



The Future of Analog IC Technology®

# MP8110 Precision High-Side Current-Sense Amplifier

## DESCRIPTION

The MP8110 is a low-cost, precision, high-side current-sense amplifier. This device operates from a single 2.5V to 40V supply and typically consumes 12µA. It is ideal for today's notebook computers, cell phones and other systems where battery/DC current monitoring is critical.

High-side current monitoring is especially useful in battery-powered systems since it does not interfere with the ground path of the battery charger. The input common-mode range of 1.4V to 40V is independent of the supply voltage and ensures that the current-sense feedback remains viable even when connected to a 2-cell battery pack in deep discharge.

This device is available in 8-pin SOIC and MSOP packages.

## FEATURES

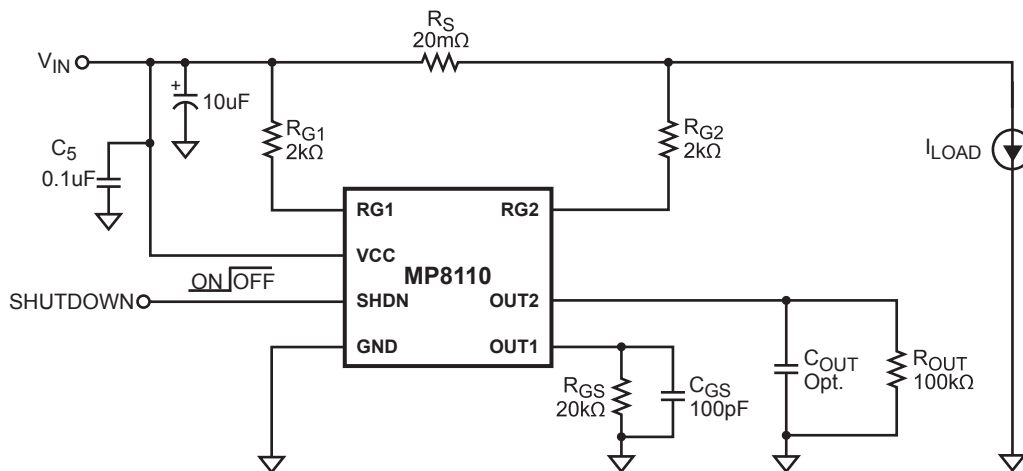
- Low-Cost, Compact Current-Sense Solution
- 12µA Typical Supply Current
- 2.5V to 40V Operating Supply Voltage
- 1.4V to 40V Input Common Mode Range
- 3µA Typical Shutdown Current
- 400µV Input Offset Voltage
- High Current Sensing Capability
- Integrated Buffer Amplifier
- Available in 8-Pin SOIC and MSOP packages,

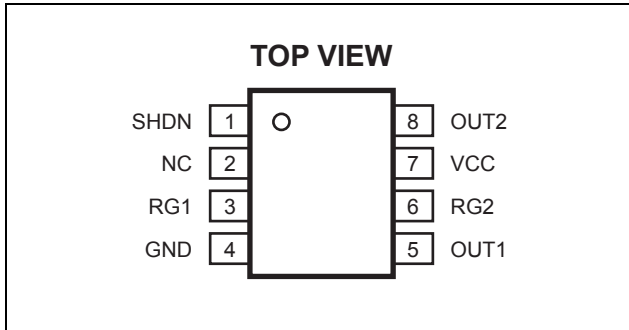
## APPLICATIONS

- Portable PCs
- PDA's
- Smart Battery Packs
- Cell Phones
- Portable Test/Measurement Systems
- Battery-Operated Systems
- Energy Management Systems

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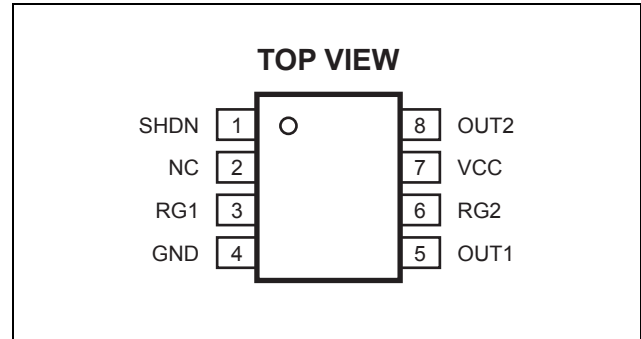
## TYPICAL APPLICATION



