# MP1528

## 9 Lamp, 36V Precision White LED Driver

The Future of Analog IC Technology™

## DESCRIPTION

The MP1528 is a step-up converter designed for driving up to nine (9) series White LEDs (LED) from a single cell Lithium-Ion battery. It regulates the LED current and includes an analog input for varying the LED brightness.

The MP1528 uses current limited, variable frequency architecture to regulate the LED current while maintaining high efficiency. The BIAS pin measures the output voltage and turns off the converter if an over voltage condition is present to prevent damage due to an open circuit condition. The LED current is measured with an external current sense resistor. The low 0.4V full-scale regulation threshold and 0.63Ω power switch minimize power loss.

The MP1528 is available in an 8 pin MSOP and a tiny 6 pin 3mm x 3mm QFN packages.

### EVALUATION BOARD REFERENCE

| Board Number | Dimensions |
|---|---|
| EV1528DQ-00A | 2.0” x 1.5” x 0.5” |

## FEATURES

- Drives up to 9 Series White LEDs
- Integrated 0.63Ω Power MOSFET
- Low 0.4V Full-Scale Current Sense Threshold
- Over 20mA Output Current Capacity
- Analog and Digital PWM Brightness Control
- Open Load Shutdown
- Soft-Start
- Internal Current Limit
- Under Voltage Lockout
- Thermal Shutdown
- Available in 8-Pin MSOP and Tiny 3mm x 3mm 6-Pin QFN Packages

## APPLICATIONS

- Handheld Computers
- PDAs
- PDA Phones
- Digital and Video Cameras
- Small LCD Displays

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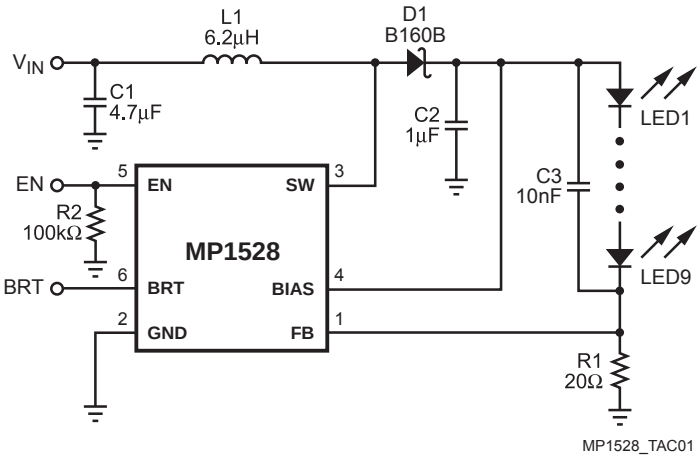
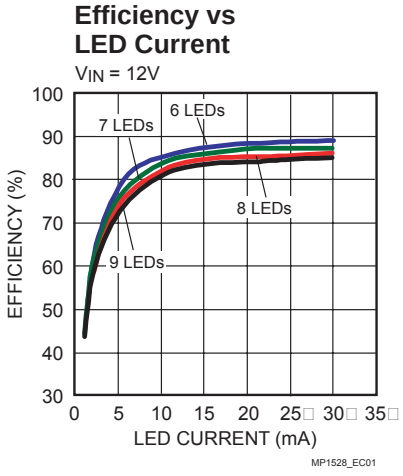
## TYPICAL APPLICATION





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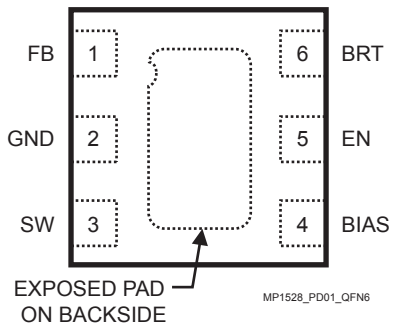
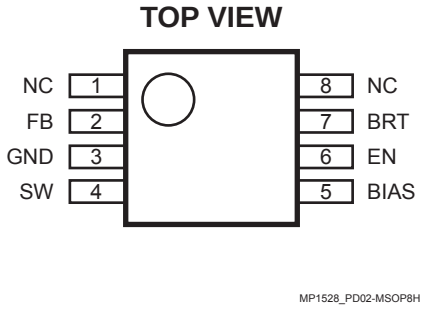
## PACKAGE REFERENCE




| Part Number* | Package | Temperature |
|---|---|---|
| MP1528DQ | QFN6 (3mm x 3mm) | –40°C to +85°C |

