MPQ8904

Industrial/Automotive-Grade 500mA Linear Regulator AEC-Q100 Qualified

DESCRIPTION

The MPQ8904 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 MPQ8904 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 MPQ8904 features thermal overload and current limit protection. It is available in an 8-pin QFN (2×3mm) package.

FEATURES

- Power-Good Open Collector Output
- Guaranteed Industrial/Automotive Temp. Range Limits
- Operates from a 2.5V-to-6.5V Input
- Low 300mV Dropout at 500mA Output
- Stable with Very Small Ceramic Capacitors
- 2.5% Feedback Reference
- Adjustable Output Voltage from 0.5V to 5V
- Better than 0.001%/mA Load Regulation
- Stable with Low-ESR Output Capacitor
- Low 140µA Ground Current
- Internal Thermal Protection
- Current Limit Protection
- 7µA Typical Quiescent Current at Shutdown
- Available in AEC-Q100 Qualified Grade 1

APPLICATIONS

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

All MPS parts are lead-free, halogen free, and adhere to the RoHS directive. For MPS green status, please visit MPS website under Quality Assurance.

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TYPICAL APPLICATION
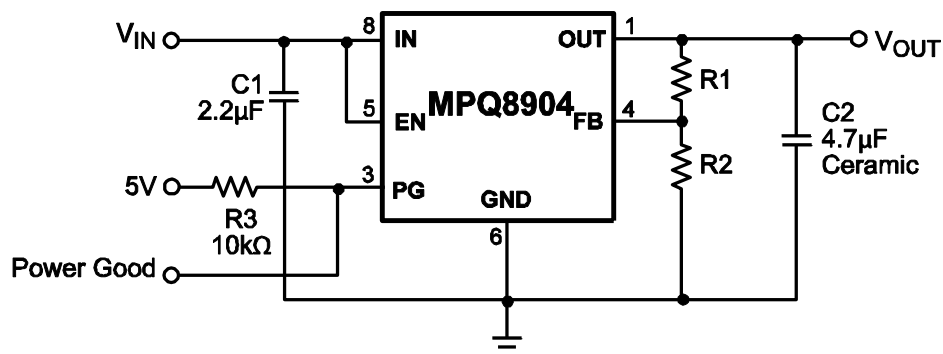
ORDERING INFORMATION

Part Number	Package	Top Marking
MPQ8904DD-AEC1*	QFN-8 (2mm x 3mm)	*See Below*
MPQ8904DD**		

* For Tape & Reel, add suffix –Z (e.g. MPQ8904DD-AEC1–Z);
For RoHS, compliant packaging, add suffix –LF (e.g. MPQ8904DD-AEC1–LF–Z).
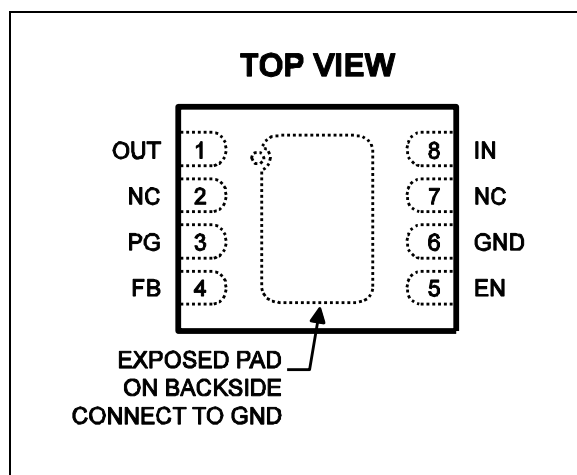
** For Tape & Reel, add suffix -Z (e.g. MPQ8904DD-Z);
For RoHS, compliant packaging, add suffix -LF (e.g. MPQ8904DD-LF-Z).

