MPQ2013A

40V, 150mA, Low Quiescent Current Linear Regulator AEC-Q100 Qualified

DESCRIPTION

The MPQ2013A is a low power linear regulator that supplies power to systems with high voltage batteries. It includes a wide 2.5V to 40V input range, low dropout voltage and low quiescent supply current. The low quiescent current and low dropout voltage allow operations at extremely low power levels. Therefore, the MPQ2013A are ideal for the low power microcontrollers and the battery-powered equipments.

The MPQ2013A provides wide variety of fixed output voltage options (if request): 1.8V, 1.9V, 2.3V, 2.5V, 3.0V, 3.3V, 3.45V, 5.0V; and also provides the output adjustable option (from 1.215V to 15V).

The regulator output current is internally limited and the device is protected against over-load and over-temperature conditions.

The MPQ2013A also includes thermal shutdown and current limiting fault protection, and is available in QFN-6 (2mmx2mm), and QFN-8 (3mmx3mm) packages.

FEATURES

- 2.5V to 40V Input Range
- 3.3μA Quiescent Supply Current
- Stable With Low-value Output Ceramic Capacitor (> 0.47 μF)
- 150mA Specified Current for QFN-6 and QFN-8 Packages
- 620mV Dropout at 150mA Load
- Available in Fixed and Adjustable Output (1.215 V to 15 V) Versions
- Output ±2% Accuracy for QFN-8 Package Output ±4% Accuracy for QFN-6 Package
- Specified Current Limit
- Thermal Shutdown
- -40°C to +150°C Specified Junction Temperature Range
- Available in QFN-6 (2mmx2mm), or QFN-8 (3mmx3mm) Packages
- Available in AEC-Q100 Grade 1

APPLICATIONS

- Industrial/Automotive Applications
- Portable/Battery-Powered Equipment
- Ultra low power Microcontrollers
- Cellular Handsets
- Medical Imaging

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.

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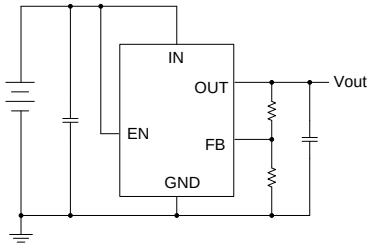
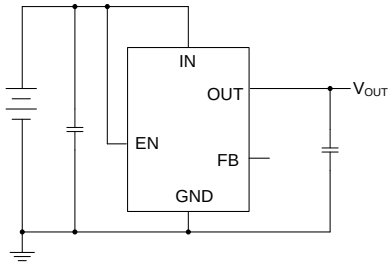
TYPICAL APPLICATION



Output Adjustable Version



Output Fixed Version

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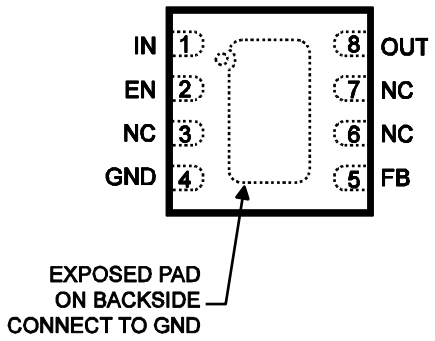
ORDERING INFORMATION

Part Number*	Package	Top Marking
MPQ2013AGQ	QFN-8 (3mmx3mm)	*See Below*
MPQ2013AGQ-18	QFN-8 (3mmx3mm)	
MPQ2013AGQ-25	QFN-8 (3mmx3mm)	
MPQ2013AGQ-33	QFN-8 (3mmx3mm)	
MPQ2013AGQ-5	QFN-8 (3mmx3mm)	
MPQ2013AGQ-AEC1	QFN-8 (3mmx3mm)	
MPQ2013AGQ-18-AEC1	QFN-8 (3mmx3mm)	
MPQ2013AGQ-25-AEC1	QFN-8 (3mmx3mm)	
MPQ2013AGQ-33-AEC1	QFN-8 (3mmx3mm)	
MPQ2013AGQ-5-AEC1	QFN-8 (3mmx3mm)	

***** For Tape & Reel, add suffix –Z (e.g. MPQ2013AGQ–Z)

TOP VIEW



QFN-8 (3mmx3mm)

TOP MARKING

AJDY
LLL

AJD: part code of MPQ2013AGQ;
Y: year code;
LLL: lot number;

AZBY
LLL

AZB: part code of MPQ2013AGQ-18;
Y: year code;
LLL: lot number;

AQNY
LLL

AQN: part code of MPQ2013AGQ-25;
Y: year code;
LLL: lot number;

AJZY
LLL

AJZ: part code of MPQ2013AGQ-33;
Y: year code;
LLL: lot number;

ALJY
LLL

ALJ: part code of MPQ2013AGQ-5;
Y: year code;
LLL: lot number;

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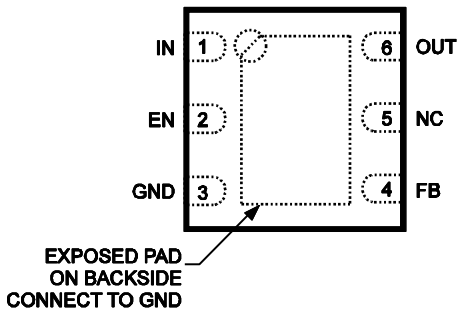
ORDERING INFORMATION

Part Number*	Package	Top Marking
MPQ2013AGG	QFN-6 (2mmx2mm)	*See Below*
MPQ2013AGG-33	QFN-6 (2mmx2mm)	
MPQ2013AGG-5	QFN-6 (2mmx2mm)	
MPQ2013AGG-AEC1	QFN-6 (2mmx2mm)	
MPQ2013AGG-33-AEC1	QFN-6 (2mmx2mm)	
MPQ2013AGG-5-AEC1	QFN-6 (2mmx2mm)	
MPQ2013AGG-18-AEC1	QFN-6 (2mmx2mm)	

***** For Tape & Reel, add suffix –Z (e.g. MPQ2013AGG–Z)

TOP VIEW



QFN-6 (2mmx2mm)

TOP MARKING

$\overline{\text{CDY}}$
LLL

CD: part code of MPQ2013AGG;
Y: year code;
LLL: lot number;

$\overline{\text{CPY}}$
LLL

CP: part code of MPQ2013AGG-33;
Y: year code;
LLL: lot number;

$\overline{\text{FRY}}$
LLL

FR: part code of MPQ2013AGG-5;
Y: year code;
LLL: lot number;

$\overline{\text{QNY}}$
LLL

QN: part code of MPQ2013AGG-18;
Y: year code;
LLL: lot number;

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ABSOLUTE MAXIMUM RATINGS (1)

IN, EN .....-0.3V to +42V
OUT .....-0.3V to +17V
FB .....-0.3V to +6V
Junction Temperature..... +150°C
Lead Temperature ..... +260°C
Storage Temperature..... -65°C to +150°C
Continuous Power Dissipation (T_A = +25°C) (2)
QFN-8(3mmx3mm)..... 2.08W
QFN-6(2mmx2mm)..... 1.25W

ESD SUSCEPTIBILITY (3)

HBM (Human Body Model) 2kV
MM (Machine Model) 200V

Recommended Operating Conditions (4)

Supply Voltage V_{IN} .....2.5V to 40V
Output Voltage V_{OUT} .....1.215V to 15V
Operating Temperature.....
.....T_A = -40°C to +125°C, $T_A \le T_J \le$ +150°C

Thermal Resistance (5) θ_{JA} θ_{JC}

QFN-6 (2mmx2mm)	80	16	°C/W
QFN-8 (3mmx3mm)	48	11	°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.

