



# MAX4073T/F/H

## Low-Cost, SC70, Voltage-Output, High-Side Current-Sense Amplifier

### ABSOLUTE MAXIMUM RATINGS

V<sub>CC</sub> to GND .....-0.3V to +30V  
RS+, RS- to GND .....-0.3V to +30V  
OUT to GND .....-0.3V to (V<sub>CC</sub> + 0.3V)  
Output Short-Circuit to GND .....Continuous  
Differential Input Voltage (V<sub>RS+</sub> - V<sub>RS-</sub>) .....±5V  
Current Into Any Pin.....±20mA  
Continuous Power Dissipation (T<sub>A</sub> = +70°C)  
5-Pin SC70 (derate 2.27mW/°C above +70°C).....200mW  
6-Pin SOT23 (derate 8.7mW/°C above +70°C).....696mW

Operating Temperature Range .....-40°C to +125°C  
Junction Temperature.....+150°C  
Storage Temperature Range.....-65°C to +150°C  
Lead Temperature (soldering, 10s).....+300°C  
Soldering Temperature .....+260°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

### ELECTRICAL CHARACTERISTICS

(V<sub>RS+</sub> = +2V to +28V, V<sub>SENSE</sub> = (V<sub>RS+</sub> - V<sub>RS-</sub>) = 0, V<sub>CC</sub> = +3V to +28V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 1)

| PARAMETER                         | SYMBOL                               | CONDITIONS                                                                                                                       |                                  | MIN  | TYP  | MAX | UNITS |
|-----------------------------------|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|----------------------------------|------|------|-----|-------|
| Operating Voltage Range           | V <sub>CC</sub>                      | (Note 2)                                                                                                                         |                                  | 3    |      | 28  | V     |
| Common-Mode Input Range           | V <sub>CMR</sub>                     | (Note 3)                                                                                                                         |                                  | 2    |      | 28  | V     |
| Common-Mode Rejection             | CMR                                  | V <sub>SENSE</sub> = 100mV, V <sub>CC</sub> = 12V                                                                                |                                  |      | 90   |     | dB    |
| Supply Current                    | I <sub>CC</sub>                      | V <sub>CC</sub> = 28V                                                                                                            |                                  |      | 0.5  | 1.2 | mA    |
| Leakage Current                   | I <sub>RS+</sub> /I <sub>RS-</sub>   | V <sub>CC</sub> = 0V, V <sub>RS+</sub> = 28V                                                                                     |                                  |      | 0.05 | 1   | μA    |
| Input Bias Current                | I <sub>RS+</sub>                     |                                                                                                                                  |                                  |      | 20   | 60  | μA    |
|                                   | I <sub>RS-</sub>                     |                                                                                                                                  |                                  |      | 40   | 120 |       |
| Full-Scale Sense Voltage          | V <sub>SENSE</sub>                   | V <sub>SENSE</sub> = (V <sub>RS+</sub> - V <sub>RS-</sub> )                                                                      |                                  |      | 150  |     | mV    |
| Total OUT Voltage Error (Note 4)  |                                      | V <sub>SENSE</sub> = 100mV, V <sub>CC</sub> = 12V, V <sub>RS+</sub> = 2V                                                         |                                  | ±1.0 |      |     | %     |
|                                   |                                      | V <sub>SENSE</sub> = 100mV, V <sub>CC</sub> = 12V, V <sub>RS+</sub> = 12V, T <sub>A</sub> = +25°C                                |                                  | ±1.0 | ±5.0 |     |       |
|                                   |                                      | V <sub>SENSE</sub> = 100mV, V <sub>CC</sub> = 12V, V <sub>RS+</sub> = 12V, T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |                                  |      | ±7.0 |     |       |
|                                   |                                      | V <sub>SENSE</sub> = 100mV, V <sub>CC</sub> = 28V, V <sub>RS+</sub> = 28V, T <sub>A</sub> = +25°C                                |                                  | ±1.0 | ±5.0 |     |       |
|                                   |                                      | V <sub>SENSE</sub> = 100mV, V <sub>CC</sub> = 28V, V <sub>RS+</sub> = 28V, T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |                                  |      | ±8.5 |     |       |
|                                   |                                      | V <sub>SENSE</sub> = 6.25mV (Note 5); V <sub>CC</sub> = 12V, V <sub>RS+</sub> = 12V                                              |                                  | ±7.5 |      |     |       |
| Extrapolated Input Offset Voltage | V <sub>OS</sub>                      | V <sub>CC</sub> = V <sub>RS+</sub> = 12V, V <sub>SENSE</sub> > 10mV                                                              |                                  |      | 1.0  |     | mV    |
| OUT High Voltage                  | (V <sub>CC</sub> - V <sub>OH</sub> ) | V <sub>SENSE</sub> = 150mV                                                                                                       | MAX4073T, V <sub>CC</sub> = 3V   | 0.8  | 1.2  | V   |       |
|                                   |                                      |                                                                                                                                  | MAX4073F, V <sub>CC</sub> = 7.5V |      |      |     |       |
|                                   |                                      |                                                                                                                                  | MAX4073H, V <sub>CC</sub> = 15V  |      |      |     |       |

# MAX4073T/F/H

## Low-Cost, SC70, Voltage-Output, High-Side Current-Sense Amplifier

### ELECTRICAL CHARACTERISTICS (continued)

( $V_{RS+} = +2V$  to  $+28V$ ,  $V_{SENSE} = (V_{RS+} - V_{RS-}) = 0$ ,  $V_{CC} = +3V$  to  $+28V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $T_A = +25^{\circ}C$ .) (Note 1)

