

#### DESCRIPTION

The MP8904 is a low-current, low-dropout, linear regulator that operates on a single 2.5V-to-6.5V input supply. An external resistor controls the output voltage. The MP8904 can supply up to 500mA of load current. The enable pin (EN) allows the part to enter a low-current shutdown mode (EN=0). The MP8904 features thermal overload and current limit protection. It is available in an 8-pin QFN (2×3mm) package.

#### FEATURES

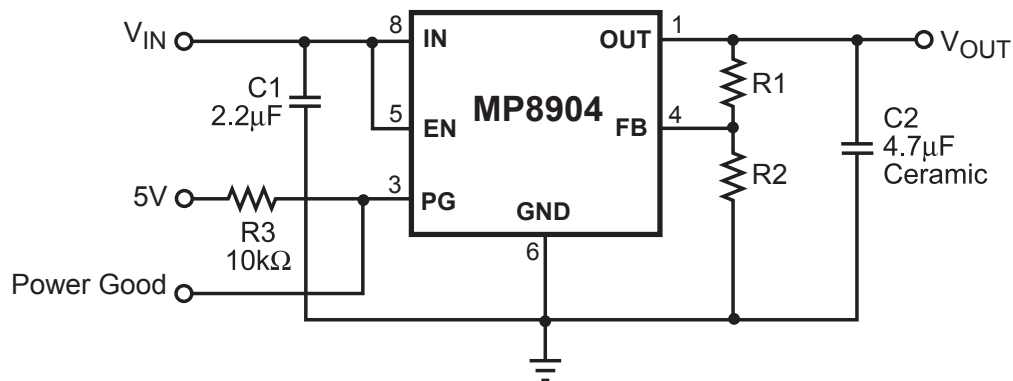
- Power-Good Open Collector Output
- Operates from a 2.5V-to-6.5V Input
- Low 300mV Dropout at 500mA Output
- Stable with Very Small Ceramic Capacitors
- 2% Feedback Reference
- Adjustable Output Voltage from 0.5V to 5V
- Better than 0.001%/mA Load Regulation
- Stable with Low-ESR Output Capacitor
- Low 100µA Ground Current
- Internal Thermal Protection
- Current Limit Protection
- 6µA Typical Quiescent Current at Shutdown

#### APPLICATIONS

- Low-Current Regulators
- Battery-Powered Systems
- Mobile Devices, such as Cell Phones and GPS Navigators

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#### TYPICAL APPLICATION

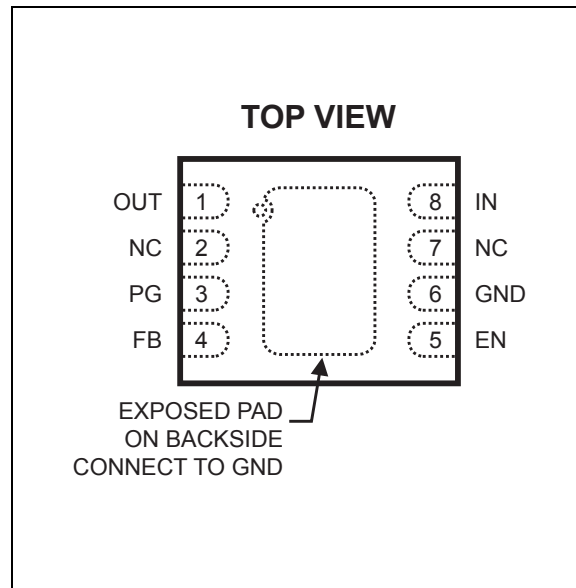


### ORDERING INFORMATION

Part Number*	Package	Top Marking
MP8904DD	QFN8(2 x 3mm)	T3

\* For Tape & Reel, add suffix -Z (eg. MP8904DD-Z)  
 For RoHS Compliant Packaging, add suffix -LF (eg. MP8904DD-LF-Z)

