



The Future of Analog IC Technology®

## MP2303

### 3A, 28V, 340KHz Synchronous Rectified Step-Down Converter

#### DESCRIPTION

The MP2303 is a monolithic synchronous buck regulator. The device integrates power MOSFETS that provide 3A continuous load current over a wide operating input voltage of 4.75V to 28V. Current mode control provides fast transient response and cycle-by-cycle current limit.

An adjustable soft-start prevents inrush current at turn-on. In shutdown mode, the supply current drops to 1µA.

This device, available in 8-pin SOIC and 3x3 10-pin QFN packages, provides a very compact system solution with minimal reliance on external components.

#### EVALUATION BOARD REFERENCE

| Board Number | Dimensions            |
|--------------|-----------------------|
| EV2303DN-00A | 2.0"X x 1.5"Y x 0.5"Z |

#### FEATURES

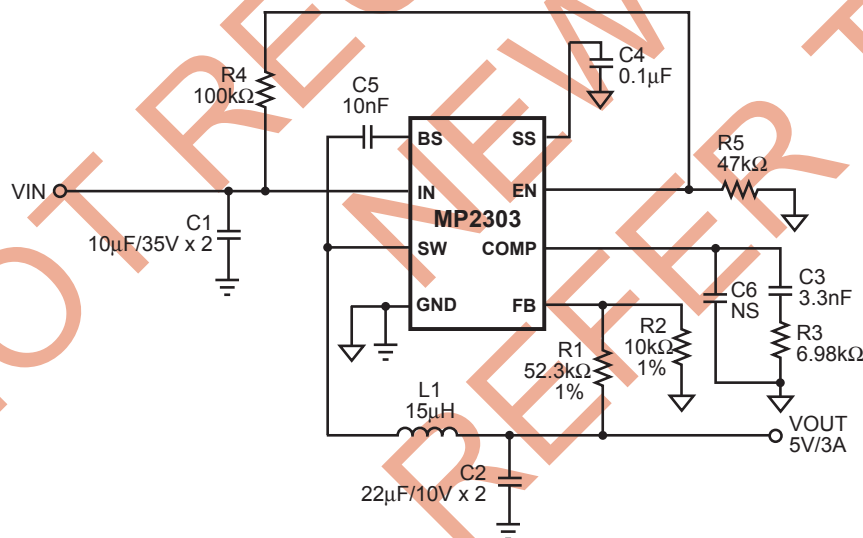
- 3A Output Current
- Wide 4.75V to 28V Operating Input Range
- Integrated Power MOSFET Switches
- Output Adjustable from 0.8V to 25V
- Up to 95% Efficiency
- Programmable Soft-Start
- Stable with Low ESR Ceramic Output Capacitors
- Fixed 340KHz Frequency
- Cycle-by-Cycle Over Current Protection
- Input Under Voltage Lockout
- Thermally Enhanced 8-Pin SOIC and 3x3 QFN10 Packages

#### APPLICATIONS

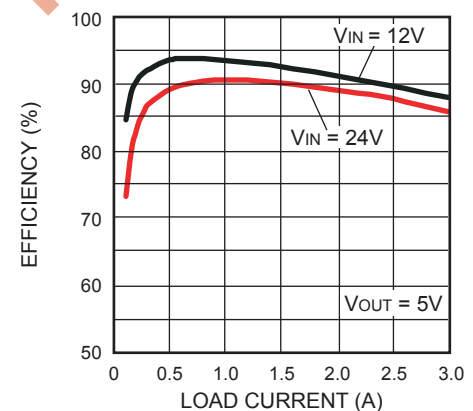
- Distributed Power Systems
- Pre-Regulator for Linear Regulators
- Notebook Computers

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#### TYPICAL APPLICATION



Efficiency vs Load Current



MP2303-EC01

## ORDERING INFORMATION

| Part Number | Package              | Top Marking | Temperature    |
|-------------|----------------------|-------------|----------------|
| MP2303DN*   | SOIC8E (Exposed Pad) | MP2303DN    | –40°C to +85°C |
| MP2303DQ**  | QFN10 (3mm x 3mm)    | K2          | MP2303DQ       |

\* For Tape & Reel, add suffix –Z (e.g. MP2303DN–Z);  
 For RoHS compliant packaging, add suffix –LF (e.g. MP2303DN–LF–Z)  
 \*\* For Tape & Reel, add suffix –Z (e.g. MP2303DQ–Z);  
 For RoHS compliant packaging, add suffix –LF (e.g. MP2303DQ–LF–Z)

## PACKAGE REFERENCE

|                                                                                                                                                                         |                                                                                                                                                                                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p style="text-align: center;"><b>TOP VIEW</b></p> <p style="text-align: center;">MP2303_PD01_SOIC8N</p> <p style="text-align: center;"><b>SOIC8E (Exposed Pad)</b></p> | <p style="text-align: center;"><b>TOP VIEW</b></p> <p style="text-align: center;">EXPOSED PAD<br/>ON BACKSIDE</p> <p style="text-align: center;">MP2303_PD02_QFN10</p> <p style="text-align: center;"><b>QFN10 (3mm x 3mm)</b></p> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### ABSOLUTE MAXIMUM RATINGS <sup>(1)</sup>

Supply Voltage  $V_{IN}$  ..... –0.3V to +30V  
 Switch Voltage  $V_{SW}$  ..... 31V  
 Boost Voltage  $V_{BS}$  .....  $V_{SW} - 0.3V$  to  $V_{SW} + 6V$   
 All Other Pins ..... –0.3V to +6V  
 Junction Temperature ..... 150°C  
 Continuous Power Dissipation ( $T_A = +25^\circ\text{C}$ ) <sup>(2)</sup>  
 SOIC8E ..... 2.5W  
 QFN10 (3mmx3mm) ..... 2.5W  
 Lead Temperature ..... 260°C  
 Storage Temperature ..... –65°C to +150°C

### Recommended Operating Conditions <sup>(3)</sup>

Input Voltage  $V_{IN}$  ..... 4.75V to 28V  
 Output Voltage  $V_{OUT}$  ..... 0.8V to 25V  
 Ambient Operating Temperature ... –40°C to +85°C

| Thermal Resistance <sup>(4)</sup> | $\theta_{JA}$ | $\theta_{JC}$ |
|-----------------------------------|---------------|---------------|
| SOIC8E                            | 50            | 10            |
| 3x3 QFN10                         | 50            | 12            |

#### Notes:

- Exceeding these ratings may damage the device.
- The maximum allowable power dissipation is a function of the maximum junction temperature  $T_J(\text{MAX})$ , 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  $P_D(\text{MAX}) = (T_J(\text{MAX}) - T_A) / \theta_{JA}$ . 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.
- The device is not guaranteed to function outside of its operating conditions.
- Measured on JESD51-7 4-layer board.