* For Tape & Reel, add suffix –Z (eg. MP1528DQ–Z)
For Lead Free, add suffix –LF (eg. MP1528DQ–LF–Z)




| Part Number** | Package | Temperature |
|---|---|---|
| MP1528DK | MSOP8 | –40°C to +85°C |

** For Tape & Reel, add suffix –Z (eg. MP1528DK–Z)
For Lead Free, add suffix –LF (eg. MP1528DK–LF–Z)

## ABSOLUTE MAXIMUM RATINGS (1)

Supply Voltage $V_{BIAS}$ to GND ..... 42V
$V_{SW}$ to GND .....–0.5V to +42V
$V_{EN}$, $V_{BRT}$, $V_{FB}$ to GND .....–0.3V to +6V
Storage Temperature..... –65°C to +150°C

## *Recommended Operating Conditions* (2)

Supply Voltage $V_{BIAS}$ ..... 2.7V to 36V
Operating Temperature .....–40°C to +85°C

## *Thermal Resistance* (3)

| | $\theta_{JA}$ | $\theta_{JC}$ | |
|---|---|---|---|
| QFN6 (3mm x 3mm) | 50 | 14 | °C/W |
| MSOP8 | 150 | 65 | °C/W |

**Notes:**
1) Exceeding these ratings may damage the device.
2) The device is not guaranteed to function outside of its operating conditions.
3) Measured on approximately 1" square of 1 oz copper.

## ELECTRICAL CHARACTERISTICS

**$V_{BIAS}$ = $V_{EN}$ = 5.0V, $V_{BRT}$ = 1.2V, $T_A$ = +25°C, unless otherwise noted.**

| Parameter | Symbol | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| Supply Current (Shutdown) | | $V_{EN}$ < 0.4V | | 1 | 3 | µA |
| Supply Current (Quiescent) | | $V_{EN}$ > 2.0V, BRT = GND | | 650 | 800 | µA |
| Minimum Off Time (Normal Operation) | | | | 330 | | ns |
| Minimum Off Time (Startup) | | | | 1.2 | | µs |
| **Under Voltage Lock Out** | | | | | | |
| BIAS Under Voltage Lock Out | UVLO | $V_{BIAS}$ Rising, 100mV Hysteresis | 2.1 | | 2.65 | V |
| **Enable** | | | | | | |
| EN High Threshold | | | 0.8 | 1.2 | 1.5 | V |
| EN Hysteresis | | | | 60 | | mV |
| EN Input Leakage Current | | | | | 150 | nA |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## ELECTRICAL CHARACTERISTICS *(continued)*

**$V_{BIAS}$ = $V_{EN}$ = 5.0V, $V_{BRT}$ = 1.2V, $T_A$ = +25°C, unless otherwise noted.**

| Parameter | Symbol | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **Open Load Shutdown** | | | | | | |
| Threshold | | Measured at BIAS | | 40 | | V |
| Bias Current | | $V_{BIAS}$ = 20V, $V_{EN}$ < 0.4V | | | 5 | µA |
| | | $V_{BIAS}$ = 40V, $V_{EN}$ < 0.4V | | 70 | 100 | µA |
| **Feedback Comparator** | | | | | | |
| FB Regulation Threshold | $V_{FB}$ | $V_{BRT}$ = 1.2V | 0.38 | 0.40 | 0.42 | V |
| FB Hysteresis | | | | 10 | | mV |
| FB Input Leakage Current | | $V_{FB}$ = 0.2V | –150 | –80 | | nA |
| **PWM Mode Using BRT** | | | | | | |
| Output-Off Threshold | | | 0.18 | | 0.27 | V |
| BRT Input Leakage Current | | $V_{BRT}$ = 0.6V | –100 | | | nA |
| BRT Full-Scale Threshold | | | | | 1.2 | V |
| **Output Switch** | | | | | | |
| SW On-Resistance | $R_{ON}$ | $V_{BIAS}$ = 5.0V | | 0.63 | | Ω |
| SW Current Limit | | | | 950 | | mA |
| Thermal Shutdown | | | | 160 | | °C |


