



**THE DATASHEET OF  
LM4130BIM5X-4.1**



## LM4130 Precision Micropower Low Dropout Voltage Reference

Check for Samples: [LM4130](#)

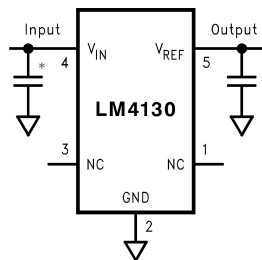
### FEATURES

- Small SOT23-5 package
- High output voltage accuracy 0.05%
- Low Temperature Coefficient 10 ppm/°C
- Stable with capacitive loads to 100µF
- Low dropout voltage  $\leq 275$  mV @ 10 mA
- Supply Current  $\leq 75$  µA
- Full accuracy  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$
- Extended operation to  $125^{\circ}\text{C}$
- Excellent load and line regulation
- Output current 20 mA
- Output impedance  $< 1\Omega$
- Voltage options: 2.500V and 4.096V

### APPLICATIONS SUMMARY

- Portable, battery powered equipment
- Instrumentation and process control
- Automotive & Industrial
- Test equipment
- Data acquisition systems
- Precision regulators
- Battery chargers
- Base stations
- Communications
- Medical equipment
- Servo systems

### Connection Diagram and Pin Configuration



\*Optional, Recommended for improved transient response and input noise reduction.  
(See Application Information)

### DESCRIPTION

The LM4130 family of precision voltage references performs comparable to the best laser-trimmed bipolar references, but in cost effective CMOS technology. Key to this break through is the use of EEPROM registers for correction of curvature, tempco, and accuracy on a CMOS bandgap architecture that allows package level programming to overcome assembly shift. The shifts in voltage accuracy and tempco during assembly of die into plastic packages limit the accuracy of references trimmed with laser techniques.

Unlike other LDO references, the LM4130 requires no output capacitor. Neither is a buffer amplifier required, even with loads up to 20mA. These advantages and the SOT23 packaging are important for cost-critical and space-critical applications.

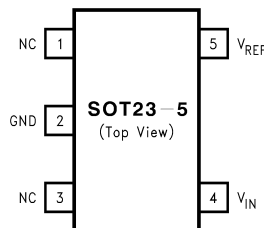
Series references provide lower power consumption than shunt references, since they don't have to idle the maximum possible load current under no load conditions. This advantage, the low quiescent current (75µA), and the low dropout voltage(275mV) make the LM4130 ideal for battery-powered solutions.

The LM4130 is available in five grades (A, B, C, D and E) for greater flexibility. The best grade devices (A) have an initial accuracy of 0.05% with ensured temperature coefficient of 10ppm/°C or less, while the lowest grade parts (E) have an initial accuracy of 0.5% and a tempco of 30ppm/°C.



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Refer to the Ordering Information Table in this Data Sheet for Specific Part Number

**Figure 1. SOT23-5 Surface Mount Package**

**Table 1. SOT23-5 Package Marking Information** Only four fields of marking are possible on the SOT23-5's small surface. This table gives the meaning of the four fields.

| Field Information   |
|---|
| First Field:  |
| R = Reference   |
| Second and Third Field:   |
| 03 = 2.50V Voltage Option   |
| 04 = 4.096V Voltage Option  |
| Fourth Field:   |
| A-E = Initial Reference Voltage Tolerance and Temperature Coefficient |
| A = $\pm 0.05\%$ , 10ppm/ $^{\circ}\text{C}$                          |
| B = $\pm 0.2\%$ , 10ppm/ $^{\circ}\text{C}$                           |
| C = $\pm 0.1\%$ , 20ppm/ $^{\circ}\text{C}$                           |
| D = $\pm 0.4\%$ , 20ppm/ $^{\circ}\text{C}$                           |
| E = $\pm 0.5\%$ , 30ppm/ $^{\circ}\text{C}$                           |