# **ELECTRICAL CHARACTERISTICS <sup>(5)</sup>**

**$V_{IN} = 12V$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.**

| Parameter                                        | Symbol        | Condition                                              | Min   | Typ <sup>(5)</sup> | Max                | Units       |
|--------------------------------------------------|---------------|--------------------------------------------------------|-------|--------------------|--------------------|-------------|
| Shutdown Supply Current                          |               | $V_{EN} = 0V$                                          |       | 0.3                | 3.0                | $\mu A$     |
| Supply Current                                   |               | $V_{EN} = 2.7V$ , $V_{FB} = 1.0V$                      |       | 1.3                | 1.5                | mA          |
| Feedback Voltage                                 | $V_{FB}$      | $4.75V \leq V_{IN} \leq 28V$ ,<br>$T_A = +25^{\circ}C$ | 0.780 | 0.800              | 0.820              | V           |
|                                                  |               | $-40^{\circ}C \leq T_A \leq +85^{\circ}C$              | 0.772 |                    | 0.828              | V           |
| OVP Threshold Voltage                            |               |                                                        | 0.90  | 0.95               | 1.00               | V           |
| Error Amplifier Voltage Gain                     | $A_{EA}$      |                                                        |       | 400                |                    | V/V         |
| Error Amplifier Transconductance                 | $G_{EA}$      | $\Delta I_C = \pm 10\mu A$                             | 550   | 820                | 1100               | $\mu A/V$   |
| High-Side Switch-On Resistance                   | $R_{DS(ON)1}$ |                                                        |       | 125                |                    | m $\Omega$  |
| Low-Side Switch-On Resistance                    | $R_{DS(ON)2}$ |                                                        |       | 125                |                    | m $\Omega$  |
| High-Side Switch Leakage Current                 |               | $V_{EN} = 0V$ , $V_{SW} = 0V$                          |       | 0                  | 10                 | $\mu A$     |
| Upper-Switch Current Limit                       |               |                                                        | 4.3   | 6.3                | 8.3 <sup>(6)</sup> | A           |
| Lower-Switch Current Limit                       |               | From Drain to Source                                   |       | 1.25               |                    | A           |
| COMP to Current Sense Transconductance           | $G_{CS}$      |                                                        |       | 9                  |                    | A/V         |
| Oscillation Frequency                            | $F_{osc1}$    | $T_A = +25^{\circ}C$                                   | 300   | 340                | 380                | KHz         |
|                                                  |               | $-40^{\circ}C \leq T_A \leq +85^{\circ}C$              | 270   |                    | 400                | KHz         |
| Short Circuit Oscillation Frequency              | $F_{osc2}$    | $V_{FB} = 0V$                                          |       | 110                |                    | KHz         |
| Maximum Duty Cycle                               | $D_{MAX}$     | $V_{FB} = 0.7V$                                        |       | 90                 |                    | %           |
| Minimum On-Time                                  |               |                                                        |       | 220                |                    | ns          |
| EN Shutdown Threshold Voltage                    |               | $V_{EN}$ Rising                                        | 1.1   | 1.5                | 2.0                | V           |
| EN Shutdown Threshold Voltage Hysteresis         |               |                                                        |       | 220                |                    | mV          |
| EN Lockout Threshold Voltage                     |               |                                                        | 2.2   | 2.5                | 2.7                | V           |
|                                                  |               | $-40^{\circ}C \leq T_A \leq +85^{\circ}C$              | 2.1   |                    | 2.8                | V           |
| EN Lockout Hysteresis                            |               |                                                        |       | 210                |                    | mV          |
| Input Under Voltage Lockout Threshold            | UVLO          | $V_{IN}$ rising, $T_A = +25^{\circ}C$                  | 3.8   | 4.05               | 4.30               | V           |
|                                                  |               | $-40^{\circ}C \leq T_A \leq +85^{\circ}C$              | 3.5   |                    | 4.70               | V           |
| Input Under Voltage Lockout Threshold Hysteresis |               |                                                        |       | 210                |                    | mV          |
| Soft-Start Current                               |               | $V_{SS} = 0V$                                          |       | 6                  |                    | $\mu A$     |
| Thermal Shutdown                                 |               |                                                        |       | 160                |                    | $^{\circ}C$ |

**Note:**

5) 100% production test at  $+25^{\circ}C$ . Specifications over the temperature range are guaranteed by design and characterization.

6) Guaranteed by design

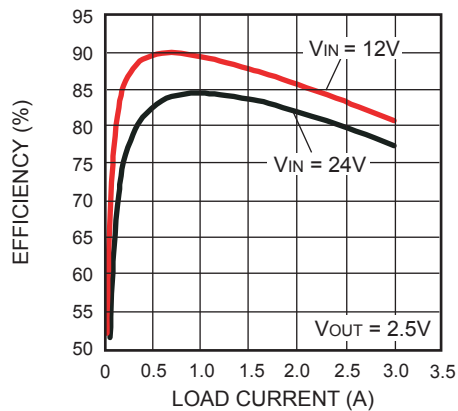
## PIN FUNCTIONS

| SOIC8N<br>Pin # | 3x3<br>QFN10<br>Pin # | Name | Description                                                                                                                                                                                                                                                                                                                                   |
|-----------------|-----------------------|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1               | 9                     | BS   | High-Side Gate Drive Boost Input. BS supplies the drive for the high-side N-Channel MOSFET switch. Connect a 0.01 $\mu$ F or greater capacitor from SW to BS to power the high side switch.                                                                                                                                                   |
| 2               | 1                     | IN   | Power Input. IN supplies the power to the IC, as well as the step-down converter switches. Drive IN with a 4.75V to 28V power source. Bypass IN to GND with a suitably large capacitor to eliminate noise on the input to the IC. See <i>Input Capacitor</i> .                                                                                |
| 3               | 2                     | SW   | Power Switching Output. SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load. Note that a capacitor is required from SW to BS to power the high-side switch.                                                                                                                   |
| 4               | 3, 4, 5               | GND  | Ground. SOIC8: Connect the exposed pad to pin 4. 3x3 QFN10: Connect to pins 3, 4 and 5 and ensure that said pins are tied together.                                                                                                                                                                                                           |
| 5               | 6                     | FB   | Feedback Input. FB senses the output voltage to regulate that voltage. Drive FB with a resistive voltage divider from the output voltage. The feedback reference voltage is 0.8V. See <i>Setting the Output Voltage</i> .                                                                                                                     |
| 6               | 7                     | COMP | Compensation Node. COMP is used to compensate the regulation control loop. Connect a series RC network from COMP to GND to compensate the regulation control loop. In some cases, an additional capacitor from COMP to GND is required. See <i>Compensation Components</i> .                                                                  |
| 7               | 8                     | EN   | Enable Input. EN is a digital input that turns the regulator on or off. Drive EN higher than 2.7V to turn on the regulator, drive it lower than 1.1V to turn it off. Pull up by a resistive voltage divider to the IN pin for automatic startup, a 47k $\Omega$ resistor from EN to Ground and a 100k $\Omega$ resistor from EN to $V_{IN}$ . |
| 8               | 10                    | SS   | Soft-start Control Input. SS controls the soft-start period. Connect a capacitor from SS to GND to set the soft-start period. See <i>Soft-Start Capacitor</i> .                                                                                                                                                                               |