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ELECTRICAL CHARACTERISTICS

V_{EN}=V_{IN}, C_{OUT} = 1µF, T_A = -40°C to +125°C, $T_A \le T_J \le$ +150°C, unless otherwise noted. Typical values are at T_A = +25°C.

Parameter	Symbol	Condition	Min	Typ	Max	Units
Input Voltage	V_{IN}		2.5		40	V
Output Voltage Range	V_{OUT}		1.215		15	V
GND Pin Current	I_{GND}	MPQ2013AGQ, 0<I_{OUT}<1mA, V_{IN}=2.5V to 40V, V_{OUT}= 5V (V_{IN}≥6V) or FB (V_{IN}<6V)		3.3	9	µA
		MPQ2013AGQ, 1mA<I_{OUT}<30mA, V_{IN}=2.5V to 15V, V_{OUT}= 5V (V_{IN}≥6V) or FB (V_{IN}<6V)		11	22	
		MPQ2013AGQ, 30mA<I_{OUT}<150mA, VIN=3V, V_{OUT}=FB		32	50	
		MPQ2013AGQ-18, 0mA<I_{OUT}<1mA,V_{IN}=2.8V to 40V		4.4	10	µA
		MPQ2013AGQ-18, 1mA<I_{OUT}<30mA,V_{IN}=2.8V to 15V		15	25	
		MPQ2013AGQ-18, 30mA<I_{OUT}<150mA, V_{IN}=2.8V		35	50	
		MPQ2013AGQ-25, 0mA<I_{OUT}<1mA,V_{IN}=3.5V to 40V		4.4	10	µA
		MPQ2013AGQ-25, 1mA<I_{OUT}<30mA,V_{IN}=3.5V to 15V		15	25	
		MPQ2013AGQ-25, 30mA<I_{OUT}<150mA, V_{IN}=3.5V		35	50	
		MPQ2013AGQ-33, 0<I_{OUT}<1mA, V_{IN}=4.3V to 40V		4.4	10	µA
		MPQ2013AGQ-33, 1mA<I_{OUT}<30mA, V_{IN}=4.3V to 15V		15	25	
		MPQ2013AGQ-33, 30mA<I_{OUT}<150mA, V_{IN}=4.3V		35	50	
		MPQ2013AGQ-5, 0<I_{OUT}<1mA, V_{IN}=6V to 40V		4.4	10	µA
		MPQ2013AGQ-5 1mA<I_{OUT}<30mA, V_{IN}=6V to 15V		15	25	
		MPQ2013AGQ-5, 30mA<I_{OUT}<150mA, V_{IN}=6V		35	50	
		MPQ2013AGG, 0<I_{OUT}<1mA, V_{IN}=2.5V to 40V, V_{OUT}= 5V (V_{IN}≥6V) or FB (VIN<6V)		3.3	9	µA
		MPQ2013AGG, 1mA<I_{OUT}<30mA, V_{IN}=2.5V to 15V, V_{OUT}= 5V (V_{IN}≥6V) or FB (VIN<6V)		11	22	
		MPQ2013AGG, 30mA<I_{OUT}<150mA, V_{IN}=3V, V_{OUT}=FB		32	50	
		MPQ2013AGG-33, 0<I_{OUT}<1mA, V_{IN}=4.3V to 40V		4.4	10	

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ELECTRICAL CHARACTERISTICS *(continued)*

V_{EN}=V_{IN}, C_{OUT} = 1µF, T_A = -40°C to +125°C, $T_A \le T_J \le$ +150°C, unless otherwise noted. Typical values are at T_A = +25°C.

Parameter	Symbol	Condition	Min	Typ	Max	Units
GND Pin Current	I_{GND}	MPQ2013AGG-33, 1mA<I_{OUT}<30mA, V_{IN}=4.3V to 15V		15	25	µA
		MPQ2013AGG-33, 30mA<I_{OUT}<150mA, V_{IN}=4.3V		35	50	
		MPQ2013AGG-5, 0<I_{OUT}<1mA, V_{IN}=6V to 40V		4.4	10	µA
		MPQ2013AGG-5, 1mA<I_{OUT}<30mA, V_{IN}=6V to 15V		15	25	
		MPQ2013AGG-5, 30mA<I_{OUT}<150mA, V_{IN}=6V		35	50	
		MPQ2013AGG-18, 0<I_{OUT}<1mA, V_{IN}=2.8V to 40V		4.4	10	µA
		MPQ2013AGG-18, 1mA<I_{OUT}<30mA, V_{IN}=2.8V to 15V		15	25	
		MPQ2013AGG-18, 30mA<I_{OUT}<150mA, V_{IN}=2.8V		35	50	
Shutdown Supply Current	I_{SHDN}	V_{EN}=0, V_{IN}=2.5 to 40V		3	9	µA
Load Current Limit	I_{LIMIT}	MPQ2013AGQ, MPQ2013AGQ-5, MPQ2013AGG, MPQ2013AGG-5, V_{OUT} = 0V, V_{IN}=6V to 15V	160	270	400	mA
		MPQ2013AGQ-33, MPQ2013AGG-33, V_{OUT} = 0V, V_{IN}=4.3V to 15V				
		MPQ2013AGQ-18, MPQ2013AGG-18 V_{OUT}=0V,V_{IN}=3.5V to 15V				
		MPQ2013AGQ-25, V_{OUT}=0V,V_{IN}=3.5V to 15V				
Output Voltage Accuracy		MPQ2013AGQ-18,V_{IN}=2.8V,I_{OUT}=0	1.746	1.8	1.854	V
		MPQ2013AGQ-18,V_{IN}=2.8V,I_{OUT}=0, T_A = +25°C	1.773	1.8	1.827	
		MPQ2013AGQ-25,V_{IN}=3.5V,I_{OUT}=0	2.45	2.5	2.55	
		MPQ2013AGQ-33,V_{IN} =4.3V, I_{OUT}=0	3.234	3.3	3.366	
		MPQ2013AGQ-5,V_{IN}=6V, I_{OUT}=0	4.9	5	5.1	
		MPQ2013AGG-33,V_{IN}=4.3V,I_{OUT}=0	3.168	3.3	3.432	
		MPQ2013AGG-33,V_{IN}=4.3V,I_{OUT}=0, T_A = +25°C	3.251	3.3	3.349	
		MPQ2013AGG-5,V_{IN}=6V,I_{OUT}=0	4.8	5	5.2	
		MPQ2013AGG-5,V_{IN}=6V,I_{OUT}=0, T_A = +25°C	4.925	5	5.075	
		MPQ2013AGG-18,V_{IN}=2.8V,I_{OUT}=0	1.728	1.8	1.872	
		MPQ2013AGG-18,V_{IN}=2.8V,I_{OUT}=0, T_A = +25°C	1.764	1.8	1.836	

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ELECTRICAL CHARACTERISTICS *(continued)*

$V_{EN}=V_{IN}$, C_{OUT} = 1µF, T_A = -40°C to +125°C, $T_A \le T_J \le$ +150°C, unless otherwise noted. Typical values are at T_A = +25°C.