TOP MARKING

T3YW
LLL

T3: product code of MPQ8904DD and MPQ8904DD-AEC1;
Y: year code;
W: week code:
LLL: lot number;

PACKAGE REFERENCE

ABSOLUTE MAXIMUM RATINGS [1]

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 $(T_A = +25°C)$**[2]**
…………………………………………….2.5W

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

Recommended Operating Conditions [3]

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 [4] θ_{JA} θ_{JC}

QFN-8 (2mm x 3mm) ....55 ...... 12... °C/W

Notes:
1) Exceeding these ratings may damage the device.
2) 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.
3) The device is not guaranteed to function outside of its operating conditions.
4) Measured on approximately 1" square of 1 oz copper.

ELECTRICAL CHARACTERISTICS

V_{IN} = 3.3V, V_{OUT} = 1.2V, C_{OUT} = 4.7µF, C_{IN} = 2.2µF, T_J = -40°C to +125°C, Typical value are T_J = 25°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ [4]	Max	Units
Operating Voltage		I_{OUT} = 1mA	2.5		6.5	V
Ground Pin Current[7]		I_{OUT} = 1mA		140	200	µA
		I_{OUT} = 500mA		7	12	mA
Shutdown Current		V_{EN} = 0V, V_{IN} = 5V		7	15	µA
FB Regulation Voltage		T_J = +25°C	0.484	0.496	0.508	V
		-40°C ≤ T_J ≤ +125°C	0.478	0.496	0.513	
Dropout Voltage [8]		I_{OUT} = 500mA	200	300	450	mV
Line Regulation[6]		I_{OUT} = 1mA, V_{IN} = (V_{OUT} + 0.5V) to 6.5V [7]	-0.1	0.015	0.1	%/V
Load Regulation[6]		I_{OUT} = 1mA to 500mA, V_{IN} = V_{OUT} + 0.5V	-0.1	0.005	0.1	%/mA
Power-Good Output Voltage, Low[9]	V_{OL}	I_{sink} = 0.5mA	0	0.5	1	V
EN Input, High			1.2			V
EN Input, Low					0.4	V
EN Input Bias Current		V_{EN} = 1.5V		0.05	1	µA
Thermal Protection[5]				155		°C
Current Limit			650	850		mA

Notes:
5) Parameter is guaranteed by design, not production tested.
6) Resistors for V_{OUT} measurement are 10kΩ, 14kΩ, 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 10kΩ pull-up to 5V
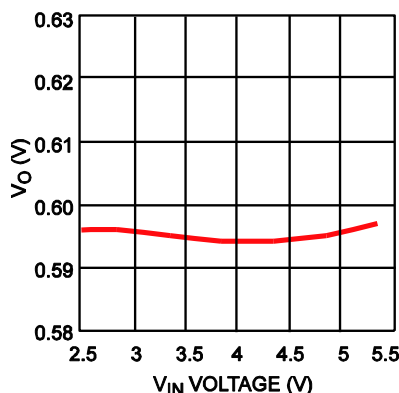
TYPICAL PERFORMANCE CHARACTERISTICS
Based on the Figure Typical Application Circuit