| PARAMETER                              | SYMBOL      | CONDITIONS                                                                                |                                               | MIN | TYP       | MAX       | UNITS     |
|----------------------------------------|-------------|-------------------------------------------------------------------------------------------|-----------------------------------------------|-----|-----------|-----------|-----------|
| Bandwidth                              | BW          | $V_{CC} = 12V$ ,<br>$V_{RS+} = 12V$ ,<br>$C_{LOAD} = 5pF$                                 | MAX4073T,<br>$V_{SENSE} = 100mV$              |     | 1.8       |           | MHz       |
|                                        |             |                                                                                           | MAX4073F,<br>$V_{SENSE} = 100mV$              |     | 1.7       |           |           |
|                                        |             |                                                                                           | MAX4073H,<br>$V_{SENSE} = 100mV$              |     | 1.6       |           |           |
|                                        |             |                                                                                           | MAX4073T/F/H<br>$V_{SENSE} = 6.25mV$ (Note 5) |     | 600       |           | kHz       |
| Gain                                   | AV          | MAX4073T                                                                                  |                                               |     | 20        |           | V/V       |
|                                        |             | MAX4073F                                                                                  |                                               |     | 50        |           |           |
|                                        |             | MAX4073H                                                                                  |                                               |     | 100       |           |           |
| Gain Accuracy                          | $\Delta AV$ | $V_{CC} = 12V$ ,<br>$V_{RS+} = 12V$ ,<br>$V_{SENSE} = 10mV$<br>to $150mV$ ,<br>MAX4073T/F | $T_A = +25^{\circ}C$                          |     | $\pm 1.0$ | $\pm 4.5$ | %         |
|                                        |             |                                                                                           | $T_A = T_{MIN}$ to $T_{MAX}$                  |     |           | $\pm 6.5$ |           |
|                                        |             | $V_{CC} = 12V$ ,<br>$V_{RS+} = 12V$ ,<br>$V_{SENSE} = 10mV$<br>to $100mV$ ,<br>MAX4073H   | $T_A = +25^{\circ}C$                          |     | $\pm 1.0$ | $\pm 4.5$ |           |
|                                        |             |                                                                                           | $T_A = T_{MIN}$ to $T_{MAX}$                  |     |           | $\pm 6.5$ |           |
| OUT Settling Time to 1% of Final Value |             | $V_{CC} = 12V$<br>$V_{RS+} = 12V$<br>$C_{LOAD} = 5pF$                                     | $V_{SENSE} = 6.25mV$ to $100mV$               |     | 400       |           | ns        |
|                                        |             |                                                                                           | $V_{SENSE} = 100mV$ to $6.25mV$               |     | 800       |           |           |
| Output Resistance                      | $R_{OUT}$   |                                                                                           |                                               |     | 12        |           | $k\Omega$ |
| Power-Supply Rejection Ratio           | PSRR        | $V_{CC} = 3V$ to $28V$                                                                    | $V_{SENSE} = 60mV$ , MAX4073T                 | 70  | 78        |           | dB        |
|                                        |             |                                                                                           | $V_{SENSE} = 24mV$ , MAX4073F                 | 70  | 85        |           |           |
|                                        |             |                                                                                           | $V_{SENSE} = 12mV$ , MAX4073H                 | 70  | 90        |           |           |
| Power-Up Time (Note 6)                 |             | $C_{LOAD} = 5pF$ , $V_{SENSE} = 100mV$                                                    |                                               |     | 5         |           | $\mu s$   |
| Saturation Recovery Time (Note 7)      |             | $V_{CC} = 12V$ , $V_{RS+} = 12V$ ,<br>$C_{LOAD} = 5pF$                                    |                                               |     | 5         |           | $\mu s$   |

**Note 1:** All devices are 100% production tested at  $T_A = +25^{\circ}C$ . All temperature limits are guaranteed by design.