Parameter	Symbol	Condition	Min	Typ	Max	Units
FB Voltage	V_{FB}	MPQ2013AGQ, MPQ2013AGQ-25, MPQ2013AGQ-33, MPQ2013AGQ-5, V_{OUT}=FB, V_{IN}=5V, I_{OUT}=0	1.191	1.215	1.239	V
		MPQ2013AGQ-18, V_{OUT}=FB, V_{IN}=5V, I_{OUT}=0	1.179	1.215	1.251	
		MPQ2013AGQ-18, V_{OUT}=FB, V_{IN}=5V, I_{OUT}=0 T_A = +25°C	1.197	1.215	1.233	
		MPQ2013AGG, MPQ2013AGG-33, MPQ2013AGG-5, MPQ2013AGG-18, V_{OUT}=FB,V_{IN}=6V,I_{OUT}=0,	1.167	1.215	1.263	
		MPQ2013AGG, MPQ2013AGG-33, MPQ2013AGG-5, MPQ2013AGG-18, V_{OUT}=FB,V_{IN}=6V,I_{OUT}=0, T_A = +25°C	1.197	1.215	1.233	
Dropout Voltage $V_{IN}=V_{OUT(NOM)}$-0.1V	$V_{DROPOUT}$	MPQ2013AGQ, MPQ2013AGQ-5, MPQ2013AGG, MPQ2013AGG-5, I_{OUT}=150mA, V_{OUT}(NOM)=5V		600	1100	mV
		MPQ2013AGQ-33, I_{OUT}=150mA, V_{OUT}(NOM)=3.3V		700	1100	
		MPQ2013AGQ-25, I_{OUT}=150mA, V_{OUT}(NOM)=2.5V		700	1300	
		MPQ2013AGQ-18, MPQ2013AGG-18 I_{OUT}=100mA, V_{OUT}(NOM)=1.8V		700	1100	
		MPQ2013AGG-33, I_{OUT}=150mA, V_{OUT}(NOM)=3.3V		700	1300	
FB Pin Input Current	I_{FB}	MPQ2013A-18, MPQ2013A-25, MPQ2013A-33, MPQ2013A-5, V_{FB}=1.3V, V_{IN}=6V, OUT Floating	0.88	1.3	1.72	µA
		MPQ2013A, V_{FB}=1.3V, V_{IN}=6V, OUT Floating	-50	0	50	nA
Line Regulation(6)		VIN = 2.5 to 40V, I_{OUT} = 1mA, OUT = FB		0.01	0.05	%/V
Load Regulation(7)		MPQ2013AGQ I_{OUT} = 100µA to 150mA, V_{IN}=3V to 6V		0.005	0.012	%/mA
		MPQ2013AGQ-18, I_{OUT} = 100µA to 150mA, V_{IN}=6V			0.020	
		MPQ2013AGQ-25, I_{OUT} = 100µA to 150mA, V_{IN}=3.5V to 6V			0.020	
		MPQ2013AGQ-33, I_{OUT} = 100µA to 150mA, V_{IN}=4.3V to 6V			0.015	
		MPQ2013AGQ-5, I_{OUT} = 100µA to 150mA, V_{IN}=6V			0.012	

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ELECTRICAL CHARACTERISTICS *(continued)*

V_{EN}=V_{IN}, C_{OUT} = 1µF, T_A = -40°C to +125°C, $T_A \le T_J \le$ +150°C, unless otherwise noted. Typical values are at T_A = +25°C.

Parameter	Symbol	Condition	Min	Typ	Max	Units
Load Regulation(7)		MPQ2013AGG I_{OUT} = 100µA to 150mA, V_{IN}=3V to 6V		0.005	0.012	%/mA
		MPQ2013AGG-33, I_{OUT} = 100µA to 150mA, V_{IN}=4.3V to 6V			0.020	
		MPQ2013AGG-5, I_{OUT} = 100µA to 150mA, V_{IN}= 6V			0.012	
		MPQ2013AGG-18, I_{OUT} = 100µA to 150mA, V_{IN}= 2.8V to 6V			0.020	
Output Voltage PSRR(8)		100Hz, C_{IN} = 100pF, C_{OUT} = 4.7µF I_{OUT}=10mA, V_{IN}=6V, V_{OUT}=5V		58		dB
		1kHz, C_{IN} = 100pF, C_{OUT} = 4.7µF I_{OUT}=10mA, V_{IN}=6V, V_{OUT}=5V		41		dB
		100kHz, C_{IN} = 100pF, C_{OUT} = 4.7µF I_{OUT}=10mA, V_{IN}=6V, V_{OUT}=5V		55		dB
Startup Response Time		MPQ2013AGQ, MPQ2013AGG, I_{OUT}=100mA, C_{OUT}=6.8µF, V_{OUT}=5V			3	ms
		MPQ2013AGQ-18, MPQ2013AGG-18 I_{OUT}=10mA, C_{OUT}=6.8µF, V_{OUT}=1.8V			1.1	
		MPQ2013AGQ-25, I_{OUT}=10mA, C_{OUT}=6.8µF, V_{OUT}=2.5V			1.5	
		MPQ2013AGQ-33, MPQ2013AGG-33, I_{OUT}=10mA, C_{OUT}=6.8µF, V_{OUT}=3.3V			1.8	
		MPQ2013AGQ-5, MPQ2013AGG-5, I_{OUT}=10mA,C_{OUT}=6.8µF,V_{OUT}=5V			3	
EN Rising Threshold	EN_{TH_R}	V_{IN}=2.5V to 40V	1.32	1.48	1.64	V
EN Falling Threshold	EN_{TH_F}	V_{IN}=2.5V to 40V	1.1	1.26	1.42	V
EN Pin Input Current	I_{EN}	V_{EN} = 0V or 15V, V_{IN}=2.5V to 40V			0.1	µA
Thermal Shutdown(8)	T_{SD}		150	165		°C
Thermal Shutdown Hysteresis(8)	ΔT_{SD}			20		°C

Notes:

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

7) Load Regulation= $\frac{|V_{OUT[I_{OUT(MAX)}]} - V_{OUT[I_{OUT(MIN)}]}|}{(I_{OUT(MAX)} - I_{OUT(MIN)}) \times V_{OUT(NOM)}} \times (\%/mA)$

8) Derived from bench characterization. Not tested in production.