### PACKAGE REFERENCE



#### ABSOLUTE MAXIMUM RATINGS <sup>(1)</sup>

IN, FB to GND .....-0.3V to +7V  
 EN to GND .....-0.3V to  $V_{IN} + 0.3V$   
 OUT .....-0.3V to  $V_{IN} + 0.3V$   
 Continuous Power Dissipation ( $T_A = +25^{\circ}C$ ) <sup>(2)</sup>  
 .....2.5W

Junction Temperature .....150°C  
 Lead Temperature .....260°C  
 Storage Temperature .....-65°C to +150°C

#### Recommended Operating Conditions <sup>(3)</sup>

Input Voltage  $V_{IN}$  .....2.5V to 6.5V  
 Output Voltage .....0.5V to 5V  
 Load Current .....500mA Maximum  
 Operating Junction Temp. ( $T_J$ ). -40°C to +125°C

Thermal Resistance <sup>(4)</sup>	$\theta_{JA}$	$\theta_{JC}$
QFN8 (2 x 3mm) .....	55	12 ... °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  $\theta_{JA}$ , and the ambient temperature  $T_A$ . The maximum allowable continuous power dissipation at any ambient temperature is calculated by  $P_D(MAX) = (T_J(MAX) - T_A) / \theta_{JA}$ . 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 approximately 1" square of 1 oz copper.

## ELECTRICAL CHARACTERISTICS

$V_{IN} = 3.3V$ ,  $V_{OUT} = 1.2V$ ,  $C_{OUT} = 4.7\mu F$ ,  $C_{IN} = 2.2\mu F$ ,  $T_A = +25^\circ C$ , unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ <sup>(4)</sup>	Max	Units
Operating Voltage		$I_{OUT} = 1mA$	2.5		6.5	V
Ground Pin Current		$I_{OUT} = 1mA$ <sup>(6)</sup>		100		$\mu A$
		$I_{OUT} = 500mA$		5		mA
Shutdown Current		$V_{EN} = 1.45V$ , $V_{IN} = 5V$		7		$\mu A$
FB Regulation Voltage			0.484	0.496	0.508	V
		$-40^\circ C \leq T_A \leq +85^\circ C$	0.481	0.496	0.510	
Dropout Voltage <sup>(7)</sup>		$I_{OUT} = 500mA$		300		mV
Line Regulation		$I_{OUT} = 1mA$ , $V_{IN} = (V_{OUT} + 0.5V)$ to $6.5V$ <sup>(7)</sup>		0.005		%/V
Load Regulation		$I_{OUT} = 1mA$ to $500mA$ , $V_{IN} = V_{OUT} + 0.5V$		0.001		%/mA
Power-Good Output Voltage, Low <sup>(8)</sup>	$V_{OL}$	$I_{sink} = 0.5mA$		0.5		V
EN Input, High			1.2			V
EN Input, Low					0.4	V
EN Input Bias Current		$V_{EN} = 1.5V$ , $5V$		0.01	1	$\mu A$
Thermal Protection				155		$^\circ C$
Current Limit			550	730		mA

### Notes:

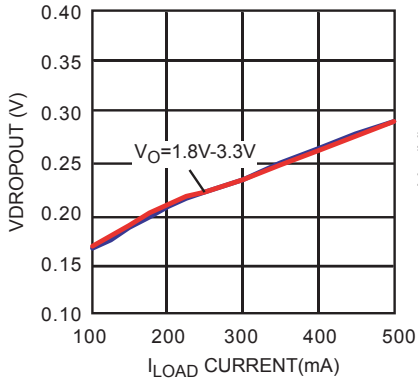
- 5) Parameter is guaranteed by design, not production tested.
- 6) Resistors for  $V_{OUT}$  measurement are 10k $\Omega$ , 14k $\Omega$ , 1%
- 7) The ground current does not include current through feedback current
- 8) Dropout Voltage is defined as the input to output differential when the output voltage drops 1% below its nominal value
- 9)  $V_{FEEDBACK}$  is 90% of the regulated value with 10k $\Omega$  pull-up to 5V