## TYPICAL PERFORMANCE CHARACTERISTICS

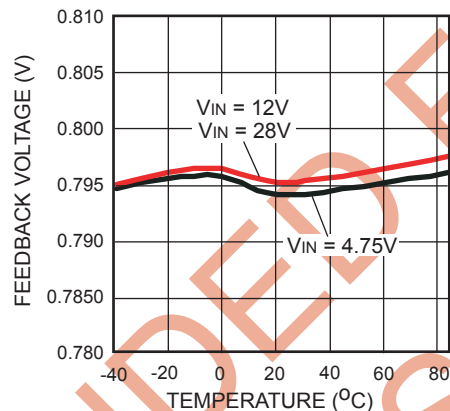
$V_{IN} = 12V$ ,  $V_O = 3.3V$ ,  $L = 10\mu H$ ,  $C1 = 10\mu F$ ,  $C2 = 22\mu F \times 2$ ,  $T_A = +25^\circ C$ , unless otherwise noted.

**Efficiency vs Load Current**



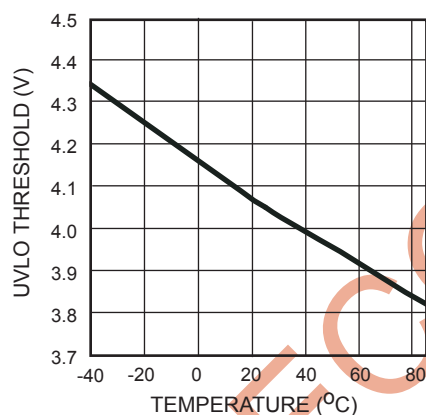
MP2303-EC02

**Feedback Voltage vs. Temperature**



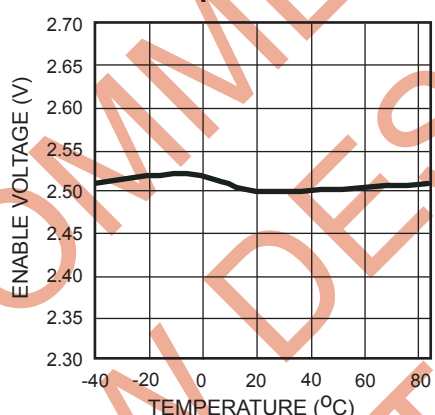
MP2303-TPC01

**UVLO Rising vs. Temperature**



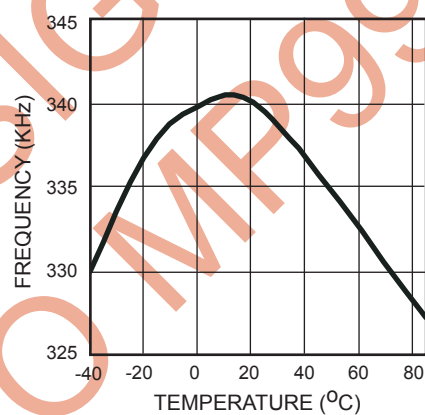
MP2303-TPC02

**Enable Lockout Threshold vs. Temperature**



MP2303-TPC03

**Oscillator Frequency**



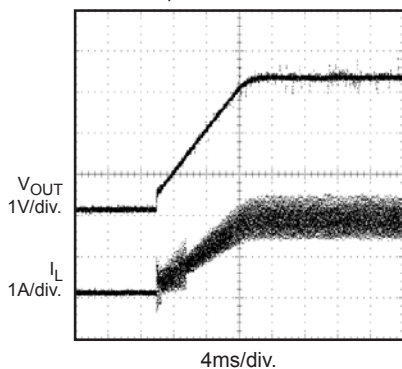
MP2303-TPC04

# **TYPICAL PERFORMANCE CHARACTERISTICS** *(continued)*

$V_{IN} = 12V$ ,  $V_O = 3.3V$ ,  $L = 10\mu H$ ,  $C_1 = 10\mu F$ ,  $C_2 = 22\mu F \times 2$ ,  $T_A = +25^\circ C$ , unless otherwise noted.

