# 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

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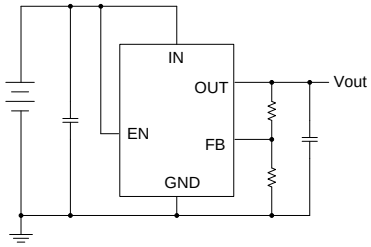
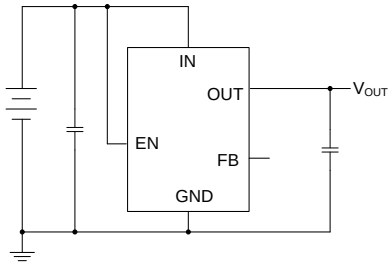
## TYPICAL APPLICATION




**Output Adjustable Version**




**Output Fixed Version**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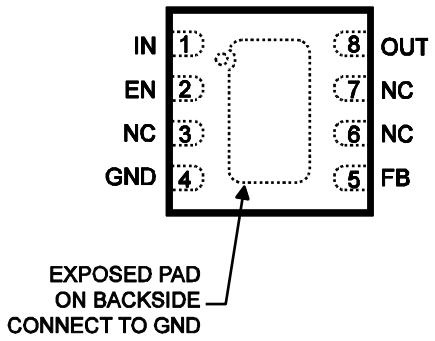
## ORDERING INFORMATION

| 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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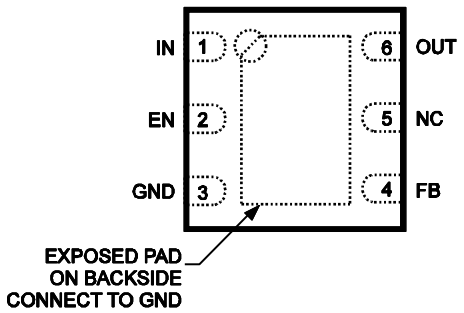
## ORDERING INFORMATION

| 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) $\theta_{JA}$ $\theta_{JC}$

| | | | |
|---|---|---|---|
| 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 $\theta_{JA}$, and the ambient temperature $T_A$. The maximum allowable continuous power dissipation at any ambient temperature is calculated by $P_D$ (MAX) = ($T_J$ (MAX)-$T_A$)/$\theta_{JA}$. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
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<br>$I_{OUT}$ = 100µA to 150mA, $V_{IN}$=3V to 6V | | 0.005 | 0.012 | %/mA |
| | | MPQ2013AGG-33,<br>$I_{OUT}$ = 100µA to 150mA, $V_{IN}$=4.3V to 6V | | | 0.020 | |
| | | MPQ2013AGG-5,<br>$I_{OUT}$ = 100µA to 150mA, $V_{IN}$= 6V | | | 0.012 | |
| | | MPQ2013AGG-18,<br>$I_{OUT}$ = 100µA to 150mA, $V_{IN}$= 2.8V to 6V | | | 0.020 | |
| Output Voltage PSRR(8) | | 100Hz, $C_{IN}$ = 100pF, $C_{OUT}$ = 4.7µF<br>$I_{OUT}$=10mA, $V_{IN}$=6V, $V_{OUT}$=5V | | 58 | | dB |
| | | 1kHz, $C_{IN}$ = 100pF, $C_{OUT}$ = 4.7µF<br>$I_{OUT}$=10mA, $V_{IN}$=6V, $V_{OUT}$=5V | | 41 | | dB |
| | | 100kHz, $C_{IN}$ = 100pF, $C_{OUT}$ = 4.7µF<br>$I_{OUT}$=10mA, $V_{IN}$=6V, $V_{OUT}$=5V | | 55 | | dB |
| Startup Response Time | | MPQ2013AGQ, MPQ2013AGG,<br>$I_{OUT}$=100mA, $C_{OUT}$=6.8µF, $V_{OUT}$=5V | | | 3 | ms |
| | | MPQ2013AGQ-18, MPQ2013AGG-18<br>$I_{OUT}$=10mA, $C_{OUT}$=6.8µF, $V_{OUT}$=1.8V | | | 1.1 | |
| | | MPQ2013AGQ-25,<br>$I_{OUT}$=10mA, $C_{OUT}$=6.8µF, $V_{OUT}$=2.5V | | | 1.5 | |
| | | MPQ2013AGQ-33, MPQ2013AGG-33,<br>$I_{OUT}$=10mA, $C_{OUT}$=6.8µF, $V_{OUT}$=3.3V | | | 1.8 | |
| | | MPQ2013AGQ-5, MPQ2013AGG-5,<br>$I_{OUT}$=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) | $\Delta T_{SD}$ | | | 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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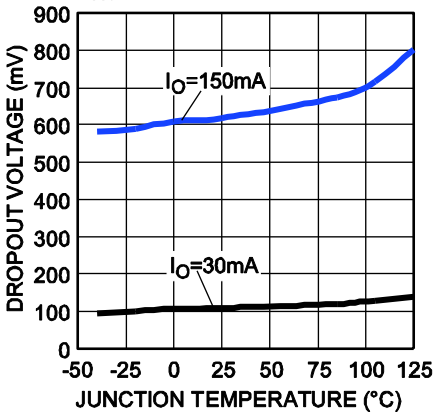
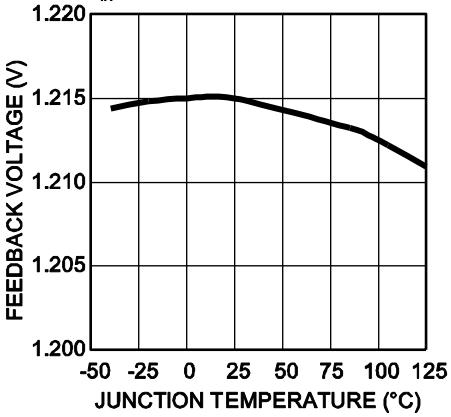
## TYPICAL CHARACTERISTICS