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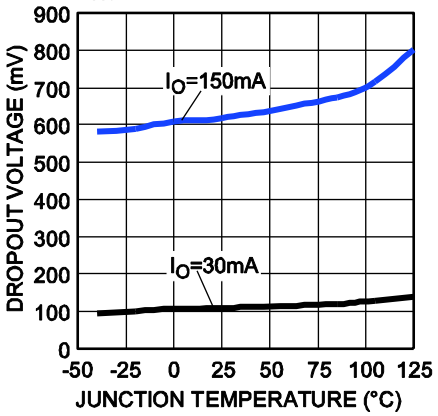
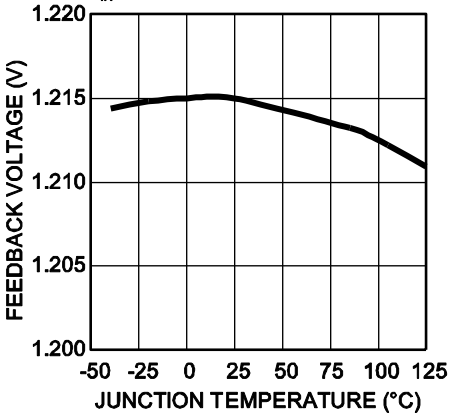
TYPICAL CHARACTERISTICS

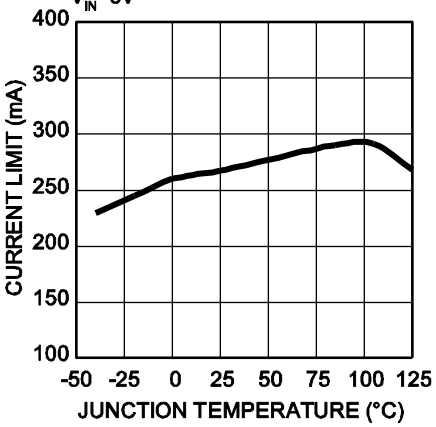
Dropout Voltage vs. Junction Temperature



Feedback Voltage vs. Junction Temperature



Current Limit vs. Junction Temperature



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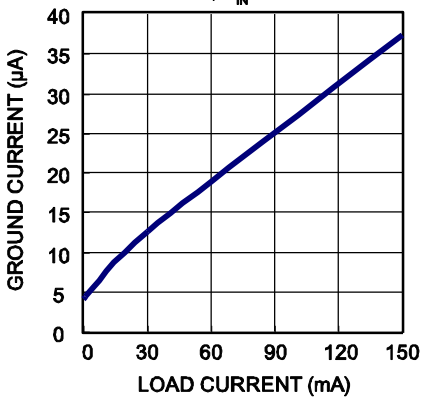
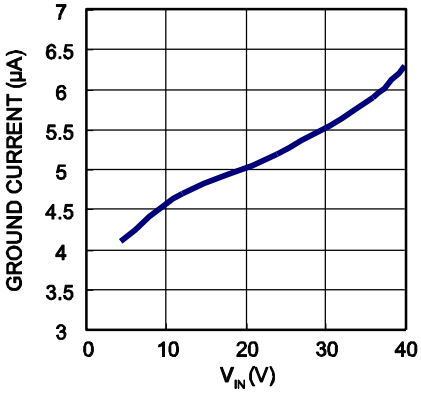
TYPICAL PERFORMANCE CHARACTERISTICS

C_{IN} = 1µF, C_{OUT} = 4.7µF, V_{OUT}=5V, T_A = +25ºC, unless otherwise noted

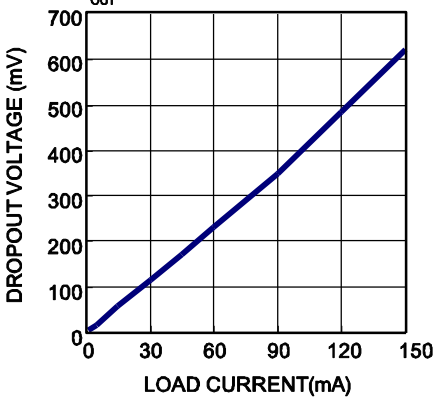
Ground Current vs. Load Current
MPQ2013A-33, V_{IN}=4.3V



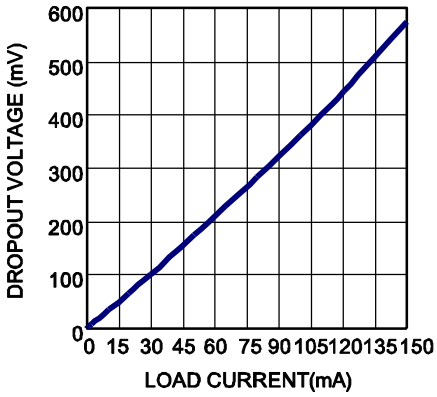
Ground Current vs. V_{IN}
MPQ2013A-33, I_{OUT}=0mA



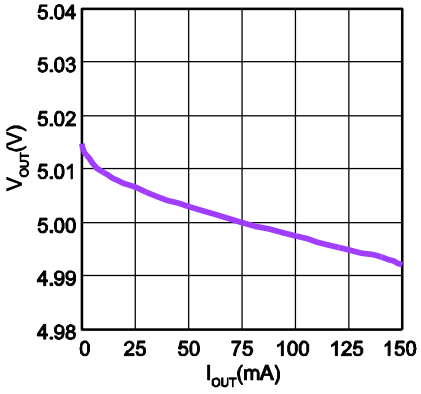
Dropout Voltage vs. Load Current
V_{OUT}=3.3V