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### Absolute Maximum Ratings <sup>(1)</sup>

|  |                         |
|--|-------------------------|
| Maximum Voltage on any Input                     | -0.3V to 6V             |
| Output Short-Circuit Duration                    | Indefinite              |
| Power Dissipation ( $T_A = 25^{\circ}\text{C}$ ) | 350 mW                  |
| <sup>(2)</sup>                                   |                         |
| ESD Susceptibility <sup>(3)</sup>                |                         |
| Human Body Model                                 | 2 kV                    |
| Machine Model                                    | 200V                    |
| Lead Temperature:                                |                         |
| Soldering, (10 sec.)                             | +260 $^{\circ}\text{C}$ |
| Vapor Phase (60 sec.)                            | +215 $^{\circ}\text{C}$ |
| Infrared (15 sec.)                               | +220 $^{\circ}\text{C}$ |

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
- (2) Without PCB copper enhancements. The maximum power dissipation must be de-rated at elevated temperatures and is limited by  $T_{JMAX}$  (maximum junction temperature),  $\theta_{J-A}$  (junction to ambient thermal resistance) and  $T_A$  (ambient temperature). The maximum power dissipation at any temperature is:  $P_{DissMAX} = (T_{JMAX} - T_A)/\theta_{J-A}$  up to the value listed in the Absolute Maximum Ratings.  $\theta_{J-A}$  for SOT23-5 package is 220 $^{\circ}\text{C}/\text{W}$ ,  $T_{JMAX} = 125^{\circ}\text{C}$ .
- (3) The human body model is a 100 pF capacitor discharged through a 1.5 k $\Omega$  resistor into each pin. The machine model is a 200 pF capacitor discharged directly into each pin.

**Operating Range** <sup>(1)</sup>

|                             |                 |
|-----------------------------|-----------------|
| Storage Temperature Range   | -65°C to +150°C |
| Operating Temperature Range | -40°C to +85°C  |

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

## LM4130-2.500

### Electrical Characteristics

Unless otherwise specified  $V_{CC} = 5V$ ,  $I_{LOAD} = 0$   $T_A = 25^\circ C$ . Limits with standard typeface are for  $T_A = 25^\circ C$ , and limits in **boldface type** apply over the operating temperature range.

| Symbol                           | Parameter  | Conditions   | Min<br>(1) | Typ<br>(2) | Max<br>(1)   | Units           |
|----------------------------------|--|--|------------|------------|--|-----------------|
| $V_{REF}$                        | Output Voltage Initial Accuracy<br>LM4130A-2.500<br>LM4130B-2.500<br>LM4130C-2.500<br>LM4130D-2.500<br>LM4130E-2.500 |  |            |            | $\pm 0.05$<br>$\pm 0.2$<br>$\pm 0.1$<br>$\pm 0.4$<br>$\pm 0.5$ | %               |
| $TCV_{REF}/^\circ C$<br>(3)      | Temperature Coefficient  |  |            |            |  | ppm/ $^\circ C$ |
|                                  | LM4130A, B   | $0^\circ C \leq T_A \leq +85^\circ C$<br>$-40^\circ C \leq T_A \leq +85^\circ C$ |            |            | 10<br><b>20</b>  |                 |
|                                  | LM4130C, D   |  |            |            | <b>20</b>  |                 |
|                                  | LM4130E  |  |            |            | <b>30</b>  |                 |
| $\Delta V_{REF}/\Delta V_{IN}$   | Line Regulation  | $I_{LOAD} = 100\mu A$  |            |            |  | ppm/V           |
|                                  |  | $V_{REF} + 200\text{ mV} \leq V_{IN} \leq 5.5V$                                  |            | 30         | 100  |                 |
|                                  |  | $V_{REF} + 400\text{ mV} \leq V_{IN} \leq 5.5V$                                  |            |            | <b>150</b>   |                 |
| $\Delta V_{REF}/\Delta I_{LOAD}$ | Load Regulation  | $0\text{ mA} \leq I_{LOAD} \leq 20\text{ mA}$                                    |            | 25         | 60<br><b>80</b>  | ppm/mA          |
| $\Delta V_{REF}$                 | Long-Term Stability (4)  | 1000 Hrs   |            | 50         |  | ppm             |
|                                  | Thermal Hysteresis (5)   | $-40^\circ C \leq T_A \leq +125^\circ C$   |            | 50         |  |                 |
| $V_{IN} - V_{REF}$               | Dropout Voltage (6)  | $I_{LOAD} = 10\text{ mA}$  |            |            | 275<br><b>400</b>  | mV              |
| $V_N$                            | Output Noise Voltage   | 0.1 Hz to 10 Hz  |            | 150        |  | $\mu V_{PP}$    |
| $I_S$                            | Supply Current   |  |            | 50         | 75<br><b>90</b>  | $\mu A$         |
| $I_{SC}$                         | Short Circuit Current  |  | 30         |            | 60   | mA              |
|                                  |  |  |            |            | <b>65</b>  | mA              |