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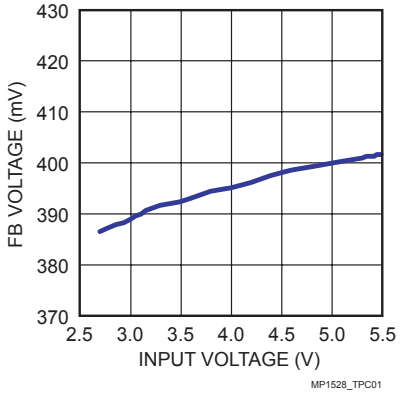
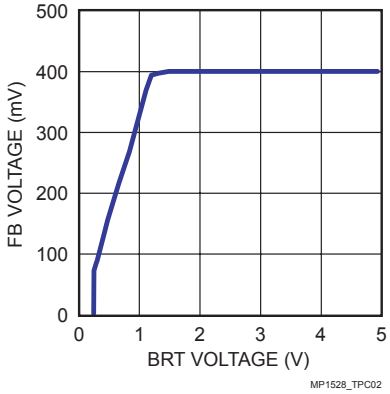
## TYPICAL PERFORMANCE CHARACTERISTICS

**Circuit on front page, $V_{IN}$ = 3.6V, 9 LEDs, $I_{LED}$ = 20mA, $V_{BRT}$ = 1.2V, $T_A$ = +25°C, unless otherwise noted.**

