MPQ20051

Low Noise, High PSRR, 1A Linear Regulator AEC-Q100 Qualified

DESCRIPTION

The MPQ20051 is a low-dropout linear regulator that supplies up to 1A current with a 140mV dropout voltage. The externally-adjustable output voltage has a range of 0.8V to 5V from an input voltage of 2.5V to 5.5V.

An internal PMOS pass element allows for a low 130µA ground current, making the MPQ20051 suitable for battery-powered devices. Other features include low-power shutdown, and short-circuit and thermal protection.

The MPQ20051 is available in 3mm x 3mm 8-pin QFN package.

FEATURES

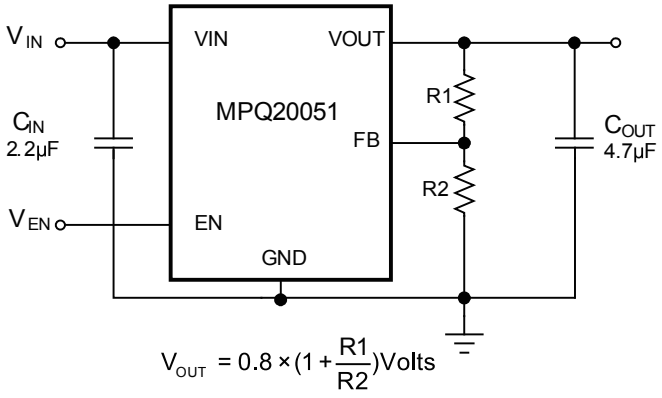
- Guaranteed Industrial/Automotive Temp Range Limits
- Up to 1A Output Current
- Low 140mV Dropout at 1A
- Low 130µA Ground Current
- Output Voltage Available from 0.8V to 5V
- Low Noise: 13µV_{RMS} typical (10Hz to 100kHz)
- 63dB PSRR @1kHz
- Stable with Ceramic Capacitor
- Excellent Load/Line Transient Response
- Current Limiting and Thermal Protection
- Available in 3mm x 3mm 8-pin QFN Package
- Available in AEC-Q100 Qualified Grade 1

APPLICATIONS

- Automotive/Industrial Power System
- Notebook Computers
- Cordless Telephones
- Cellular Phones
- Wireless Communication Equipments

All MPS parts are lead-free and adhere to the RoHS directive. For MPS green status, please visit MPS website under Quality Assurance. “MPS” and “The Future of Analog IC Technology” are Registered Trademarks of Monolithic Power Systems, Inc.

TYPICAL APPLICATION



$$V_{OUT} = 0.8 \times (1 + \frac{R1}{R2}) \text{Volts}$$

ORDERING INFORMATION

Part Number	Package	Top Marking	MSL Rating
MPQ20051DQ-AEC1*	QFN-8(3mmx3mm)	*See Below*	Level1
MPQ20051DQ**	QFN-8(3mmx3mm)		

* For Tape & Reel, add suffix -Z (e.g. MPQ20051DQ-AEC1-Z)
For RoHS compliant packaging, add suffix –LF (e.g. MPQ20051DQ-AEC1-LF-Z).

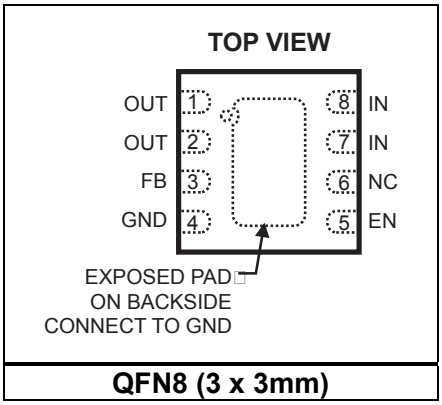
** For Tape & Reel, add suffix -Z (e.g. MPQ20051DQ-Z)
For RoHS compliant packaging, add suffix –LF (e.g. MPQ20051DQ-LF-Z).