**PACKAGE REFERENCE**


Part Number*	Package	Temperature
MP8110DS	SOIC8	-40°C to +85°C

\* For Tape & Reel, add suffix -Z (eg. MP8110DS-Z)  
 For RoHS Compliant Packaging, add suffix -LF  
 (eg. MP8110DS-LF-Z)



Part Number*	Package	Temperature
MP8110DK	MSOP8	-40°C to +85°C

\* For Tape & Reel, add suffix -Z (eg. MP8110DK-Z)  
 For RoHS Compliant Packaging, add suffix -LF  
 (eg. MP8110DK-LF-Z)

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

V<sub>CC</sub>, RG1, RG2 to GND.....-0.3V to +42V  
 Max Differential Input Voltage, RG1 to RG2..... 5V  
 Max Junction Temperature (T<sub>j</sub>) ..... 150°C  
 Storage Temperature ..... -65°C to +150°C

**Recommended Operating Conditions <sup>(2)</sup>**

V<sub>CC</sub>, RG1, RG2 to GND .....2.5V to 40V  
 Operating Ambient Temperature-40°C to +85°C

**Thermal Resistance <sup>(3)</sup>**

	$\theta_{JA}$	$\theta_{JC}$
SOIC8 .....	90 .....	42... °C/W
MSOP8 .....	150 .....	65... °C/W
Continuous Power Dissipation (T <sub>A</sub> =70°C) .....		800mW

**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<sub>CC</sub> = 24V, V<sub>SHDN</sub> = 0V, T<sub>A</sub> = +25°C, unless otherwise noted.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply Voltage	V <sub>CC</sub>		2.5		40	V
Supply Current	I <sub>CC</sub>	I <sub>LOAD</sub> = 0A, V <sub>CC</sub> = 40V		12	30	μA
Common Mode Input Voltage	V <sub>IN,CM</sub>	V <sub>CC</sub> > V <sub>IN</sub> Low		1.4		V
		V <sub>CC</sub> > V <sub>IN</sub> High		40		
OUT1 Input Offset Voltage	V <sub>OS1</sub>			0.4	2	mV
OUT2 Input Offset Voltage	V <sub>OS2</sub>			1	5	mV
Input Bias Current <sup>(4)</sup>	I <sub>RG1</sub> , I <sub>RG2</sub>			4	20	nA
OUT1 Current Accuracy	I <sub>RG1</sub> /I <sub>GS</sub>	V <sub>SENSE</sub> = 100mV		±2	±5	%
No-Load OUT1 Error		V <sub>SENSE</sub> = 0V		0.1	1	μA
Low-Level OUT1 Error		V <sub>SENSE</sub> = 5mV		0.3	2	μA
No-Load OUT2 Error		V <sub>SENSE</sub> = 0V		0.01	1	μA
Low-Level OUT2 Error		V <sub>SENSE</sub> = 5mV		0.05	2	μA
Power Supply Rejection Ratio	PSRR	2.5V < V <sub>CC</sub> < 40V, V <sub>SENSE</sub> = 100mV	70	97		dB
Shutdown Supply Current	I <sub>CC(SHDN)</sub>	V <sub>SHDN</sub> = 3V		3	6	μA