**Note 2:** Inferred from PSRR test.

**Note 3:** Inferred from OUT Voltage Error test.

**Note 4:** Total OUT Voltage Error is the sum of the gain and offset errors.

**Note 5:**  $6.25mV = 1/16$  of  $100mV$  full-scale sense voltage.

**Note 6:** Output settles to within 1% of final value.

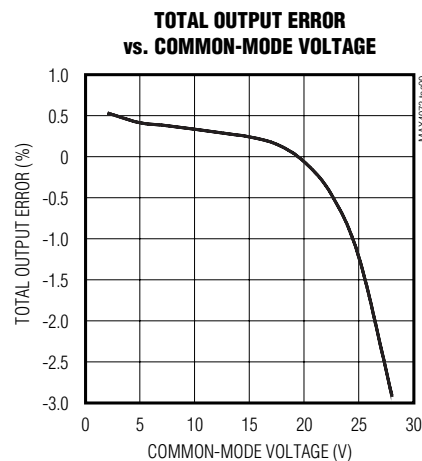
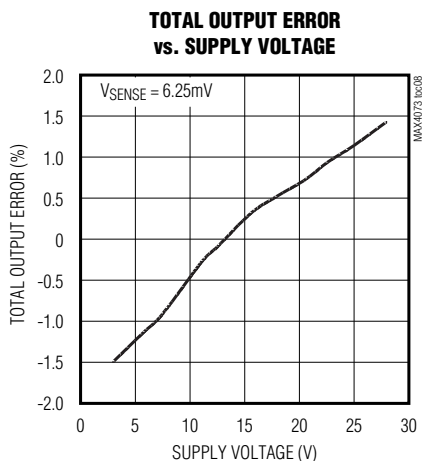
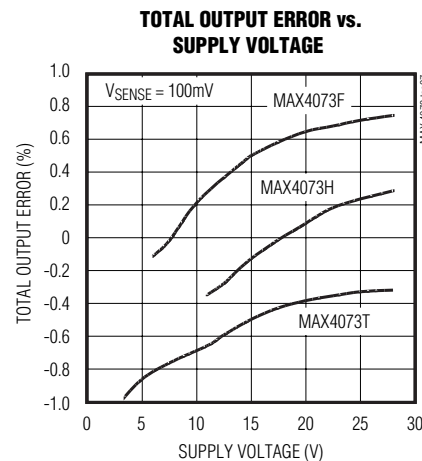
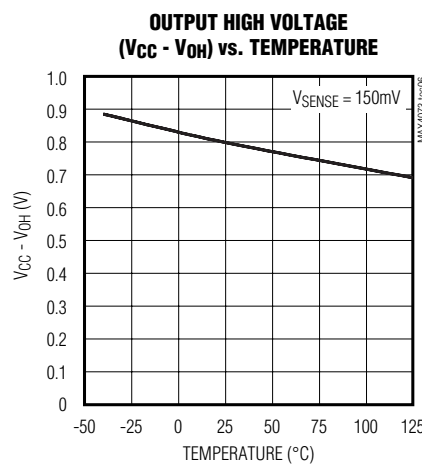
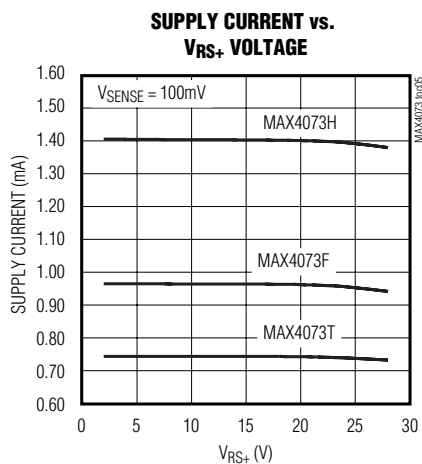
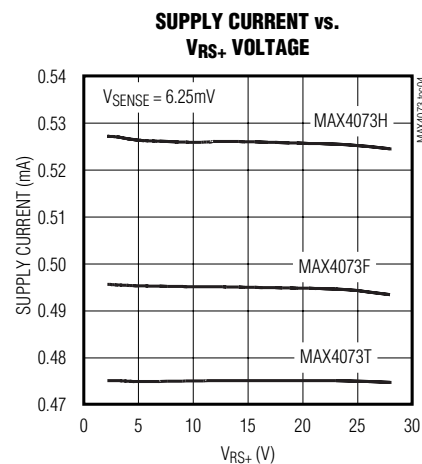
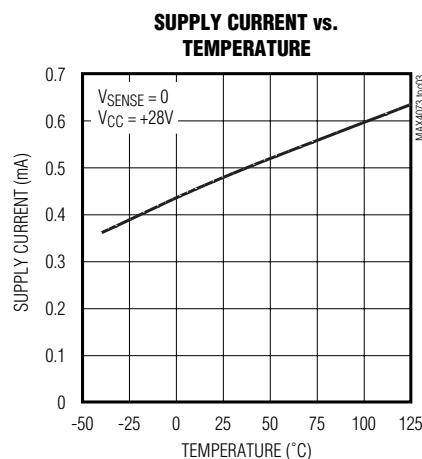
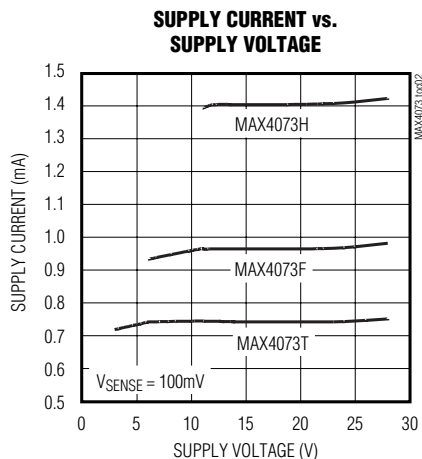
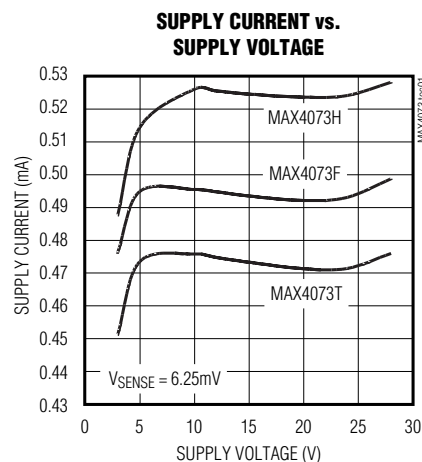
**Note 7:** The device will not experience phase reversal when overdriven.

# MAX4073T/F/H

## Low-Cost, SC70, Voltage-Output, High-Side Current-Sense Amplifier

### Typical Operating Characteristics

( $V_{CC} = +12V$ ,  $V_{RS+} = +12V$ ,  $V_{SENSE} = 100mV$ ,  $C_L = 5pF$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.)