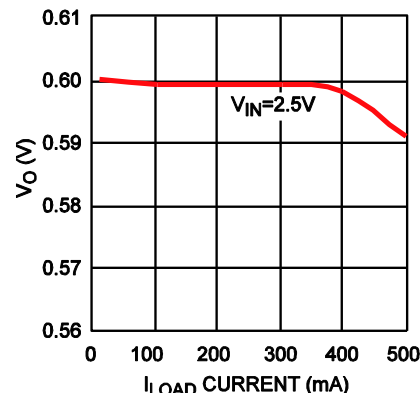C1=2.2µF, C2 =4.7µF, C3=1nF, T_A = +25°C, unless otherwise noted.
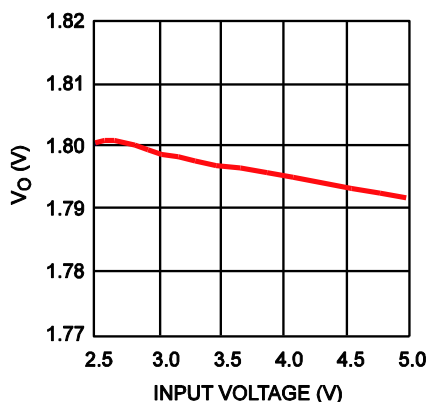
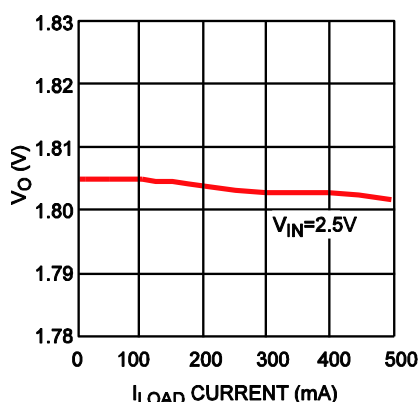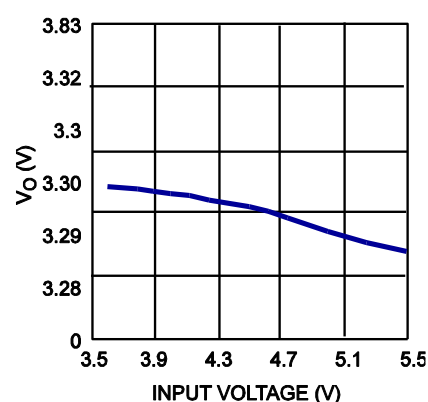**Voltage Dropout vs Current**
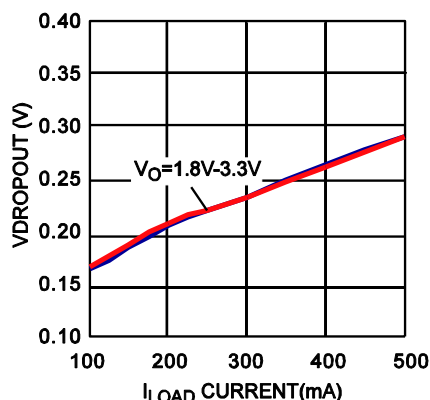
Line Regulation

Load Regulation
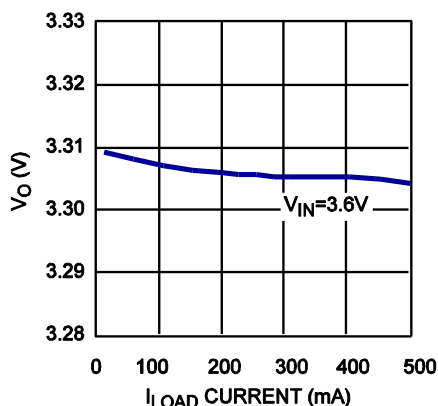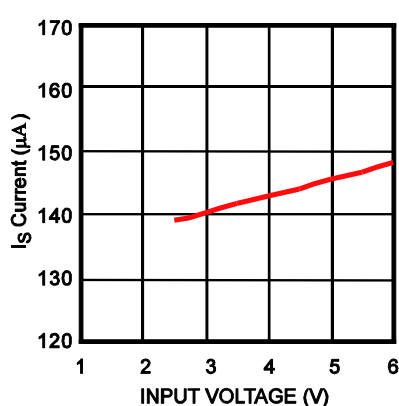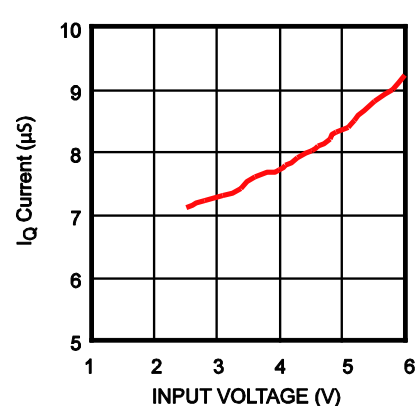
Line Regulation