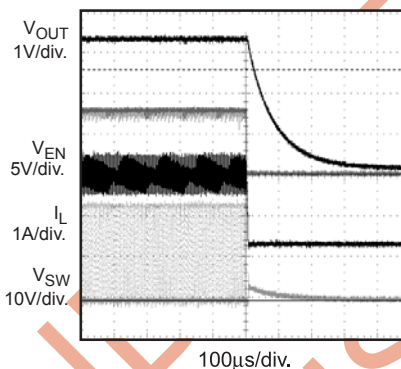
## **Power Up**

$V_{IN} = 24V$ ,  $V_{OUT} = 3.3V$ ,  $I_{OUT} = 2A$ ,  
 $C_{SS} = 0.1\mu F$



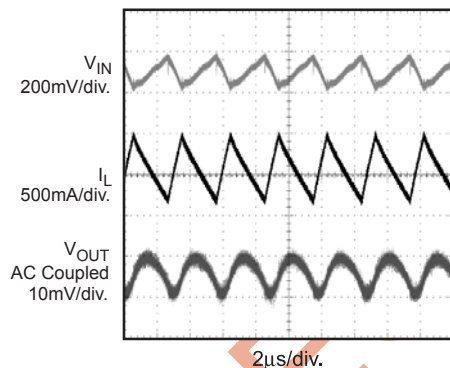
## **Power Off through Enable**

$V_{IN} = 24V$ ,  $V_{OUT} = 3.3V$ ,  $I_{OUT} = 2A$



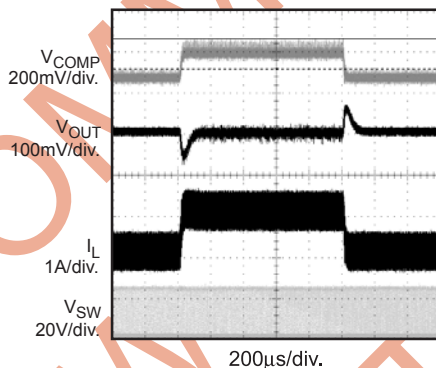
## **Steady State Test**

$V_{IN} = 12V$ ,  $V_{OUT} = 3.3V$ ,  $I_{OUT} = 1A$



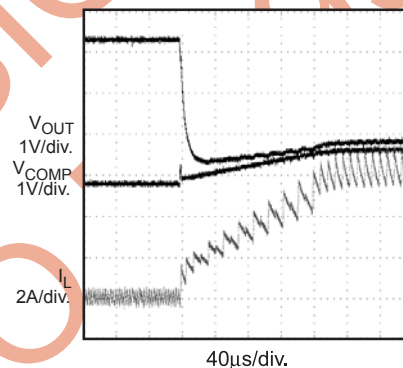
## **Load Transient Test**

$V_{IN} = 24V$ ,  $V_{OUT} = 3.3V$ ,  
 $I_{OUT} = 0A-1A$  step with  $C_{FF} = 470pF$



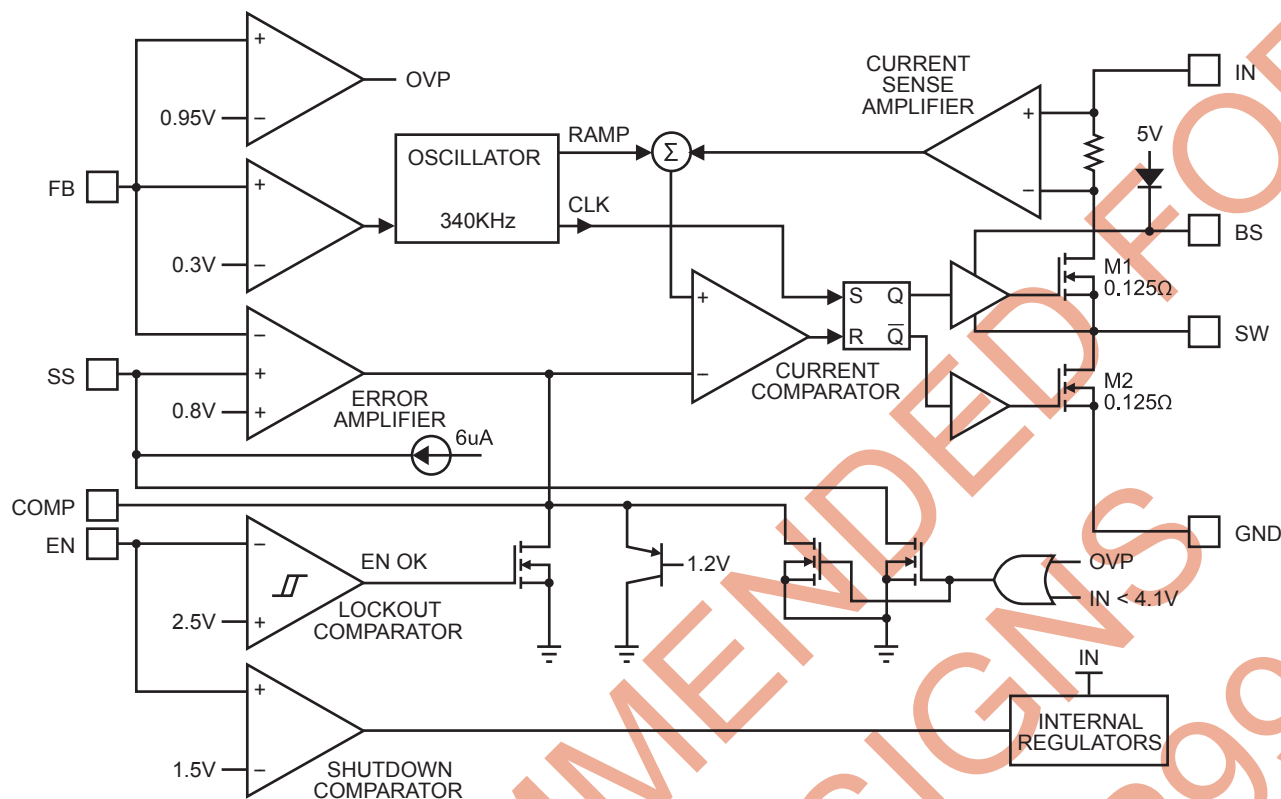
## **Short Circuit Protection**

$V_{IN} = 24V$ ,  $V_{OUT} = 3.3V$ ,  $I_{OUT} = 0A$





## OPERATION



**Figure 1—Functional Block Diagram**

The MP2303 is a synchronous rectified, current-mode, step-down regulator. It regulates input voltages from 4.75V to 28V down to an output voltage as low as 0.8V, and supplies up to 3A of load current.

The MP2303 uses current-mode control to regulate the output voltage. The output voltage is measured at FB through a resistive voltage divider and amplified through the internal transconductance error amplifier. The voltage at COMP pin is compared to the switch current measured internally to control the output voltage.

The converter uses internal N-Channel MOSFET switches to step-down the input voltage to the regulated output voltage. Since the high-side MOSFET requires a gate voltage greater than the input voltage, a boost capacitor connected between SW and BS is needed to drive the high-side gate. The boost capacitor is charged from the internal 5V rail when SW is low.

When the MP2303 FB pin exceeds 20% of the nominal regulation voltage of 0.8V, the over voltage comparator is tripped; the COMP pin and the SS pin are discharged to GND, forcing the high-side switch off.

## APPLICATIONS INFORMATION

### COMPONENT SELECTION

#### Setting the Output Voltage

The output voltage is set using a resistive voltage divider from the output voltage to FB pin. The voltage divider divides the output voltage down to the feedback voltage by the ratio:

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

Thus the output voltage is:

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

Where  $V_{FB}$  is the feedback voltage and  $V_{OUT}$  is the output voltage.