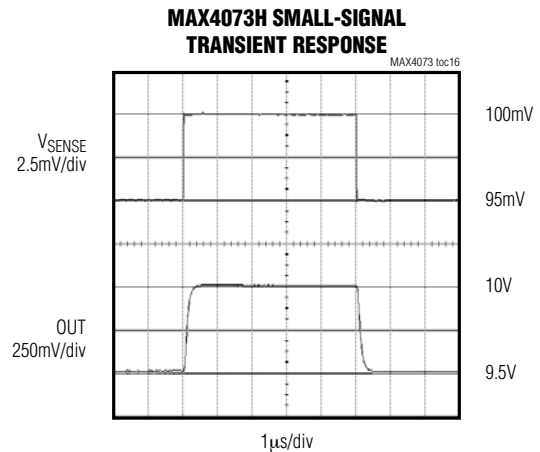
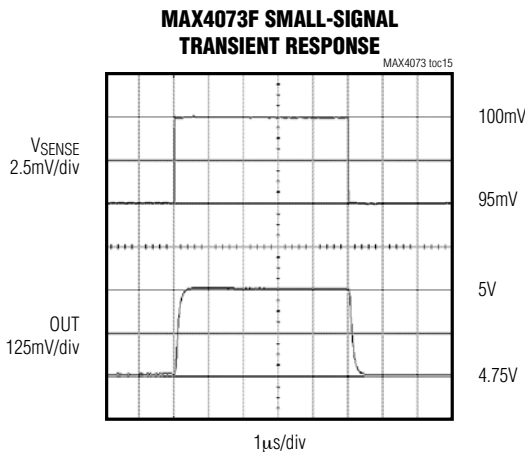
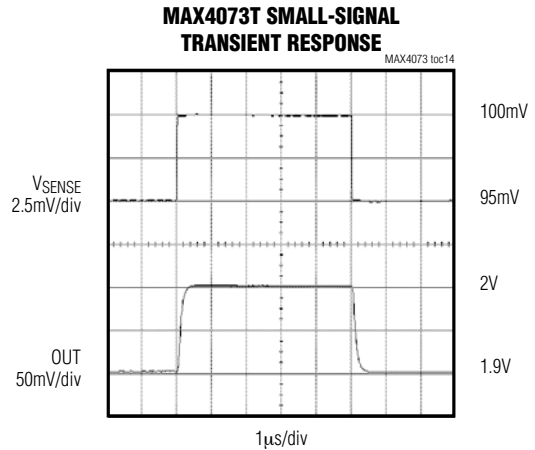
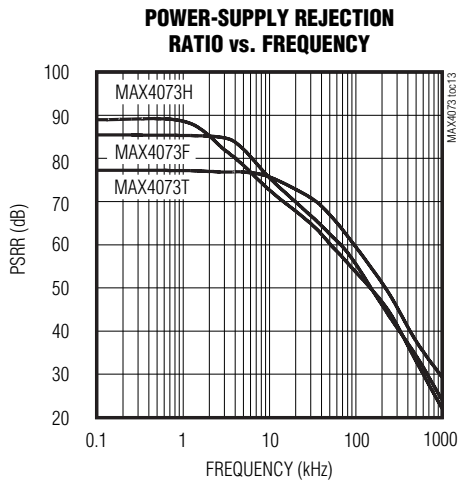
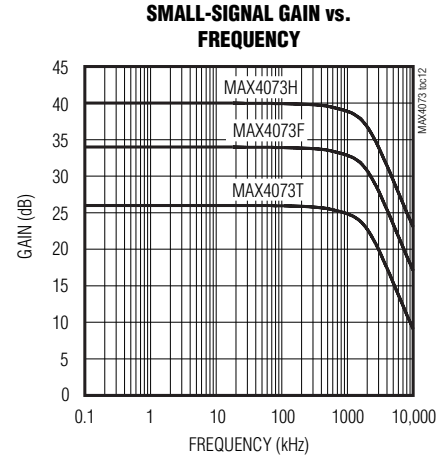
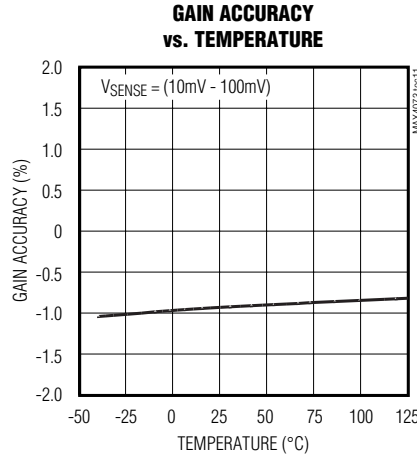
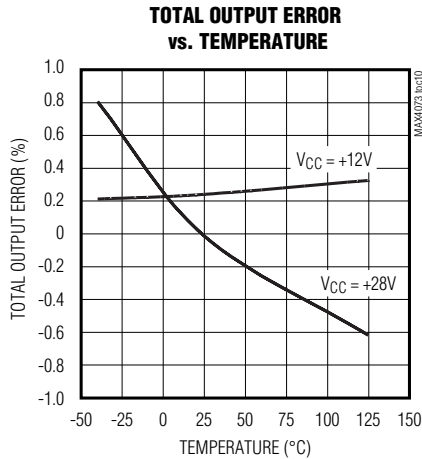


# MAX4073T/F/H

## Low-Cost, SC70, Voltage-Output, High-Side Current-Sense Amplifier

### Typical Operating Characteristics (continued)

( $V_{CC} = +12V$ ,  $V_{RS+} = +12V$ ,  $V_{SENSE} = 100mV$ ,  $C_L = 5pF$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.)



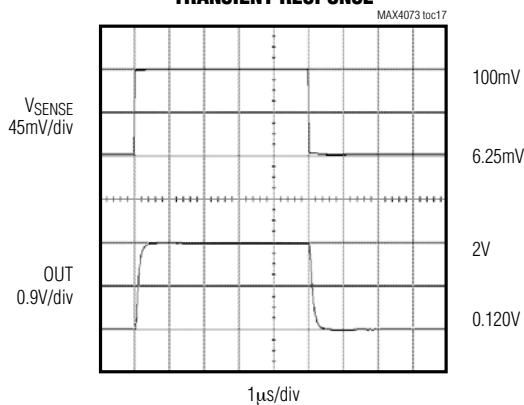
# MAX4073T/F/H

## Low-Cost, SC70, Voltage-Output, High-Side Current-Sense Amplifier

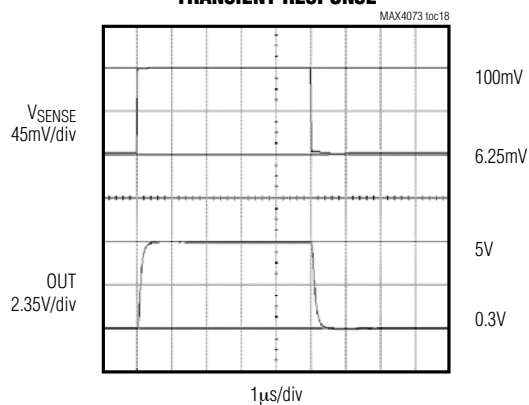
### Typical Operating Characteristics (continued)

( $V_{CC} = +12V$ ,  $V_{RS+} = +12V$ ,  $V_{SENSE} = 100mV$ ,  $C_L = 5pF$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.)

