

#### 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  $12\mu A$ . 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**

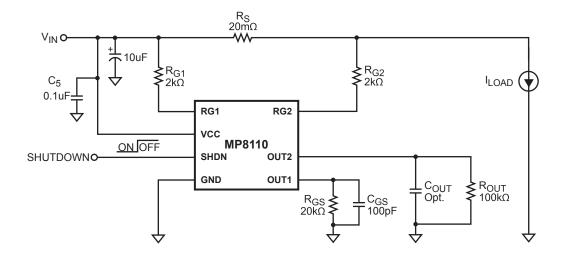
- Low-Cost, Compact Current-Sense Solution
- 12µA Typical Supply Current
- 2.5V to 40V Operating Supply Voltage
- 1.4V to 40V Input Common Mode Range
- 3µA Typical Shutdown Current
- 400µV Input Offset Voltage
- High Current Sensing Capability
- Integrated Buffer Amplifier
- Available in 8-Pin SOIC and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

#### **APPLICATIONS**

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

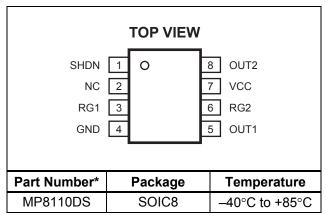
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#### TYPICAL APPLICATION





## **PACKAGE REFERENCE**



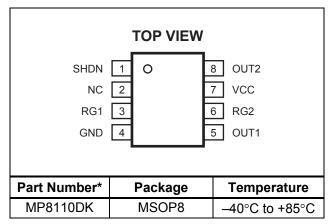
For Tape & Reel, add suffix –Z (eg. MP8110DS–Z)
 For RoHS Compliant Packaging, add suffix –LF (eg. MP8110DS–LF–Z)

# **ABSOLUTE MAXIMUM RATINGS** (1)

VCC, 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 (2)

V<sub>CC</sub>, RG1, RG2 to GND ......2.5V to 40V Operating Ambient Temperature—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)

| Thermal Resistance <sup>(3)</sup> | $oldsymbol{	heta}_{JA}$ | $oldsymbol{	heta}_{JC}$ |
|-----------------------------------|-------------------------|-------------------------|
| SOIC8                             | 90                      | 42 °C/W                 |
| MSOP8                             | 150                     | 65 °C/W                 |
| Continuous Power Dissipation      | on                      |                         |
| (T <sub>A</sub> =70°C)            |                         | 800mW                   |

#### Notes:

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

#### **ELECTRICAL CHARACTERISTICS**

 $V_{CC}$  = 24V,  $V_{SHDN}$  = 0V,  $T_A$  = +25°C, unless otherwise noted.

| Parameter                    | Symbol                              | Conditions                                 | Min | Тур  | Max | Units |
|------------------------------|-------------------------------------|--|-----|------|-----|-------|
| Supply Voltage               | $V_{CC}$                            |  | 2.5 |      | 40  | V     |
| Supply Current               | I <sub>cc</sub>                     | $I_{LOAD} = 0A$ , $V_{CC} = 40V$           |     | 12   | 30  | μΑ    |
| 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 (4)       | 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   | μΑ    |
| No-Load OUT2 Error           |                                     | V <sub>SENSE</sub> = 0V                    |     | 0.01 | 1   | μΑ    |
| Low-Level OUT2 Error         |                                     | V <sub>SENSE</sub> = 5mV                   |     | 0.05 | 2   | μA    |
| Power Supply Rejection Ratio | PSRR                                | $2.5V < V_{CC} < 40V,$ $V_{SENSE} = 100mV$ | 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°C, unless otherwise noted.

| Parameter                    | Symbol             | Conditions  | Min | Тур                    | 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 (4)     | t <sub>R</sub>     | $V_{SENSE}$ = 40mV,<br>$R_{GS}$ = 20k $\Omega$ ,<br>$R_{OUT}$ = 100k $\Omega$ ,       |     | 17                     |     | μs    |
| OOTT Rise, I all Time        | t <sub>F</sub>     | $R_{G1} = R_{G2} = 2k\Omega,$<br>$C_{GS} = 100pF,$<br>$C_{OUT} = 100pF, 10\% to 90\%$ |     | 29                     |     |       |
| OUT2 Rise, Fall Time (4)     | t <sub>R</sub>     | $V_{SENSE}$ = 40mV,<br>$R_{GS}$ = 20k $\Omega$ ,<br>$R_{OUT}$ = 100k $\Omega$ ,       |     | 18                     |     | μs    |
|                              | t <sub>F</sub>     | $R_{G1} = R_{G2} = 2k\Omega,$<br>$C_{GS} = 100pF,$<br>$C_{OUT} = 100pF, 10\% to 90\%$ |     | 26                     |     |       |
| OUT1 Output Voltage<br>Range | $V_{GS}$           |   |     | V <sub>CC</sub> – 0.15 | 24  | V     |
| OUT2 Output Voltage<br>Range | V <sub>OUT</sub>   |   |     | V <sub>CC</sub> – 1    | 24  | V     |
| Maximum OUT1 Current (4)     | $I_{GS}$           |   |     | 500                    |     | μA    |
| Maximum OUT2 Current (4)     | I <sub>OUT2</sub>  |   |     | 5                      |     | mA    |

#### Notes:

## **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.  |

<sup>4)</sup> Guaranteed by design.