TOP MARKING

ABRY
LLL

ABR: product code
Y: year code
LLL: lot number

PACKAGE REFERENCE



QFN8 (3 x 3mm)

ABSOLUTE MAXIMUM RATINGS (1)

VIN, EN, FB to GND ..... -0.3V to +6V
OUT to GND..... -0.5V to (V_{IN} + 0.5V)
Continuous Power Dissipation ..... (T_A=25°C) (2)
QFN8 (3x3mm) 2.0W
Junction Temperature..... 150°C
Storage Temperature Range.....-65°C to 150°C
Lead Temperature (Soldering, 10sec).....260°C

ESD SUSCEPTIBILITY(3)

HBM (Human Body Mode)..... 2kV
CDM (Changed Device Mode) 750V

Recommended Operating Conditions (4)

Supply Input Voltage..... 2.5V to 5.5V
Enable Input Voltage ..... 0V to 5.5V
Operating Junction Temp. (T_J). -40°C to +125°C

Thermal Resistance (5) θ_{JA} θ_{JC}

QFN-8 (3mmx3mm) .....50 ..... 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) Devices are ESD sensitive. Handling precaution recommended.
4) The device is not guaranteed to function outside of its operating conditions.
5) Measured on JESD51-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

V_{IN}=V_{OUT}+0.5V or V_{IN}=2.5V, EN=V_{IN}, T_J=-40ºC to +125ºC Typical values are at T_J=25°C, unless otherwise specified

Parameter	Condition		Min	Typ	Max	Units
Input Voltage			2.5		5.5	V
Input Under Voltage Lockout	V_{IN} rising		1.95		2.3	V
Hysteresis of UVLO				160		mV
FB Voltage	V_{OUT}=0.8V, I_{OUT}=1mA	T_J=25°C	0.784	0.8	0.816	V
		-40 ≤T_J ≤125°C	0.776	0.8	0.824	
Output Voltage Accuracy	I_{OUT}=1mA, T_J=25°C		-2		2	%
	I_{OUT}=1mA, -40≤T_J≤125°C		-3		3	
Maximum Output Current	Continuous, V_{IN}≥2.5V, V_{OUT}=2.5V		1			A
Short-Circuit Current Limit	V_{OUT}=0, V_{IN}≥2.5V		1.2	1.6	2.3	A
In-Regulation Current Limit	V_{OUT}=2.5V, V_{OUT} within 4% of normal output voltage V_{IN}=5.5V		1.4	2.2	3.0	A
Ground Current	I_{OUT}=0.1mA, V_{OUT}=2.5V			130	200	µA
	I_{OUT}=1A, V_{OUT}=2.5V			400	700	
Dropout Voltage(6)	I_{OUT}=1A, V_{OUT}=2.5V			140	280	mV
	I_{OUT}=750mA, V_{OUT}=2.5V			105	210	
	I_{OUT}=500mA, V_{OUT}=2.5V			70	140	
Line Regulation(7)	V_{OUT}=2.5V, V_{IN} from V_{OUT}+0.5V to 5.5V, I_{OUT}=100mA,		-0.15		0.15	%/V
Load Regulation (8)	I_{OUT} from 100mA to 1A, V_{OUT}=2.5V		-0.5		0.5	%
Output Voltage Noise (9)	I_{OUT}=100mA, f ranges from 10Hz to 100kHz	V_{OUT}=1.1V		13		μV_{RMS}
		V_{OUT}=3.3V		35		
		V_{OUT}=5V		55		
PSRR (9)	V_{IN} = 2.5V, V_{OUT} = 1.1V, I_{OUT} = 1A	f=100Hz		65		dB
		f=1kHz		63		
		f=10kHz		63		
		f=1MHz		33		
Shutdown Supply Current	V_{IN}=+5.5V	T_J=25°C		0.1	0.3	µA
		-40 ≤T_J ≤125°C			30	
EN Pin Current , Enabled	V_{IN}=V_{EN}=+5.5V			0.1	0.3	µA
Feedback Pin Current	V_{IN}=+5.5V, V_{FB}=6V			0.1	0.3	µA
Startup Time	$V_{OUT(NOM)}$=2.5V, C_{OUT}=4.7µF, V_{OUT}=10% to 90%$V_{OUT(NOM)}$			45	100	µs
EN PIN Threshold	EN Logic High		1.5			V
	EN Logic Low				0.4	
Thermal Shutdown Temperature (9)	Typical thermal hysteresis =20°C			150		°C

Notes:

6) Dropout Voltage is defined as the input to output differential when the output voltage drops 100mV below its nominal value.