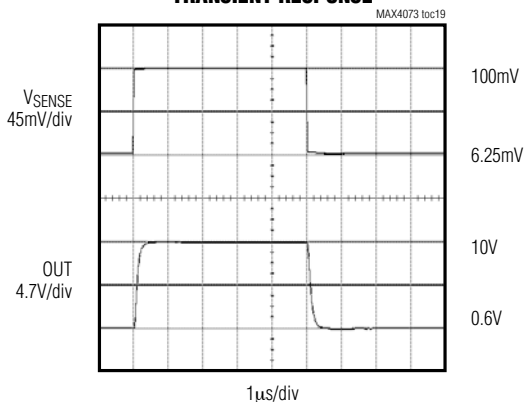
**MAX4073T LARGE-SIGNAL  
TRANSIENT RESPONSE**



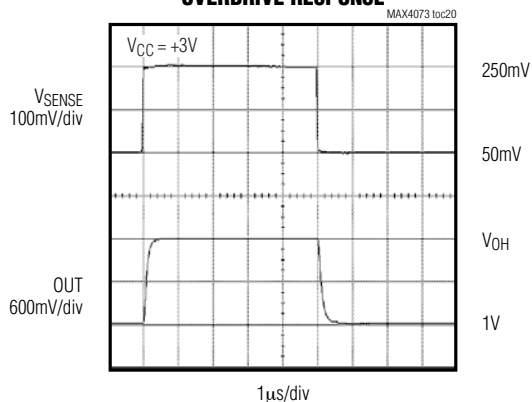
**MAX4073F LARGE-SIGNAL  
TRANSIENT RESPONSE**



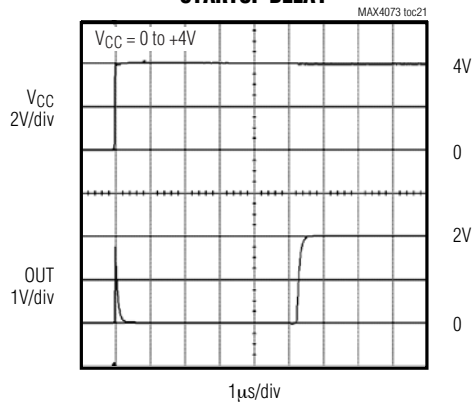
**MAX4073H LARGE-SIGNAL  
TRANSIENT RESPONSE**



**MAX4073T  
OVERDRIVE RESPONSE**



**MAX4073T  
STARTUP DELAY**



# MAX4073T/F/H

## Low-Cost, SC70, Voltage-Output, High-Side Current-Sense Amplifier

### Pin Description

| PIN   |      | NAME | FUNCTION                                                                                                         |
|-------|------|------|------------------------------------------------------------------------------------------------------------------|
| SOT23 | SC70 |      |                                                                                                                  |
| 1, 2  | 2    | GND  | Ground                                                                                                           |
| 3     | 3    | VCC  | Supply Voltage Input. Bypass to GND with a 0.1μF capacitor.                                                      |
| 4     | 4    | RS+  | Power-Side Connection to the External Sense Resistor                                                             |
| 5     | 5    | RS-  | Load-Side Connection to the External Sense Resistor                                                              |
| 6     | 1    | OUT  | Voltage Output. V <sub>OUT</sub> is proportional to V <sub>SENSE</sub> . Output impedance is approximately 12kΩ. |

### Detailed Description

The MAX4073 high-side current-sense amplifier features a +2V to +28V input common-mode range that is independent of supply voltage. This feature allows the monitoring of current out of a battery as low as +2V and also enables high-side current sensing at voltages greater than the supply voltage (V<sub>CC</sub>).

The MAX4073 operates as follows: current from the source flows through R<sub>SENSE</sub> to the load (Figure 1). Since the internal-sense amplifier's inverting input has high impedance, negligible current flows through R<sub>G2</sub> (neglecting the input bias current). Therefore, the sense amplifier's inverting-input voltage equals V<sub>SOURCE</sub> - (I<sub>LOAD</sub>)(R<sub>SENSE</sub>). The amplifier's open-loop gain forces its noninverting input to the same voltage as the inverting input. Therefore, the drop across R<sub>G1</sub> equals (I<sub>LOAD</sub>)(R<sub>SENSE</sub>). Since I<sub>RG1</sub> flows through R<sub>G1</sub>, I<sub>RG1</sub> = (I<sub>LOAD</sub>)(R<sub>SENSE</sub>) / R<sub>G1</sub>. The internal current mirror multiplies I<sub>RG1</sub> by a current gain factor, β, to give I<sub>RGD</sub> = β × I<sub>RG1</sub>. Solving I<sub>RGD</sub> = β × (I<sub>LOAD</sub>)(R<sub>SENSE</sub>) / R<sub>G1</sub>. Assuming infinite output impedance, V<sub>OUT</sub> = (I<sub>RGD</sub>)(R<sub>GD</sub>). Substituting in for I<sub>RGD</sub> and rearranging, V<sub>OUT</sub> = β × (R<sub>GD</sub>/R<sub>G1</sub>)(R<sub>SENSE</sub> × I<sub>LOAD</sub>). The parts gain equals β × R<sub>GD</sub>/R<sub>G1</sub>. Therefore, V<sub>OUT</sub> = (GAIN) (R<sub>SENSE</sub>) (I<sub>LOAD</sub>), where GAIN = 20V/V for MAX4073T, GAIN = 50V/V for MAX4073F, and GAIN = 100V/V for MAX4073H.

Set the full-scale output range by selecting R<sub>SENSE</sub> and the appropriate gain version of the MAX4073.

### Applications Information

#### Recommended Component Values

The MAX4073 senses a wide variety of currents with different sense resistor values. Table 1 lists common resistor values for typical operation of the MAX4073.

#### Choosing R<sub>SENSE</sub>

To measure lower currents more accurately, use a large value for R<sub>SENSE</sub>. The larger value develops a

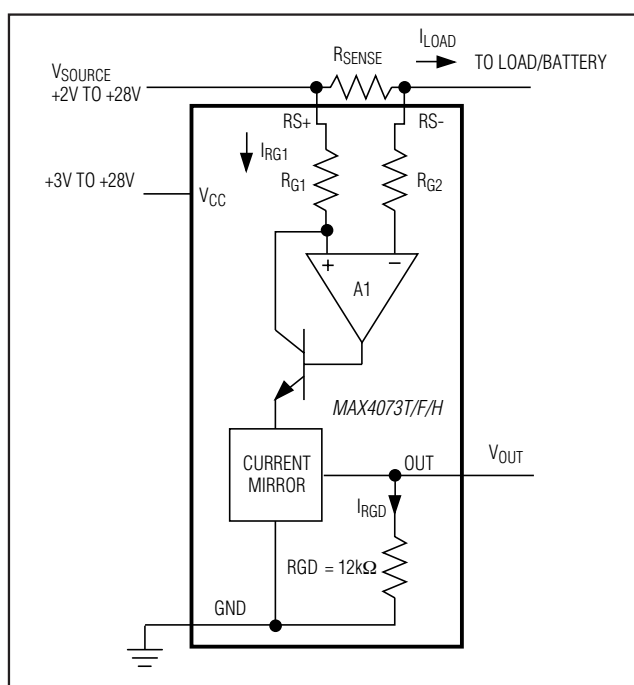


Figure 1. Functional Diagram

higher-sense voltage that reduces offset voltage errors of the internal op amp. Typical sense voltages range between 10mV and 150mV.