Load Regulation

Line Regulation

Load Regulation

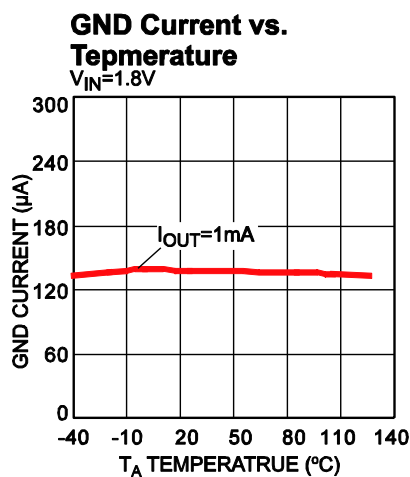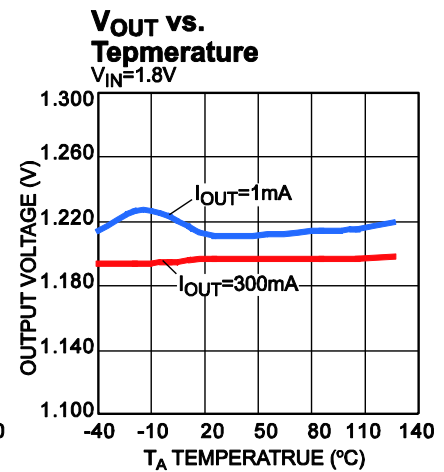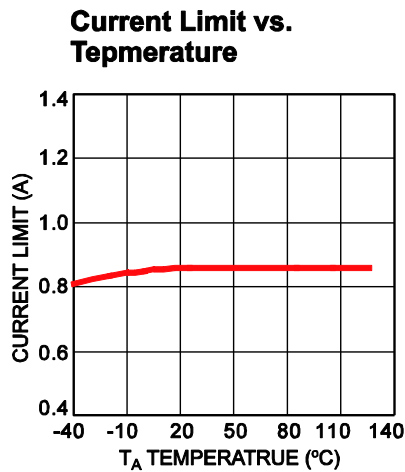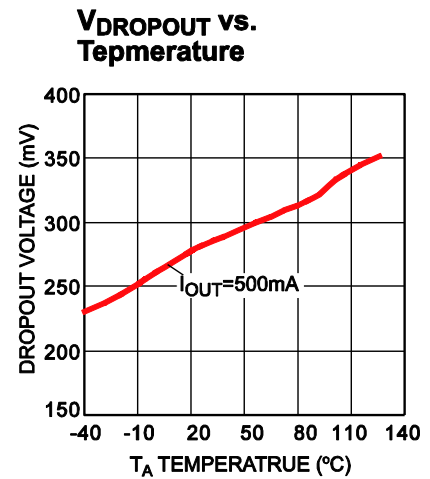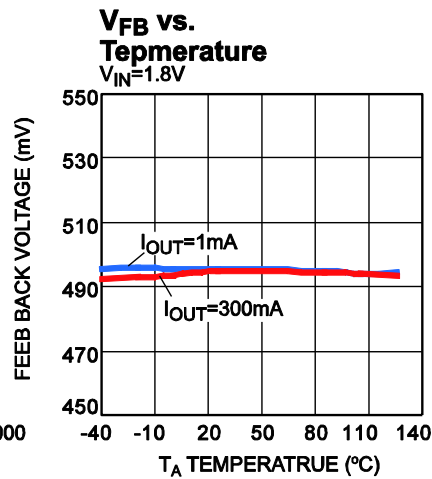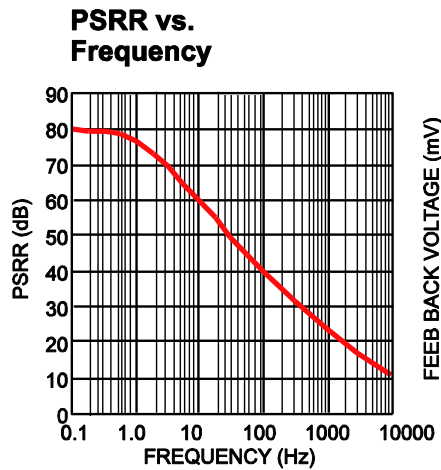**Supply Current vs. Input Voltage**

Shut Down Current vs. Input Voltage

TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*
C1=2.2µF, C2 =4.7µF, C3=1nF, T_A = +25°C, unless otherwise noted.