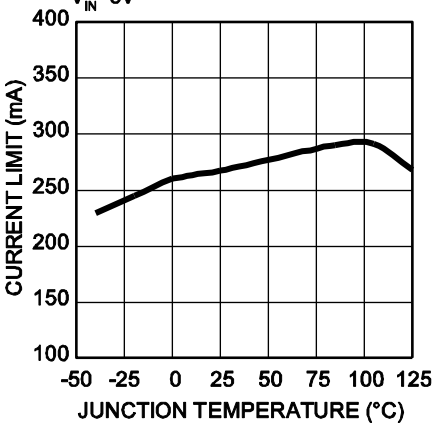
**Dropout Voltage vs. Junction Temperature**




**Feedback Voltage vs. Junction Temperature**




**Current Limit vs. Junction Temperature**





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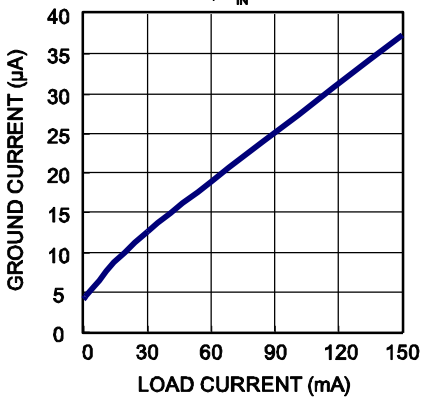
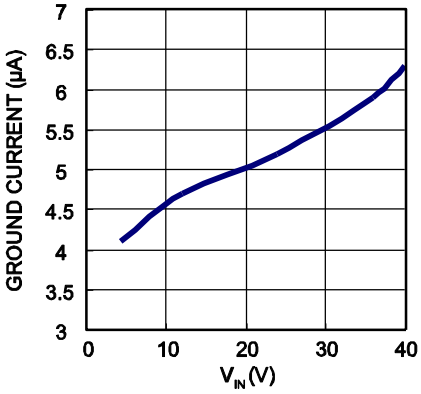
## TYPICAL PERFORMANCE CHARACTERISTICS

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

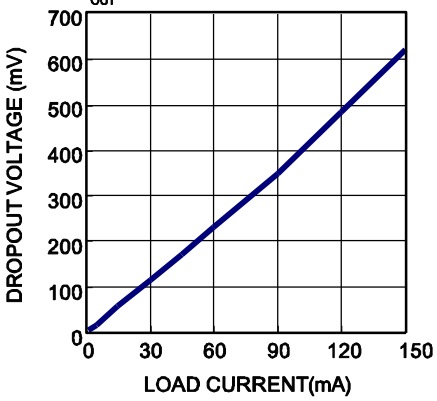
**Ground Current vs. Load Current**
MPQ2013A-33, $V_{IN}$=4.3V