- (1) Limits are 100% production tested at  $25^\circ C$ . Limits over the operating temperature range are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate TI's Average Outgoing Quality Level (AOQL).
- (2) Typical numbers are at  $25^\circ C$  and represent the most likely parametric norm.
- (3) Temperature coefficient is measured by the "Box" method; i.e., the maximum  $\Delta V_{REF}$  is divided by the maximum  $\Delta T$ .
- (4) Long term stability is  $V_{REF}$  @  $25^\circ C$  measured during 1000 hrs.
- (5) Thermal hysteresis is defined as the change in  $+25^\circ C$  output voltage before and after cycling the device from  $-40^\circ C$  to  $125^\circ C$ .
- (6) Dropout voltage is defined as the minimum input to output differential at which the output voltage drops by 0.5% below the value measured with a 5V input.

## LM4130-4.096 Electrical Characteristics

Unless otherwise specified  $V_{CC} = 5.0V$ ,  $I_{LOAD} = 0$   $T_A = 25^\circ C$ . Limits with standard typeface are for  $T_A = 25^\circ C$ , and limits in **boldface type** apply over the operating temperature range.

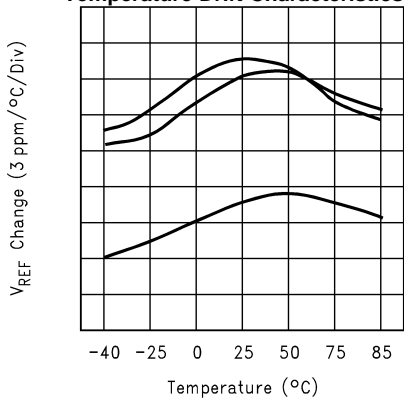
| Symbol                           | Parameter  | Conditions   | Min<br>(1) | Typ<br>(2) | Max<br>(1)   | Units           |
|----------------------------------|--|--|------------|------------|--|-----------------|
| $V_{REF}$                        | Output Voltage Initial Accuracy<br>LM4130-4.096A<br>LM4130-4.096B<br>LM4130-4.096C<br>LM4130-4.096D<br>LM4130-4.096E |  |            |            | $\pm 0.05$<br>$\pm 0.2$<br>$\pm 0.1$<br>$\pm 0.4$<br>$\pm 0.5$ | %               |
| $TCV_{REF}/^\circ C$<br>(3)      | Temperature Coefficient  |  |            |            |  | ppm/ $^\circ C$ |
|                                  | LM4130A, B   | $0^\circ C \leq T_A \leq +85^\circ C$<br>$-40^\circ C \leq T_A \leq +85^\circ C$ |            |            | 10<br><b>20</b>  |                 |
|                                  | LM4130C, D   |  |            |            | <b>20</b>  |                 |
|                                  | LM4130E  |  |            |            | <b>30</b>  |                 |
| $\Delta V_{REF}/\Delta V_{IN}$   | Line Regulation  | $I_{LOAD} = 100\mu A$  |            |            |  | ppm/V           |
|                                  |  | $V_{REF} + 500\text{ mV} \leq V_{IN} \leq 5.5V$                                  |            | 75         | 250<br><b>400</b>  |                 |
| $\Delta V_{REF}/\Delta I_{LOAD}$ | Load Regulation  | $0\text{ mA} \leq I_{LOAD} \leq 20\text{ mA}$                                    |            | 16         | 60<br><b>80</b>  | ppm/mA          |
| $\Delta V_{REF}$                 | Long-Term Stability (4)  | 1000 Hrs   |            | 50         |  | ppm             |
|                                  | Thermal Hysteresis (5)   | $-40^\circ C \leq T_A \leq +125^\circ C$   |            | 50         |  |                 |
| $V_{IN} - V_{REF}$               | Dropout Voltage (6)  | $I_{LOAD} = 10\text{ mA}$  |            |            | 275<br><b>500</b>  | mV              |
| $V_N$                            | Output Noise Voltage   | 0.1 Hz to 10 Hz  |            | 245        |  | $\mu V_{PP}$    |
| $I_S$                            | Supply Current   |  |            | 50         | 75<br><b>90</b>  | $\mu A$         |
| $I_{SC}$                         | Short Circuit Current  |  | 30         |            | 60   | mA              |
|                                  |  |  |            |            | <b>65</b>  | mA              |