**TYPICAL PERFORMANCE CHARACTERISTICS**

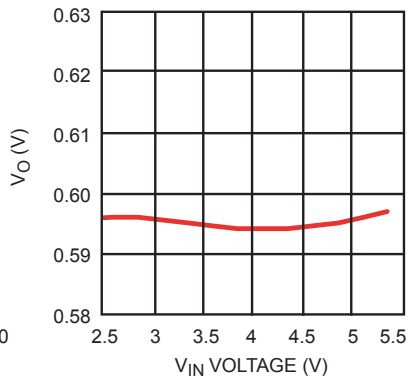
Based on the Figure 2 Typical Application Circuit

C1=2.2µF, C2 =4.7µF, C3=1nF, T<sub>A</sub> = +25°C, unless otherwise noted.

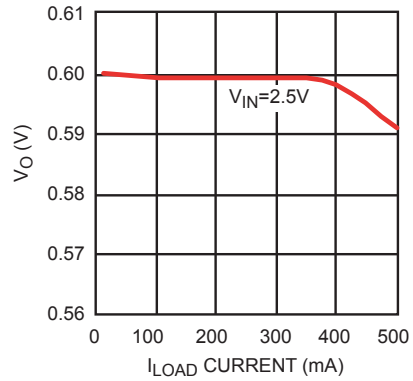
**Voltage Dropout vs Current**



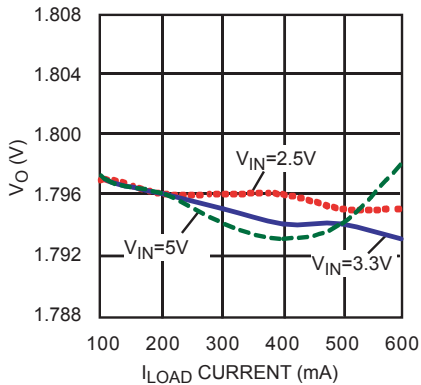
**Line Regulation**



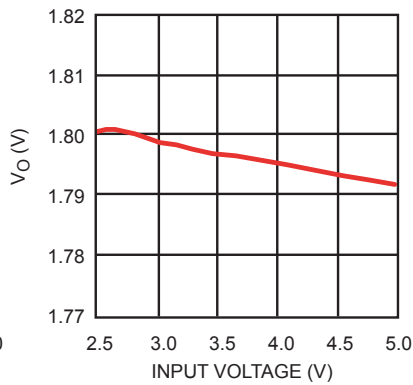
**Load Regulation**



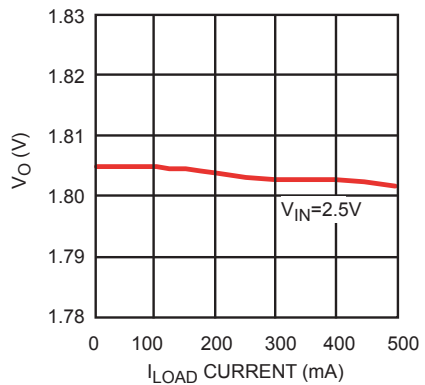
**85 °C Load Regulation**



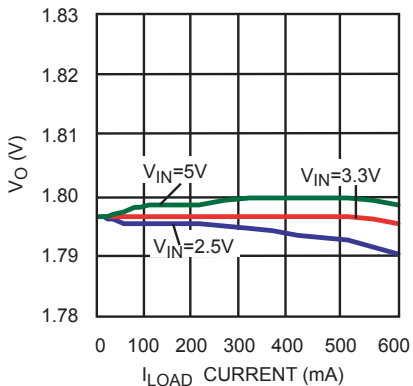
**Line Regulation**



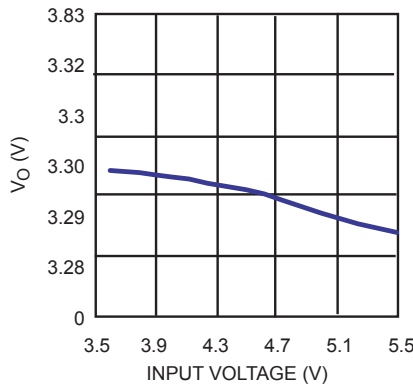
**Load Regulation**



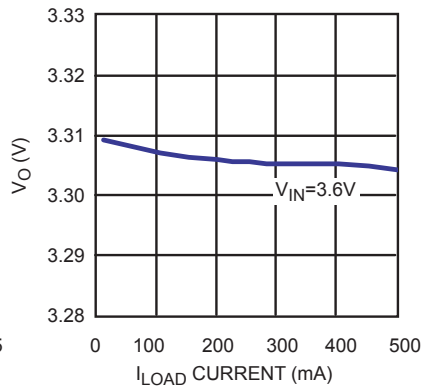