In applications monitoring very high currents, R<sub>SENSE</sub> must be able to dissipate the I<sup>2</sup>R losses. If the resistor's rated power dissipation is exceeded, its value may drift or it may fail altogether, causing a differential voltage across the terminals in excess of the absolute maximum ratings (±5V).

If I<sub>SENSE</sub> has a large high-frequency component, minimize the inductance of R<sub>SENSE</sub>. Wire-wound resistors have the highest inductance, metal-film resistors are

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## Low-Cost, SC70, Voltage-Output, High-Side Current-Sense Amplifier

somewhat better, and low-inductance metal-film resistors are best suited for these applications.

For  $V_{SENSE} = 100\text{mV}$ , full-scale output voltage can be 2V, 5V, or 10V depending on the gain. For proper operation, ensure  $V_{CC}$  exceeds the full-scale output voltage by 1.2V (see Output High Voltage ( $V_{CC} - V_{OH}$ ) vs. Temperature in the *Typical Operating Characteristics*).

### Using a PCB Trace as $R_{SENSE}$

If the cost of  $R_{SENSE}$  is an issue and accuracy is not critical, use the alternative solution shown in Figure 2. This solution uses copper PC board traces to create a sense resistor. The resistivity of a 0.1-inch-wide trace of 2-ounce copper is approximately  $30\text{m}\Omega/\text{ft}$ . The resistance-temperature coefficient of copper is fairly high (approximately  $0.4\%/^{\circ}\text{C}$ ), so systems that experience a wide temperature variance must compensate for this effect. In addition, do not exceed the maximum power dissipation of the copper trace.

For example, the MAX4073T (with a maximum load current of 10A and an  $R_{SENSE}$  of  $5\text{m}\Omega$ ) creates a full-scale  $V_{SENSE}$  of 50mV that yields a maximum  $V_{OUT}$  of 1V.  $R_{SENSE}$  in this case requires about 2 inches of 0.1 inch-wide copper trace.

### Output Impedance

The output of the MAX4073 is a current source driving a  $12\text{k}\Omega$  resistance. Resistive loading added to OUT reduces the output gain of the MAX4073. To minimize output errors for most applications, connect OUT to a high-impedance input stage. When output buffering is required, choose an op amp with a common-mode input range and an output voltage swing that includes ground when operating with a single supply. The op amp's supply voltage range should be at least as high as any voltage the system may encounter.

The percent error introduced by output loading is determined with the following formula:

$$\% \text{ERROR} = 100 \left( \frac{R_{LOAD}}{12\text{k}\Omega + R_{LOAD}} - 1 \right)$$

where  $R_{LOAD}$  is the external load applied to OUT.

### Current Source Circuit

Figure 3 shows a block diagram using the MAX4073 with a switching regulator to make a current source.