- (1) Limits are 100% production tested at  $25^\circ C$ . Limits over the operating temperature range are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate TI's Average Outgoing Quality Level (AOQL).
- (2) Typical numbers are at  $25^\circ C$  and represent the most likely parametric norm.
- (3) Temperature coefficient is measured by the "Box" method; i.e., the maximum  $\Delta V_{REF}$  is divided by the maximum  $\Delta T$ .
- (4) Long term stability is  $V_{REF}$  @  $25^\circ C$  measured during 1000 hrs.
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- (6) Dropout voltage is defined as the minimum input to output differential at which the output voltage drops by 0.5% below the value measured with a 5V input.

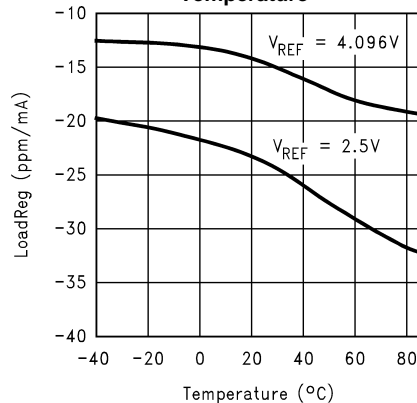
### LM4130 Typical Performance Characteristics

$T_A = 25^\circ\text{C}$ , No Load,  $V_{IN} = 5.0\text{V}$ , unless otherwise noted.