**ELECTRICAL CHARACTERISTICS (continued)**
 $V_{CC} = 24V$ ,  $V_{SHDN} = 0V$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
SHDN Threshold Voltage	$V_{TH\_SHUTDOWN}$	(Low - High)	0.7	0.9	1.2	V
SHDN Hysteresis				30		mV
OUT1 Rise, Fall Time <sup>(4)</sup>	$t_R$	$V_{SENSE} = 40mV$ , $R_{GS} = 20k\Omega$ , $R_{OUT} = 100k\Omega$ ,		17		$\mu s$
	$t_F$	$R_{G1} = R_{G2} = 2k\Omega$ , $C_{GS} = 100pF$ , $C_{OUT} = 100pF$ , 10% to 90%		29		
OUT2 Rise, Fall Time <sup>(4)</sup>	$t_R$	$V_{SENSE} = 40mV$ , $R_{GS} = 20k\Omega$ , $R_{OUT} = 100k\Omega$ ,		18		$\mu s$
	$t_F$	$R_{G1} = R_{G2} = 2k\Omega$ , $C_{GS} = 100pF$ , $C_{OUT} = 100pF$ , 10% to 90%		26		
OUT1 Output Voltage Range	$V_{GS}$			$V_{CC} - 0.15$	24	V
OUT2 Output Voltage Range	$V_{OUT}$			$V_{CC} - 1$	24	V
Maximum OUT1 Current <sup>(4)</sup>	$I_{GS}$			500		$\mu A$
Maximum OUT2 Current <sup>(4)</sup>	$I_{OUT2}$			5		mA

**Notes:**

4) Guaranteed by design.

5) Input common mode range cannot exceed the supply voltage.

**PIN FUNCTIONS**

SOIC8	Name	Description
1	SHDN	Shutdown. Connect to ground for normal operation. When high, supply current is less than 3 $\mu A$ .
2	NC	Not Connected.
3	RG1	Gain Resistor. Connect to battery side of current-sense resistor through the gain resistor.
4	GND	Ground or Battery Negative Terminal.
5	OUT1	Output for Driving Resistor Load.
6	RG2	Gain Resistor. Connect to load side of current-sense resistor through the gain resistor.
7	VCC	Power Input. Connect to Battery Input.
8	OUT2	Output For Driving Capacitive Loads.

## OPERATION

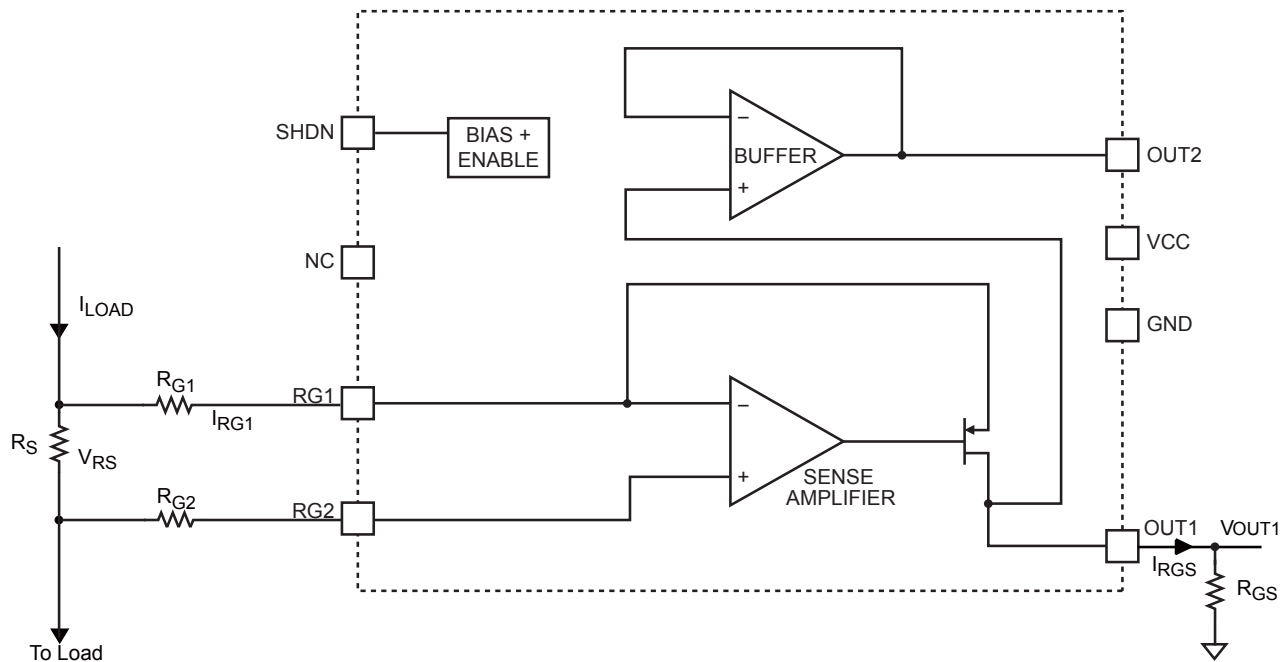
The MP8110 is a current-sense amplifier with a wide operating input voltage range of 2.5V to 40V. It has 1.4V to 40V Common-Mode range.