A typical value for R2 can be as high as 100kΩ, but a typical value is 10kΩ. Using that value, R1 is determined by:

$$R1 = 12.5 \times (V_{OUT} - 0.8)(k\Omega)$$

For example, for a 3.3V output voltage, R2 is 10kΩ, and R1 is 31.3kΩ.

#### Inductor

The inductor is required to supply constant current to the output load while being driven by the switched input voltage. A larger value inductor will result in less ripple current that will result in lower output ripple voltage. However, the larger value inductor will have a larger physical size, higher series resistance, and/or lower saturation current. A good rule for determining the inductance to use is to allow the peak-to-peak ripple current in the inductor to be approximately 30% of the maximum switch current limit. Also, make sure that the peak inductor current is below the maximum switch current limit. The inductance value can be calculated by:

$$L = \frac{V_{OUT}}{f_s \times \Delta I} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where  $V_{IN}$  is the input voltage,  $f_s$  is the 340KHz switching frequency, and  $\Delta I_L$  is the peak-to-peak inductor ripple current.

Choose an inductor that will not saturate under the maximum inductor peak current. The peak inductor current can be calculated by:

$$I_{LP} = I_{LOAD} + \frac{V_{OUT}}{2 \times f_s \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where  $I_{LOAD}$  is the load current.

#### Optional Schottky Diode

During the transition between high-side switch and low-side switch, the body diode of the low-side power MOSFET conducts the inductor current. The forward voltage of this body diode is high. An optional Schottky diode may be paralleled between the SW pin and GND pin to improve overall efficiency. Table 2 lists example Schottky diodes and their Manufacturers.

**Table 2—Diode Selection Guide**

| Part Number | Voltage/Current Rating | Vendor                  |
|-------------|------------------------|-------------------------|
| B130        | 30V, 1A                | Diodes, Inc.            |
| SK13        | 30V, 1A                | Diodes, Inc.            |
| MBRS130     | 30V, 1A                | International Rectifier |

#### Input Capacitor

The input current to the step-down converter is discontinuous, therefore a capacitor is required to supply the AC current to the step-down converter while maintaining the DC input voltage. Use low ESR capacitors for the best performance. Ceramic capacitors are preferred, but tantalum or low-ESR electrolytic capacitors may also suffice. Choose X5R or X7R dielectrics when using ceramic capacitors.

Since the input capacitor (C1) absorbs the input switching current it requires an adequate ripple current rating. The RMS current in the input capacitor can be estimated by:

$$I_{C1} = I_{LOAD} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)}$$

The worst-case condition occurs at  $V_{IN} = 2V_{OUT}$ , where:

$$I_{C1} = \frac{I_{LOAD}}{2}$$



For simplification, choose the input capacitor whose RMS current rating greater than half of the maximum load current.

The input capacitor can be electrolytic, tantalum or ceramic. When using electrolytic or tantalum capacitors, a small, high quality ceramic capacitor, i.e. 0.1μF, should be placed as close to the IC as possible. When using ceramic capacitors, make sure that they have enough capacitance to provide sufficient charge to prevent excessive voltage ripple at input. The input voltage ripple caused by capacitance can be estimated by:

$$\Delta V_{IN} = \frac{I_{LOAD}}{f_s \times C1} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

### Output Capacitor

The output capacitor is required to maintain the DC output voltage. Ceramic, tantalum, or low ESR electrolytic capacitors are recommended. Low ESR capacitors are preferred to keep the output voltage ripple low. The output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_s \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times f_s \times C2}\right)$$

Where C2 is the output capacitance value and  $R_{ESR}$  is the equivalent series resistance (ESR) value of the output capacitor.

In the case of ceramic capacitors, the impedance at the switching frequency is dominated by the capacitance. The output voltage ripple is mainly caused by the capacitance. For simplification, the output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times f_s^2 \times L \times C2} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

In the case of tantalum or electrolytic capacitors, the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated to:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_s \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times R_{ESR}$$

The characteristics of the output capacitor also affect the stability of the regulation system. The

MP2303 can be optimized for a wide range of capacitance and ESR values.

### Compensation Components

MP2303 employs current mode control for easy compensation and fast transient response. The system stability and transient response are controlled through the COMP pin. COMP pin is the output of the internal transconductance error amplifier. A series capacitor-resistor combination sets a pole-zero combination to control the characteristics of the control system.

The DC gain of the voltage feedback loop is given by:

$$A_{VDC} = R_{LOAD} \times G_{CS} \times A_{VEA} \times \frac{V_{FB}}{V_{OUT}}$$

Where  $A_{VEA}$  is the error amplifier voltage gain, 400V/V;  $G_{CS}$  is the current sense transconductance, 9.0A/V;  $R_{LOAD}$  is the load resistor value.

The system has 2 poles of importance. One is due to the compensation capacitor (C3) and the output resistor of error amplifier, and the other is due to the output capacitor and the load resistor. These poles are located at:

$$f_{P1} = \frac{G_{EA}}{2\pi \times C3 \times A_{VEA}}$$

$$f_{P2} = \frac{1}{2\pi \times C2 \times R_{LOAD}}$$

Where,  $G_{EA}$  is the error amplifier transconductance, 820μA/V, and  $R_{LOAD}$  is the load resistor value.

The system has one zero of importance, due to the compensation capacitor (C3) and the compensation resistor (R3). This zero is located at:

$$f_{Z1} = \frac{1}{2\pi \times C3 \times R3}$$

The system may have another zero of importance, if the output capacitor has a large capacitance and/or a high ESR value. The zero, due to the ESR and capacitance of the output capacitor, is located at:

$$f_{ESR} = \frac{1}{2\pi \times C2 \times R_{ESR}}$$

In this case, a third pole set by the optional compensation capacitor (C6) and the compensation resistor (R3) is used to compensate the effect of the ESR zero on the loop gain. This pole is located at:

$$f_{P3} = \frac{1}{2\pi \times C6 \times R3}$$

The goal of compensation design is to shape the converter transfer function to get a desired loop gain. The system crossover frequency where the feedback loop has the unity gain is important.

Lower crossover frequencies result in slower line and load transient responses, while higher crossover frequencies could cause system instability. A good rule of thumb is to set the crossover frequency to approximately one-tenth of the switching frequency. Switching frequency for the MP2303 is 340KHz, so the desired crossover frequency is 34KHz.

Table 3 lists the typical values of compensation components for some standard output voltages with various output capacitors and inductors. The values of the compensation components have been optimized for fast transient responses and good stability at given conditions.