PSRR vs. Frequency

V_{FB} vs. Tepmerature
V_{IN}=1.8V

$V_{DROPOUT}$ vs. Tepmerature

Current Limit vs. Tepmerature

Line Regulation vs. Tepmerature

V_{OUT} vs. Tepmerature
V_{IN}=1.8V

GND Current vs. Tepmerature
V_{IN}=1.8V

TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

$C_1 = 2.2\mu F$, $C_2 = 4.7\mu F$, $C_3 = 1nF$, $T_A = +25°C$, unless otherwise noted.

Line Transient
V_{IN} = 2.0V to 3.0V, V_O = 1.8V, V_{EN}= V_{IN},
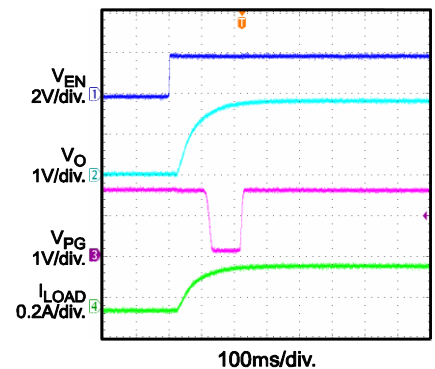I_{LOAD} = 50mA, with Resisitor Load

2 ms/div.
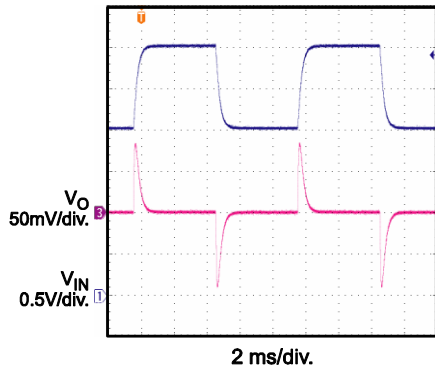
Load Transient
V_{IN} = 2.5V, V_O = 1.8V, V_{EN}= V_{IN},
I_{LOAD} = 50 to 300mA, with Resisitor Load

400ms/div.
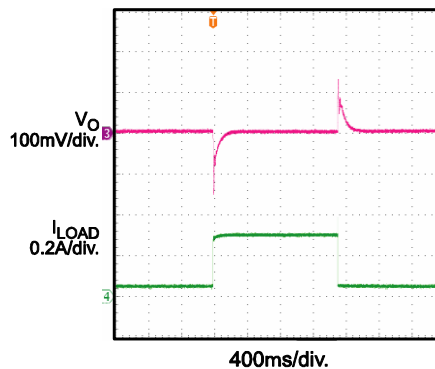
Enable Turn On
V_{IN} = 3.3V, V_O = 1.8V, V_{EN} = 0V - 2V,
I_O = 200mA, with Resisitor Load

100ms/div.

Enable Turn Off
V_{IN} = 3.3V, V_O = 1.8V, V_{EN} = 2V - 0V,
I_O = 200mA, with Resisitor Load

1ms/div.
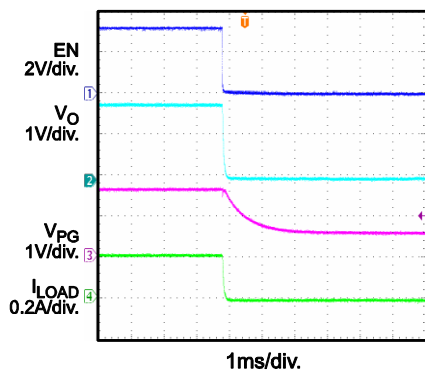
Thermal Protection
V_{IN} = V_{EN} = 5V,
V_O = 1.8V, I_{LOAD} = 0.5A