This feature allows the monitoring of current flow out of a battery in deep discharge, and also enables high-side current sensing up to the supply voltage,  $V_{CC}$ . Current flows through the sense resistor,  $R_S$ , which generates a sense voltage  $V_{RS}$ . The high precision sense amplifier built into the MP8110 monitors the differential voltage across  $R_S$  and dynamically adjusts the gate voltage of the internal P-channel MOSFET to maintain an equal passing current as  $I_{RG1}$ . The current amplifier gain is therefore set as:  $R_{GS} / R_{G1}$ .

### Choosing Sensing Resistor

Given the gain and maximum load current, select  $R_S$  such that  $V_{RS}$  does not exceed +0.25V and  $V_{OUT1}$  does not exceed 5V. To measure lower currents more accurately, use a high value for  $R_S$ . A higher value develops a higher sense voltage, which overcomes offset voltage errors of the internal current amplifier.

In applications of monitoring very high current, ensure  $R_S$  is able to dissipate its own  $I^2R$  losses. If the resistor rating power is exceeded, its value may drift or it may fail altogether, causing a differential voltage across the terminals in excess of the absolute maximum range (0.25V).


**Figure 1—Functional Block Diagram**

## APPLICATION INFORMATION

### COMPONENT SELECTION

**Table 1—Suggested Component Values** (refer to Typical Circuit on page 1)

Full-Scale Load Current, $I_{SENSE}$ (A)	Current Sense Resistor (m $\Omega$ )	Gain Setting Resistor (k $\Omega$ ) ( $R_{G1} = R_{G2}$ )	$R_{GS}$ (k $\Omega$ )	Gain
0.1	500	2	20	10
1	50	2	20	10
5	10	2	20	10
10	5	2	20	10

