting in lower efficiencies. The following tab le provides a list of recommended inductors:

PART NUMBER	DCR (Ω)	CURRENT RATING (mA)	MANUFACTURER
LQH3C220	0.71	250	MURATA
CDRH3D16-220	0.53	350	SUMIDA
LB2012B220M	1.7	75	TAIYO YUDEN
LEM2520-220	5.5	125	TAIYO YUDEN
EJPC220KF	4.0	160	PANASONIC

■ Capacitor Selection

The small size of ceramic capacitors makes them ideal for PT4101 applications. X5R and X7R types are recommended because they retain their capacitance over wider voltage and temperature ranges than other types such as Y5V or Z5U. A 1μF input capacitor and a 0.22 μF output capacitor are sufficient for most PT4101 applications.

APPLICATION INFORMATION(Contd.)

■ Diodes Selection

Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for PT4101 applications. The forward voltage drop of a Schottky diode represents the conduction losses in the diode, while the diode capacitance (C_T or C_D) represents the switching losses. For diode selection, both forward voltage drop and diode capacitance need to be considered. Schottky diodes with higher current ratings usually have lower forward voltage drop and larger diode capacitance, which can cause significant switching losses at the 1.25MHz switching frequency of the PT4101. A Schottky diode rated at 100mA to 200mA is sufficient for most PT4101 applications. Some recommended Schottky diodes are listed in the following table:

PART NUMBER	FORWARD CURRENT （mA）	VOLTAGE DROP （V）	DIODE CAPACITANCE （pF）	MMANUFACTURER
CMDSH-3	100	0.58@100mA	7.0@10V	Central
CMDSH2-3	200	0.49@200mA	15@10v	Central
BAT54	200	0.53@100mA	10@25v	Zetex

■ LED Current Control

The LED current is controlled by the feedback resistor. The feedback reference is 104mV. The LED current is 104mV/Rfb. In order to have accurate LED current, precision resistors are preferred (1% is recommended). The formula and table for R_{FB} selection are shown below:

$$R_{FB} = 104mV/I_{LED}$$

I_{LED}（mA）	R_{FB} Value（Ω）
5	20.8
10	10.4
15	6.93
20	5.2

■ Open Circuit Protection

Open circuit protection will shut off the PT4101 if the output voltage goes too high when the OV pin is tied to the output. In some cases an LED may fail, which will result in the feedback voltage always being zero. The PT4101 will then switch at its maximum duty cycle boosting the output voltage higher and higher. By connecting the OV pin to the top of the LED string the PT4101 checks this condition and if the output ever exceeds 30V, the PT4101 will shut down. The part will not switch again until the power is recycled, or a reset signal is applied to the EN pin.

APPLICATION INFORMATION(Contd.)

■ **Dimming Control**

There are three different types of dimming control circuits:

1. Using a DC Voltage

For some applications, the preferred method of brightness control is a variable DC voltage to adjust the LED current. The dimming control using a DC voltage is shown in Figure 8. As the DC voltage increases, the voltage drop on R2 increases and the voltage drop on R1 decreases. Thus, the LED current decreases. The selection of R2 and R3 will make the current from the variable DC source much smaller than the LED current and much larger than the FB pin bias current.

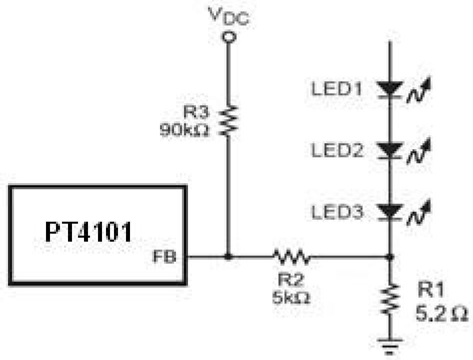


Figure 8. Dimming Control Using a DC Voltage

2. Using a PWM Signal to EN Pin

With the PWM signal applied to the EN pin, the PT4101 is turned on or off by the PWM signal, as shown in Figure 9. The LEDs operate at either zero or full current. The average LED current increases proportionally with the duty cycle of the PWM signal. A 0% duty cycle will turn off the PT4101 and corresponds to zero LED current. A 100% duty cycle corresponds to full current. The typical frequency range of the PWM signal should be 1KHz or less due to the soft start function.

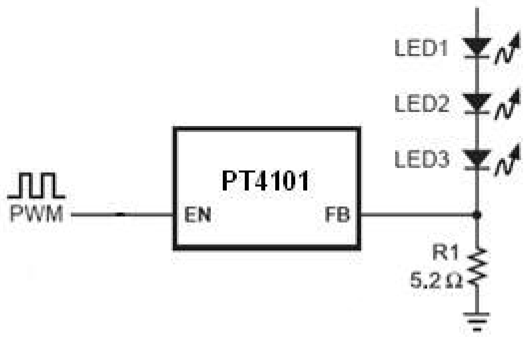


Figure 9. Dimming Control Using a PWM Signal

APPLICATION INFORMATION(Contd.)

3. Using a Filtered PWM Signal

The filtered PWM signal can be considered as an adjustable DC voltage. It can be used to replace the variable DC voltage source in dimming control. The circuit is shown in Figure 10.