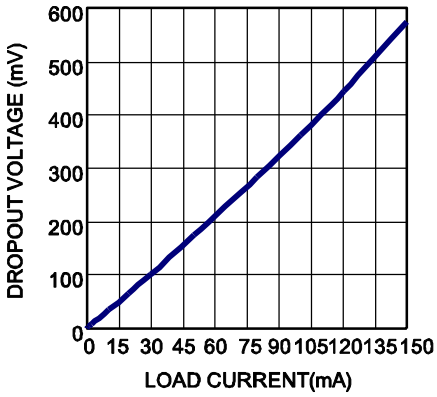

**Ground Current vs. $V_{IN}$**
MPQ2013A-33, $I_{OUT}$=0mA



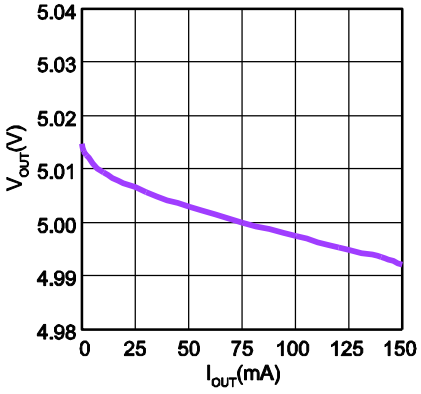

**Dropout Voltage vs. Load Current**
$V_{OUT}$=3.3V



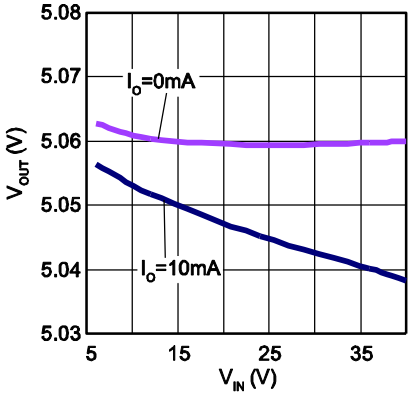

**Dropout Voltage vs. Load Current**



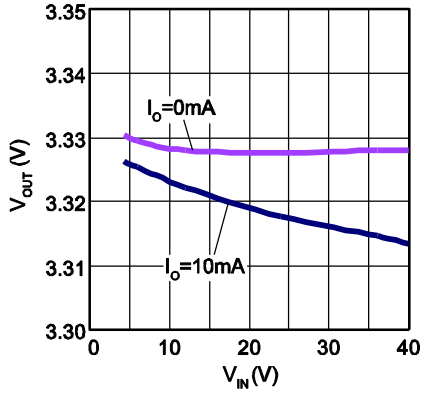

**$V_{OUT}$ vs. $I_{OUT}$**
$V_{IN}$=6V



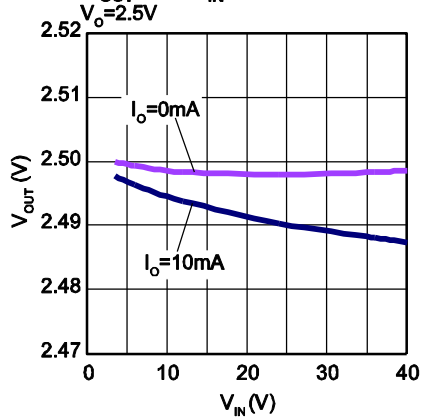

**$V_{OUT}$ vs. $V_{IN}$**
$V_O$=5V



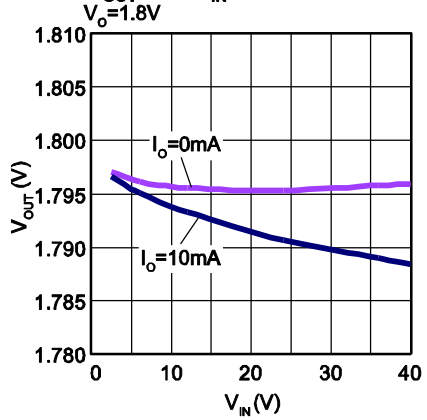

**$V_{OUT}$ vs. $V_{IN}$**
$V_O$=3.3V




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




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





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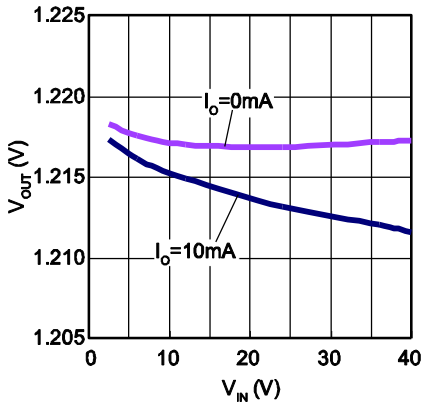
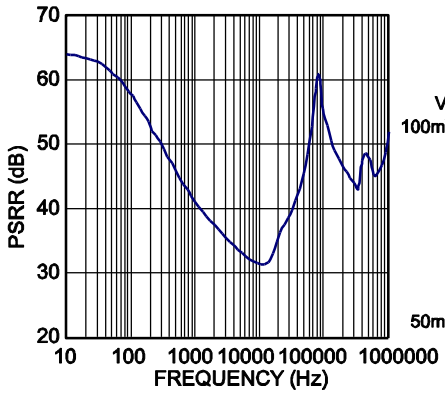
## TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