**-40 °C Load Regulation**



**Line Regulation**



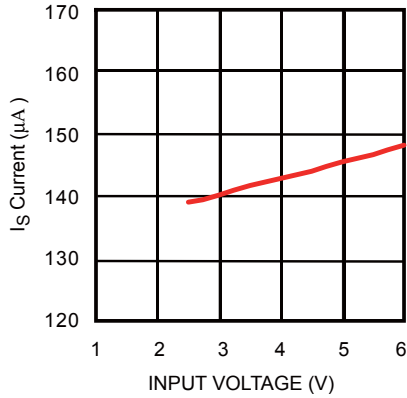
**Load Regulation**



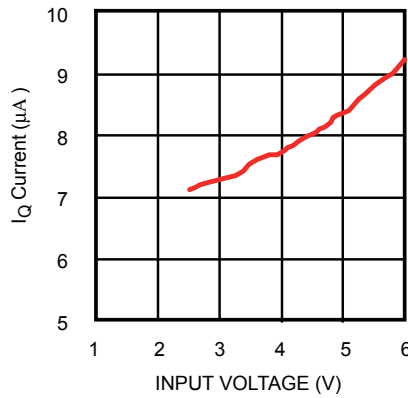
**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

C1=2.2µF, C2 =4.7µF, C3=1nF, T<sub>A</sub> = +25°C, unless otherwise noted.

**Supply Current vs. Input Voltage**

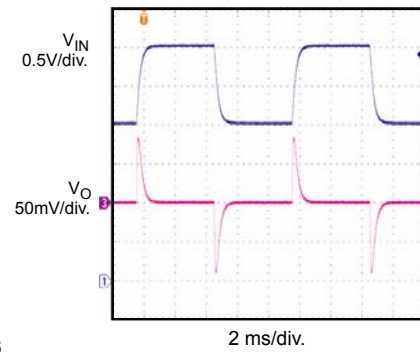


**Shut Down Current vs. Input Voltage**

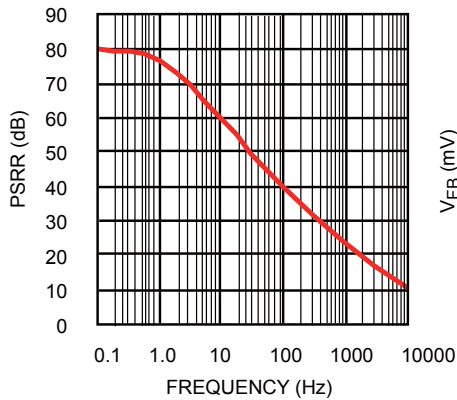


**Line Transient**

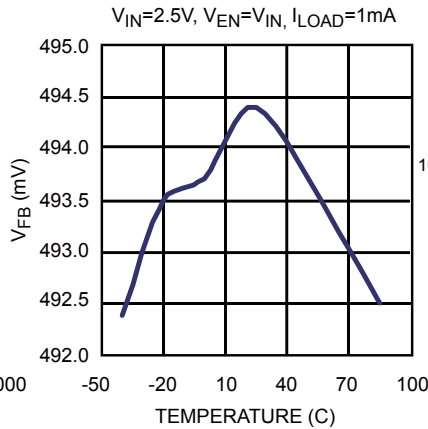
V<sub>IN</sub> = 2.5V to 3.5V, V<sub>O</sub> = 1.8V, V<sub>EN</sub> = V<sub>IN</sub>, I<sub>LOAD</sub> = 50mA, with Resistor Load



