MPQ2016

40V, 30mA,Low I_Q Linear Regulator AEC-Q100 Qualified

DESCRIPTION

The MPQ2016 is a low power linear regulator that supplies power to systems with high voltage batteries. It includes a wide 4V to 40V input range, low dropout voltage and low quiescent supply current.

The MPQ2016 provides excellent line transient response time and 50dB power supply rejection ratio (PSRR). The MPQ2016 can be set externally from 1.2V to 24V through a simple resistor divider network.

The MPQ2016 also includes thermal shutdown and current limiting fault protection. It is available inQFN-8 package.

FEATURES

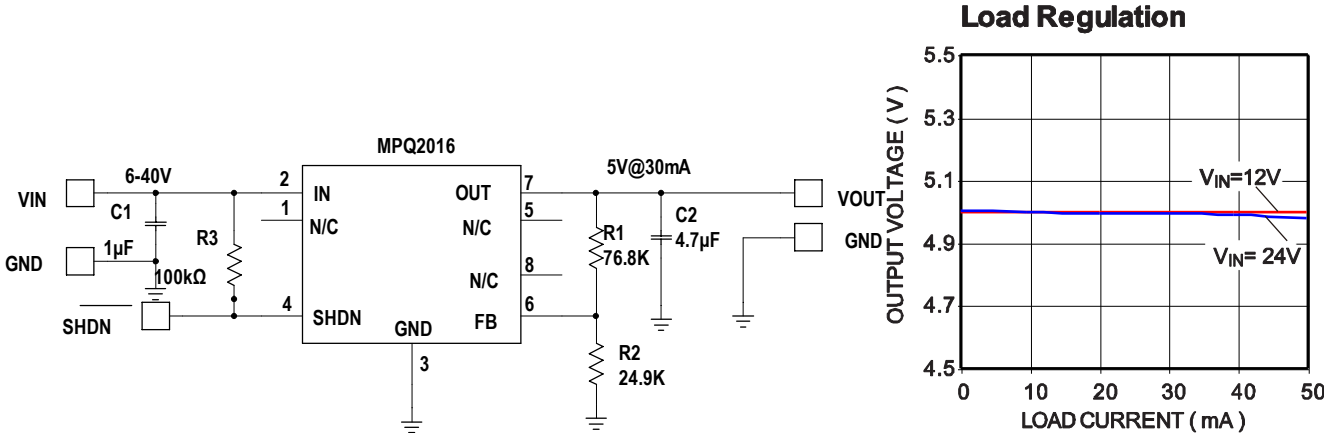
- Guaranteed Industrial/Automotive Temp Range Limits
- 4V to 40V Input Range
- 12µA Quiescent Supply Current
- <1.4µA Shutdown Supply Current
- 1.2V to 24V Adjustable Output
- 30mA Output Current with 50mA Peak Current Limit
- Better than 0.001%/mA Load Regulation
- Thermal Shutdown
- Available in QFN-8 Package
- Available in AEC-Q100 Qualified Grade 1

APPLICATIONS

- Notebook Computers
- Smart-Battery Packs
- PDAs
- Handheld Devices
- Battery-Powered Systems

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

TYPICAL APPLICATION



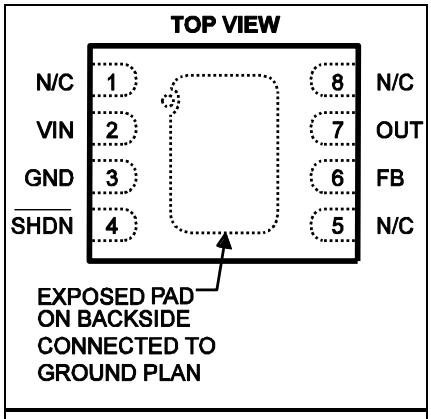
ORDERING INFORMATION

Part Number	Package	Top Marking
MPQ2016DD*	QFN-8 (2 x 3mm)	R2YW
MPQ2016DD-AEC1**	QFN-8 (2 x 3mm)	R2YW

*For Tape & Reel, add suffix –Z (g. MPQ2016DD–Z).
For RoHS compliant packaging, add suffix –LF (e.g. MPQ2016DD–LF–Z)