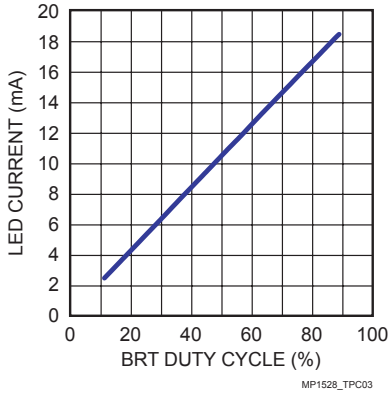
**Feedback Voltage vs Input Voltage**



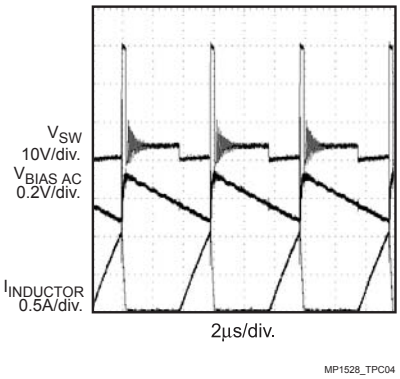

**Feedback Voltage vs BRT Voltage**



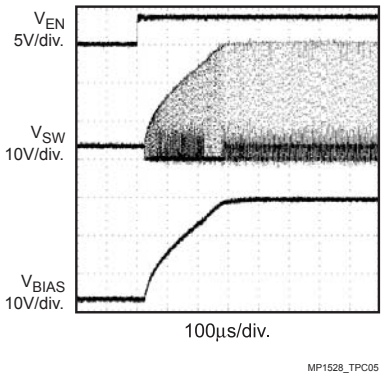

**LED Current vs BRT Duty Cycle @ 200Hz**



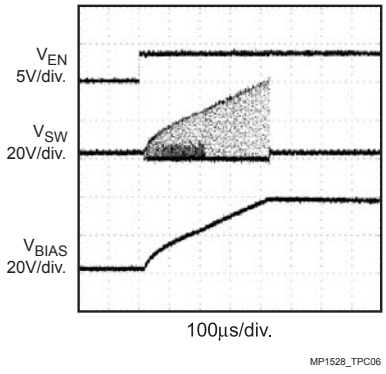

**Steady-State Operation**



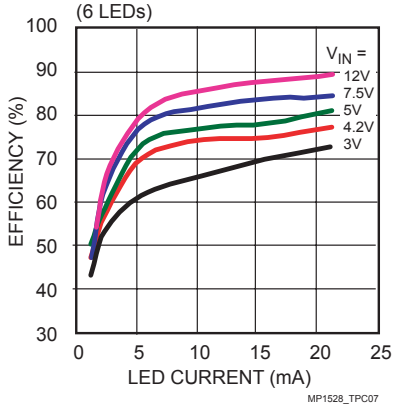

**Startup**



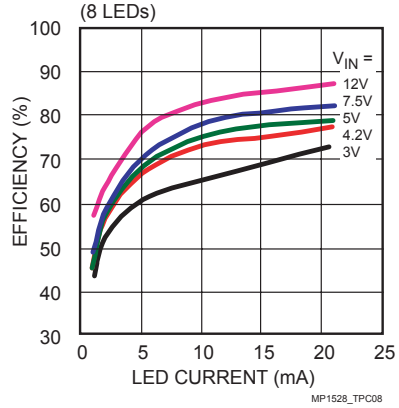

**Startup into an Open Load**



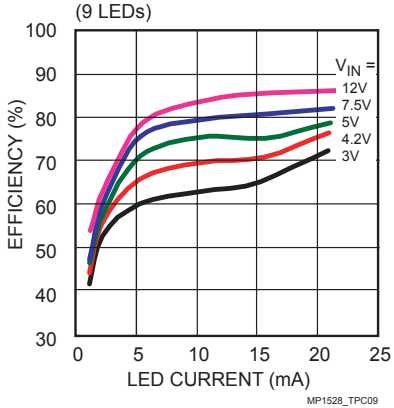

**Efficiency vs LED Current**
(6 LEDs)




**Efficiency vs LED Current**
(8 LEDs)




**Efficiency vs LED Current**
(9 LEDs)





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## PIN FUNCTIONS

| Pin # | | Name | Description |
|---|---|---|---|
| QFN6 | MSOP8 | | |
| 1 | 2 | FB | Feedback Input. The MP1528 regulates the voltage across the current sense resistor between FB and GND. Connect a current sense resistor from the bottom of the LED string to GND and connect the bottom of the LED string to FB. The regulation threshold is set at 0.4V for $V_{BRT} \geq 1.2V$. |
| 2 | 3 | GND | Ground. |
| 3 | 4 | SW | Power Switch Output. SW is the drain of the internal MOSFET switch. Connect the power inductor and output rectifier to SW, which can swing between GND and 42V. |
| 4 | 5 | BIAS | Internal Power Input. BIAS powers the internal circuitry and measures the output voltage for open circuit protection. Connect BIAS to the output at the top of the LED string. If open circuit protection is not required, BIAS may be connected to the input source to reduce power consumption of the MP1528. |
| 5 | 6 | EN | Regulator On/Off Control Input. A high voltage applied to EN turns on the converter; a low voltage turns it off. When not used, connect EN to the input source for automatic startup. If EN is driven over 6V, place a 100kΩ resistor in series with EN. Never leave EN floating. |
| 6 | 7 | BRT | Analog or PWM Input for Controlling LED Brightness. When used in analog mode, apply a DC voltage of 0.27V to 1.2V. This input voltage is attenuated by 1/3 to set the voltage across the sense resistor at FB. Maximum brightness (20mA) occurs with an application of 1.2V. To control the brightness in PWM mode, apply a PWM signal with a minimum voltage less than 0.18V and a maximum voltage greater than 1.2V (when a voltage less than 0.18V is applied to this pin, the output switch is turned off). The regulator operates at maximum brightness when more than 1.2V is applied. The frequency of the PWM signal must be between 100Hz to 400Hz. |
| | 1, 8 | NC | No Connect |