**PSRR vs Frequency**

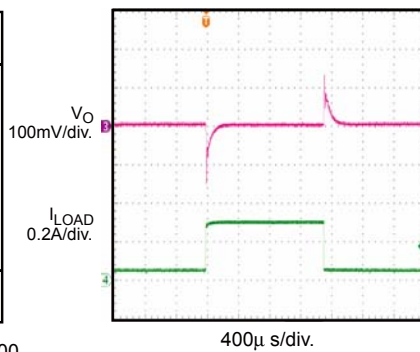


**V<sub>FB</sub> vs Temperature**



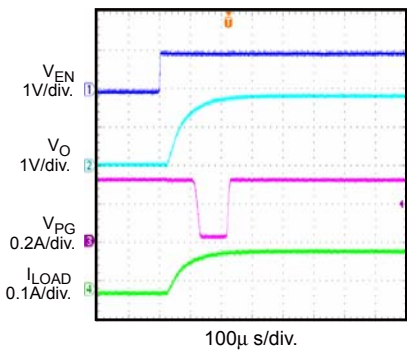
**Load Transient**

V<sub>IN</sub> = 2.5V, V<sub>O</sub> = 1.8V, V<sub>EN</sub> = V<sub>IN</sub>, I<sub>LOAD</sub> = 50 to 300mA, with Resistor Load



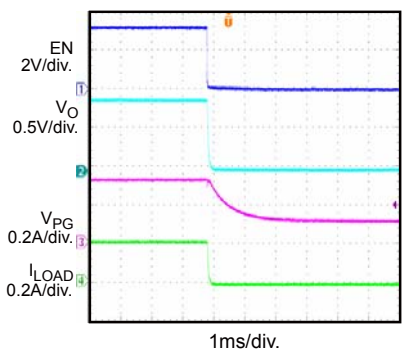
**Enable Turn On**

V<sub>IN</sub> = 3.3V, V<sub>O</sub> = 1.8V, V<sub>EN</sub> = 0V - 2V, I<sub>O</sub> = 200mA, with Resistor Load



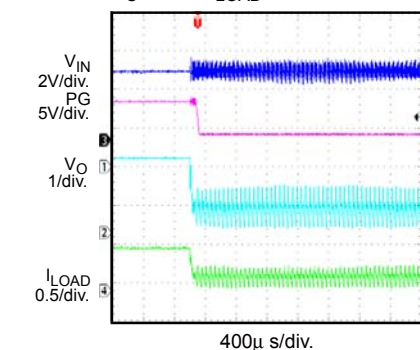
**Enable Turn Off**

V<sub>IN</sub> = 3.3V, V<sub>O</sub> = 1.8V, V<sub>EN</sub> = 2V - 0V, I<sub>O</sub> = 200mA, with Resistor Load



**Thermal Protection**

V<sub>IN</sub> = V<sub>EN</sub> = 5V, V<sub>O</sub> = 1.8V, I<sub>LOAD</sub> = 0.5A

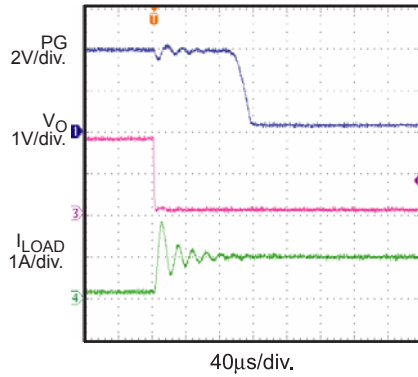


**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

C1=2.2µF, C2 =4.7µF, C3=1nF, T<sub>A</sub> = +25°C, unless otherwise noted.