**For Tape & Reel, add suffix –Z (g. MPQ2016DD-AEC1–Z).
For RoHS compliant packaging, add suffix –LF (e.g. MPQ2016DD-AEC1–LF–Z)

PACKAGE REFERENCE



QFN-8 (2mm x 3mm)

ABSOLUTE MAXIMUM RATINGS (1)

IN, $\overline{SHDN}$ ..... –0.3V to +42V
GND ..... –0.3V to V_{IN}
FB ..... –0.3V to + 1.5V
Continuous Power Dissipation (T_A = +25°C) (2)
QFN8 (2X3mm)……2.3W
Lead Temperature ..... 260°C
Storage Temperature..... –65°C to +150°C

Recommended Operating Conditions (3)

Supply Voltage V_{IN} ..... 4V to 40V
Output Voltage V_{OUT}..... 1.2V to 24V
Operating Junction Temp. (T_J). -40°C to +125°C

Thermal Resistance (4) θ_{JA} θ_{JC}

QFN8 (2 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 JESD51-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

V_{IN} = 15V, I_{LOAD} = 5µA, T_J = -40ºC To +125°C, Typical values are at T_J=25°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
Input Voltage	V_{IN}		4		40	V
Input Quiescent Current	I_Q	T_J = +25°C, No load		12		µA
		T_J = –40°C to +125°C, No load			30	
Shutdown Supply Current	I_S	Shutdown Mode, T_J = +25°C		1.4	8	µA
		Shutdown Mode, T_J = –40°C to +125°C			10	
FB Threshold	V_{FB}	FB = OUT, I_{LOAD} = 1mA	1.205	1.23	1.254	V
		FB = OUT, I_{LOAD} = 5µA to 30mA, T_J = –40°C to +125°C	1.181	1.23	1.279	
FB Input Current	I_{FB}	V_{FB} = 1.3V	-50	+4	+50	nA
Dropout Voltage (6)	$V_{DROPOUT}$	I_{LOAD} = 30mA, V_{OUT}=5V, T_J = +25°C		700	1000	mV
		I_{LOAD} = 30mA, V_{OUT}=5V, T_J = –40°C to +125°C			1500	
PSRR (7)		DC, I_{OUT}=10mA		65		dB
Current Limit		V_{IN} = 6V	40	70	120	mA
Ground current		I_{OUT}=30mA		27	50	µA
Startup Response Time		R_L = 500Ω, C2 = 6.8µF, V_{OUT} = 5V			1	ms
$\overline{SHDN}$ Input Threshold Voltage	V_{IL}				0.2	V
	V_{IH}		1.8			
$\overline{SHDN}$ Input Current		$\overline{SHDN}$ = 0V or 15V		0.6	1.5	µA
Line Regulation		V_{IN} = 4V to 40V, I_{OUT} =1mA, V_{OUT} =V_{FB}		0.023	0.05	%/V
Load Regulation		V_{IN} =15V, I_{OUT} =5µA-30mA, V_{OUT} =V_{FB}		0.003	0.08	%/mA
Thermal Shutdown (7)		$\overline{SHDN}$ = 0V or 15V, Hysteresis = +20°C		150		°C

Note:

5) 100% production tested at TA=25°C Specifications over the temperature range are guaranteed by design and characterization.
6) Dropout Voltage is defined as the in put to output differential when the output voltage drops 1% below its nominal value.
7) Not test in production, guaranteed by design.

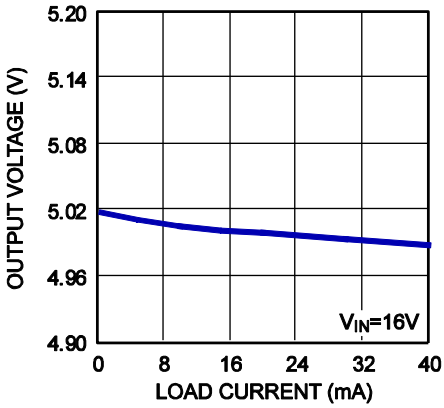
PIN FUNCTIONS

QFN Pin #	Name	Description
2	VIN	Input Voltage. Connect a 4V to 40V supply to this pin.
3	GND, Exposed Pad	Ground (the exposed pad and GND pin must be connected to the same ground plane for QFN package).
4	$\overline{SHDN}$	Shutdown. A logic LOW on this pin will shut down the IC, a logic HIGH will be enable the MPQ2016. Connect this pin to IN for automatic startup.
6	FB	Feedback. This is the feedback input pin, regulated to 1.23V.
7	OUT	Regulator Output.
1, 5, 8	N/C	No Connect.