**Table 3—Compensation Values for Typical Output Voltage/Capacitor Combinations**

| V <sub>OUT</sub> | L             | C2                 | R3    | C3    | C6    |
|------------------|---------------|--------------------|-------|-------|-------|
| 1.8V             | 4.7μH         | 100μF Ceramic      | 6.6kΩ | 3.3nF | None  |
| 2.5V             | 4.7μH - 6.8μH | 47μF Ceramic       | 4.7kΩ | 5.6nF | None  |
| 3.3V             | 6.8μH - 10μH  | 22μFx2 Ceramic     | 5.6kΩ | 4.7nF | None  |
| 5V               | 10μH - 15μH   | 22μFx2 Ceramic     | 8.2kΩ | 4.7nF | None  |
| 12V              | 15μH - 22μH   | 22μFx2 Ceramic     | 20kΩ  | 2.2nF | None  |
| 2.5V             | 4.7μH - 6.8μH | 560μF Al. 30mΩ ESR | 56kΩ  | 2.2nF | 300pF |
| 3.3V             | 6.8μH - 10μH  | 560μF Al. 30mΩ ESR | 68kΩ  | 2.2nF | 200pF |
| 5V               | 10μH - 15μH   | 470μF Al. 30mΩ ESR | 91kΩ  | 2.2nF | 50pF  |
| 12V              | 15μH - 22μH   | 220μF Al. 30mΩ ESR | 100kΩ | 2.2nF | None  |

To optimize the compensation components for conditions not listed in Table 2, the following procedure can be used.

1. Choose the compensation resistor (R3) to set the desired crossover frequency. Determine the R3 value by the following equation:

$$R3 = \frac{2\pi \times C2 \times f_c}{G_{EA} \times G_{CS}} \times \frac{V_{OUT}}{V_{FB}}$$

Where  $f_c$  is the desired crossover frequency, 34KHz.

2. Choose the compensation capacitor (C3) to achieve the desired phase margin. For applications with typical inductor values, setting the compensation zero,  $f_{Z1}$ , below one forth of the crossover frequency provides sufficient phase margin. Determine the C3 value by the following equation:

$$C3 > \frac{4}{2\pi \times R3 \times f_c}$$

3. Determine if the second compensation capacitor (C6) is required. It is required if the ESR zero of the output capacitor is located at less than half of the 340KHz switching frequency, or the following relationship is valid:

$$\frac{1}{2\pi \times C2 \times R_{ESR}} < \frac{f_s}{2}$$

If this is the case, then add the optional compensation capacitor (C6) to set the pole  $f_{P3}$  at the location of the ESR zero. Determine the C6 value by the equation:

$$C6 = \frac{C2 \times R_{ESR}}{R3}$$

### Soft-Start Capacitor

To reduce input inrush current during startup, a programmable soft-start is provided by connecting a capacitor (C4) from pin SS to GND. The soft-start time is given by:

$$t_{SS} = C4 \times \frac{0.8V}{6\mu A}$$

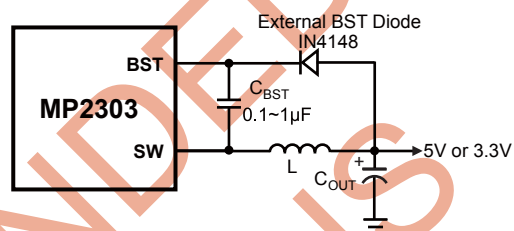
To reduce the susceptibility to noise, do not leave SS pin open. Use a capacitor with small value if you do not need soft-start function.

### External Bootstrap Diode

An external bootstrap diode may enhance the efficiency of the regulator, and it will be a must if the applicable condition is:

- $V_{OUT}$  is 5V or 3.3V, and duty cycle is high:  
 $D = \frac{V_{OUT}}{V_{IN}} > 65\%$

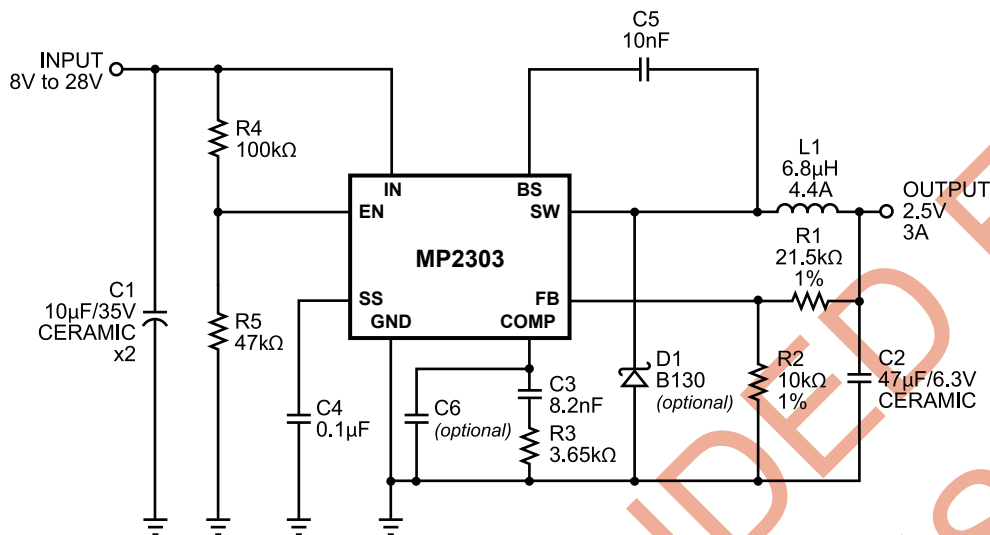
In these cases, an external BST diode is recommended from the output of the voltage regulator to BST pin, as shown in Figure.2