400ms/div.
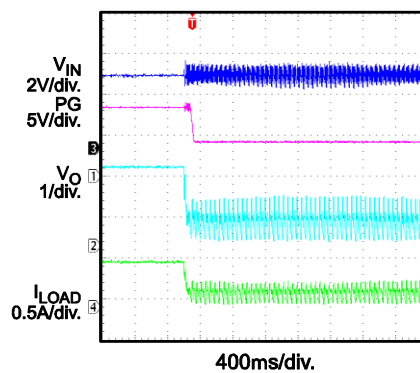
Short Circuit Protection
V_{IN} = 4V, V_O = 1.8V, V_{EN} = V_{IN}

40ms/div.
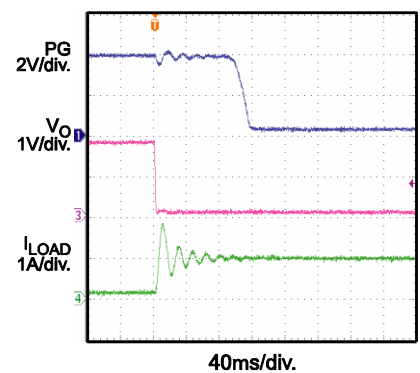
Short Circuit Recovery
V_{IN} = 4V, V_O = 1.8V, V_{IN} = V_{EN}

200ms/div.
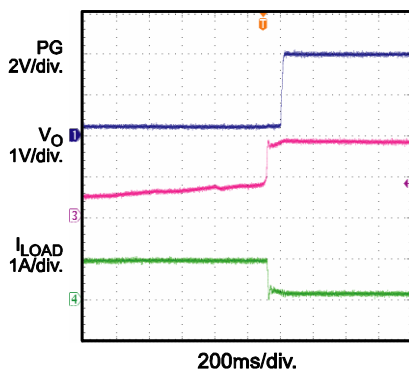
PIN FUNCTIONS

Pin #	Name	Description
1	OUT	Regulator Output. Bypass OUT to GND with a ≥4.7µF 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 MPQ8904. 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 MPQ8904 and is the source for the pass transistor. Bypass IN to GND with a ≥2.2µF capacitor.
Exposed Pad		Connect to GND.

OPERATION

The MPQ8904 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 MPQ8904 uses a PNP pass element and features internal thermal shutdown and internal current limit circuit.
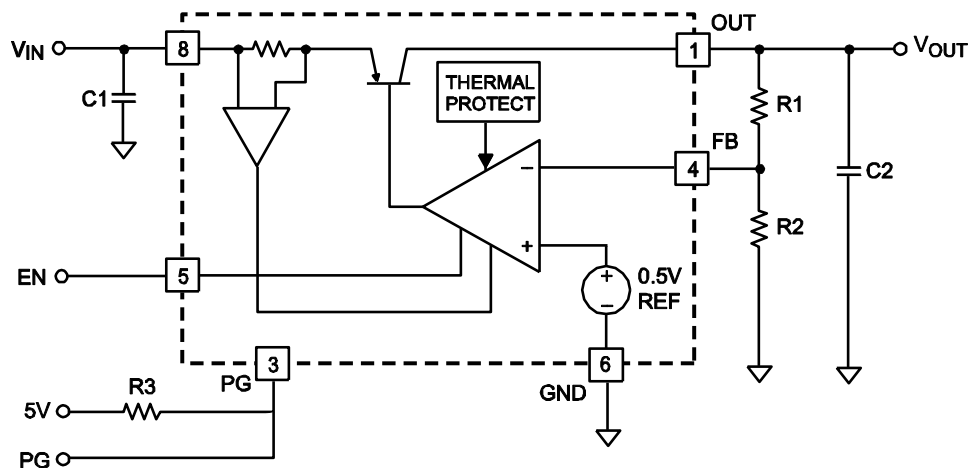

Figure 1: Functional Block Diagram

APPLICATION INFORMATION

Setting the Output Voltage

The MPQ8904 has an adjustable output voltage set via an external resistor divider (R1 and R2 in Figure).

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

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

Example: For a 2.5V output and R2=10kΩ

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

Use a standard 40kΩ (±1%) resistor for R1.

Table 1 lists selected R1 values for typical output voltages (R2 = 10kΩ).