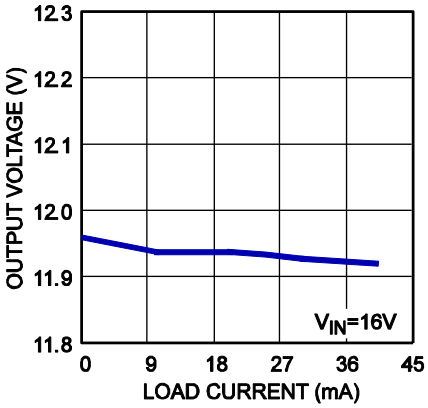
TYPICAL PERFORMANCE CHARACTERISTICS

C_{IN} = 1µF, C_{OUT} = 4.7µF, T_A = +25ºC, unless otherwise noted.

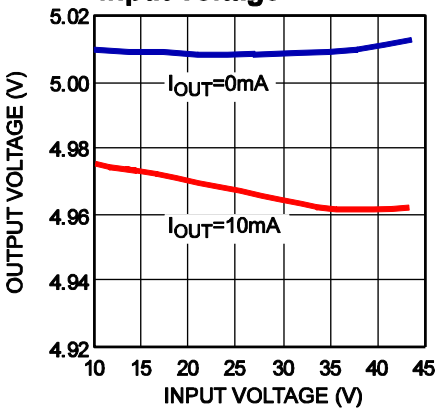
Output Voltage vs. Load Current



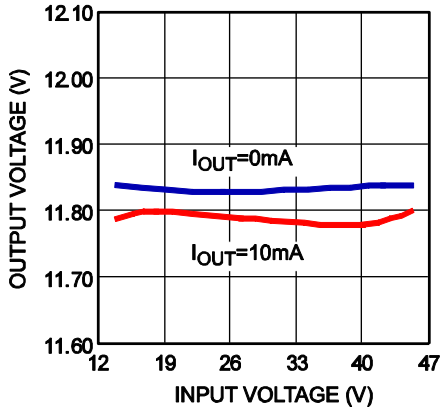
Output Voltage vs. Load Current



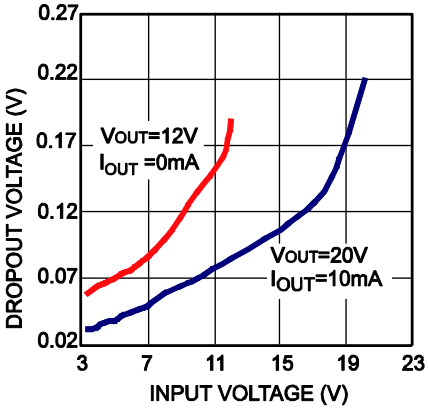
Output Voltage vs. Input Voltage



Output Voltage vs. Input Voltage

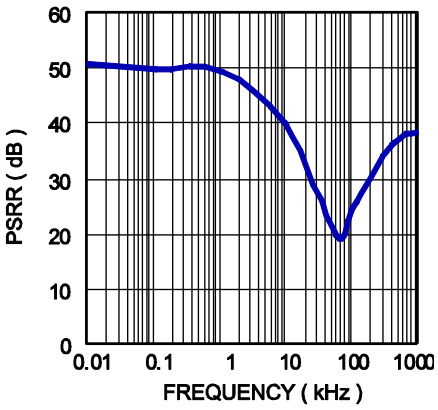


Dropout Voltage

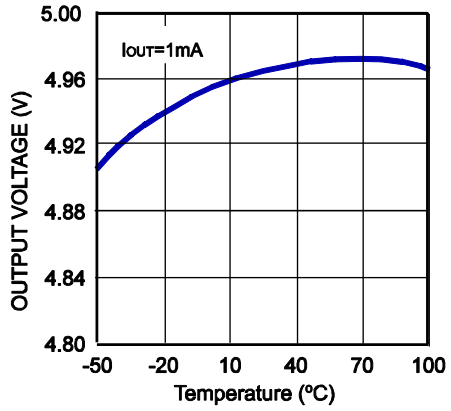


PSRR vs.Frequency

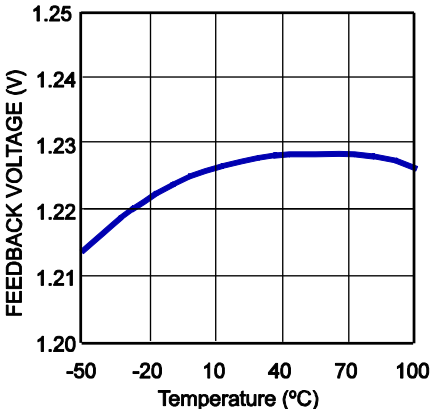
V_{IN}=$V_{\overline{SHDN}}$=4V,
V_{OUT}=1.8V, I_{OUT}=10mA,



VOUT vs. Temperature



VFB vs. Temperature

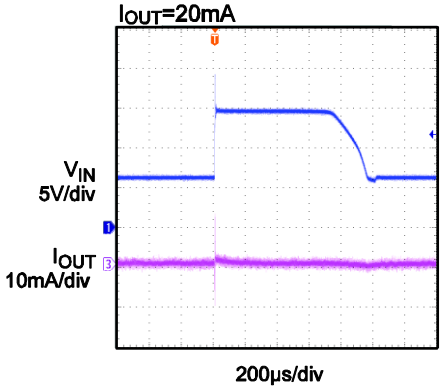


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

C_{IN} = 1µF, C_{OUT} = 4.7µF, T_A = +25ºC, unless otherwise noted.