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

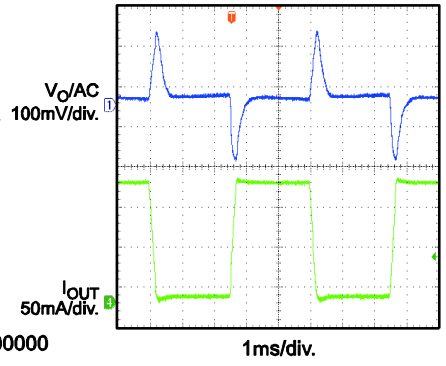
### $V_{OUT}$ vs. $V_{IN}$
$V_O$=1.215V



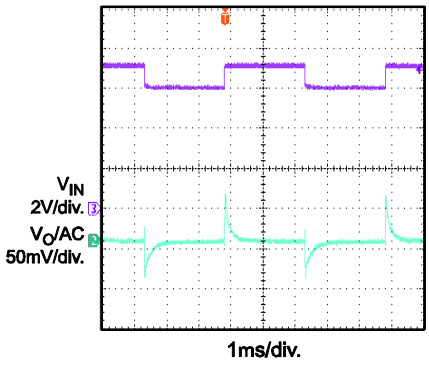

### PSRR vs. Frequency
$V_{IN1}$=$V_{IN2}$=6V, $I_O$=10mA, $C_{IN}$=100pF



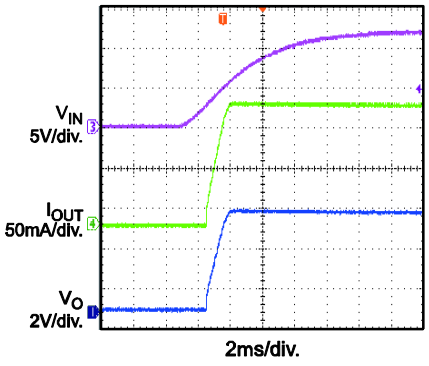

### Load Transient
$V_{IN}$ = 12V, $I_{OUT}$ = 8mA-150mA



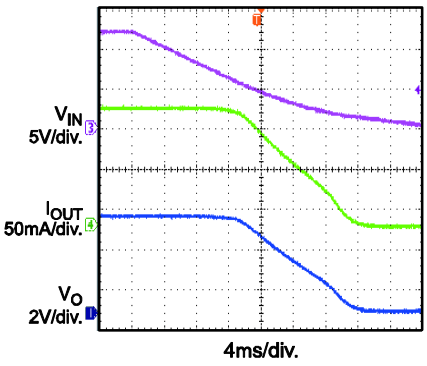

### Line Transient
$V_{IN}$ = 6V-7V, $I_{OUT}$ = 150mA



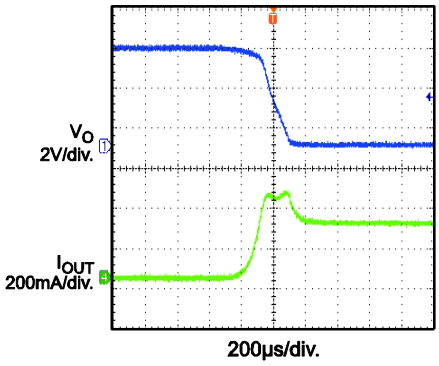

### Startup Through $V_{IN}$
$V_{IN}$ = 12V, $I_{OUT}$ = 150mA



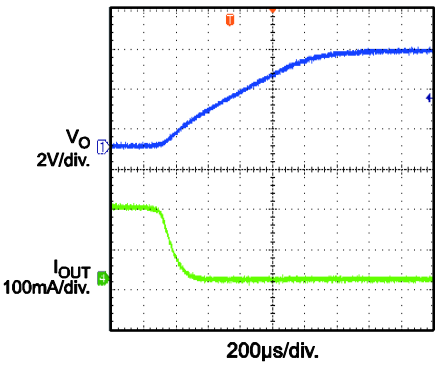

### Shutdown Through $V_{IN}$
$V_{IN}$ = 12V, $I_{OUT}$ = 150mA



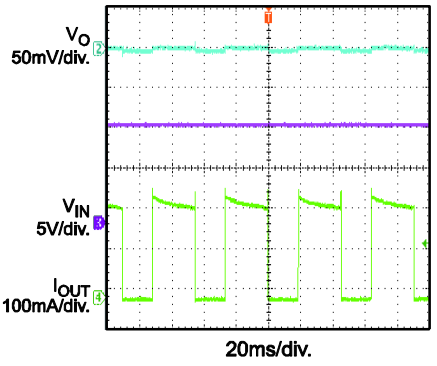