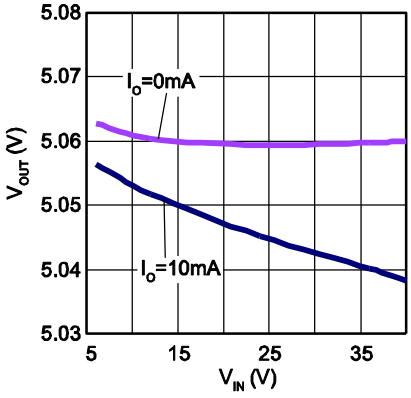
Dropout Voltage vs. Load Current



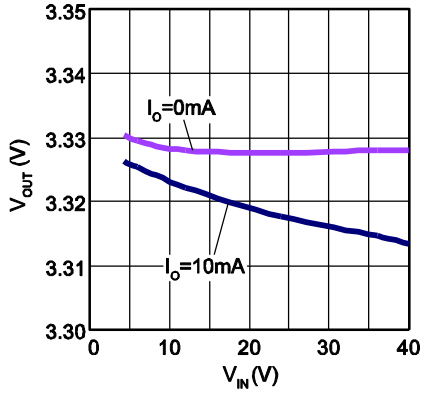
V_{OUT} vs. I_{OUT}
V_{IN}=6V



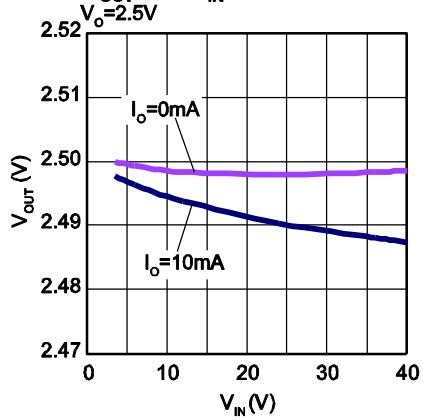
V_{OUT} vs. V_{IN}
V_O=5V



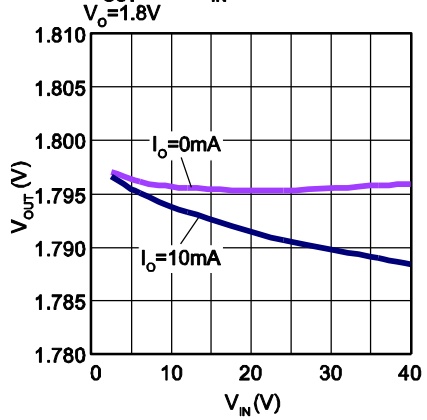
V_{OUT} vs. V_{IN}
V_O=3.3V



V_{OUT} vs. V_{IN}
V_O=2.5V



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



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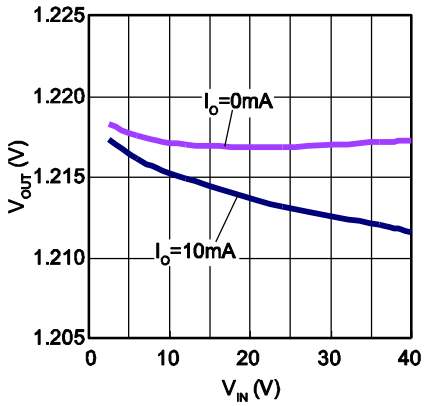
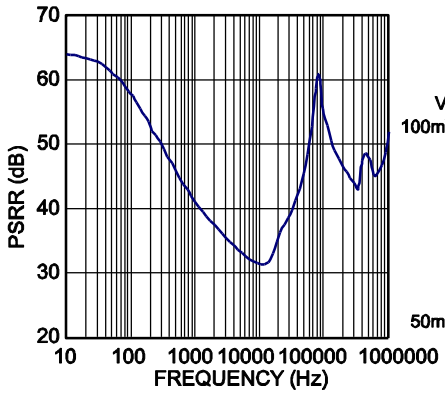
TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

C_{IN} = 1µF, C_{OUT} = 4.7µF, V_{OUT}=5V, T_A = +25°C, unless otherwise noted

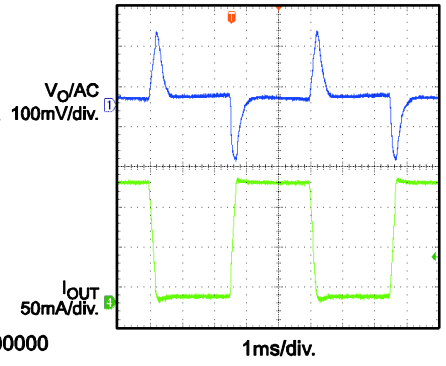
V_{OUT} vs. V_{IN}
V_O=1.215V



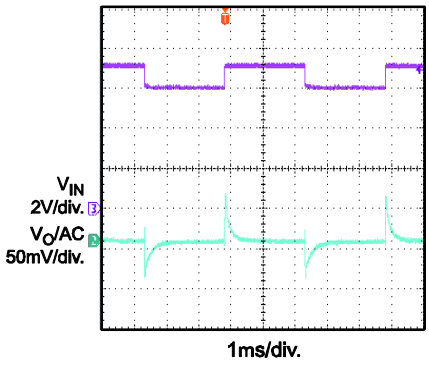
PSRR vs. Frequency
V_{IN1}=V_{IN2}=6V, I_O=10mA, C_{IN}=100pF



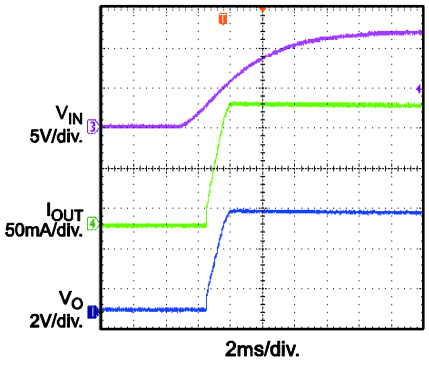
Load Transient
V_{IN} = 12V, I_{OUT} = 8mA-150mA



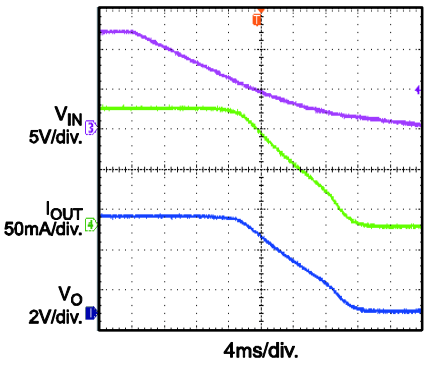
Line Transient
V_{IN} = 6V-7V, I_{OUT} = 150mA



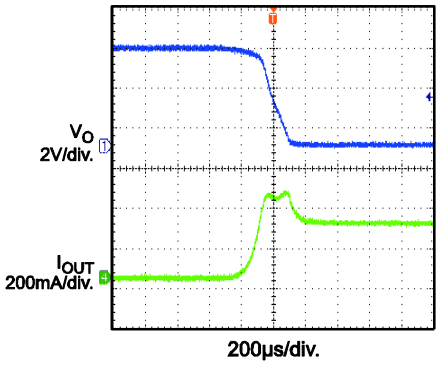
Startup Through V_{IN}
V_{IN} = 12V, I_{OUT} = 150mA



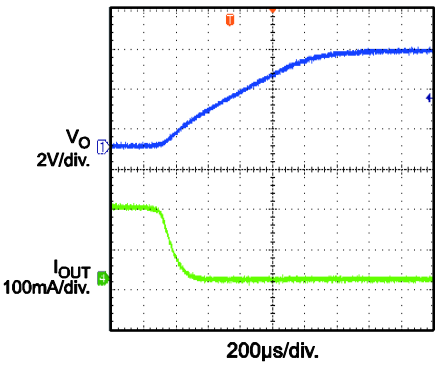
Shutdown Through V_{IN}
V_{IN} = 12V, I_{OUT} = 150mA



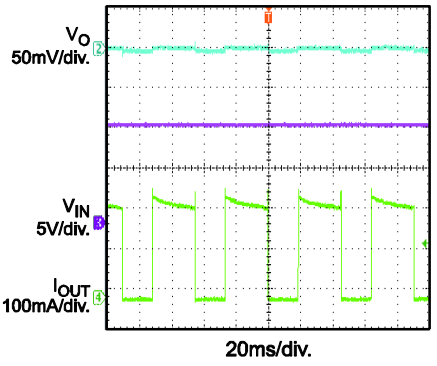
Short Circuit Entry
V_{IN} = 12V, I_{OUT} = 0mA to short circuit



Short Circuit Recovery
V_{IN} = 12V, short circuit to I_{OUT} = 0mA



Short Circuit Steady State
V_{IN} = 12V



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PIN FUNCTIONS

Pin # QFN6 (2x2mm)	Pin # QFN8 (3x3mm)	Name	Description
1	1	IN	Input Voltage. Connect a 2.5V to 40V supply to this pin.
2	2	EN	A logic LOW on this pin will shut down the IC; a logic HIGH will start it up. Connect this pin to IN for automatic startup.
3, exposed pad	4, exposed pad	GND	Ground (the exposed pad and GND pin must be connected to the same ground plane).
4	5	FB	Feedback input pin, regulated to 1.215V nominally. Connected to an external resistive divider between OUT and GND to set output voltage. For fixed output version, this pin can be just float.
6	8	OUT	Regulated output voltage, only low-value ceramic capacitor (≥ 0.47μF) on output is required for stability.
5	3, 6, 7	NC	No connection. May be left open or tied to Ground for improved thermal performance.

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OPERATION

The MPQ2013A is a linear regulator that supplies power to systems with high voltage batteries. It includes a wide 2.5V to 40V input range, low dropout voltage and low quiescent supply current.