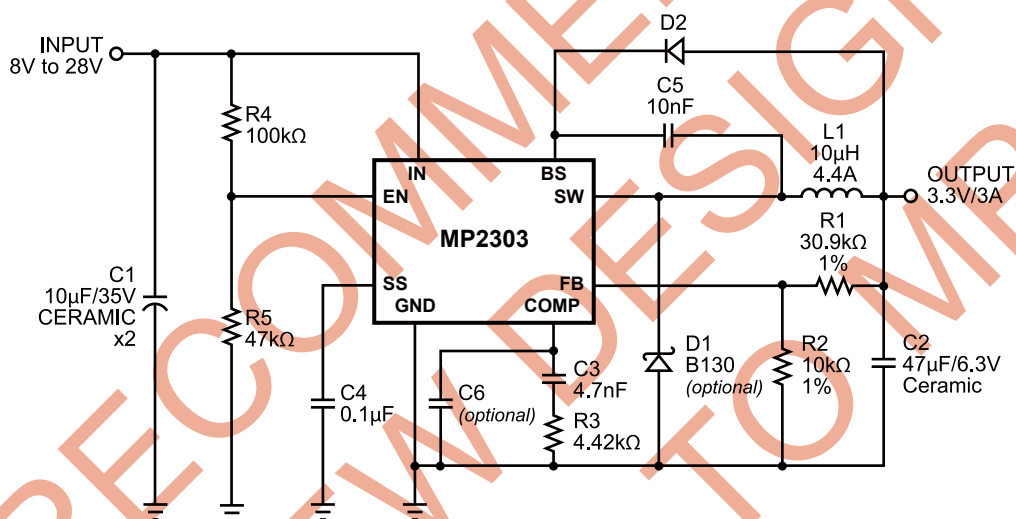
**Figure 2—Add Optional External Bootstrap Diode to Enhance Efficiency**

The recommended external BST diode is IN4148, and the BST cap is 0.1~1μF.

## TYPICAL APPLICATION CIRCUITS



**Figure 3—MP2303 with 2.5V Output, 47µF/6.3V Ceramic Output Capacitor**



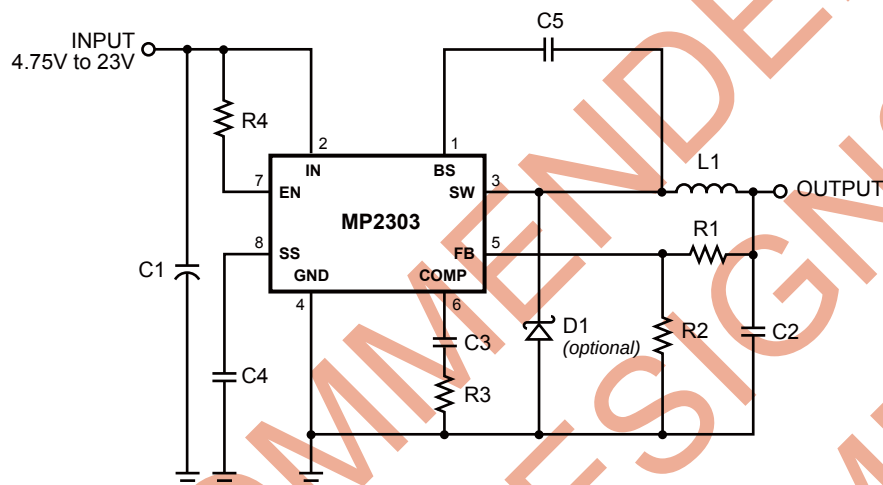
**Figure 4—MP2303 with 3.3V Output, 47µF/6.3V Ceramic Output Capacitor**

## PCB LAYOUT GUIDE

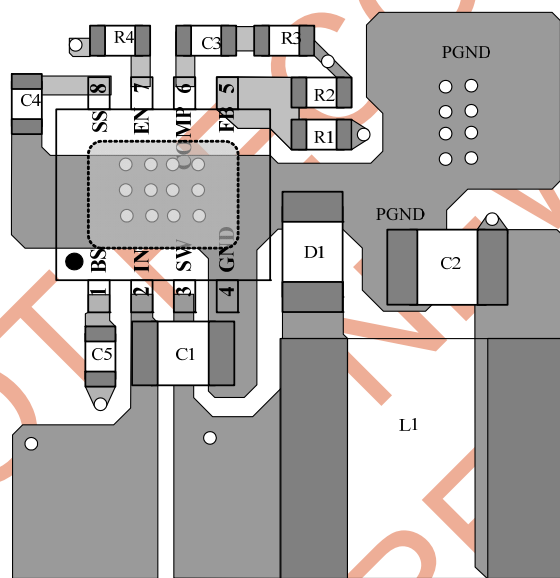
PCB layout is very important to achieve stable operation. It is highly recommended to duplicate EVB layout for optimum performance.

If change is necessary, please follow these guidelines and take Figure 5 for reference.

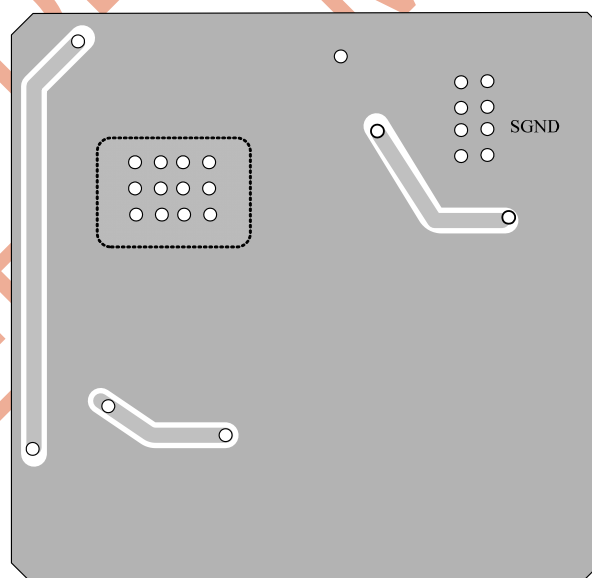
- 1) Keep the path of switching current short and minimize the loop area formed by Input cap, high-side MOSFET and low-side MOSFET.
- 2) Bypass ceramic capacitors are suggested to be put close to the  $V_{IN}$  Pin.
- 3) Ensure all feedback connections are short and direct. Place the feedback resistors and compensation components as close to the chip as possible.
- 4) Route SW away from sensitive analog areas such as FB.
- 5) Connect IN, SW, and especially GND respectively to a large copper area to cool the chip to improve thermal performance and long-term reliability.