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## OPERATION

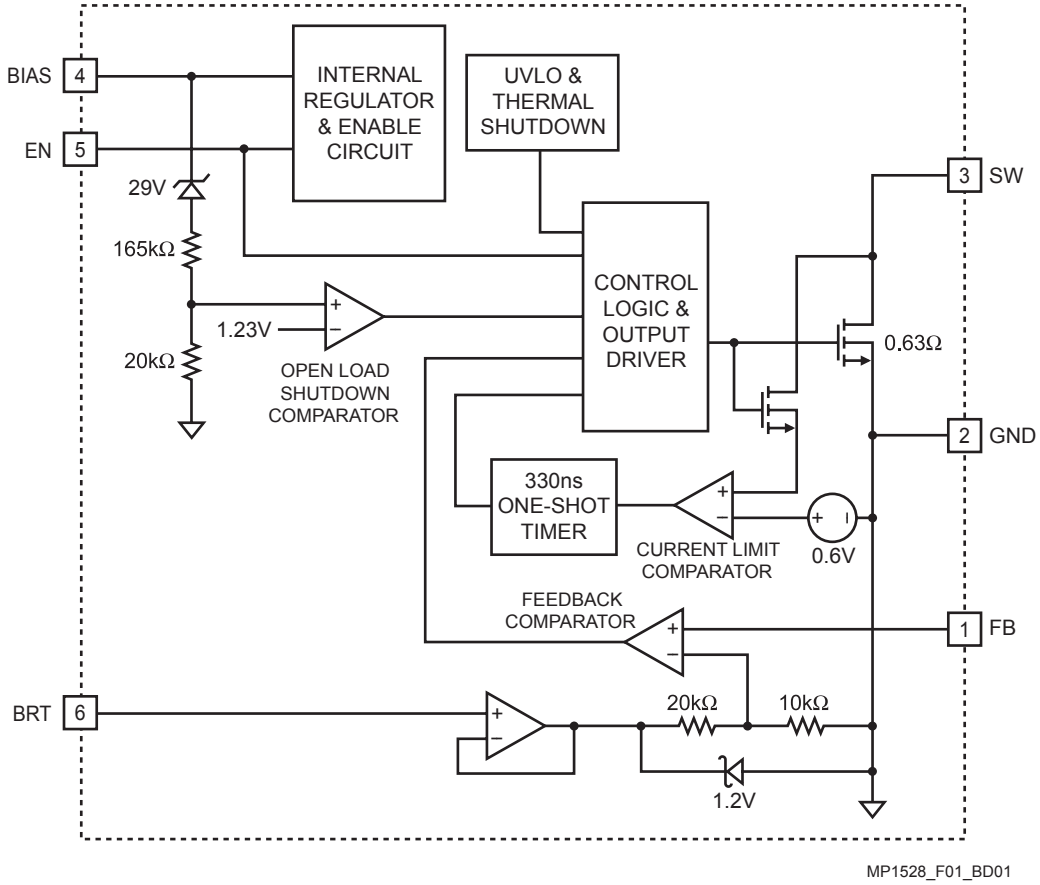


**Figure 1—Functional Block Diagram**

The MP1528 utilizes a constant off-time control scheme. For maximum brightness, the BRT pin is biased at or above 1.2V. Its voltage is routed through the unity gain buffer whose output is clamped at 1.2V. A resistor divider from the buffer to the inverting input of the feedback comparator divides the BRT voltage by three to set the current sense threshold. If the FB pin voltage is lower than this threshold the power MOSFET is turned on. The MOSFET and inductor currents increase until the current limit comparator trips at 950mA, turning off the MOSFET for at least 330ns. At the end of the 330ns, if the FB pin is still lower than the current sense threshold, the MOSFET is turned on again.

### Analog Brightness Adjust

Analog brightness adjustments are accomplished by applying a voltage between 0.27V to 1.2V on the BRT pin.

### PWM Brightness Adjust

PWM brightness adjustments are accomplished by driving the BRT pin with a digital signal whose low voltage is below 0.18V and high voltage is greater than 1.2V. A voltage below 0.18V forces the power MOSFET to turn off. A voltage greater than 1.2V will cause the FB pin to regulate at 0.4V.

### Open Load Shutdown

Open Load Shutdown is implemented by connecting the BIAS pin to the top of the LED string. In the fault condition where the connection to the LED is open, $V_{OUT}$ will rise up, as the FB pin has no voltage. Once $V_{OUT}$ exceeds 40V, the MP1528 will cease operation until the EN pin is cycled off and on. Connecting the BIAS pin to the input will disable Open Load Shutdown.


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## APPLICATION INFORMATION

### Setting the LED Current

The LED current is set by the voltage at BRT ($V_{BRT}$) and the sense resistor (R1) at FB. The $V_{BRT}$ range for adjusting the LED current is 0.27V to 1.2V. Over this range, the LED current can be calculated as:

$$I_{LED} = \frac{V_{BRT}}{3 \times R1}$$

Voltages greater than 1.2V can be applied to BRT. Use 1.2V in the equation if $V_{BRT} \geq 1.2V$ or the BRT pin is left open.

For example, the LED current is set to 20mA if $V_{BRT} \geq 1.2V$ (or left open) and R1 = 20Ω.

### Capacitor Selection

A 4.7μF to 10μF ceramic input capacitor (C1) and a 0.47μF to 1μF ceramic output capacitor (C2) are recommended for most applications. A capacitor (C3, typically 1nF to 10nF) in parallel with the LED string improves stability, input ripple and output ripple, especially when large inductance values (10μH or above) are used. For the best stability over a wide temperature range, use capacitors with a X5R or X7R dielectric.