The MPQ2013A provides wide variety of fixed output voltage options: 1.8V, 1.9V, 2.3V, 2.5V, 3.0V, 3.3V, 3.45V, 5.0V; and also provides the output adjustable option (from 1.215V to 15V).

The output adjustable version has an output that is adjustable from 1.215V to 15V with a simple resistor divider. It uses external feedback, allowing the user to set the output voltage with an external resistor divider. The typical FB pin voltage is 1.215V.

The IC enters shutdown mode when EN is low. In shutdown mode, the pass transistor, control circuitry, reference and all biases turn off, reducing the supply current to <3μA. Connect EN pin to IN for automatic startup.

The regulator output current is internally limited and the device is protected against over-load and over-temperature conditions.

The peak output current is limited to around 270mA, which exceeds the 150mA 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 cooled.

The maximum power output current is a function of the package's maximum power dissipation for a given temperature.

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.

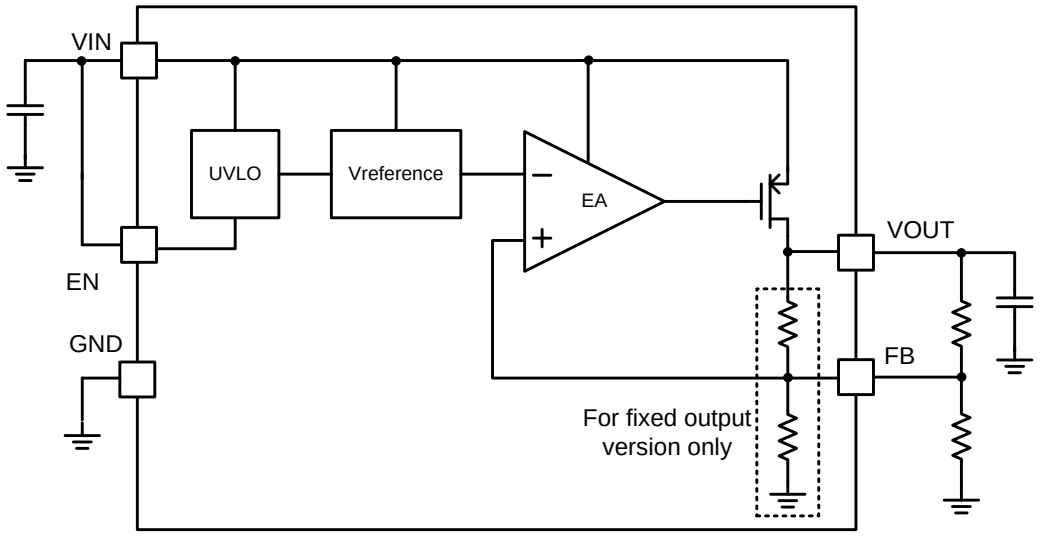

Figure 1: Functional Block Diagram

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APPLICATION INFORMATION

Component Selection

Setting the Output Voltage

Set the output voltage of the MPQ2013A by using a resistor divider as shown:

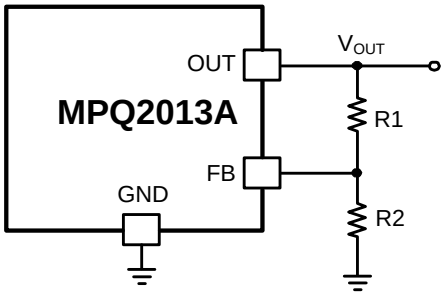

Figure 2: FB Resistor Divider to Set V_{OUT}

Choose R2=1MΩ to maintain a 1.215μA minimum load. Calculate the value for R1 using the following equation:

$$R1 = R2 \times \left(\frac{V_{OUT}}{1.215V} - 1 \right)$$

For fixed output version, V_{OUT} also can be adjusted by adding external resistor divider. Just note to take internal FB resistor divider into consideration when choose external divider.

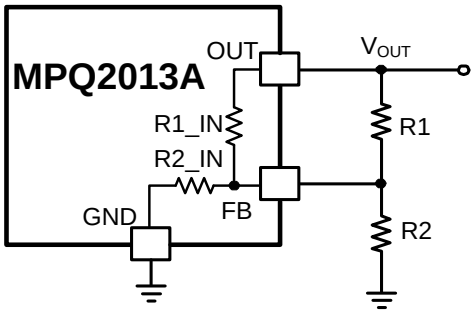

Figure 3: FB Divider of Fixed Output Version

When R2 is selected, R1 can be calculated by below equation:

$$R1 = \frac{R1_IN}{\frac{1.215xR1_INx(R2+R2_IN)}{(V_{OUT}-1.215)xR2xR2_IN} - 1}$$

The internal FB resistor dividers for different fixed output versions please see below table.

Table 1: Internal FB Resistor Divider

Fixed Output Voltage (V)	R1_IN (MΩ)	R2_IN (MΩ)
2.5	1.058	1
3.3	1.716	1
5	3.117	1

Table 2 is an example of external FB divider to get various output voltages on fixed 3.3V output version.

Table 2 –3.3V Fixed Output Version External FB Divider

V_{OUT} (V)	R1 (kΩ)	R2 (kΩ)
11	84.5	10
8.5	61.9	10
8	57.6	10
6.5	44.2	10
5	31.6	10

Setting VIN UVLO

To prevent part from operating at an insufficient power supply voltage, a resistor divider as show in figure 3 can be used to adjust the VIN UVLO point.

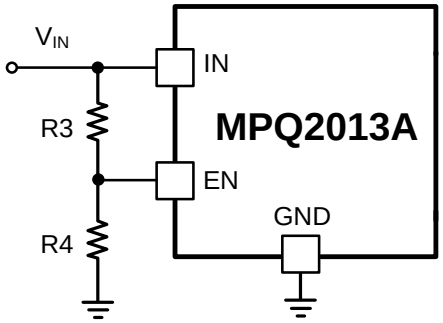

Figure 4: EN Resistor Divider to Set VIN UVLO

If choose R3 first, then R4 can be calculated by below equation:

$$R4 = R3 \times \frac{EN_{TH_L}}{V_{IN_UVLO} - EN_{TH_L}}$$

Where EN_{TH_L} is the EN falling threshold 1.26V. To limit the divider current, high value resistors are recommended. For example, if V_{IN_UVLO} is set at 4.5V, R3=2MΩ and R4=778kΩ can be used.

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Input Capacitor

For proper operation, place a ceramic capacitor (C1) between 1µF and 10µF of dielectric type X5R or X7R between the input pin and ground. Larger values in this range will help improve line transient response.

Output Capacitor

For stable operation, use a ceramic capacitor (C3) of type X5R or X7R between 1µF and 10µF. Larger values in this range will help improve load transient response and reduce noise. Output capacitors of other dielectric types may be used, but are not recommended as their capacitance can deviate greatly from their rated value over temperature.

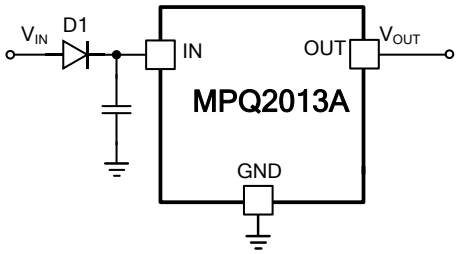
To improve load transient response, add a small ceramic (X5R, X7R or Y5V dielectric) 22nF feed forward capacitor in parallel with R1. The feed forward capacitor is not required for stable operation.