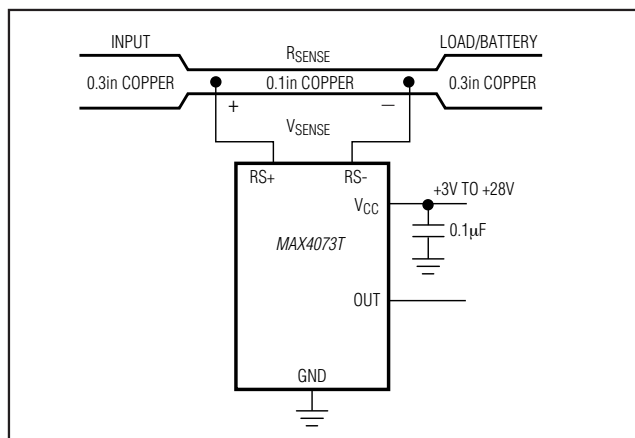


Figure 2. MAX4073T Connections Showing Use of PC Board

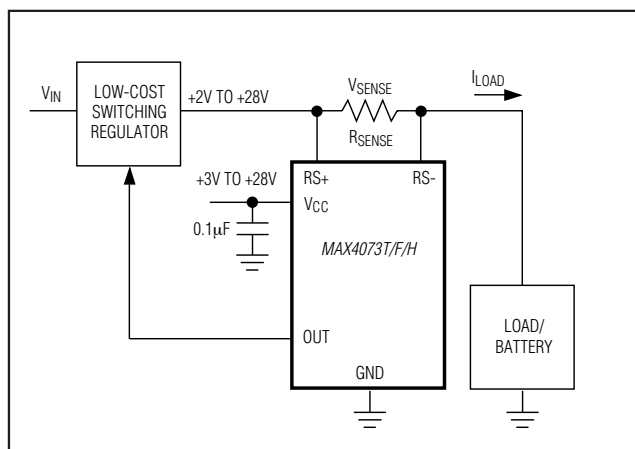


Figure 3. Current Source

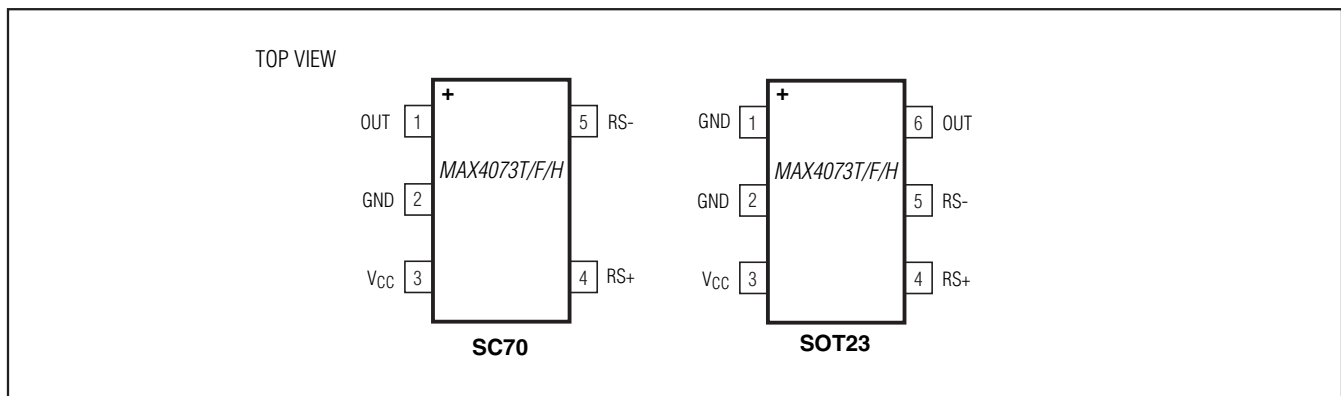
# MAX4073T/F/H

## Low-Cost, SC70, Voltage-Output, High-Side Current-Sense Amplifier

Table 1. Recommended Component Values

| FULL-SCALE LOAD CURRENT<br>$I_{LOAD}$ (A) | CURRENT-SENSE RESISTOR<br>$R_{SENSE}$ (m $\Omega$ ) | GAIN | FULL-SCALE OUTPUT VOLTAGE<br>(FULL-SCALE $V_{SENSE} = 100\text{mV}$ )<br>$V_{OUT}$ (V) |
|-------------------------------------------|-----------------------------------------------------|------|----------------------------------------------------------------------------------------|
| 0.1                                       | 1000                                                | 20   | 2.0                                                                                    |
|                                           |                                                     | 50   | 5.0                                                                                    |
|                                           |                                                     | 100  | 10.0                                                                                   |
| 1                                         | 100                                                 | 20   | 2.0                                                                                    |
|                                           |                                                     | 50   | 5.0                                                                                    |
|                                           |                                                     | 100  | 10.0                                                                                   |
| 5                                         | 20                                                  | 20   | 2.0                                                                                    |
|                                           |                                                     | 50   | 5.0                                                                                    |
|                                           |                                                     | 100  | 10.0                                                                                   |
| 10                                        | 10                                                  | 20   | 2.0                                                                                    |
|                                           |                                                     | 50   | 5.0                                                                                    |
|                                           |                                                     | 100  | 10.0                                                                                   |

### Pin Configurations



### Chip Information

PROCESS: Bipolar

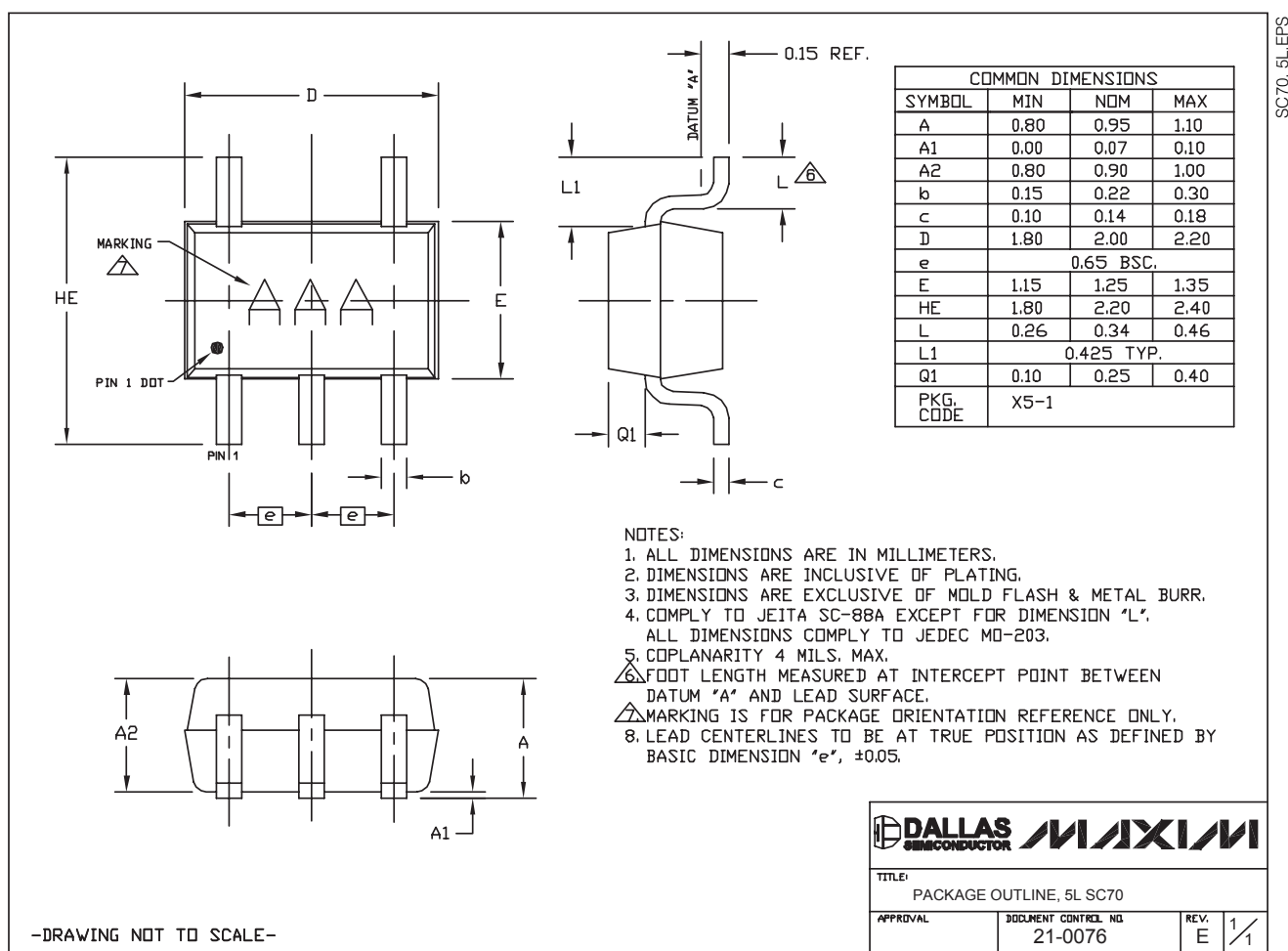
# MAX4073T/F/H

## Low-Cost, SC70, Voltage-Output, High-Side Current-Sense Amplifier

### Package Information

For the latest package outline information and land patterns (footprints), go to [www.maximintegrated.com/packages](http://www.maximintegrated.com/packages). Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