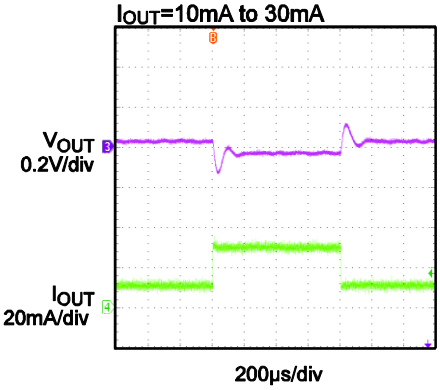
Line Transient

V_{IN}=$V_{\overline{SHDN}}$=7V to 12V, V_{OUT}=5V, I_{OUT}=20mA



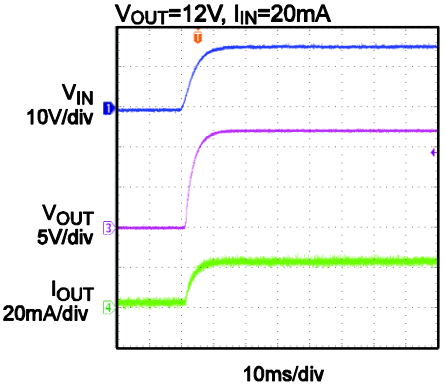
Load Transient

V_{IN}=$V_{\overline{SHDN}}$=15V, V_{OUT}=12V, I_{OUT}=10mA to 30mA



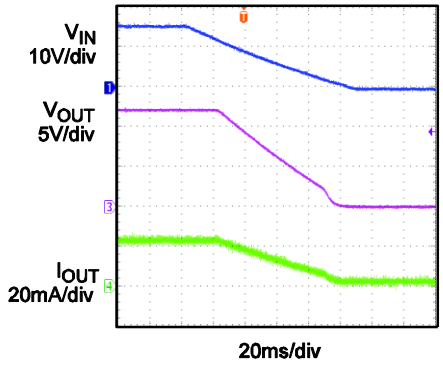
V_{IN} Ramp Up

V_{IN}=$V_{\overline{SHDN}}$=16V, V_{OUT}=12V, I_{IN}=20mA



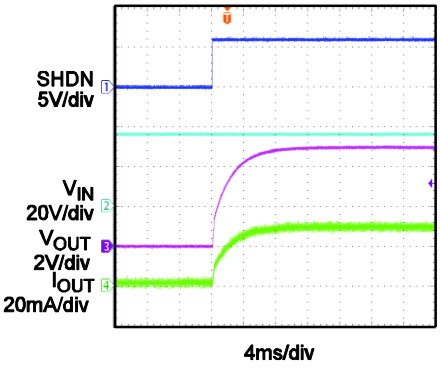
V_{IN} Ramp Down

V_{IN}=$V_{\overline{SHDN}}$=16V, V_{OUT}=12V, I_{IN}=20mA



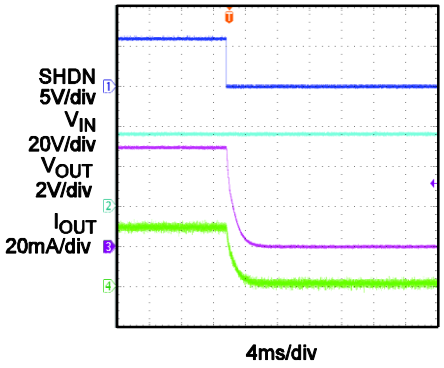
Enable Response

V_{IN}=35V, $V_{\overline{SHDN}}$=6V, V_{OUT}=5V, I_{OUT}=30mA



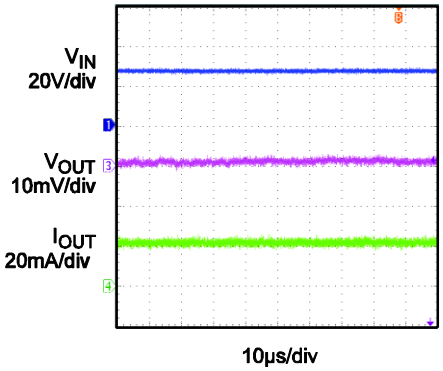
Shutdown Response

V_{IN}=35V, $V_{\overline{SHDN}}$=6V, V_{OUT}=5V, I_{OUT}=30mA



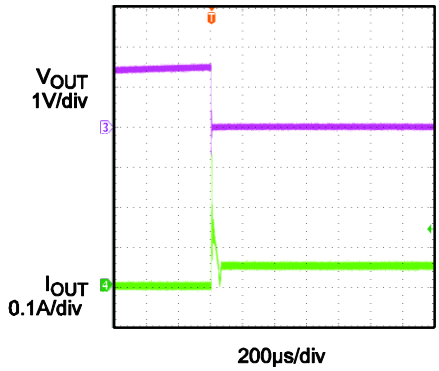
Load Ripple

V_{IN}=$V_{\overline{SHDN}}$=28V,V_{OUT}=24V I_{OUT}=20mA



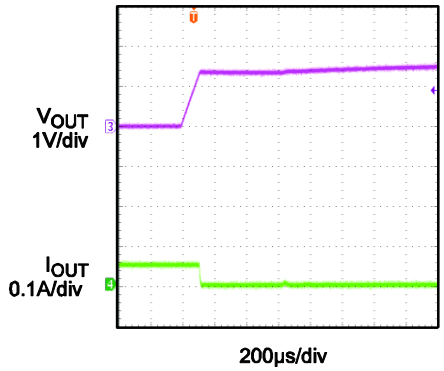
Short Circuit

V_{IN}=$V_{\overline{SHDN}}$=5V, V_{OUT}=1.8V



Short Circuit Recovery

V_{IN}=$V_{\overline{SHDN}}$=5V, V_{OUT}=1.8V



FUNCTION BLOCK DIAGRAM

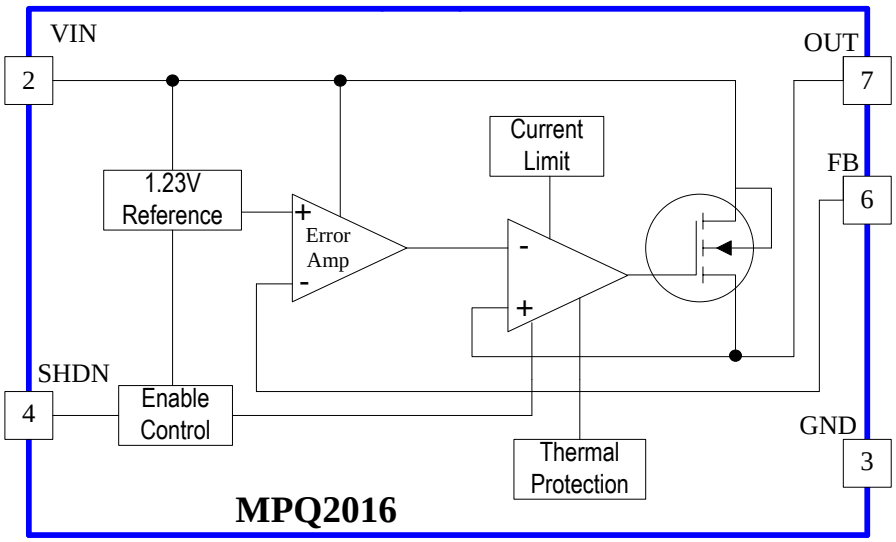


Figure 1: Functional Block Diagram

OPERATION

The MPQ2016 is a linear regulator designed primarily for high input voltage applications. The MPQ2016 has an output that is adjustable from 1.2V to 24V with a simple resistor divider. The maximum power output current is a function of the package's maximum power dissipation for a given temperature.