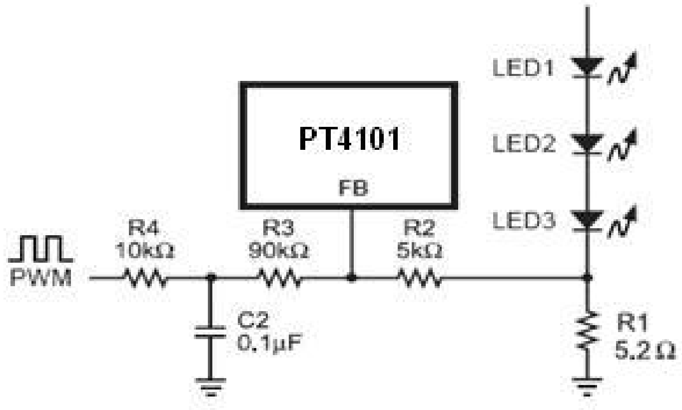


Figure 10. Dimming Control Using a Filtered PWM Signal

■ Start-up and Inrush Current

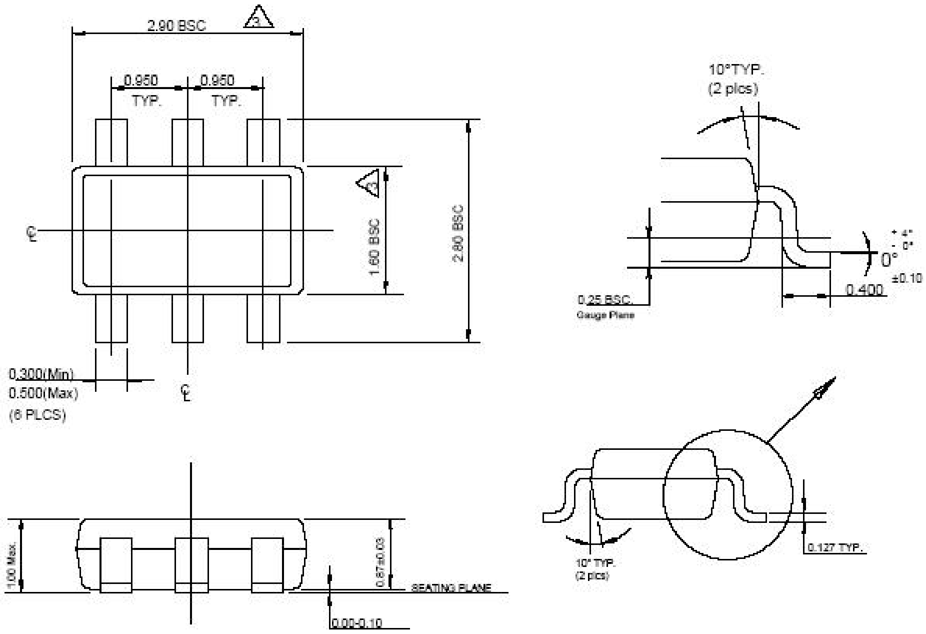
The PT4101 has internal soft start to limit the amount of current through V_{IN} at startup and to also limit the amount of overshoot on the output. The soft start is realized by gradually increasing the current limit during start-up. The current limit is increased by a third every 60µS giving a total soft start time of around 180µS.

■ Board Layout Consideration

As with all switching regulators, careful attention must be paid to the PCB board layout and component placement. To maximize efficiency, switch rise and fall times are made as short as possible. To prevent electromagnetic interference (EMI) problems, proper layout of the high frequency switching path is essential. The voltage signal of the SW pin has sharp rise and fall edges. Minimize the length and area of all traces connected to the SW pin and always use a ground plane under the switching regulator to minimize interplane coupling. In addition, the ground connection for the feedback resistor R1 should be tied directly to the GND pin and not shared with any other component, ensuring a clean, noise-free connection.

PACKAGE INFORMATION

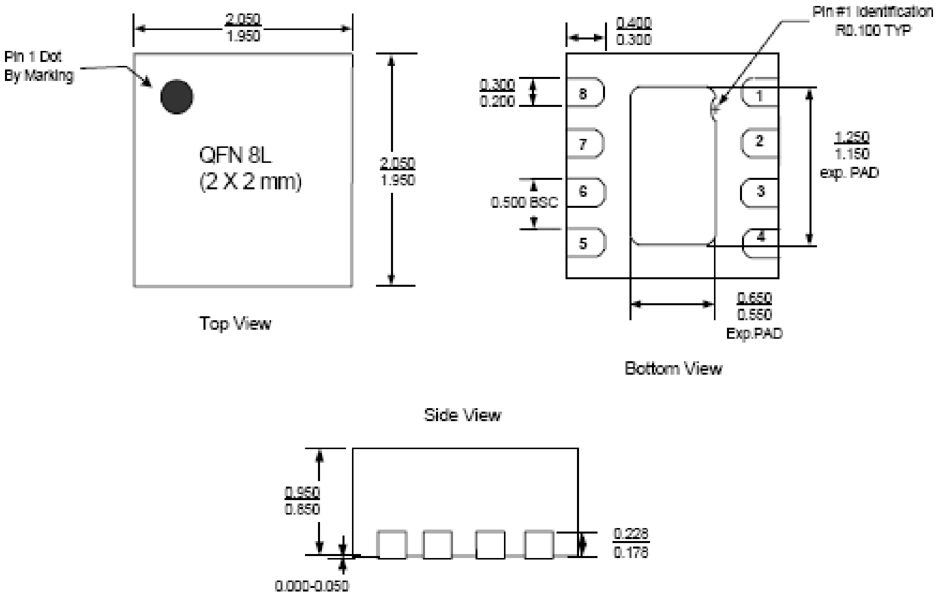
1. SOT-23-6



NOTE:

1. Dimensions and tolerances are as per ANSI Y14.5M, 1994.
2. Die is facing up for mold. Die is facing down for trim/form, ie. reverse trim/form.
3. Dimensions are exclusive of mold flash and gate burr.
4. The footlength measuring is based on the gauge plane method.
5. All specification comply to Jedec Spec MO193 Issue C.

2. QFN8 2x2



Note: Dimensions are mm