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 10kΩ). 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 =10kΩ)

V$_{OUT}$ (V)	R1 (Ω)
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.

Fast Power On

The MPQ8904 may need an RC circuit to slow down the fast power on if the power on time is less than 100μs (see Figure 2). The typical resistor (R4) value is 100kΩ and the typical capacitor (C3) value is 10nF.
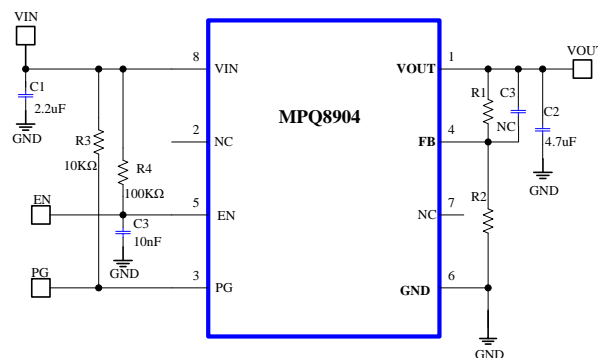

Figure 2: Fast Power-On Start-Up Circuit
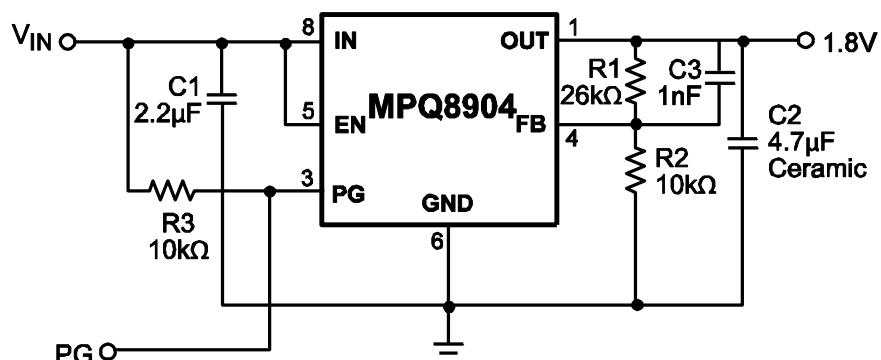
TYPICAL APPLICATION CIRCUIT

Figure 3: 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.