### Short Circuit Entry
$V_{IN}$ = 12V, $I_{OUT}$ = 0mA to short circuit




### 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.

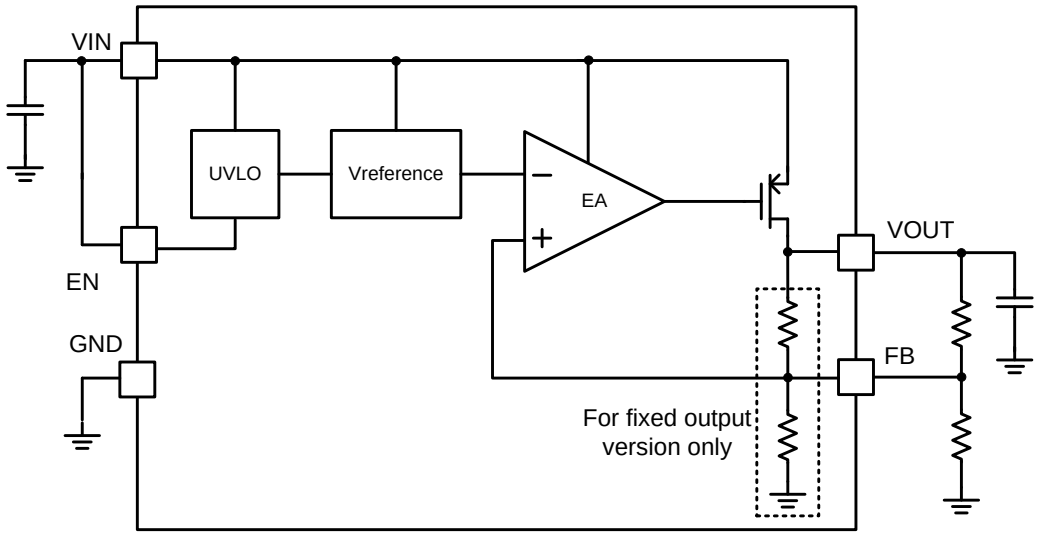


**Figure 1: Functional Block Diagram**


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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:

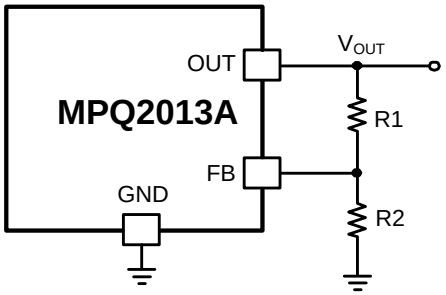


**Figure 2: FB Resistor Divider to Set $V_{OUT}$**

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.

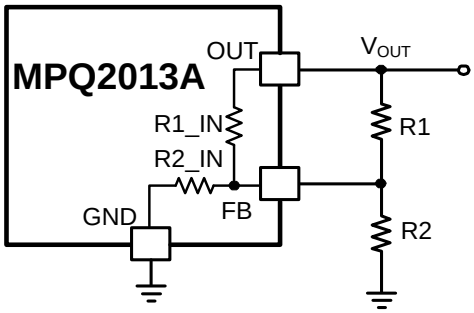


**Figure 3: FB Divider of Fixed Output Version**

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.

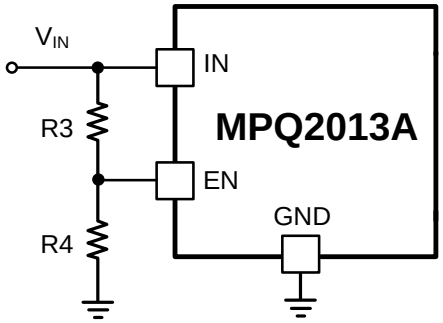


**Figure 4: EN Resistor Divider to Set VIN UVLO**

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.