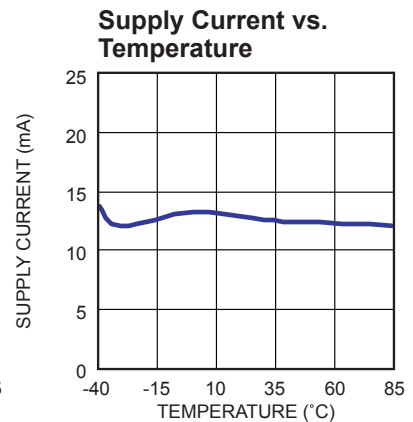
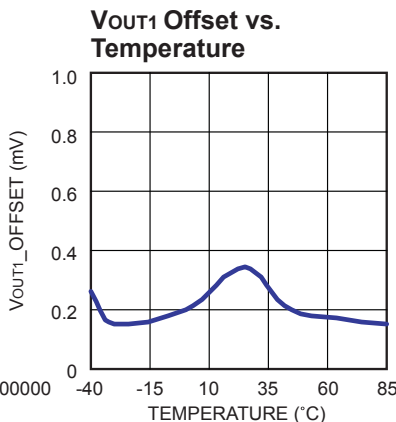
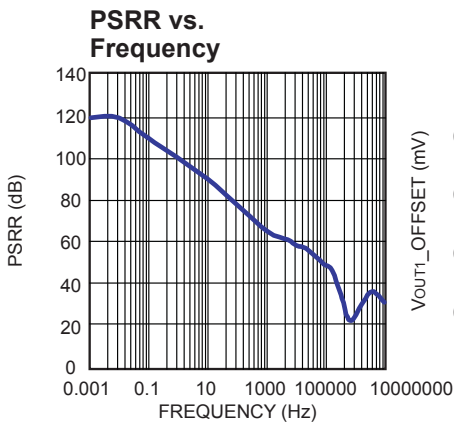
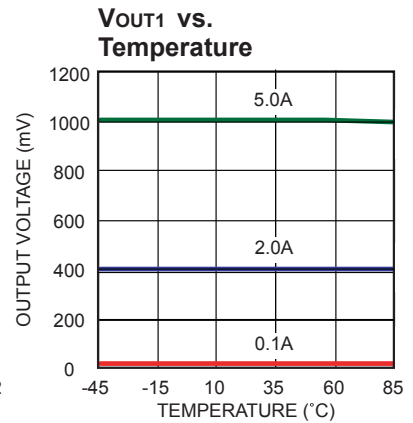
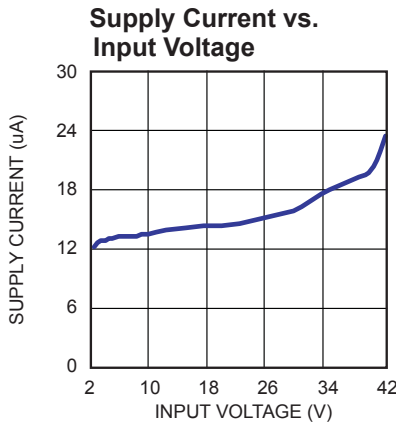
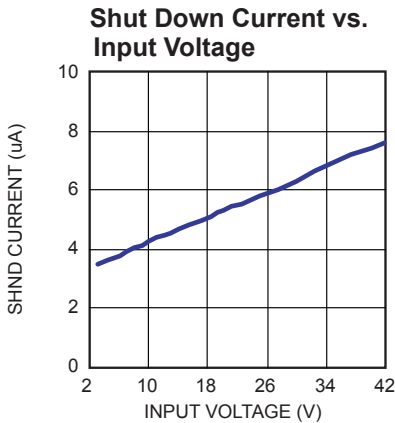
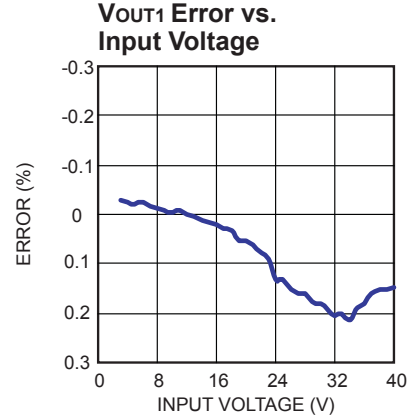
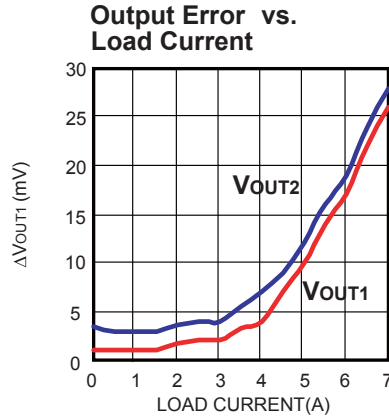
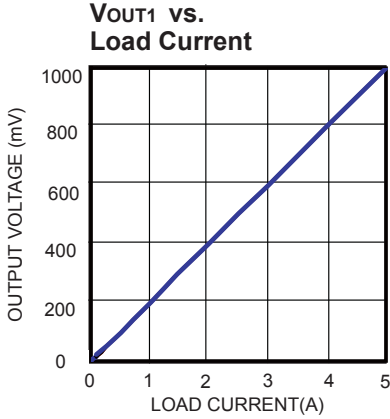
The value of  $V_{OUT1}$  can be obtained with the equation:

$$V_{OUT1} = \frac{I_{LOAD} \times R_S \times R_{GS}}{R_{G1}} = I_{LOAD} \times R_S \times \text{Gain}$$

Where  $R_{G1}$  is the sense resistor and  $I_{LOAD}$  is the load current.