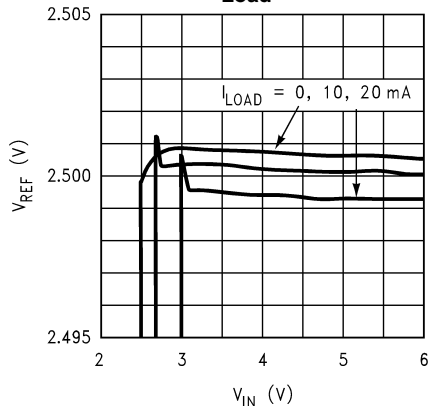
Temperature Drift Characteristics



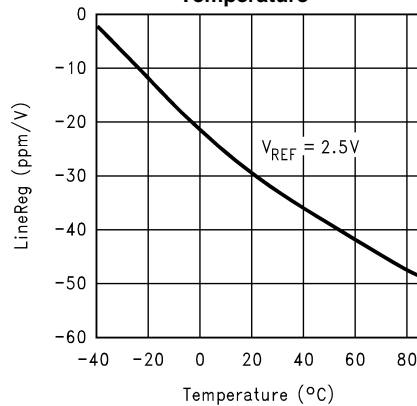
Load Regulation vs Temperature



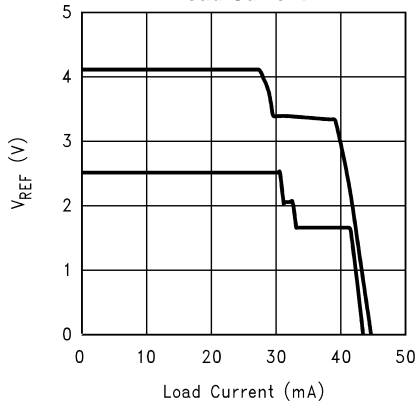
Line Regulation vs Load



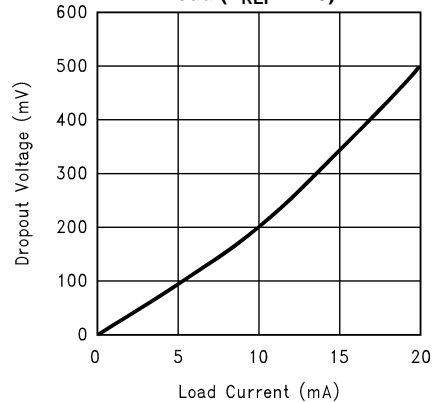
Line Regulation vs Temperature



Output Voltage vs Load Current

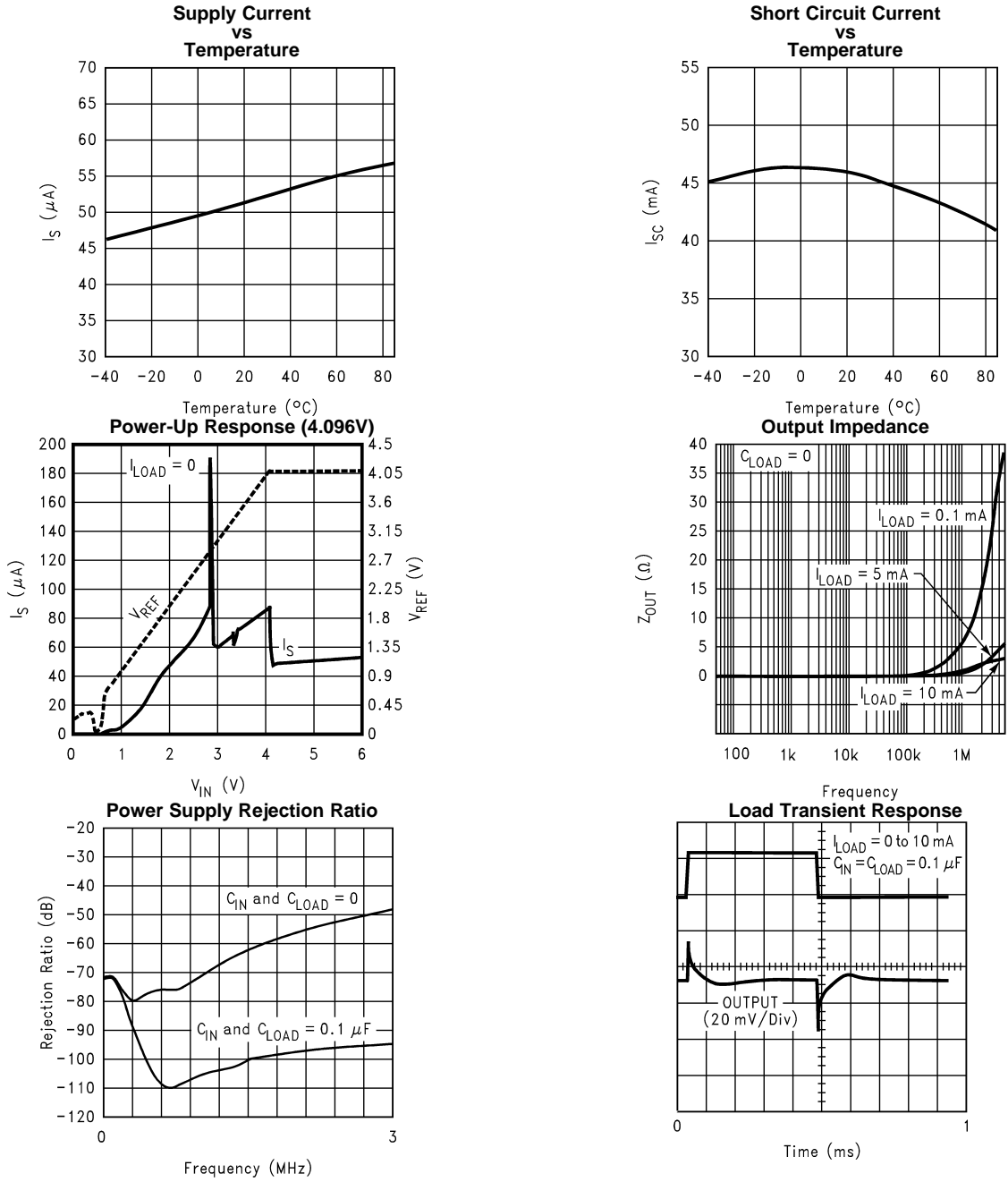