The MPQ2016 uses external feedback, allowing the user to set the output voltage with an external resistor divider. The typical FB pin threshold is 1.23V.

The IC enters shutdown mode when $\overline{SHDN}$ is low. In shutdown mode, the pass transistor, control circuitry, reference and all biases turn off, reducing the supply current to <2μA. Connect $\overline{SHDN}$ to IN for automatic startup.

The peak output current is limited to 50mA, which exceeds the 30mA recommended continuous output current. When the junction temperature is too high, the thermal sensor sends a signal to the control logic that will shutdown the IC. The IC will restart, when the temperature has sufficiently cooling down.

The maximum power dissipation is dependent on the thermal resistance of the case and the circuit board, the temperature difference between the die junction and the ambient air, and the rate of air flow. The GND pin and Exposed Pad must be connected to the ground plane for proper dissipation.

APPLICATION INFORMATION

COMPONENT SELECTION

Setting the Output Voltage

Set the output voltage of the MPQ2016 by using a resistor divider as shown:

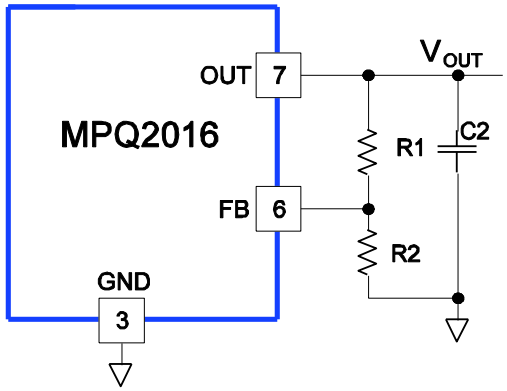


Figure 2: MPQ2016 with External Resistor Divider

Choose R1=76.8kΩ to maintain a 5μA minimum load. Calculate the value for R1 using the following equation:

$$R1 = R2 \times \left(\frac{V_{OUT}}{1.23V} - 1 \right)$$

Input Capacitor

For proper operation, place a 1μF to 10μF ceramic capacitor (C1) between the input pin and ground. Larger values in this range will help improve line transient response.

Output Capacitor

For stable operation, use a 1μF to 10μF ceramic capacitor (C2) between Vout to Ground. Larger values in this range will help improve load transient response and reduce noise.

To improve load transient response, add a small ceramic 22nF feed forward capacitor in parallel with R1(X7R type capacitor is recommended for their performance over temperature). The feed forward capacitor is not required for stable operation.

Output Noise

The MPQ2016 will exhibit noise on the output during normal operation. This noise is negligible for most applications. However, in applications that include analog-to-digital converters (ADCs) of more than 12 bits, one needs to consider the ADC's power supply rejection specifications.

The feed forward capacitor C3 across R1 will significantly reduce the output noise.

Output Short Circuit Protection

The MPQ2016 is protected for most of the applications where the VOUT≤5V. However, when the output is shorted to GND with high input voltage (VIN>36V) and High output voltage (VOUT>7V) the parasitic inductance will caused a current spike in the loop. It is recommended to add a 100Ω resistor from MPQ2016 GND to power GND to protect the MPQ2016.