<sup>5)</sup> Input common mode range cannot exceed the supply voltage.



#### **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,  $V_{\rm CC}$ . Current flows through the sense resistor,  $R_{\rm S}$ , which generates a sense voltage  $V_{\rm RS}$ . The high precision sense amplifier built into the MP8110 monitors the differential voltage across  $R_{\rm S}$  and dynamically adjusts the gate voltage of the internal P-channel MOSFET to maintain a equal passing current as  $I_{\rm RG1}$ . The current amplifier gain is therefore set as:  $R_{\rm GS}$  /  $R_{\rm G1}$ .

#### **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 Rs. 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).



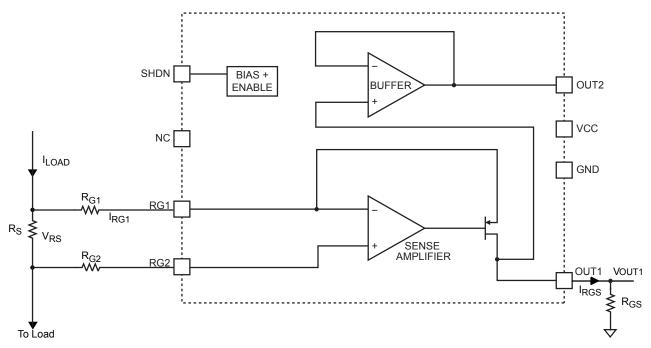


Figure 1—Functional Block Diagram

### **APPLICATION INFORMATION**

### **COMPONENT SELECTION**

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

| Full-Scale Load<br>Current, I <sub>SENSE</sub> (A) | Current Sense<br>Resistor (mΩ) | Gain Setting Resistor $(k\Omega)$ (R <sub>G1</sub> = R <sub>G2</sub> ) | $R_{GS}$ (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:

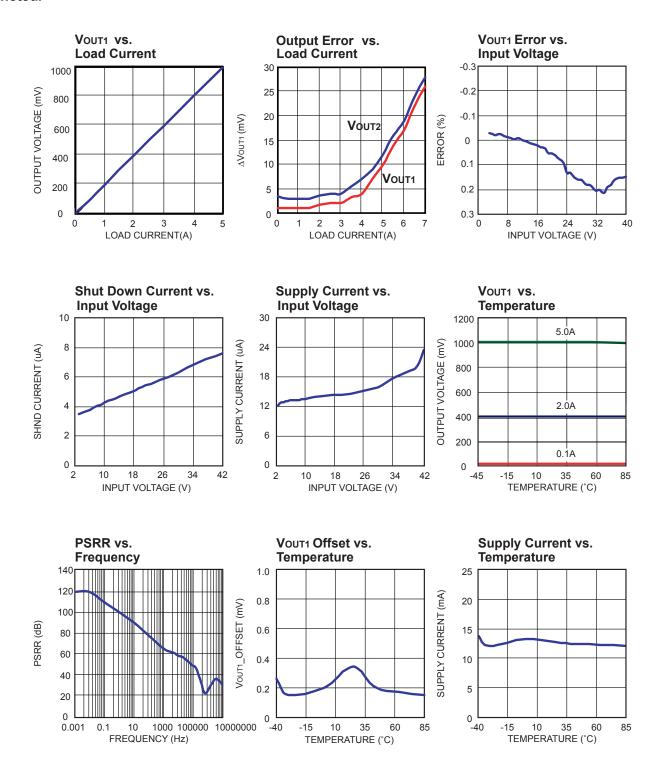
$$V_{OUT_1} = \frac{I_{LOAD} \times R_S \times R_{GS}}{R_{G1}} = I_{LOAD} \times R_S \times Gain$$