Dropout vs Load ( $V_{REF} = 2.5$ )



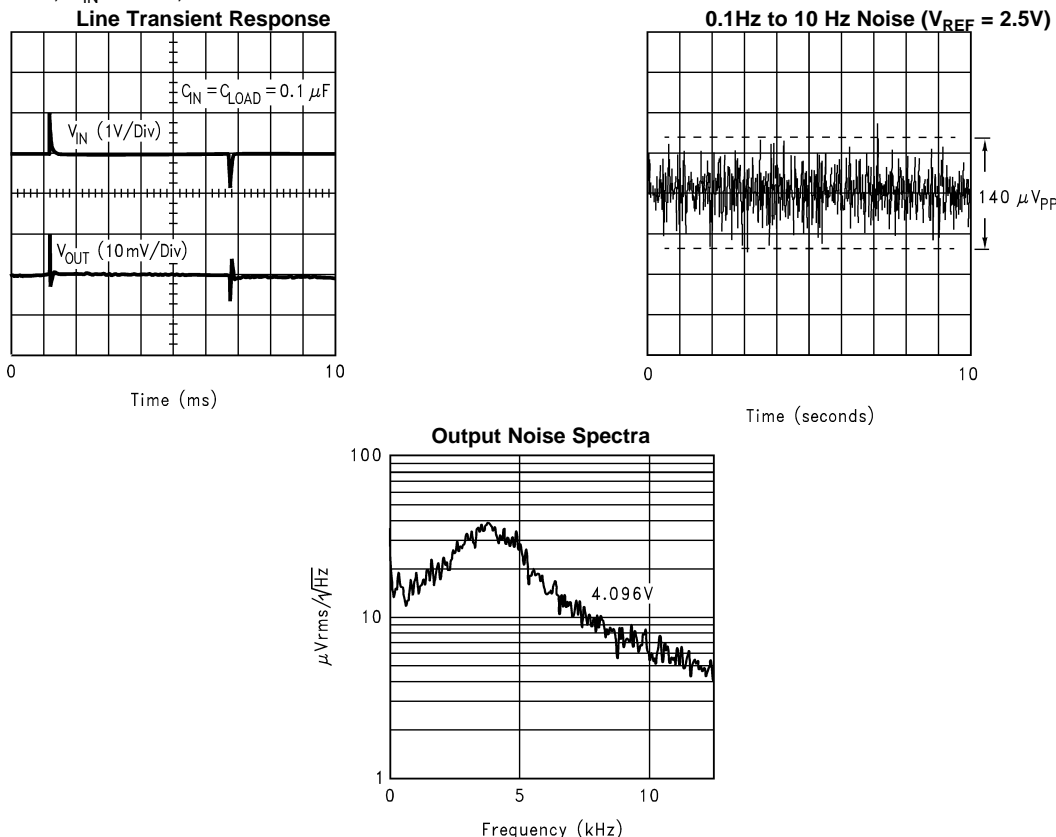
**LM4130 Typical Performance Characteristics (continued)**

$T_A = 25^\circ\text{C}$ , No Load,  $V_{IN} = 5.0\text{V}$ , unless otherwise noted.



### LM4130 Typical Performance Characteristics (continued)

$T_A = 25^\circ\text{C}$ , No Load,  $V_{IN} = 5.0\text{V}$ , unless otherwise noted.