7) Line Regulation= $\frac{\left|V_{OUT\left[V_{IN(MAX)}\right]} - V_{OUT\left[V_{IN(MIN)}\right]}\right|}{\left[V_{IN(MAX)} - V_{IN(MIN)}\right] \times V_{OUT(NOM)}} \times (\% / V)$

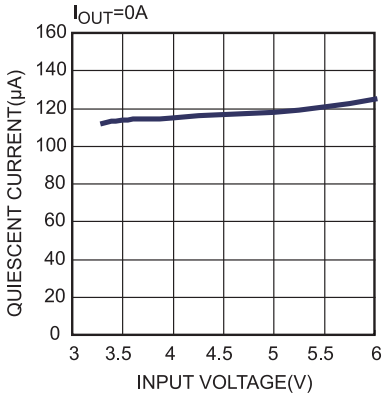
8) Load Regulation= $\frac{\left|V_{OUT\left[I_{OUT(MAX)}\right]} - V_{OUT\left[I_{OUT(MIN)}\right]}\right|}{V_{OUT(NOM)}} \times (\%)$

9) Design guarantee, not production test.

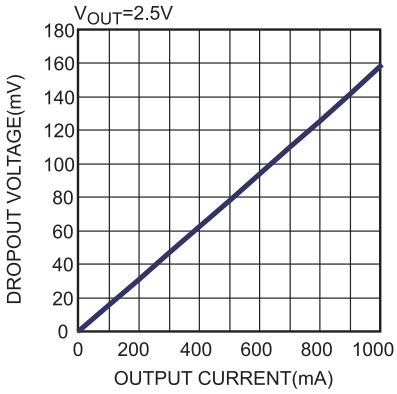
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 2.5V, V_{OUT} = 1.1V, C_{IN}=2.2µF, C_{OUT}=4.7µF, T_A = 25°C, unless otherwise noted.