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



### TYPICAL PERFORMANCE CHARACTERISTICS

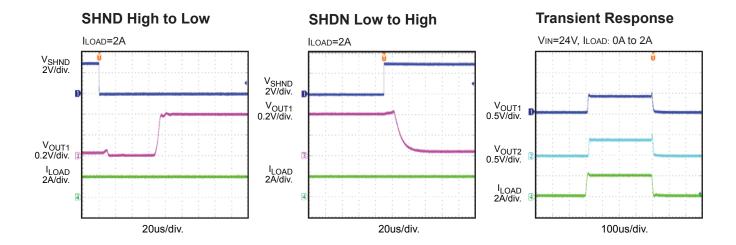
 $V_{\text{IN}}$  =24V,  $R_{\text{G1}}$  = $R_{\text{G2}}$  =2K $\Omega$ ,  $R_{\text{G3}}$  =20K $\Omega$ ,  $R_{\text{S}}$  =20m $\Omega$ ,  $C_{\text{GS}}$  =100pF,  $C_{\text{5}}$  =0.1 $\mu$ F,  $T_{\text{A}}$  = +25°C, unless otherwise noted.



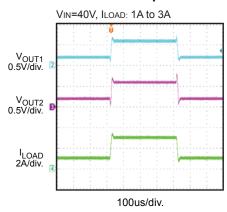


# TYPICAL PERFORMANCE CHARACTERISTICS (continued)

 $V_{\text{IN}}\text{=}24V\text{, }R_{\text{G1}}\text{=}R_{\text{G2}}\text{=}2K\Omega\text{, }R_{\text{G3}}\text{=}20K\Omega\text{, }R_{\text{S}}\text{=}20m\Omega\text{, }C_{\text{GS}}\text{=}100p\text{F, }C_{\text{5}}\text{=}0.1\mu\text{F, }T_{\text{A}}\text{=}+25^{\circ}\text{C, unless otherwise noted.}$ 



#### **Transient Response**





# **TYPICAL APPLICATION**

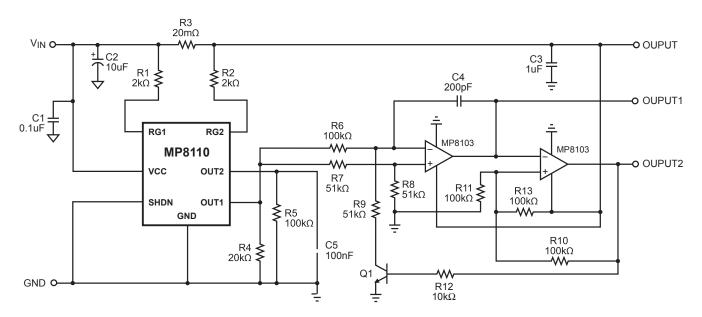
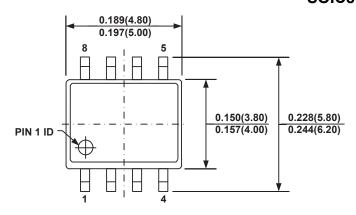


Figure 2—Current Control Oscillator

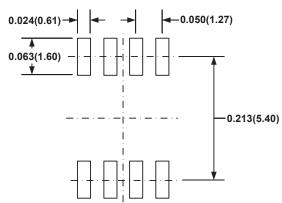


## **PACKAGE INFORMATION**

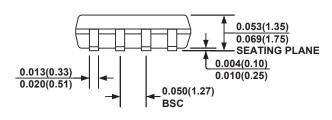
#### SOIC8



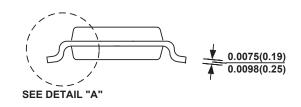
**TOP VIEW** 



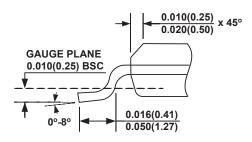
**RECOMMENDED LAND PATTERN** 



**FRONT VIEW** 



**SIDE VIEW** 



**DETAIL "A"** 

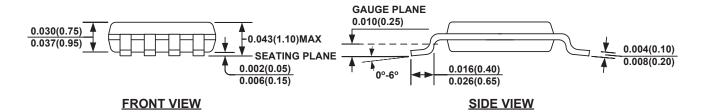
#### **NOTE:**

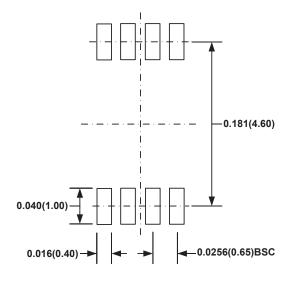
- 1) CONTROL DIMENSION IS IN INCHES. DIMENSION IN BRACKET IS IN MILLIMETERS.
- 2) PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
- 3) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
- 4) LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.004" INCHES MAX.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



# MSOP8 0.114(2.90) 0.122(3.10) 8 5 0.114(2.90) 0.122(3.10) 0.122(3.10) 0.199(5.05) 0.010(0.25) 0.014(0.35) 0.014(0.35) 0.015(0.65)BSC







#### **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.

#### **RECOMMENDED LAND PATTERN**

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