### Inductor Selection

The MP1528 has a 950mA inductor current limit and can drive up to 9 LEDs at 20mA. Inductance values (for L1) from 4.7μH to 22μH will work as well. 6.2μH or 6.8μH is a good choice for high efficiency and small size. To prevent saturation, use an inductor with a saturation current rating that is higher than the device current limit.

### Diode Selection

The MP1528's high switching frequency demands a high speed rectifier (D1) for optimum efficiency. A Schottky diode is recommended due to its fast recovery time and low forward voltage drop. Ensure the diode's average and peak current ratings exceed the average output current and peak inductor current. In addition, the diode's reverse breakdown voltage must exceed the output voltage.

### Layout

Careful PC board layout is required due to fast switching. All components must be placed as close to the IC as possible. Keep the path between the inductor L1, diode D1, and output capacitor C2 extremely short for minimal noise and ringing. The feedback components such as the sense resistor R1 must be kept close to the FB pin to prevent noise injection on the FB pin trace. The ground return of C1 and C2 should be tied close to the GND pin. See the MP1528 demo board layout for reference.


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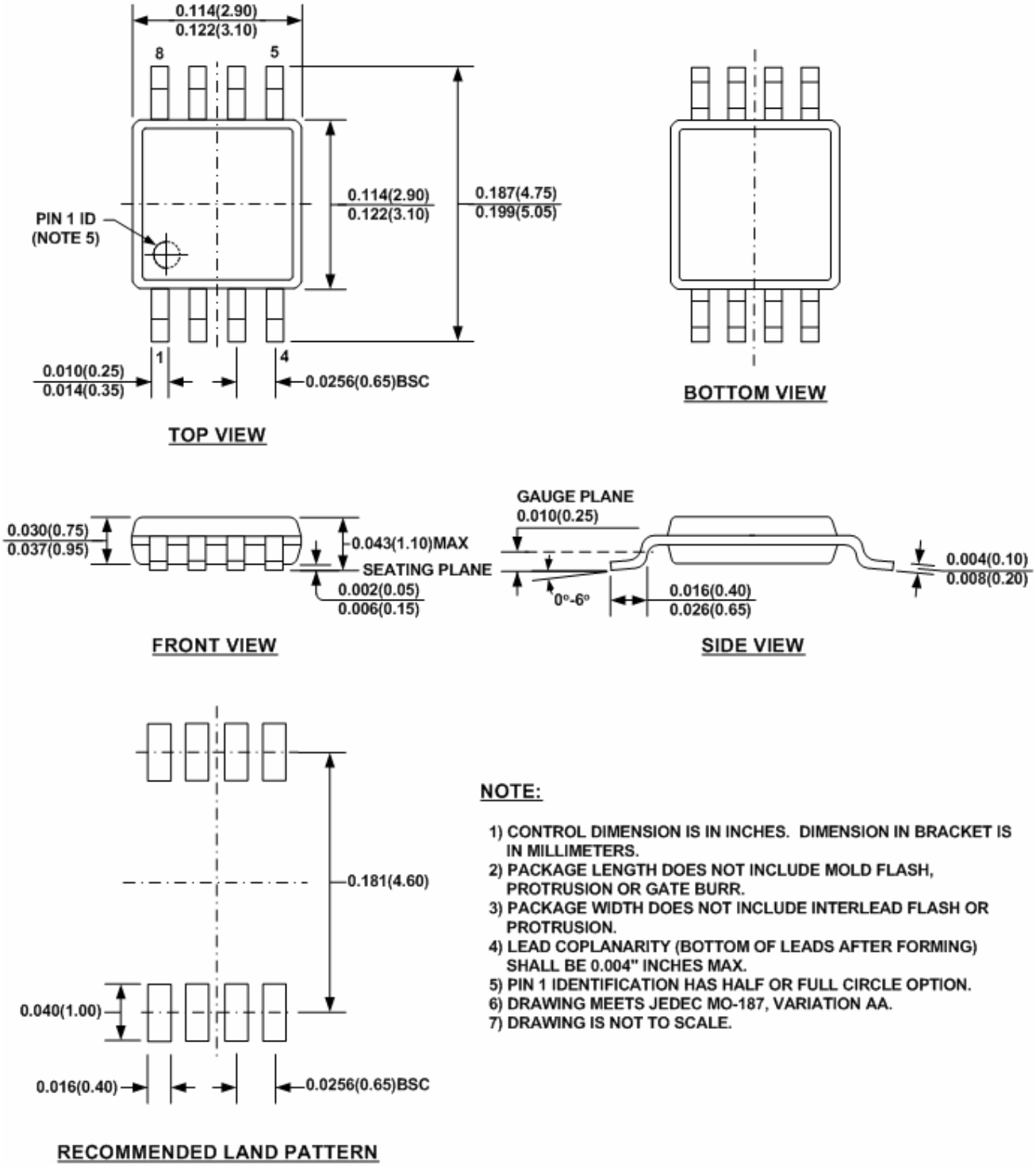
## PACKAGE INFORMATION