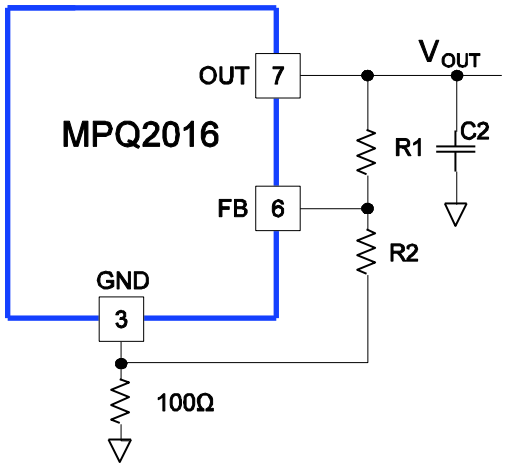


Figure 3: Short Circuit Protection Resistor

External Reverse Voltage Protection

In some situations, e.g. a backup battery is connected as MPQ2016 load, the output voltage may be held up while the input is either pulled to ground to some intermediated voltage or is floating. Thus, the output voltage is higher than input voltage. Since MPQ2016 internal NMOS pass element has a body diode, a current will conduct from the output to input and is not internally limited. It's possible that the IC will be damaged by this unlimited reverse current. To avoid this, it's recommended to place an external diode at input like below.

PCB Layout Guide

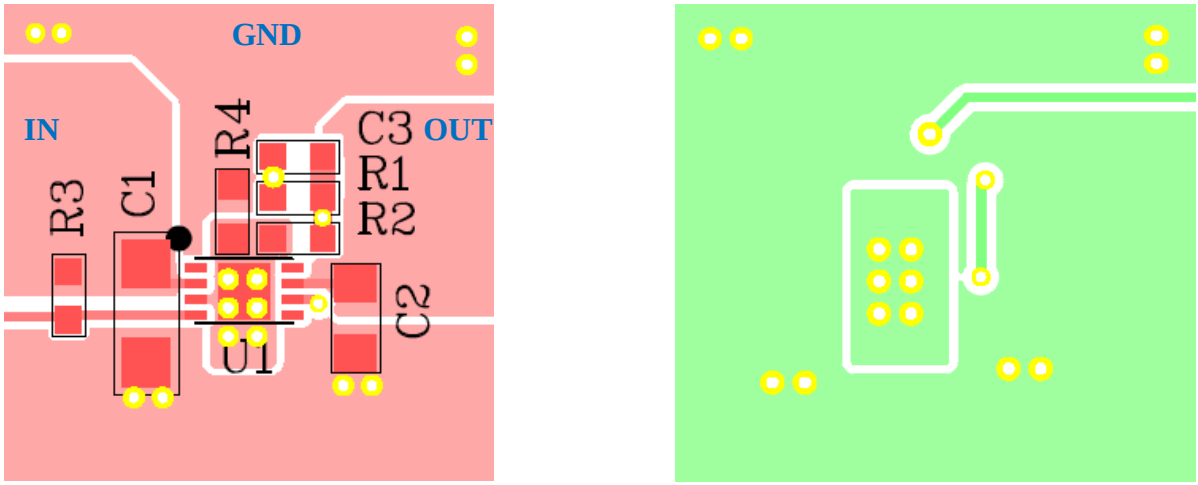
PCB layout is very important to achieve good regulation, ripple rejection, transient response and thermal performance. It is highly recommended to duplicate EVB layout for optimum performance.

If change is necessary, please follow these guidelines and take Figure 4 for reference.

(1) Input and output bypass ceramic capacitors are suggested to be put close to the IN Pin and OUT Pin respectively.

(2) Ensure all feedback connections are short and direct. Place the feedback resistors and compensation components as close to the chip as possible.

(3) Connect IN, OUT and especially GND respectively to a large copper area to cool the chip to improve thermal performance and long-term reliability.



Top Layer **Bottom Layer**

Figure 4: PCB Layout

Design Example

The detailed application schematic is shown in Figure 5. The typical performance and circuit waveforms have been shown in the Typical Performance Characteristics section. For more device applications, please refer to the related Evaluation Board Datasheets.