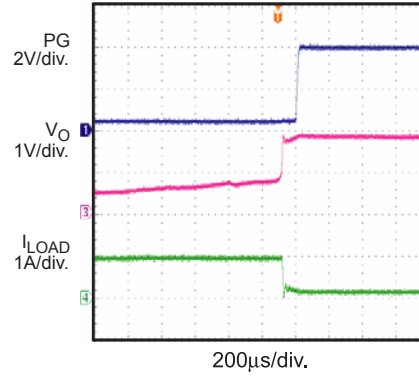
**Short Circuit Protection**

V<sub>IN</sub> = 4V, V<sub>O</sub> = 1.8V, V<sub>EN</sub> = V<sub>IN</sub>



**Short Circuit Recovery**

V<sub>IN</sub> = 4V, V<sub>O</sub> = 1.8V, V<sub>IN</sub> = V<sub>EN</sub>



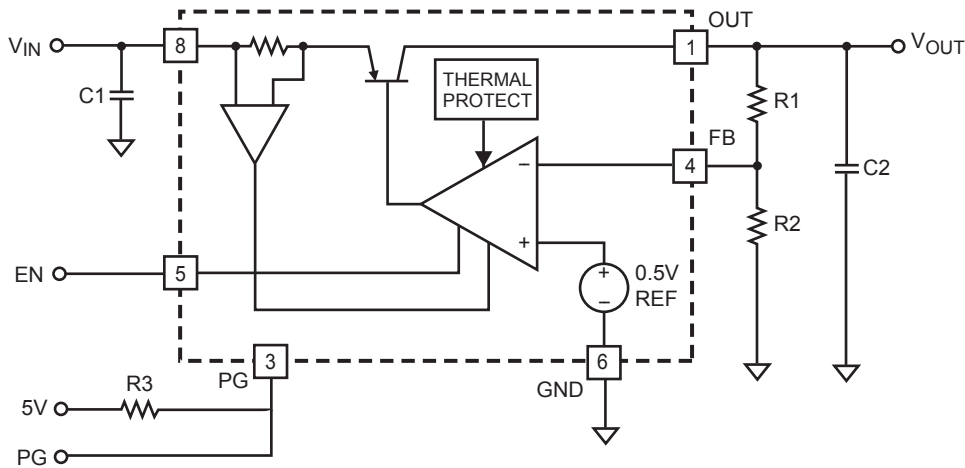
## PIN FUNCTIONS

Pin #	Name	Description
1	OUT	Regulator Output. Bypass OUT to GND with a $\geq 4.7\mu\text{F}$ capacitor.
2	NC	No connect.
3	PG	Power-Good Open Collector Output. Monitors the regulator output. If the regulator output falls below 10% of its regulation point, the power-good pin goes low.
4	FB	Feedback. Connect a resistive voltage divider from OUT to FB to set the output voltage. OUT feedback threshold is 0.5V.
5	EN	Enable Input. Drive EN above 1.2V to turn on the MP8904. Drive EN below 0.4V to turn it off.
6	GND	Ground.
7	NC	No connect.
8	IN	Power Source Input. IN supplies the internal power to the MP8904 and is the source for the pass transistor. Bypass IN to GND with a $\geq 2.2\mu\text{F}$ capacitor.
Exposed Pad		Connect to GND.

## OPERATION

The MP8904 is a low-current, low-voltage, low-dropout, linear regulator. It is intended for devices that require very low voltage and low quiescent current power, such as wireless modems and cellular phones.

The MP8904 uses a PNP pass element and features internal thermal shutdown and internal current limit circuit.



**Figure 1: Functional Block Diagram**

## APPLICATION INFORMATION

### Setting the Output Voltage

The MP8904 has an adjustable output voltage set via an external resistor divider (R1 and R2 in Figure 2).

$$R1 = R2 \times \left( \frac{V_{OUT} - V_{FB}}{V_{FB}} \right)$$

where  $V_{FB} = 0.5V$  is the OUT feedback threshold voltage.

Example: For a 2.5V output and  $R2=10k\Omega$

$$R1 = 10k \times \left( \frac{2.5 - 0.5}{0.5} \right) = 40k$$

Use a standard  $40k\Omega (\pm 1\%)$  resistor for R1.

Table 1 lists selected R1 values for typical output voltages ( $R2 = 10k\Omega$ ).