Output Noise

The MPQ2013A 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 C2 across R1 will significantly reduce the output noise.

External Reverse Voltage Protection

In some situations, e.g. a backup battery is connected as MPQ2013A load, the output voltage may be held up while the input is either pulled to ground, pulled to some intermediate voltage or is floating. Thus, the output voltage is higher than input voltage. Since the MPQ2013A 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.

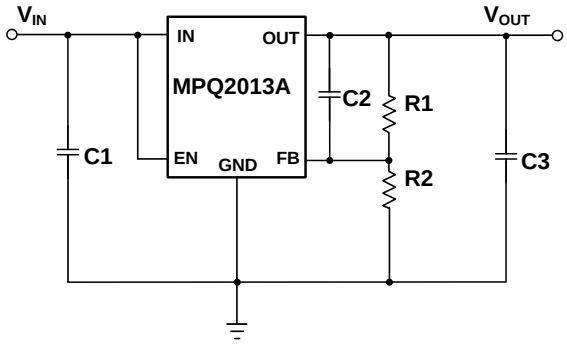


PCB Layout Guide

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 5 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.



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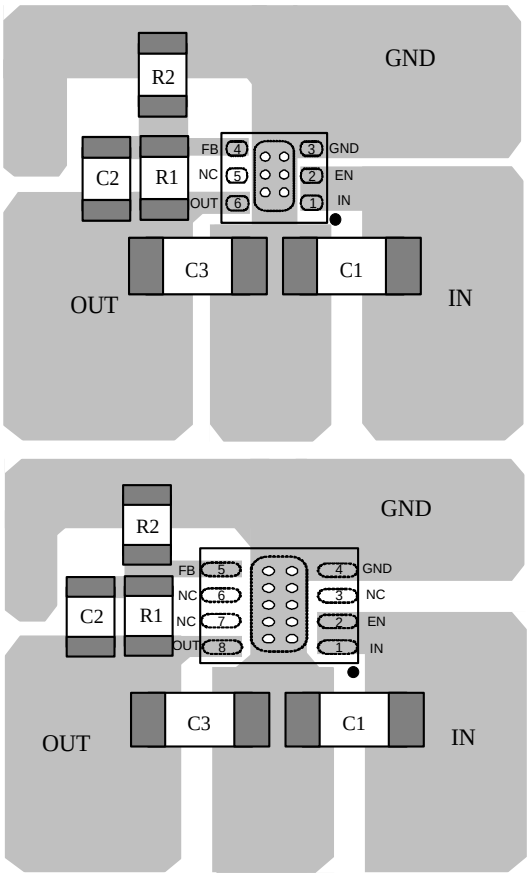

Figure 5: PCB Layout (Top Layer)

Design Example

Below is a design example following the application guidelines for V_{OUT}=3.3V with feedforward cap.

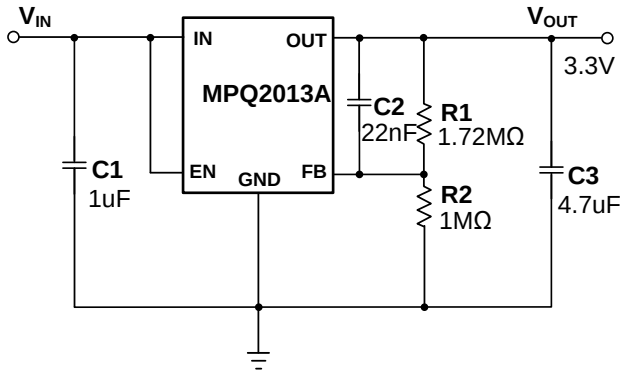

Figure 6: Design Example

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TYPICAL APPLICATION CIRCUITS