## TYPICAL PERFORMANCE CHARACTERISTICS

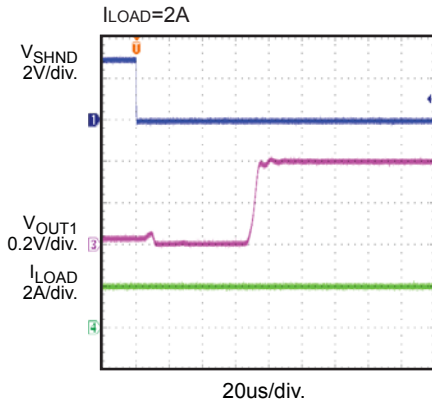
$V_{IN}=24V$ ,  $R_{G1}=R_{G2}=2K\Omega$ ,  $R_{G3}=20K\Omega$ ,  $R_S=20m\Omega$ ,  $C_{GS}=100pF$ ,  $C_5=0.1\mu F$ ,  $T_A=+25^\circ C$ , unless otherwise noted.



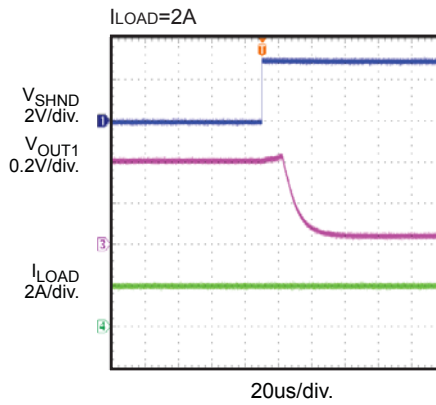
**TYPICAL PERFORMANCE CHARACTERISTICS** (continued)

$V_{IN}=24V$ ,  $R_{G1}=R_{G2}=2K\Omega$ ,  $R_{G3}=20K\Omega$ ,  $R_S=20m\Omega$ ,  $C_{GS}=100pF$ ,  $C_5=0.1\mu F$ ,  $T_A=+25^\circ C$ , unless otherwise noted.