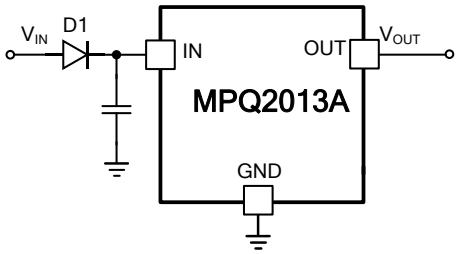
To improve load transient response, add a small ceramic (X5R, X7R or Y5V dielectric) 22nF feed forward capacitor in parallel with R1. The feed forward capacitor is not required for stable operation.

### 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.

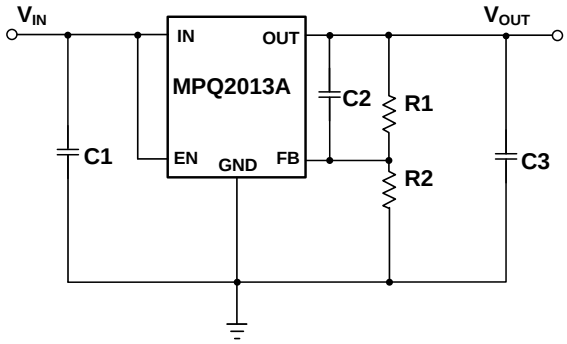



### PCB Layout Guide

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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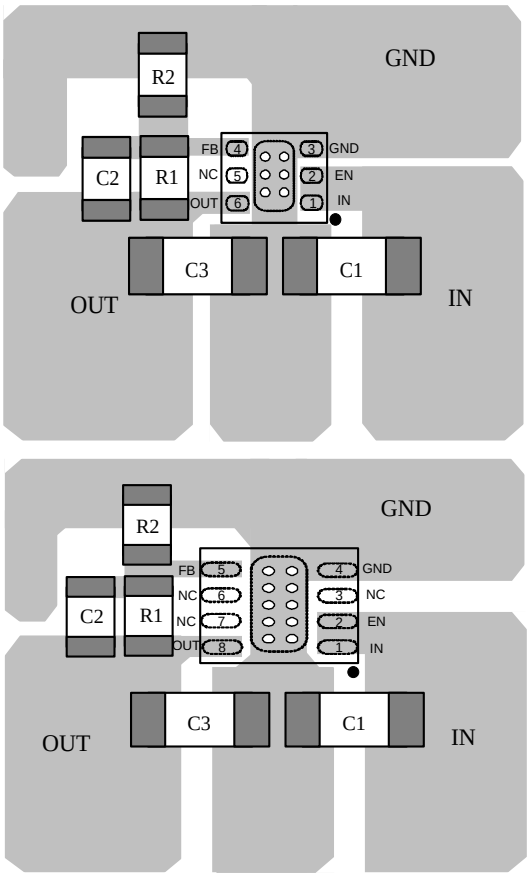


**Figure 5: PCB Layout (Top Layer)**

## Design Example

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

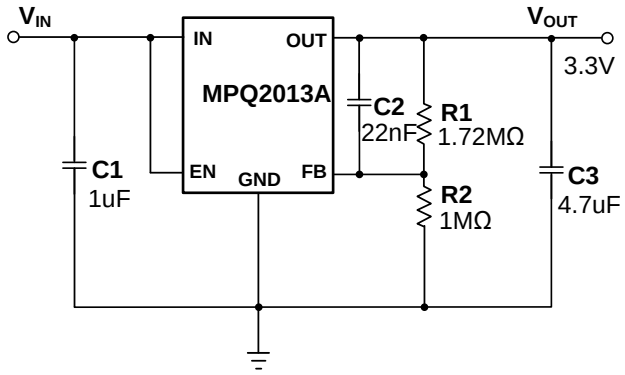


**Figure 6: Design Example**


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## TYPICAL APPLICATION CIRCUITS