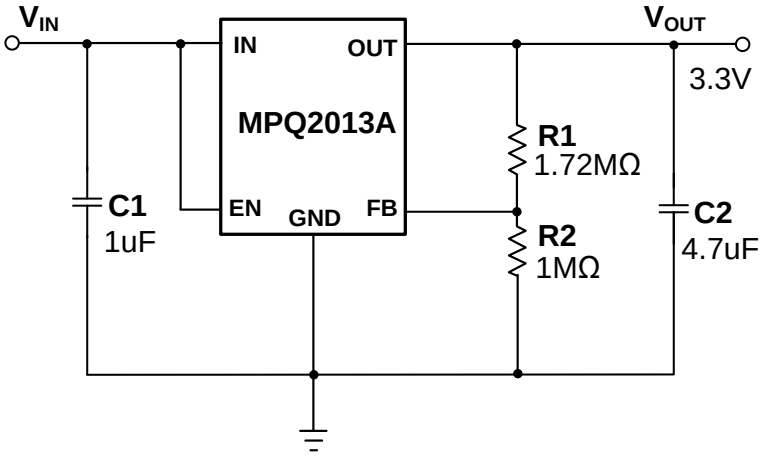

Figure 7: 3.3V Output Typical Application Circuit

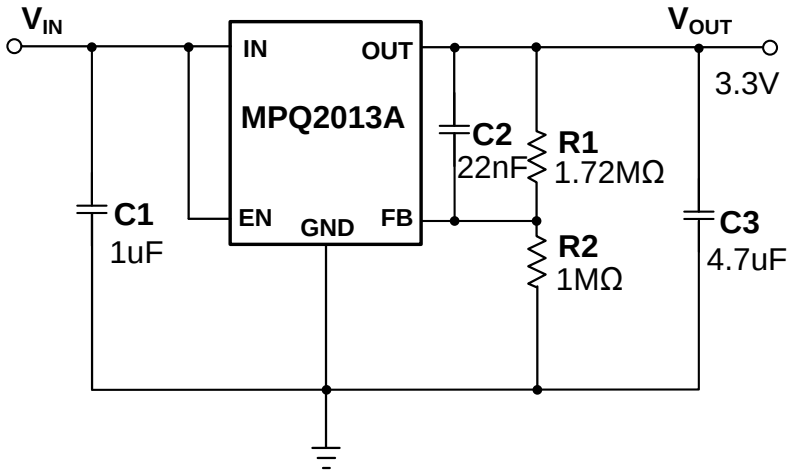

Figure 8: 3.3V Output with Feedforward Capacitor

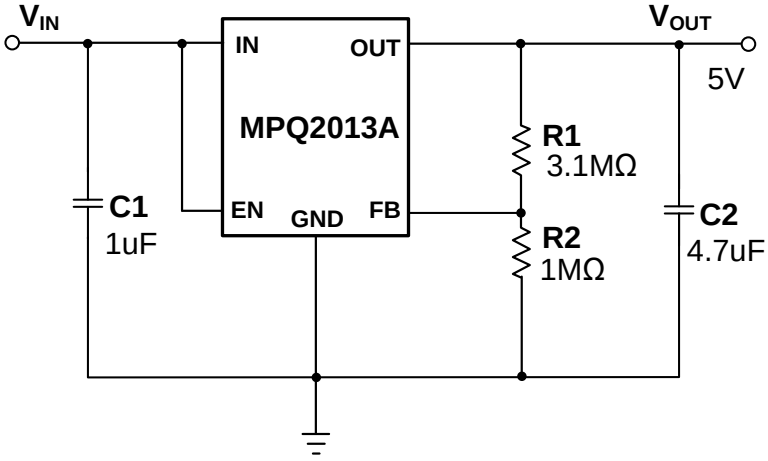

Figure 9: 5V Output Typical Application Circuit

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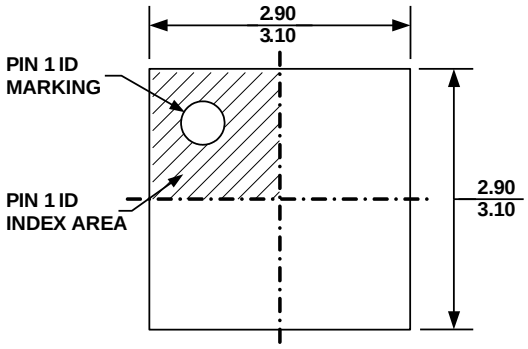
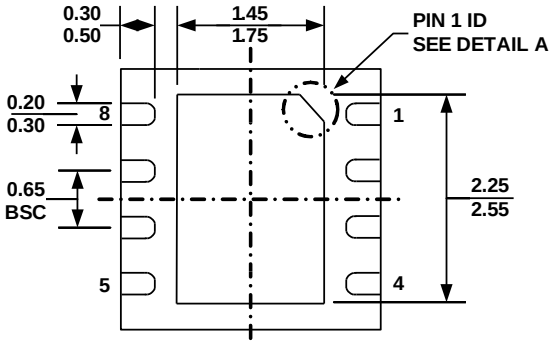
PACKAGE INFORMATION

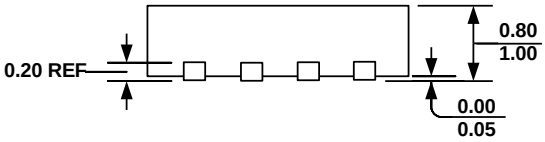
QFN-8 (3mmx3mm)



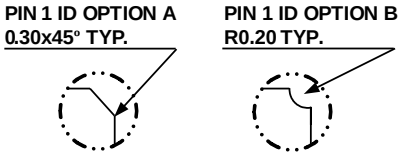
TOP VIEW



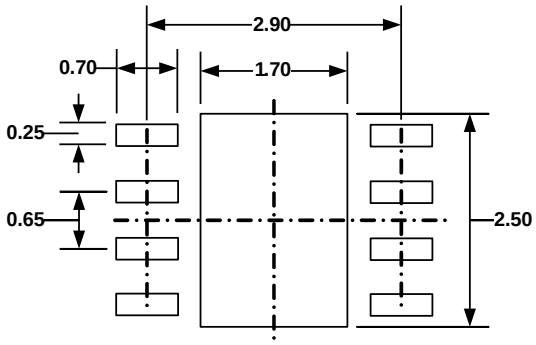
BOTTOM VIEW



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

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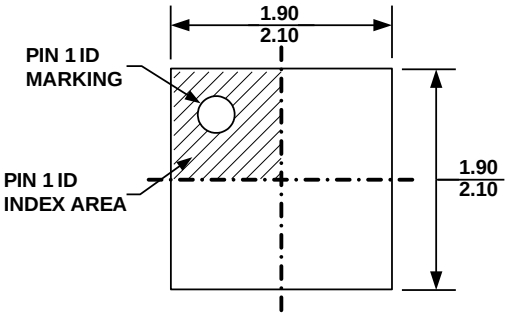
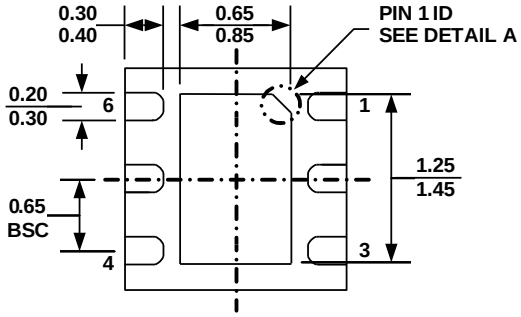
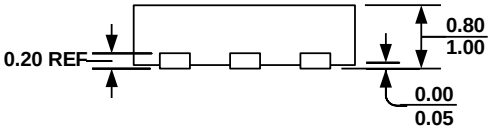
QFN-6 (2mmx2mm)



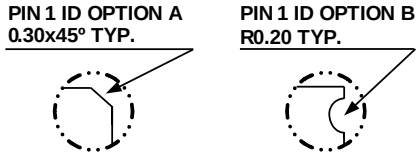
TOP VIEW



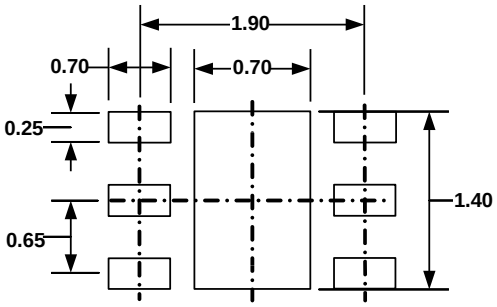
BOTTOM VIEW



SIDE VIEW



DETAIL A



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5) DRAWING IS NOT TO SCALE.

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REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	7/14/2014	Initial Release	-
1.01	8/5/2014	Added the numbers of MPQ2013AGJ-25 into EC table. Updated the table 2	2, 5–8, 14
1.02	9/17/2014	Changed the minimum load current limit of MPQ2013AGQ-33 to 160mA.	3
1.03	6/10/2015	Added the TSOT23 package	3, 19
1.04	7/17/2015	Listed the top marking for all packages	9
1.05	8/6/2015	Added “External Reverse Voltage Protection” section. Removed the Page 3. Updated page header from page 4 to page 19. Removed the MPQ2013AGJ (RED mark) page 5 and 8. Deleted the TSOT23-5’s pin functions -Page 12.	3–5, 8, 4–19, 12
1.06	5/26/2016	Updated EC and AEC mark	1–17
1.07	8/24/2017	Added MPQ2013AGQ-18 and MPQ2013AGG-5 Updated the top marking Added “External Reverse Voltage Protection” section.	2, 3, 5–8, 15
1.1	8/15/2025	Added MPQ2013AGG-18-AEC1 to the Ordering Information section; added the Top Marking for the MPQ2013AGG-18.	3
		Moved the MPQ2013AGG-33’s GND pin current for $0<I_{OUT}<1mA$, $V_{IN}=4.3V$ to 40V from page 6 to page 5.	5
		Added the GND pin current, load current limit, and output voltage accuracy parameters for the MPQ2013AGG-18 in the Electrical Characteristics section.	6
		Updated the following in the Electrical Characteristics section: • Added the FB voltage and dropout voltage parameters for the MPQ2013AGG-18 • Moved the FB voltage parameters for the MPQ2013AGQ, MPQ2013AGQ-25, MPQ2013AGQ-33, MPQ2013AGQ-5, and MPQ2013AGQ-18 from page 6 to page 7	7
		Updated the following in the Electrical Characteristics section: • Added the load regulation and start-up response time parameters for the MPQ2013AGG-18 • Moved the load regulation parameters for the MPQ2013AGG, MPQ2013AGG-33, and MPQ2013AGG-5 from page 7 to page 8	8

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