| PACKAGE TYPE | PACKAGE CODE | OUTLINE NO.             | LAND PATTERN NO.        |
|--------------|--------------|-------------------------|-------------------------|
| 5 SC70       | X5+1         | <a href="#">21-0076</a> | <a href="#">90-0188</a> |
| 6 SOT23      | U6+4         | <a href="#">21-0058</a> | <a href="#">90-0175</a> |



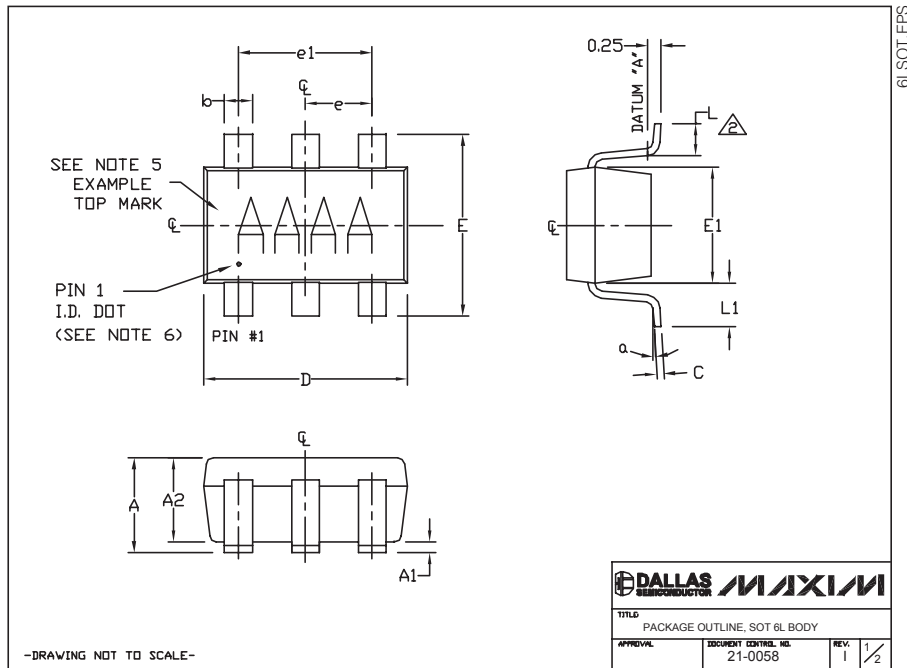
SC70, 5L EPS

# MAX4073T/F/H

## Low-Cost, SC70, Voltage-Output, High-Side Current-Sense Amplifier

### Package Information (continued)

For the latest package outline information and land patterns (footprints), go to [www.maximintegrated.com/packages](http://www.maximintegrated.com/packages). Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.



#### NOTES:

- ALL DIMENSIONS ARE IN MILLIMETERS.
- FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE.
- PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR. MOLD FLASH, PROTRUSION OR METAL BURR SHOULD NOT EXCEED 0.25mm.
- PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.
- PIN 1 IS LOWER LEFT PIN WHEN READING TOP MARK FROM LEFT TO RIGHT. (SEE EXAMPLE TOP MARK)
- PIN 1 I.D. DOT IS 0.3mm Ø MIN. LOCATED ABOVE PIN 1.
- MEETS JEDEC MO17B, VARIATION AB.
- SOLDER THICKNESS MEASURED AT FLAT SECTION OF LEAD BETWEEN 0.08mm AND 0.15mm FROM LEAD TIP.
- LEAD TO BE COPLANAR WITHIN 0.1mm.
- NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.
- MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.

| SYMBOL | MIN  | NOMINAL | MAX  |
|--------|------|---------|------|
| A      | 0.90 | 1.25    | 1.45 |
| A1     | 0.00 | 0.05    | 0.15 |
| A2     | 0.90 | 1.10    | 1.30 |
| b      | 0.35 | 0.40    | 0.50 |
| c      | 0.08 | 0.15    | 0.20 |
| D      | 2.80 | 2.90    | 3.00 |
| E      | 2.60 | 2.80    | 3.00 |
| E1     | 1.50 | 1.625   | 1.75 |
| L      | 0.35 | 0.45    | 0.60 |
| L1     |      | 0.60    | REF. |
| e1     |      | 1.90    | BSC. |
| e      |      | 0.95    | BSC. |
| a      | 0°   | 2.5°    | 10°  |

PKG CODES:  
U6-1, U6-2, U6-4, U6C-8,  
U6SN-1, U6CN-2, U6S-3, U6F-5,  
U6F-6, U6FH-5, U6FH-6

| <b>DALLAS SEMICONDUCTOR</b> <b>MAXIM</b> |                                 |
|------------------------------------------|---------------------------------|
| TITLE<br>PACKAGE OUTLINE, SOT 6L BODY    |                                 |
| APPROVAL                                 | DOCUMENT CONTROL NO.<br>21-0058 |
| REV.<br>1                                | 2<br>2                          |

-DRAWING NOT TO SCALE-

# MAX4073T/F/H

## Low-Cost, SC70, Voltage-Output, High-Side Current-Sense Amplifier

### Revision History

| REVISION<br>NUMBER | REVISION<br>DATE | DESCRIPTION                                       | PAGES<br>CHANGED |
|--------------------|------------------|---------------------------------------------------|------------------|
| 0                  | 5/01             | Initial release                                   | —                |
| 2                  | 8/12             | Added lead-free notation to Ordering Information. | 1                |



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