### Pin Functions

**$V_{REF}$  (Pin 5):** Reference Output. The output of the LM4130 can source up to 20 mA. It is stable with output capacitor ranges from 0 to 100  $\mu\text{F}$ .

**$V_{IN}$  (Pin 4):** Positive Supply. Bypassing with a 0.1  $\mu\text{F}$  capacitor is recommended if the output loading changes or input is noisy.

**Ground (Pin 2):** Negative Supply or Ground Connection.

**NC (Pins 1, 3):** No Connection (internally terminated). These pins must be left unconnected.

### Application Information

#### OUTPUT CAPACITOR

The LM4130 is designed to operate with or without an output capacitor and is stable with capacitive loads of up to 100  $\mu\text{F}$ .

Connecting a capacitor between the output and ground will significantly improve the load transient response when switching from a light load to a heavy load. However, the output capacitor should not be made arbitrarily large because it will effect the turn-on time as well as line and load transients.

#### INPUT CAPACITOR

A small 0.1  $\mu\text{F}$  capacitor on the input significantly improves stability under a wide range of load conditions. With an input bypass capacitor, the LM4130 will drive any combination of resistance and capacitance up to  $V_{REF}/20\text{mA}$  and 100  $\mu\text{F}$  respectively.

Noise on the power-supply input can effect the output noise, but it can be reduced by using an optional bypass capacitor between the input pin and the ground.

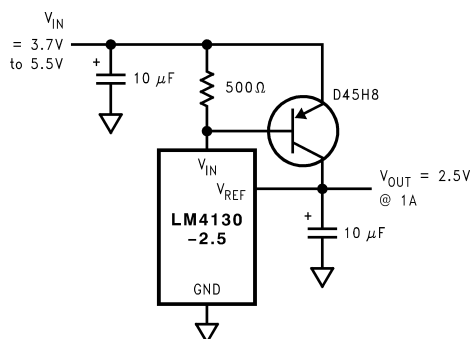
**PRINTED CIRCUIT BOARD LAYOUT CONSIDERATION**

References in SOT packages are generally less prone to assembly stress than devices in Small Outline (SOIC) package.

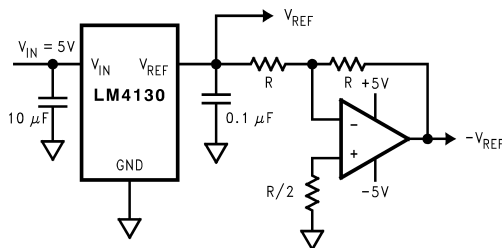
To minimize the mechanical stress due to PC board mounting that can cause the output voltage to shift from its initial value, mount the reference on a low flex area of the PC board, such as near the edge or a corner.

**Typical Application Circuits**

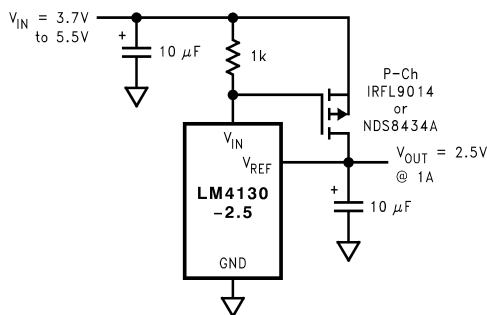
**Figure 2. Precision High Current Low Dropout Regulator**



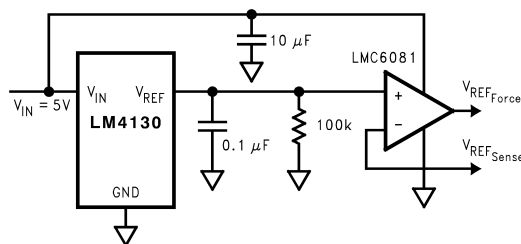
**Figure 3. Voltage Reference with Complimentary Output**