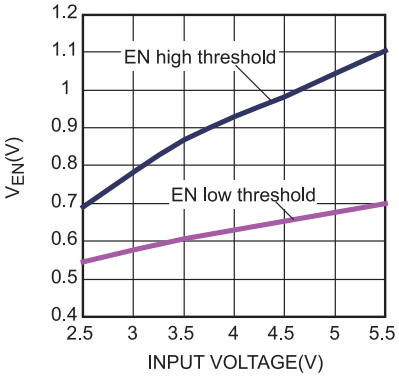
Quiescent Current vs. Input Voltage



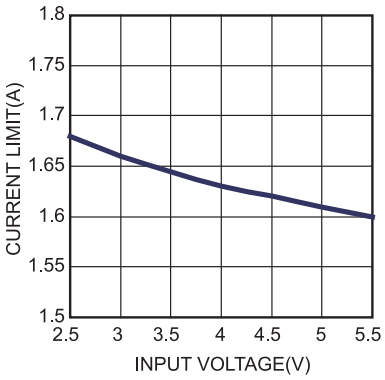
Dropout Voltage vs. Output Current



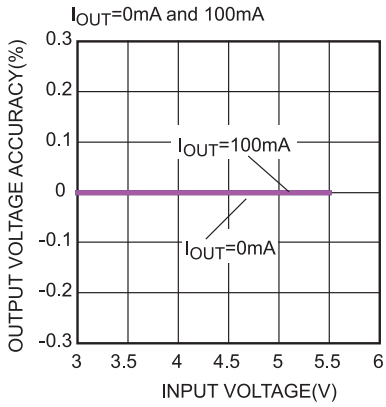
EN threshold vs. Input Voltage



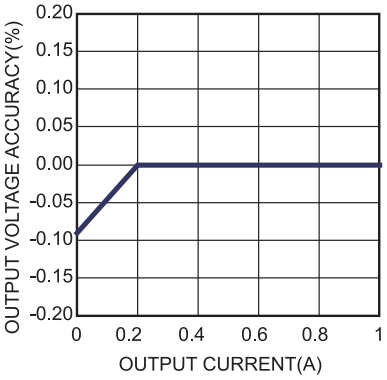
Current Limit vs. Input Voltage



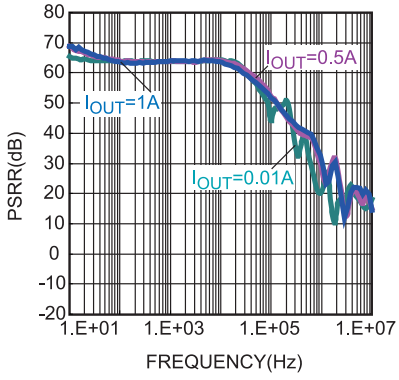
Line Regulation



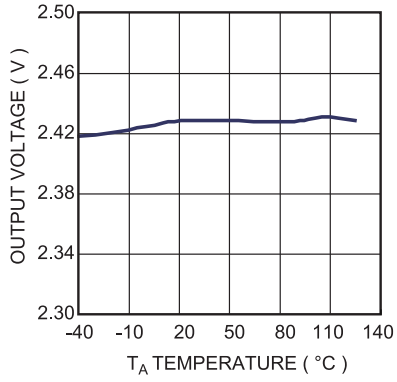
Load Regulation



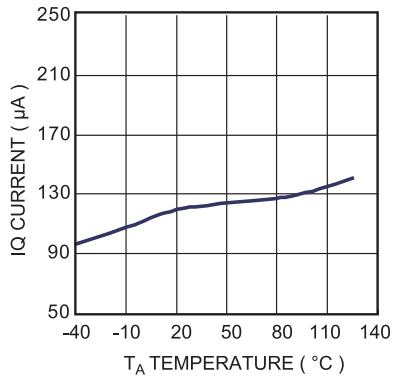
PSRR Vs. Frequency



V_{OUT} vs. T_A



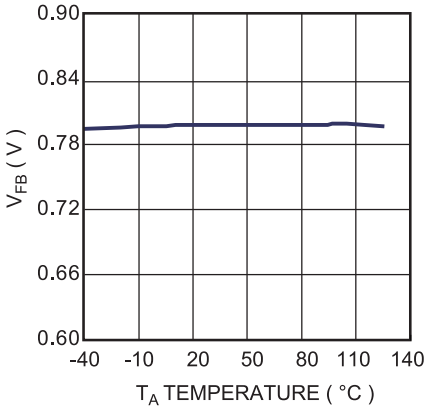
I_Q Current vs. T_A



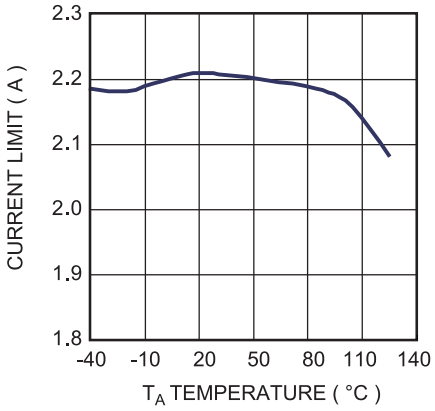
TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 2.5V, V_{OUT} = 1.1V, C_{IN}=2.2µF, C_{OUT}=4.7µF, T_A = 25°C, unless otherwise noted.

V_{FB} vs. T_A



Current Limit vs. T_A

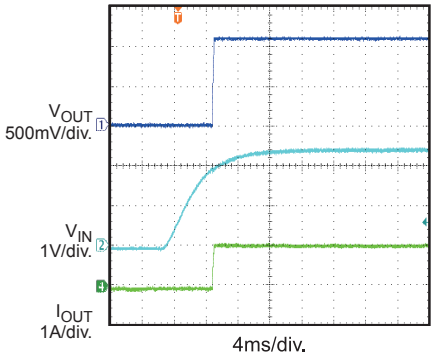


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 2.5V, V_{OUT} = 1.1V, C_{IN}=2.2µF, C_{OUT}=4.7µF, T_A = 25°C, unless otherwise noted.