### Power-Good

The power-good (PG) pin monitors the output voltage; if the output voltage goes below 10% of its regulation point, the PG pin goes low. The PG pin is an open collector output that connects to a pull-up resistor (typically  $10k\Omega$ ). Tie the

pull-up resistor to 0V-to-5.5V supply, such as regulated input voltage.

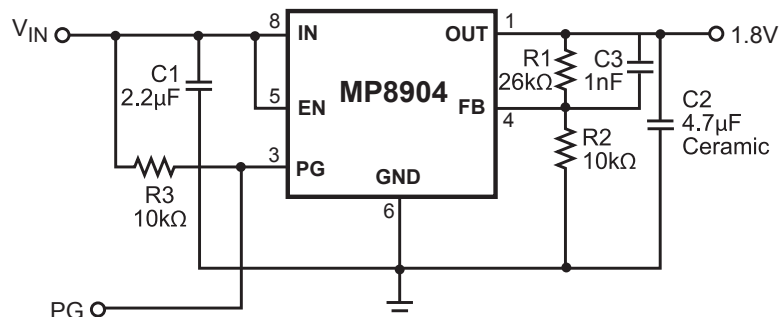
**Table 1: Adjustable Output Voltage Values vs. R1 ( $R2 = 10k\Omega$ )**

$V_{OUT} (V)$	$R1 (\Omega)$
1.25	15k
1.5	20k
1.8	26k
2	30k
2.5	40k
2.8	46k
3	50k
3.3	56k
4	70k
5	90k

### Bypass Capacitors

Bypass the reference voltage can be bypassed with an external capacitor to reduce noise. Use a low-ESR ceramic capacitor for the best performance.

## TYPICAL APPLICATION CIRCUIT



**Figure 2: Typical Application Circuit**



### PCB layout guide

PCB layout is very important to achieve good regulation, ripple rejection, transient response and thermal performance. For optimal performance, duplicate the EVB layout from Figure 3.

For any changes, follow the guidelines below:

- 1) Place the input and output ceramic bypass capacitors close to their respective IN and OUT pins.
- 2) Use short and direct feedback connections. Place the feedback resistors and compensation components as close to the chip as possible.
- 3) Connect IN, OUT and GND to large copper surfaces to help cool the chip to improve thermal performance and long-term reliability.

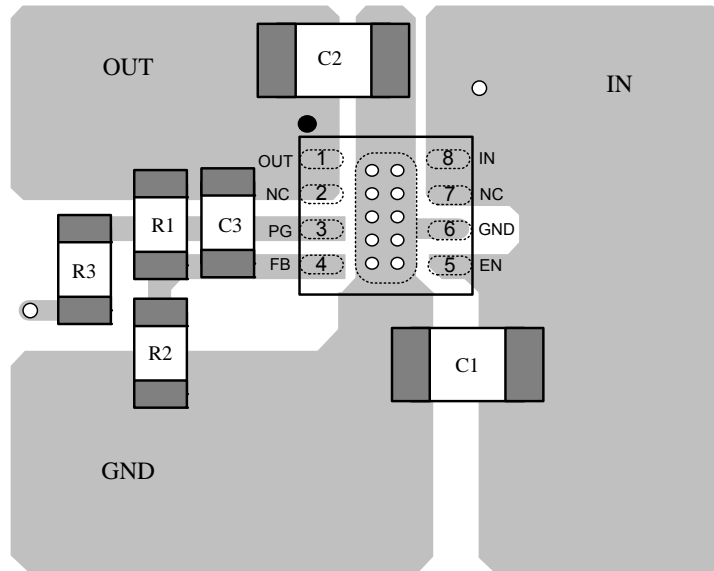
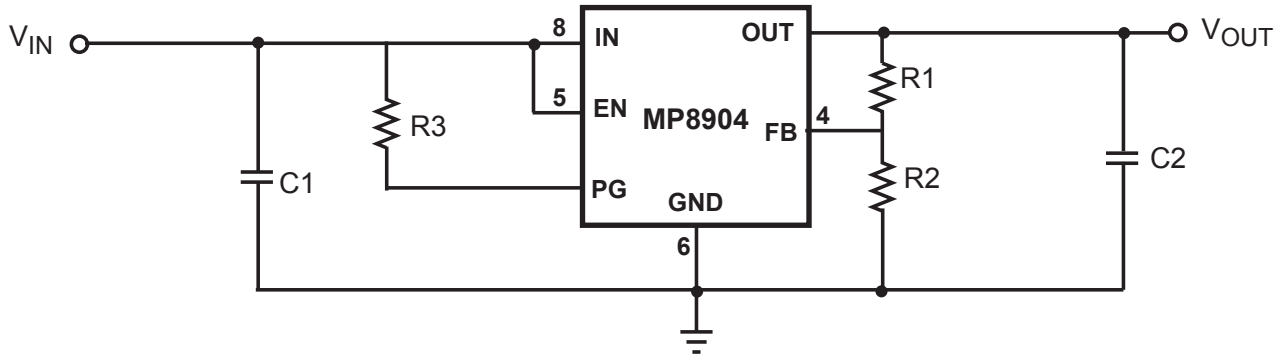
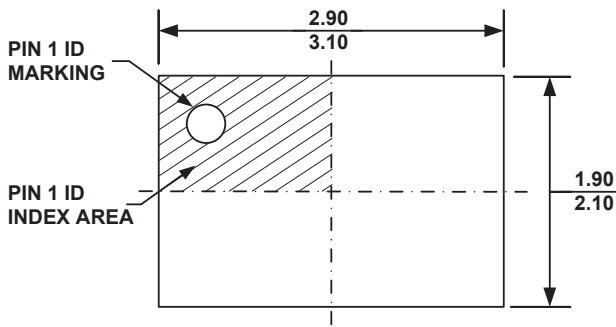