**MP2303 Typical Application Circuit**



**TOP Layer**

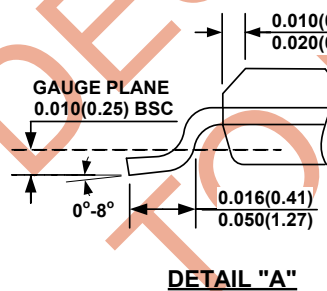
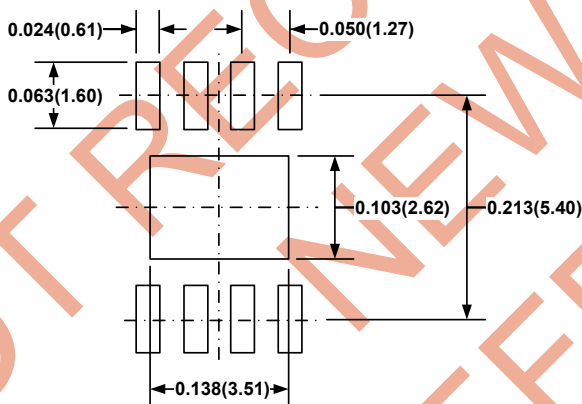
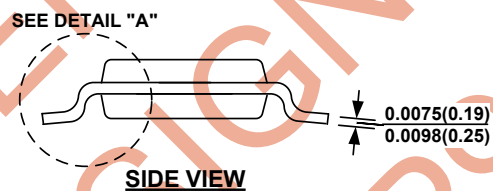
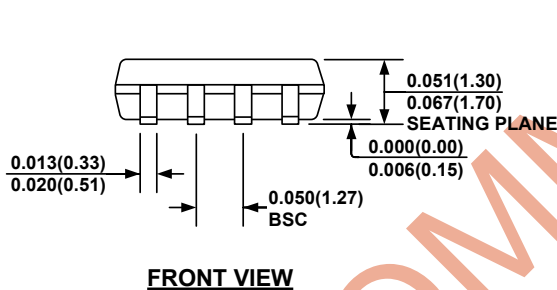
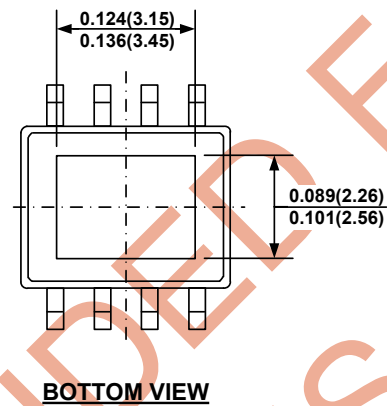
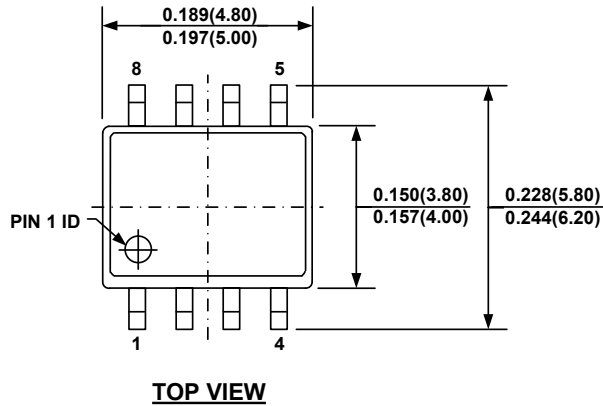


**Bottom Layer**

**Figure 5—MP2303 Typical Application Circuit and PCB Layout Guide**

# PACKAGE INFORMATION

## SOIC8E (EXPOSED PAD)

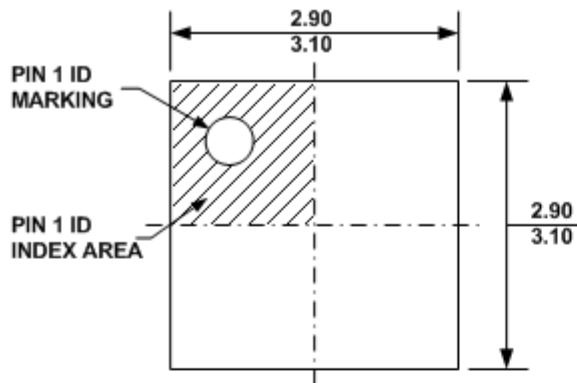


### NOTE:

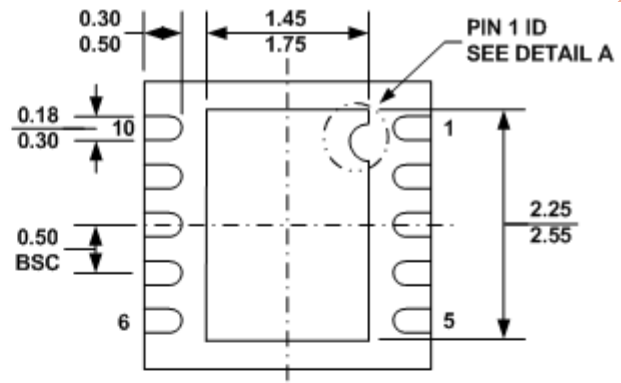
- 1) CONTROL DIMENSION IS IN INCHES. DIMENSION IN BRACKET IS IN MILLIMETERS.
- 2) PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
- 3) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
- 4) LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.004" INCHES MAX.
- 5) DRAWING CONFORMS TO JEDEC MS-012, VARIATION BA.
- 6) DRAWING IS NOT TO SCALE.



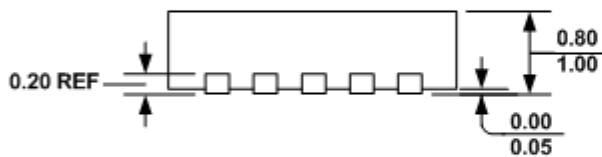
**QFN10 (3mm x 3mm)**



**TOP VIEW**



**BOTTOM VIEW**



**SIDE VIEW**

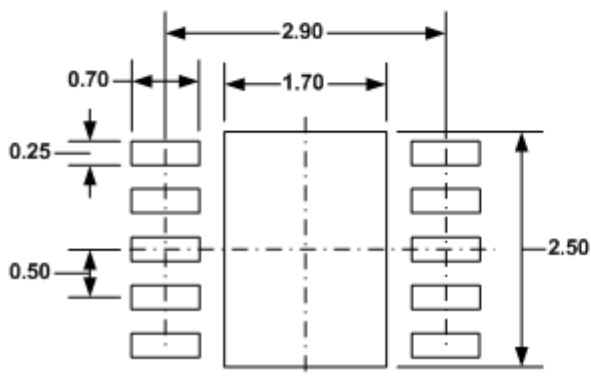
**PIN 1 ID OPTION A  
R0.20 TYP.**



**PIN 1 ID OPTION B  
R0.20 TYP.**



**DETAIL A**



**RECOMMENDED LAND PATTERN**

**NOTE:**

- 1) ALL DIMENSIONS ARE IN MILLIMETERS.
- 2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
- 3) LEAD COPLANARITY SHALL BE 0.10 MILLIMETER MAX.
- 4) DRAWING CONFORMS TO JEDEC MO-229, VARIATION VEED-5.
- 5) DRAWING IS NOT TO SCALE.

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