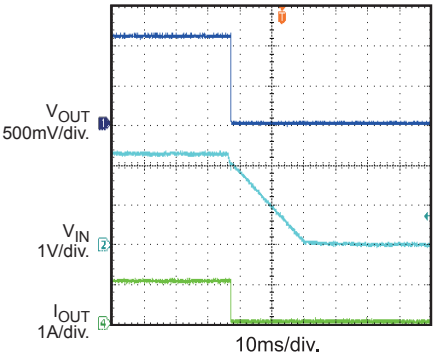
Input Power Start Up

V_{IN}=2.5V, V_{OUT}=1.1V, I_{OUT}=1A, with Resistor Load



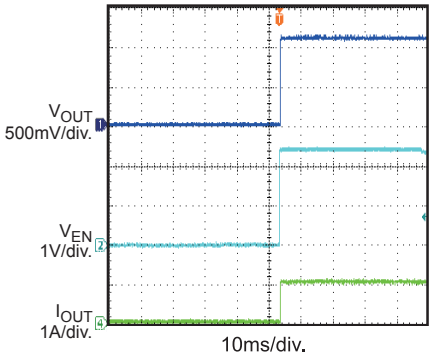
Input Power Shutdown

V_{IN}=2.5V, V_{OUT}=1.1V, I_{OUT}=1A, with Resistor Load



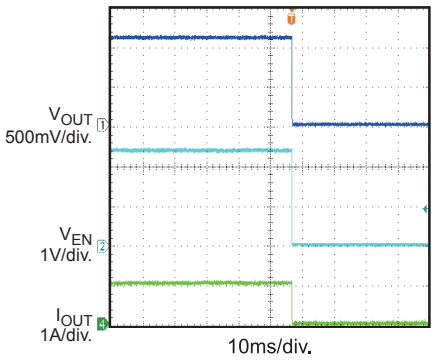
EN Start Up

V_{EN}=2.5V, V_{OUT}=1.1V, I_{OUT}=1A, with Resistor Load



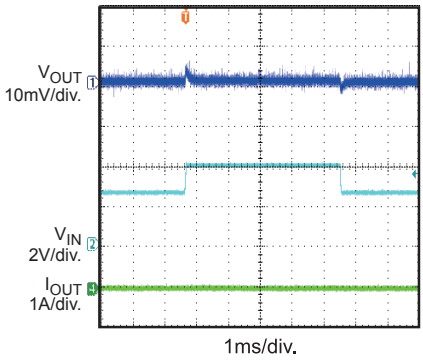
EN Shutdown

V_{EN}=2.5V, V_{OUT}=1.1V, I_{OUT}=1A, with Resistor Load

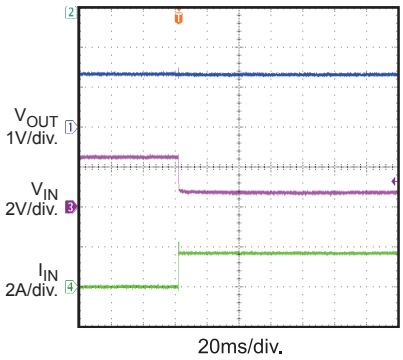


Line Transient

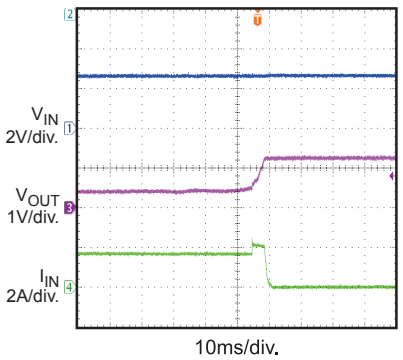
V_{IN}=2.5V to 4V, V_{OUT}=1.1V, I_{OUT}=10mA, with Resistor Load



Short Output

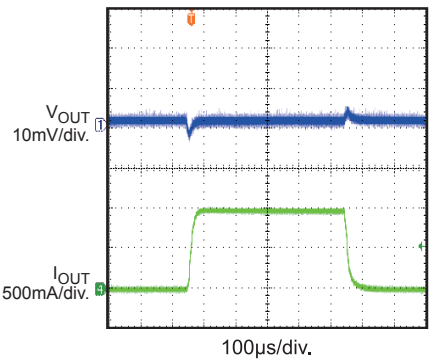


Short Output Recovery



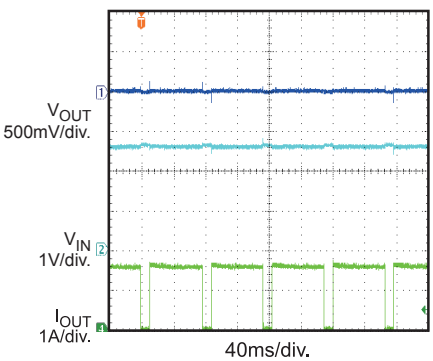
Over Current Protection Steady State

V_{IN}=2.5V, V_{OUT}=1.1V



Over Current Protection Steady State

V_{IN}=2.5V, V_{OUT}=1.1V



PIN FUNCTIONS

Pin #	Name	Pin Function
1, 2	VOUT	Regulator output. Bypass with a standard 4.7μF ceramic capacitor to GND. Connect all the pins together externally.
3	FB	Feedback Input. Connect FB to the center point of the external resistor divider. The feedback threshold voltage is 0.8V.
4	GND Exposed pad	Ground. Connect exposed pad to GND plane for optimal thermal performance.
5	EN	Regulator Enable Control Input. Drive EN above 1.5V to turn on the MPQ20051. Drive EN below 0.4V to turn it off. Do not float the EN pin.
6	NC	No Connection. Leave this NC pin open.
7, 8	VIN	Regulator Input. Supply voltage ranges from 2.5V to 5.5V. Bypass with 2.2μF capacitor. These pins must be externally connected for proper operation even if they are internally connected.