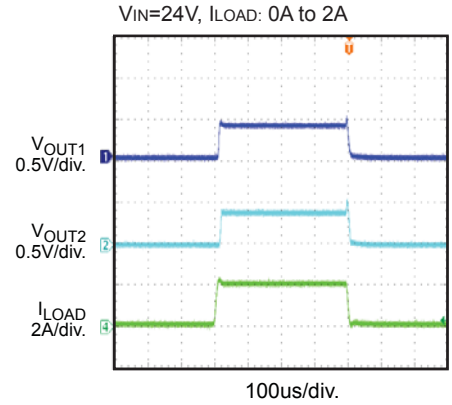
**SHND High to Low**



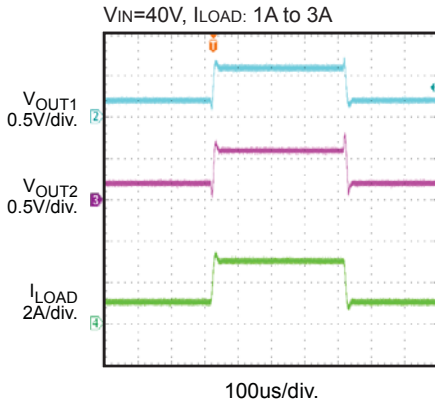
**SHDN Low to High**



**Transient Response**



**Transient Response**



TYPICAL APPLICATION

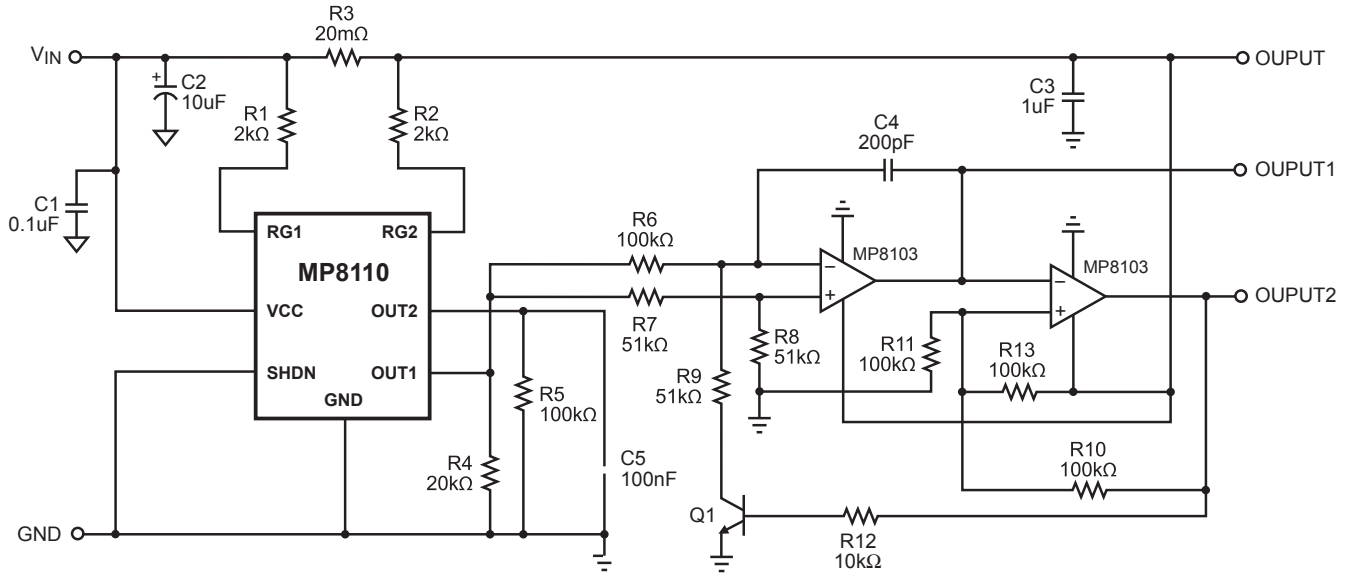
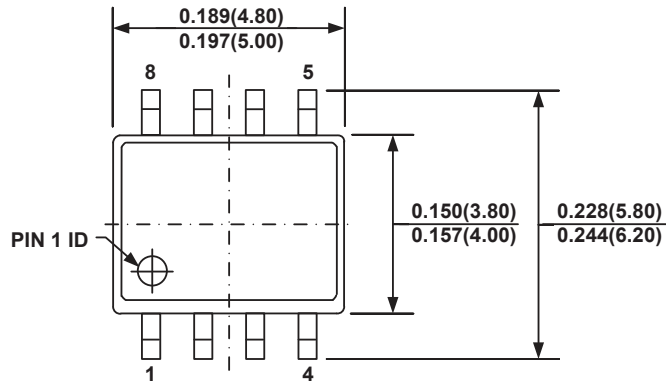
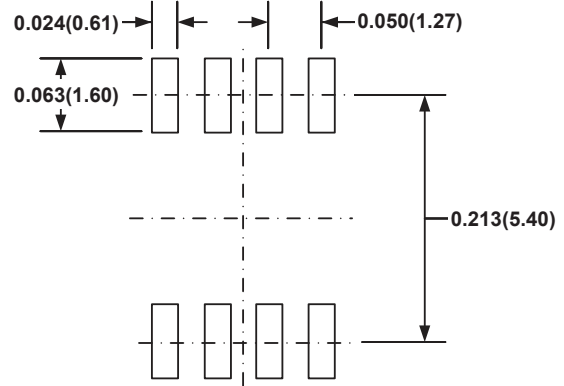
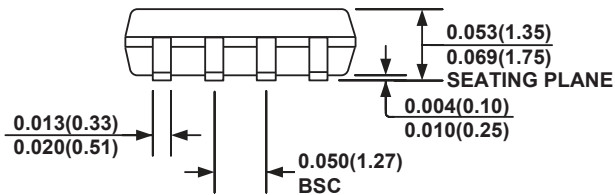
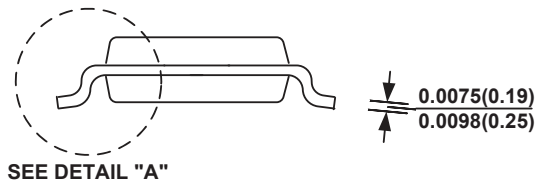
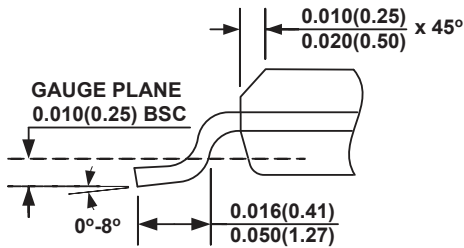