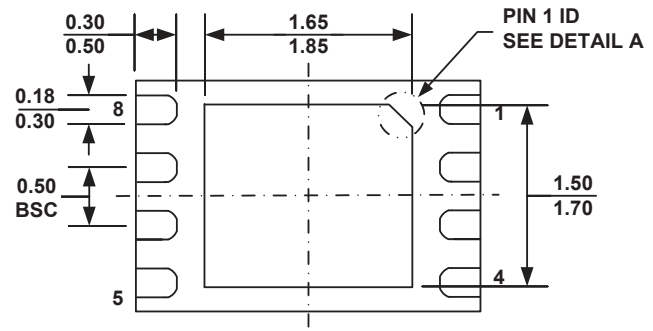
Figure 3: PCB Layout, Top Layer

**PACKAGE INFORMATION**

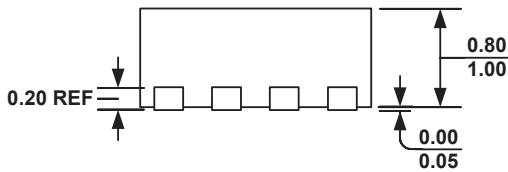
**QFN8 (2mm x 3mm)**



**TOP VIEW**



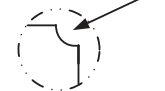
**BOTTOM VIEW**



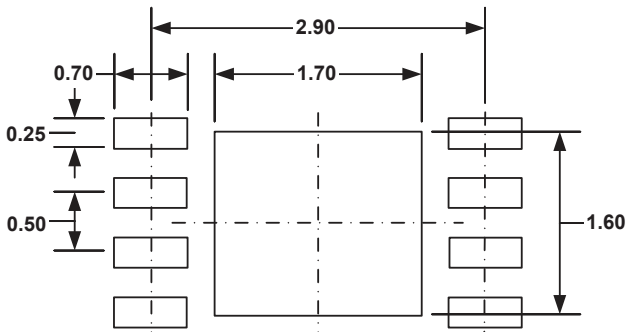
**SIDE VIEW**

**PIN 1 ID OPTION A**  
0.30x45° TYP.

**PIN 1 ID OPTION B**  
R0.20 TYP.



**DETAIL A**



**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) DRAWING CONFORMS TO JEDEC MO-229, VARIATION VCED-2.
- 5) DRAWING IS NOT TO SCALE.

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