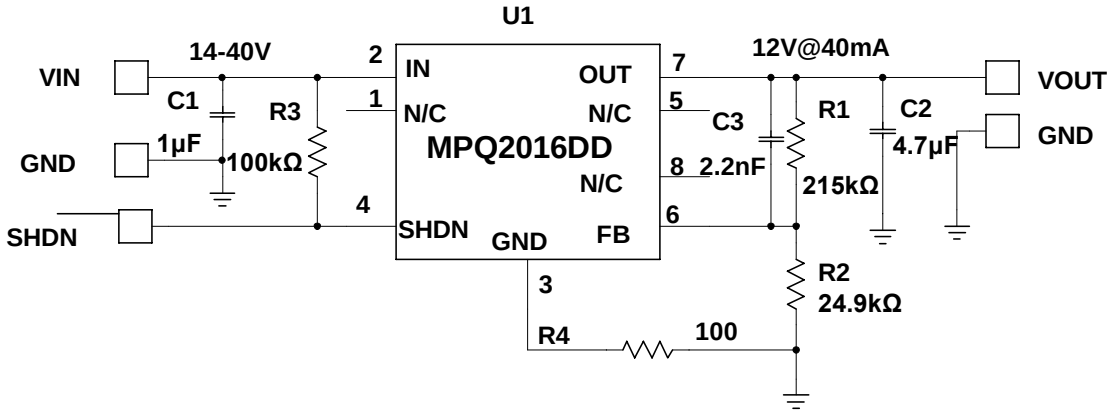
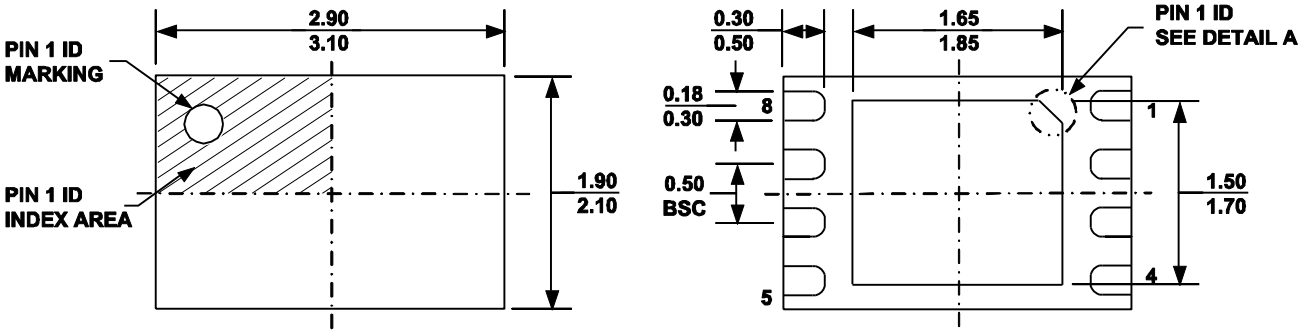


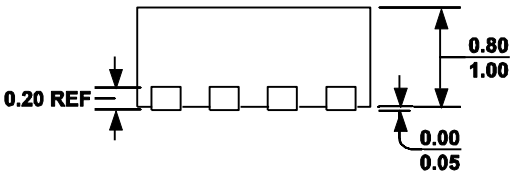
Figure 5: 12V Output Application Schematic

PACKAGE INFORMATION

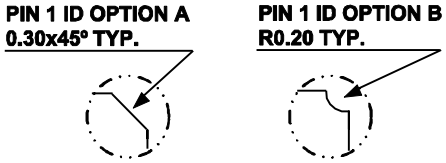
QFN8 (2mm x 3mm)



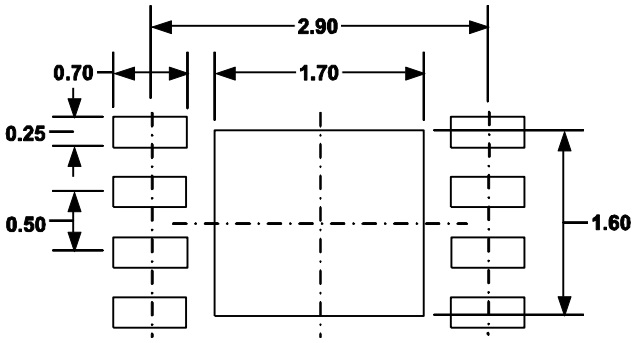
TOP VIEW **BOTTOM VIEW**



SIDE VIEW



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.