FUNCTIONAL BLOCK DIAGRAM

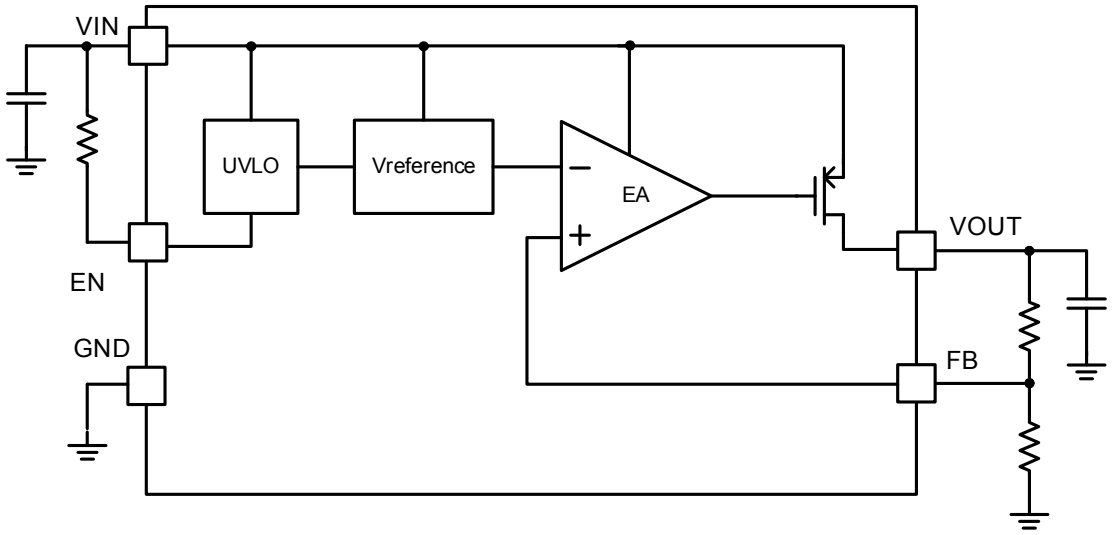


Figure 1—Functional Block Diagram

OPERATION

The MPQ20051 is a low-dropout linear regulator that can supply up to 1A current, which makes it suitable for very low voltage, low quiescent, low noise, and high PSRR applications such as wireless LAN transceivers, notebook computers, smartphones, and other low-power electronics.

The MPQ20051 uses an internal PMOS as the pass element and includes both thermal shutdown and an internal current-limiting circuit.

Dropout Voltage

Dropout voltage is the minimum input to output differential voltage required for the regulator to maintain an output voltage within 100mV of its nominal value. Because the PMOS pass element behaves as a low-value resistor, the dropout voltage of MPQ20051 is only 140mV.

Shutdown

The MPQ20051 can be switched ON or OFF by a logic input at the EN pin: Logic high turns the regulator on and logic low turns it off. Tie the EN pin to VIN if the application does not require the shutdown feature. Do not float the EN pin.

Current Limit

The MPQ20051 includes a current limit structure that monitors and controls the PMOS gate voltage to limit the guaranteed maximum output current to 1.6A.

Thermal Protection

Thermal protection turns off the PMOS when the junction temperature exceeds 150°C, allowing the IC to cool. When the IC's junction temperature drops by 20°C, the PMOS will turn on again. Thermal protection limits total power dissipation in the MPQ20051. For reliable operation, limit the junction temperature to a maximum of 125°C.

Load-Transient Considerations

The output response of the load-transient consists of a transient response and DC shift—the MPQ20051's excellent load regulation effectively limits the DC shift. The output voltage transient depends on the output capacitor's value and ESR. Increasing the capacitance and decreasing the ESR will improve the transient response.

APPLICATION INFORMATION

Setting the Output Voltage

The MPQ20051 has an externally-set output voltage with a range of 0.8V to 5V given a 2.5V to 5.5V input. Set the output voltage using a resistive voltage divider from the output voltage to the FB pin. The result of the voltage divider at the FB pin is:

$$V_{FB} = V_{OUT} \frac{R2}{R1+R2}$$

Where V_{FB} is the feedback threshold voltage (V_{FB} = 0.8V), and V_{OUT} is the output voltage. Thus the output voltage is:

$$V_{OUT} = 0.8 \times \frac{R1+R2}{R2}$$

R2 can go as high as 100kΩ, but typical applications use 10kΩ. After selecting R2, R1 is determined by:

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

For example, for a 1.1V output voltage, R2 is 10kΩ, and R1 is 3.75kΩ. You can select a standard 3.75kΩ (±1%) resistor for R1.