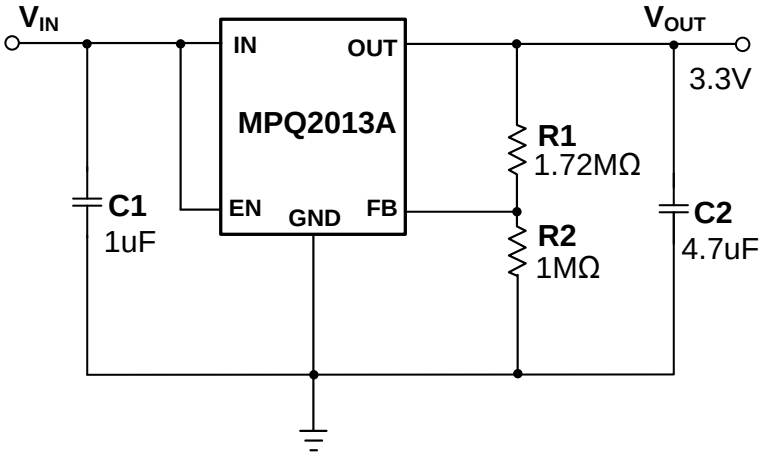


**Figure 7: 3.3V Output Typical Application Circuit**

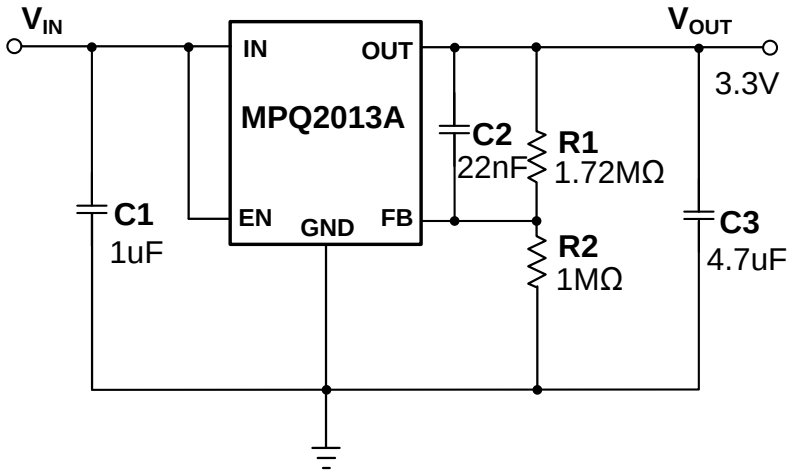


**Figure 8: 3.3V Output with Feedforward Capacitor**

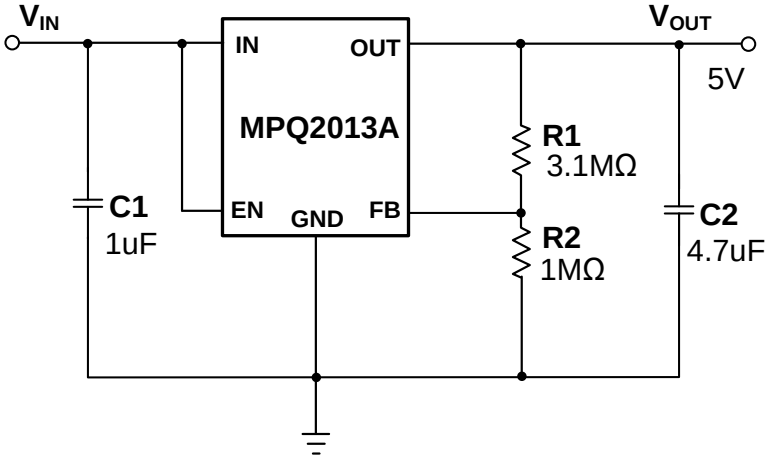


**Figure 9: 5V Output Typical Application Circuit**


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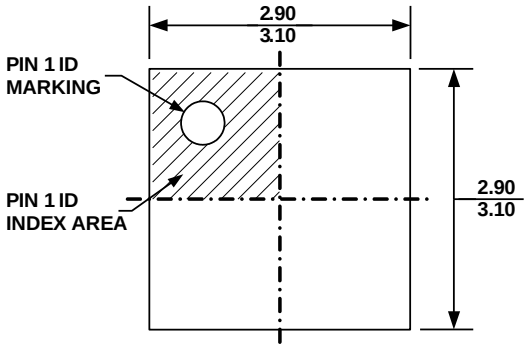
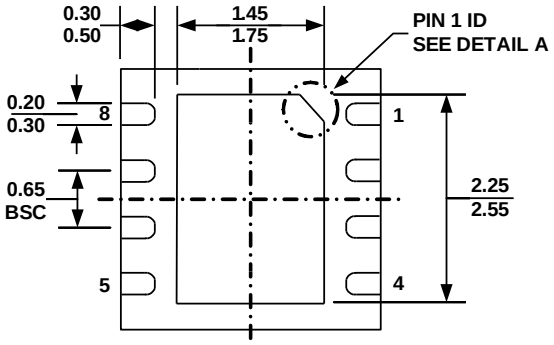
# PACKAGE INFORMATION