### MSOP8




**NOTE:**

1) CONTROL DIMENSION IS IN INCHES. DIMENSION IN BRACKET IS IN MILLIMETERS.
2) PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSION OR GATE BURR.
3) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION.
4) LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.004" INCHES MAX.
5) PIN 1 IDENTIFICATION HAS HALF OR FULL CIRCLE OPTION.
6) DRAWING MEETS JEDEC MO-187, VARIATION AA.
7) DRAWING IS NOT TO SCALE.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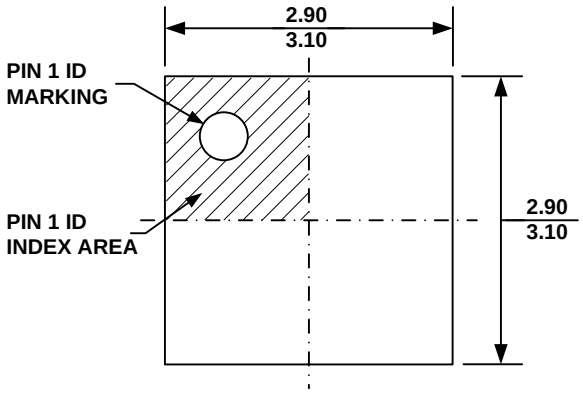
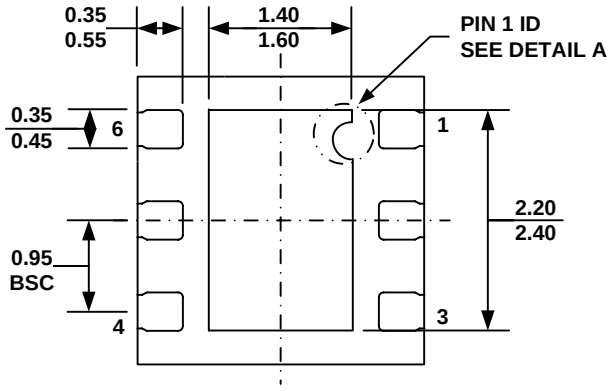
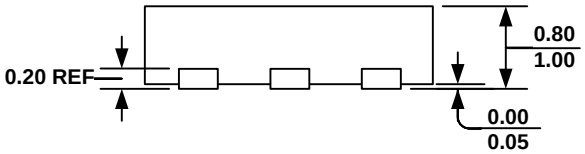
## QFN6 (3mm x 3mm)



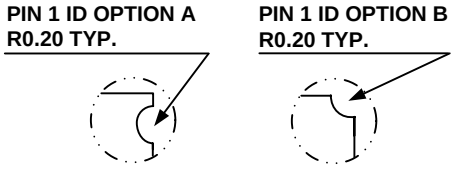

**TOP VIEW**



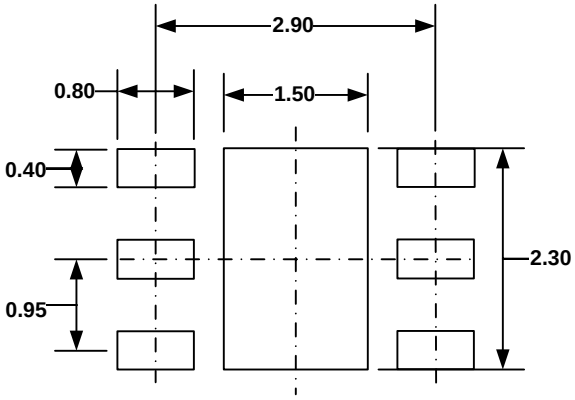

**BOTTOM VIEW**




**SIDE VIEW**




**DETAIL A**




**RECOMMENDED LAND PATTERN**

**NOTE:**

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

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