Power Dissipation

The power dissipation for any package depends on the thermal resistance of the case and circuit board, the temperature differential between the junction and ambient air, and the rate of air flow. The power dissipation across the device can be represented by the equation:

$$P = (V_{IN} - V_{OUT}) \times I_{OUT}$$

The allowable power dissipation can be calculated using the following equation:

$$P_{(MAX)} = (T_{Junction} - T_{Ambient}) / \theta_{JA}$$

Where ($T_{Junction}$ − $T_{Ambient}$) is the temperature differential between the junction and the surrounding environment, θ_{JA} is the thermal resistance from the junction to the ambient environment. Connecting the exposed GND pad to a large ground pad or plane helps to channel away heat.

Output Capacitor Selection

The MPQ20051 is specifically designed to work with a standard ceramic output capacitor to save space and improve performance. Use a 4.7μF ceramic capacitor for most applications. Larger output capacitors will improve load transient response and reduce noise at the cost of increased size.

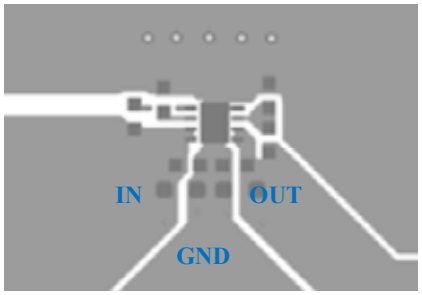
PCB Layout Guide

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 2 for reference.

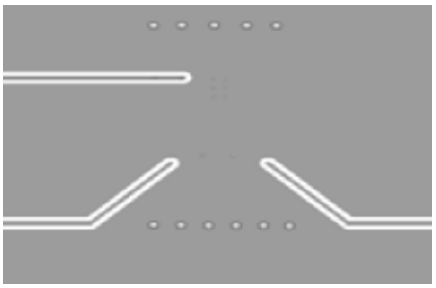
1) Input and output bypass ceramic capacitors are suggested to be put close to the IN Pin and OUT Pin respectively.

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

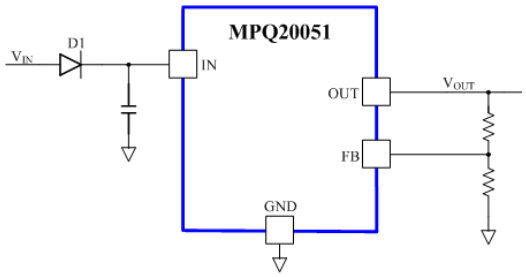


Bottom Layer

Figure 2: PCB Layout

External Reverse Voltage Protection

In some situations, e.g. a backup battery is connected as MPQ20051 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 MPQ20051 internal PMOS 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.



Adding A Input Diode

Design Example

The detailed application schematic is shown in Figure 3. 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.

TYPICAL APPLICATION CIRCUITS

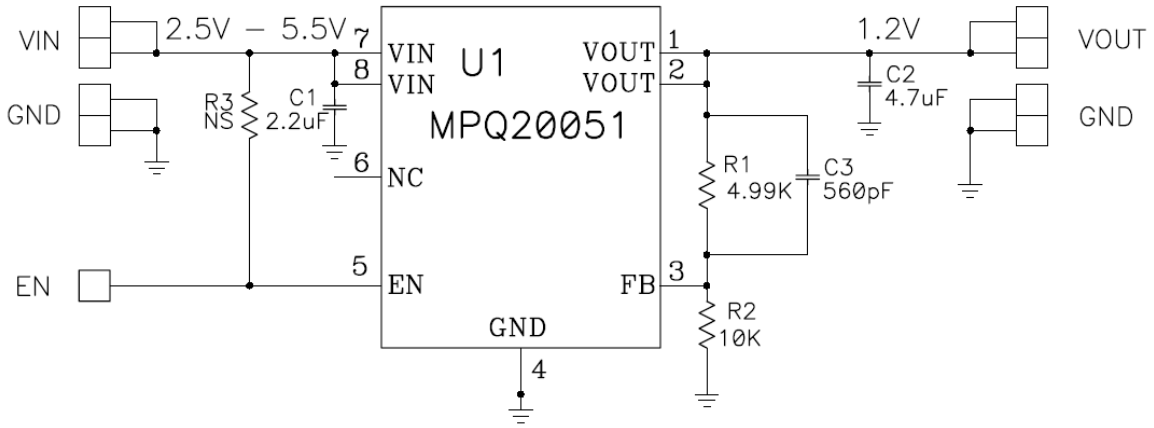
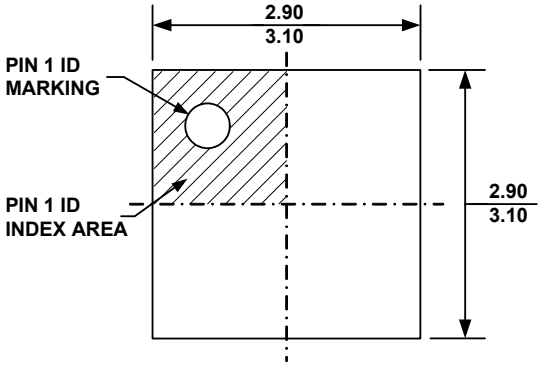