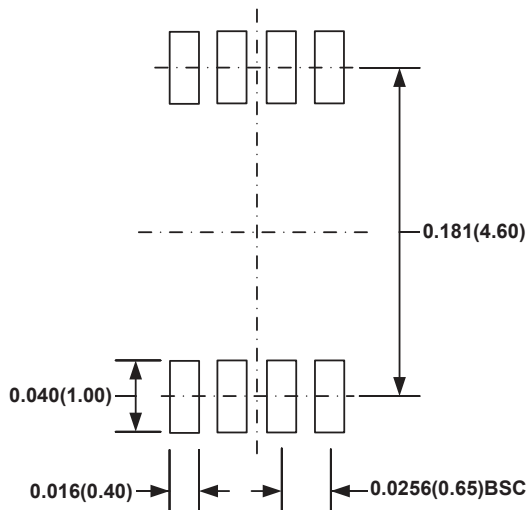
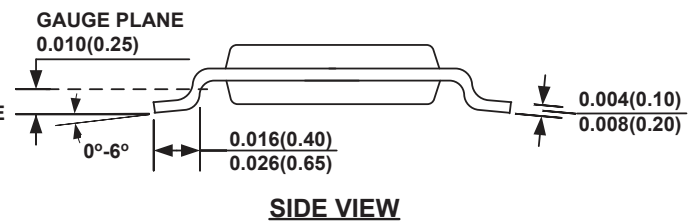
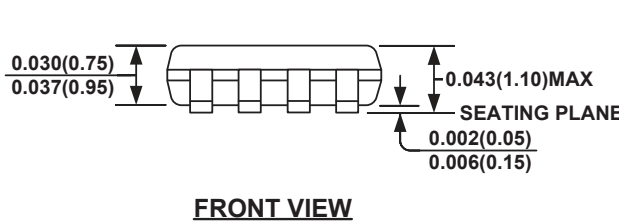
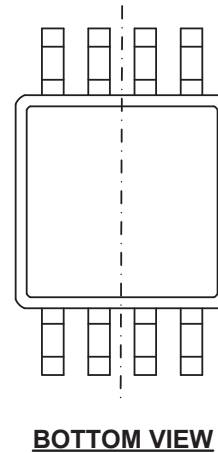
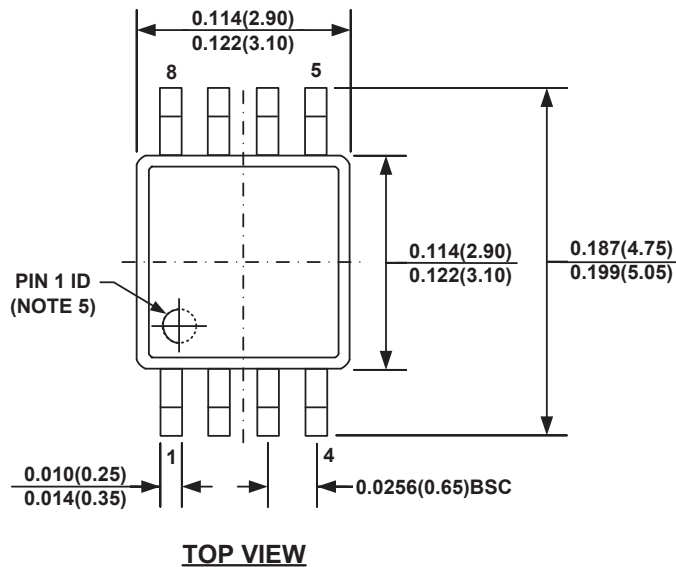
Figure 2—Current Control Oscillator



**PACKAGE INFORMATION**
**SOIC8**

**TOP VIEW**

**RECOMMENDED LAND PATTERN**

**FRONT VIEW**

**SIDE VIEW**

**DETAIL "A"**
**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 AA.
- 6) DRAWING IS NOT TO SCALE.

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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