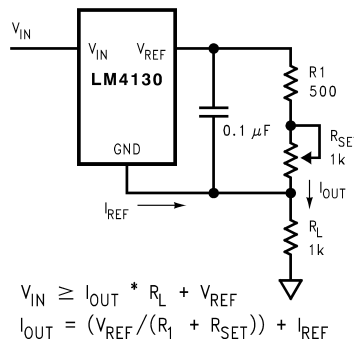
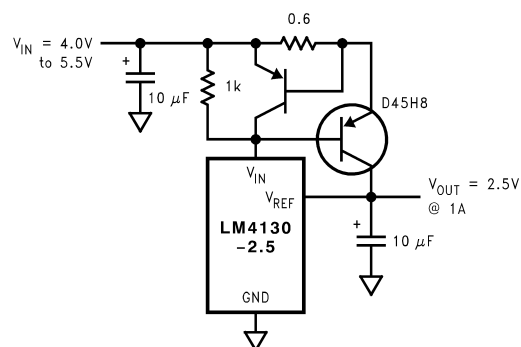
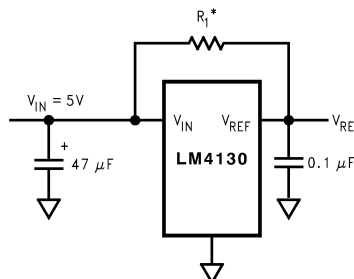


**Figure 4. Precision High Current Low Dropout Regulator**

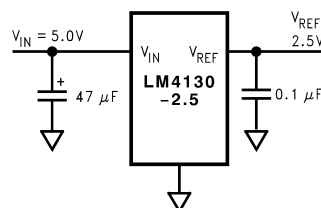


**Figure 5. Precision Voltage Reference with Force and Sense Output**



**Figure 6. Programmable Current Source****Figure 7. Precision Regulator with Current Limiting Circuit****Figure 8. Low Cost Higher Output Current Circuit**

\* Select  $R_1$  to deliver 80% of typical load current. The LM4130 then will source as necessary, up to 20mA, to maintain the output regulation. Care must be taken not to remove the load as the output will be driven to the rail. This approach will effect line regulation.

**Figure 9. Supply Splitter**

**REVISION HISTORY**

| <b>Changes from Revision C (April 2013) to Revision D</b>  | <b>Page</b>        |
|--|--------------------|
| • Changed layout of National Data Sheet to TI format ..... | <a href="#">10</a> |

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| DSP                          | <a href="http://dsp.ti.com">dsp.ti.com</a>   |
| Clocks and Timers            | <a href="http://www.ti.com/clocks">www.ti.com/clocks</a>                             |
| Interface                    | <a href="http://interface.ti.com">interface.ti.com</a>                               |
| Logic                        | <a href="http://logic.ti.com">logic.ti.com</a>                                       |
| Power Mgmt                   | <a href="http://power.ti.com">power.ti.com</a>                                       |
| Microcontrollers             | <a href="http://microcontroller.ti.com">microcontroller.ti.com</a>                   |
| RFID                         | <a href="http://www.ti-rfid.com">www.ti-rfid.com</a>                                 |
| OMAP Applications Processors | <a href="http://www.ti.com/omap">www.ti.com/omap</a>                                 |
| Wireless Connectivity        | <a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a> |

### Applications

|                               |  |
|-------------------------------|--|
| Automotive and Transportation | <a href="http://www.ti.com/automotive">www.ti.com/automotive</a>                         |
| Communications and Telecom    | <a href="http://www.ti.com/communications">www.ti.com/communications</a>                 |
| Computers and Peripherals     | <a href="http://www.ti.com/computers">www.ti.com/computers</a>                           |
| Consumer Electronics          | <a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>                   |
| Energy and Lighting           | <a href="http://www.ti.com/energy">www.ti.com/energy</a>                                 |
| Industrial                    | <a href="http://www.ti.com/industrial">www.ti.com/industrial</a>                         |
| Medical                       | <a href="http://www.ti.com/medical">www.ti.com/medical</a>                               |
| Security                      | <a href="http://www.ti.com/security">www.ti.com/security</a>                             |
| Space, Avionics and Defense   | <a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a> |
| Video and Imaging             | <a href="http://www.ti.com/video">www.ti.com/video</a>                                   |

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-  Alternative Solution
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