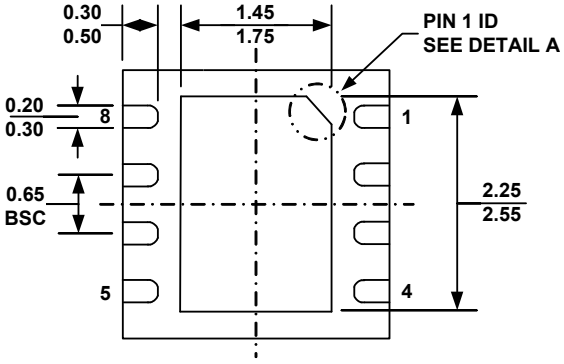
Figure 3: 1.2V Output Typical Application Schematic

PACKAGE INFORMATION

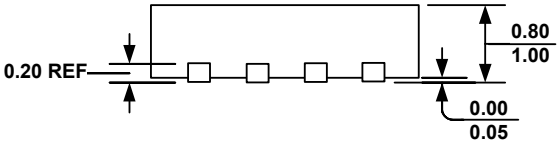
QFN-8 (3mm×3mm)



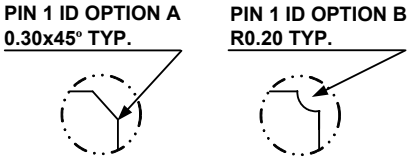
TOP VIEW



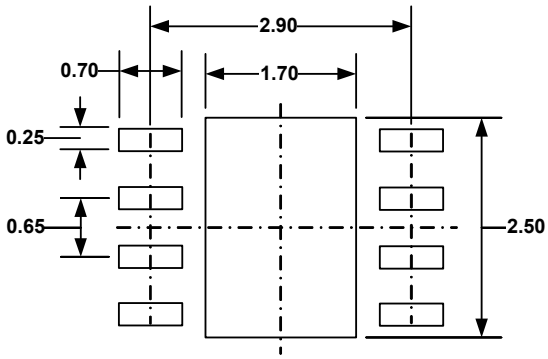
BOTTOM VIEW



SIDE VIEW



DETAIL A

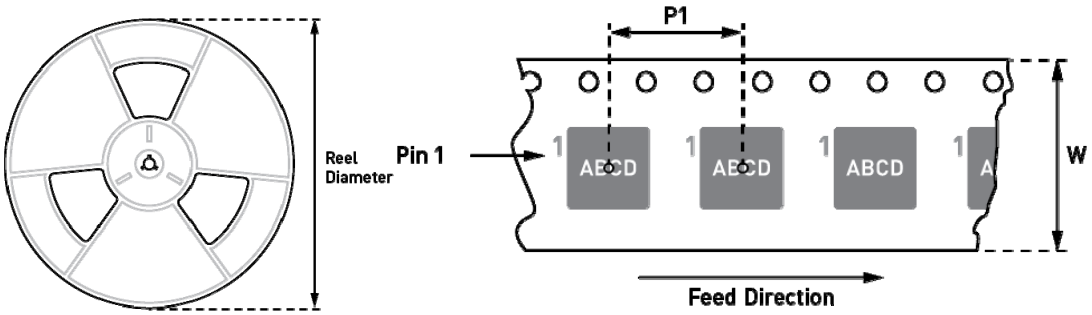


RECOMMENDED LAND PATTERN

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) JEDEC REFERENCE IS MO-229, VARIATION VEEC-2.
5) DRAWING IS NOT TO SCALE.

CARRIER INFORMATION



Part Number	Package Description	Quantity/Reel	Quantity/Tube	Reel Diameter	Carrier Tape Width	Carrier Tape Pitch
MPQ20051DQ	QFN 3x3	5000	N/A	13 in.	12mm	8mm