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.
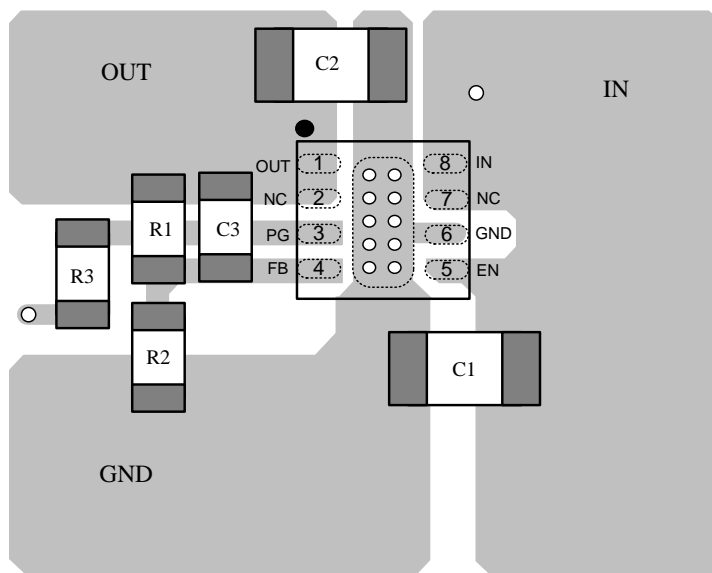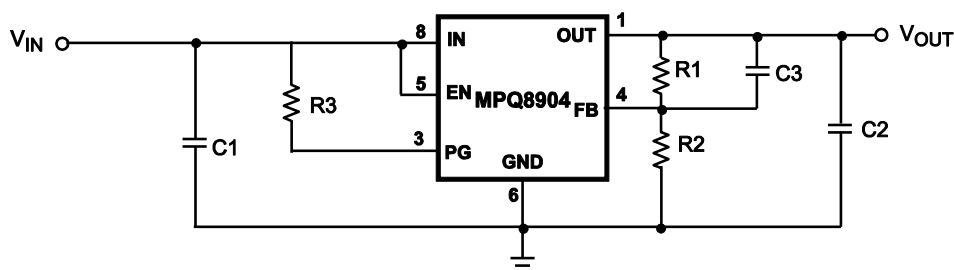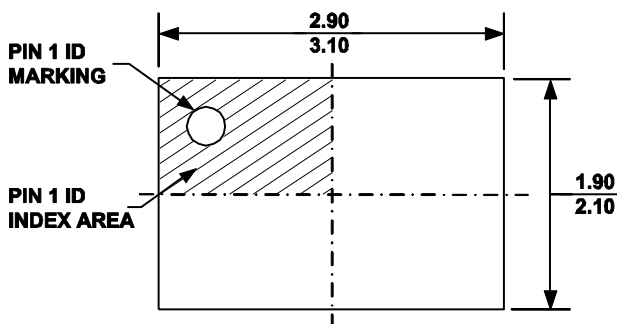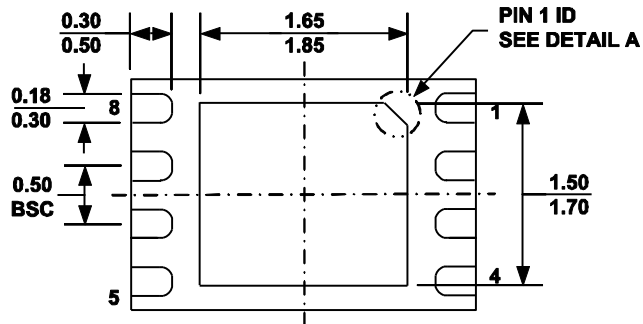

Figure 4: PCB Layout, Top Layer

PACKAGE INFORMATION

QFN-8 (2mm x 3mm)

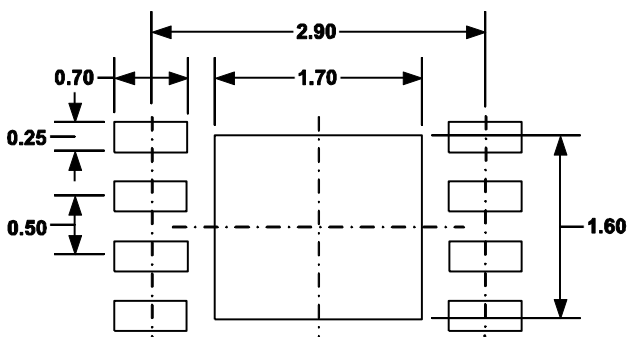**TOP VIEW**

PIN 1 ID MARKING
PIN 1 ID INDEX AREA

2.90 / 3.10
1.90 / 2.10

BOTTOM VIEW

PIN 1 ID SEE DETAIL A

0.30 / 0.50
1.65 / 1.85
0.18 / 0.30
0.50 BSC
1.50 / 1.70

8
1
4
5

SIDE VIEW

0.20 REF
0.80 / 1.00
0.00 / 0.05

DETAIL A

PIN 1 ID OPTION A 0.30x45° TYP.
PIN 1 ID OPTION B R0.20 TYP.
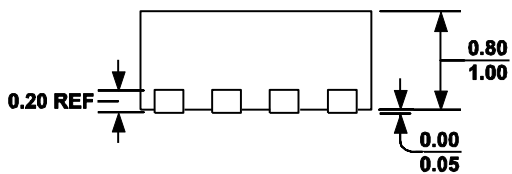
RECOMMENDED LAND PATTERN

2.90
0.70
1.70
0.25
0.50
1.60

Revision History

Revision #	Revision date	Description	Pages Updated
r1.04	6/30/2020	Change page 3 test condition V$_{EN}$=0V	PAGE3
r1.04	6/30/2020	Change page 5 Shut Down Current "mA" to "uA"	PAGE5

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