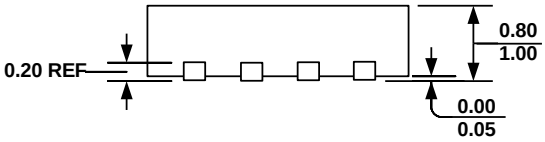
## QFN-8 (3mmx3mm)



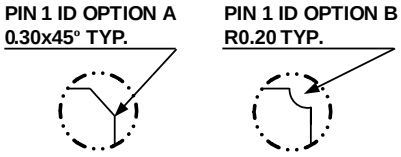

TOP VIEW



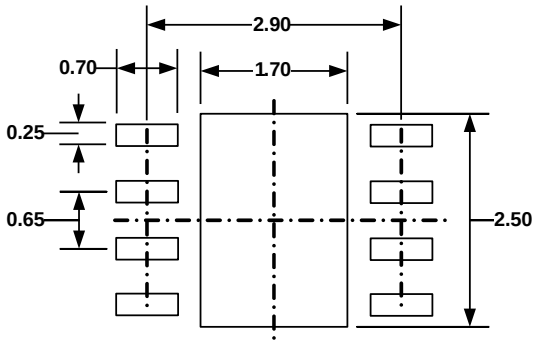

BOTTOM VIEW




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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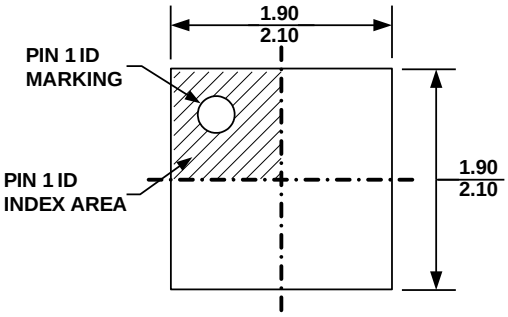
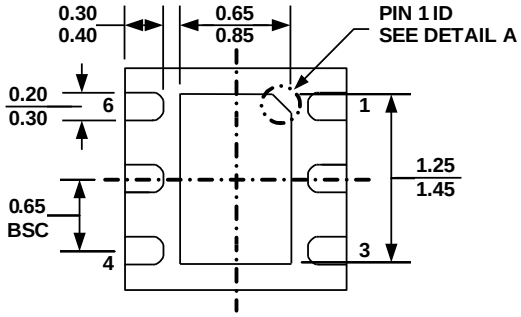
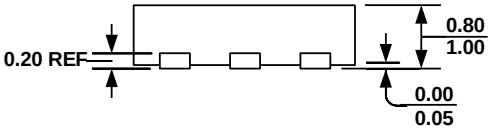
## QFN-6 (2mmx2mm)



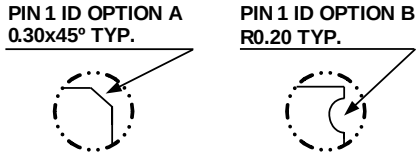

TOP VIEW



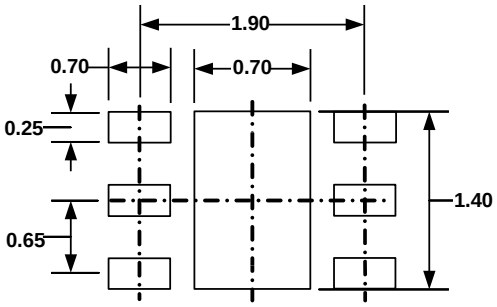

BOTTOM VIEW




SIDE VIEW




DETAIL A




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 VCCC.
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.<br>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.<br>Removed the Page 3.<br>Updated page header from page 4 to page 19.<br>Removed the MPQ2013AGJ (RED mark) page 5 and 8.<br>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<br>Updated the top marking<br>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:<br>• Added the FB voltage and dropout voltage parameters for the MPQ2013AGG-18<br>• 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:<br>• Added the load regulation and start-up response time parameters for the MPQ2013AGG-18<br>• Moved the load regulation parameters for the MPQ2013AGG, MPQ2013AGG-33, and MPQ2013AGG-5 from page 7 to page 8 | 8 |

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