**General Description**

Maxim’s MX581 is a three-terminal, temperature-compensated, bandgap voltage reference which provides a precision 10V output from an unregulated input of 12.5V to 30V. Laser trimming is used to minimize initial error and temperature drift, to as low as 10mV and 15ppm/°C with the MX581.

No external components are needed to achieve full accuracy over the operating temperature range. Total supply current to the device, including the internal output buffer amplifier is typically 750µA.

The MX581 is designed for use with 8- to 14-bit ADCs and DACs as well as data acquisition systems. The reference is available in a 3-pin TO-39 metal can and an 8-pin SO surface-mount package.

**Applications**
- CMOS DAC Reference
- A/D Converter Reference
- Measurement Instrumentation
- Threshold Detectors
- Precision Analog Systems

**Features**
- ±10mV Tolerance (MX581K)
- Low Tempco—15ppm/°C max (MAX581K)
- No External Components or Trims
- Short-Circuit Proof
- Output Sources and Sinks Current
- 10mA Output Current
- Low-Supply Current—1.0mA (max)
- Three-Terminal Package

**Ordering Information**

<table>
<thead>
<tr>
<th>PART</th>
<th>TEMP RANGE</th>
<th>PIN-PACKAGE</th>
<th>ERROR</th>
</tr>
</thead>
<tbody>
<tr>
<td>MX581JH</td>
<td>0°C to +70°C</td>
<td>3 TO-39 Can</td>
<td>±30mV</td>
</tr>
<tr>
<td>MX581KH</td>
<td>0°C to +70°C</td>
<td>3 TO-39 Can</td>
<td>±10mV</td>
</tr>
<tr>
<td>MX581JCSA</td>
<td>0°C to +70°C</td>
<td>8 SO</td>
<td>±30mV</td>
</tr>
<tr>
<td>MX581KCSA</td>
<td>0°C to +70°C</td>
<td>8 SO</td>
<td>±10mV</td>
</tr>
<tr>
<td>MX581JESA</td>
<td>-40°C to +85°C</td>
<td>8 SO</td>
<td>±30mV</td>
</tr>
<tr>
<td>MX581KESA</td>
<td>-40°C to +85°C</td>
<td>8 SO</td>
<td>±10mV</td>
</tr>
<tr>
<td>MX581SH</td>
<td>-55°C to +125°C</td>
<td>3 TO-39 Can</td>
<td>±20mV</td>
</tr>
<tr>
<td>MX581TH</td>
<td>-55°C to +125°C</td>
<td>3 TO-39 Can</td>
<td>±10mV</td>
</tr>
</tbody>
</table>

**Typical Operating Circuit**

[Typical Operating Circuit Diagram]

**Pin Configurations**

[Pin Configuration Diagram]
## Absolute Maximum Ratings

Input Voltage (V\textsubscript{IN} to GND) .................................. -0.3V, +40V  
Continuous Power Dissipation  
TO-39 Can (derate 8.7mW/°C above +60°C) ............. 600mW  
SO (derate 5.3mW/°C above +75°C) ................. 400mW  
Output Short-Circuit Duration (Note 1) ................. Indefinite  
Operating Temperature Range  
Commercial (J, K) ....................................................... 0°C to +70°C  
Extended (J, K) ......................................................... -40°C to +85°C  
Military (S, T) ......................................................... -55°C to +125°C  
Storage Temperature Range ................................... -65°C to +175°C  
Lead Temperature (soldering, 10s) ......................... +300°C  
Die Junction Temperature (T\textsubscript{J}) ......... -55°C to +150°C  
Thermal Resistance, Junction to Ambient  
TO-39 CAN ............................................................... +150°C/W  
SO .......................................................... +170°C/W  

Note 1: Absolute maximum power dissipation must not be exceeded. 
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\textsubscript{IN} = +15V, T\textsubscript{A} = +25°C, unless otherwise noted.)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Voltage Tolerance</td>
<td>(V_{\text{IL}} = 0\text{mA})</td>
<td>MX581J/S</td>
<td>30</td>
<td></td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MX581K/T</td>
<td>±10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Voltage Change with Temperature (Temperature Coefficient)</td>
<td></td>
<td>MX581JH/JCSA</td>
<td>13.5</td>
<td></td>
<td></td>
<td>(30) mV/°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MX581JESA</td>
<td>19.5</td>
<td></td>
<td></td>
<td>(30)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MX581KH/KCSA</td>
<td>6.75</td>
<td></td>
<td></td>
<td>(15)</td>
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<tr>
<td></td>
<td></td>
<td>MX581KESA</td>
<td>13</td>
<td></td>
<td></td>
<td>(20)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MX581S</td>
<td>30</td>
<td></td>
<td></td>
<td>(30)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MX581T</td>
<td>15</td>
<td></td>
<td></td>
<td>(15)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MX581T</td>
<td>15</td>
<td></td>
<td></td>
<td>(15)</td>
</tr>
<tr>
<td>Line Regulation</td>
<td>No load</td>
<td>12.5V &lt; (V_{\text{IN}}) &lt; 15V</td>
<td>0.005</td>
<td></td>
<td></td>
<td>%/\text{V}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15V &lt; (V_{\text{IN}}) &lt; 30V</td>
<td>0.002</td>
<td></td>
<td></td>
<td>(3.0)</td>
</tr>
<tr>
<td>Load Regulation</td>
<td>(V_{\text{IL}} = 0\text{mA}) to 5mA</td>
<td>20</td>
<td></td>
<td></td>
<td>50</td>
<td>ppm/mA/°C</td>
</tr>
<tr>
<td>Quiescent Supply Current</td>
<td>(I_{\text{Q}})</td>
<td>(V_{\text{IL}} = 0\text{mA})</td>
<td>750</td>
<td></td>
<td></td>
<td>µA</td>
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<tr>
<td>Turn-On Settling Time to 0.1%</td>
<td>(t_{ON})</td>
<td></td>
<td>200</td>
<td></td>
<td></td>
<td>µs</td>
</tr>
<tr>
<td>Noise</td>
<td>(e_{n}(P-P))</td>
<td>0.1Hz to 10Hz</td>
<td>50</td>
<td></td>
<td></td>
<td>µVP-P</td>
</tr>
<tr>
<td>Long-Term Stability</td>
<td>Noncumulative</td>
<td></td>
<td>25</td>
<td></td>
<td></td>
<td>ppm/KHz</td>
</tr>
<tr>
<td>Short-Circuit Current</td>
<td>(I_{\text{SC}})</td>
<td></td>
<td>30</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Output Current</td>
<td>Source</td>
<td>(V_{\text{IN}} &gt; V_{\text{OUT}} + 2.5V)</td>
<td>(T_{\text{A}} = +25°C)</td>
<td>10</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(T_{\text{MIN}}) to (T_{\text{MAX}})</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(I_{\text{LOAD}} = 0\text{mA}) to 2mA</td>
<td>MX581J/K</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MX581S/T</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(T_{\text{A}} = -55°C) to +125°C</td>
<td>MX581J/S/T</td>
<td>5</td>
</tr>
<tr>
<td>Note 2:</td>
<td>(C_{\text{LOAD}} \geq 10\text{nF}) (see the Output Current section).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**MX581**

High-Precision, 10V Reference
**High-Precision, 10V Reference**

**Typical Operating Characteristics**

As shown in Figure 1, most applications of the MX581 require no external components. Connections are +VS, VOUT, and GND (GND is tied to the case in the TO-5 package). Usually the desired accuracy is obtained by selecting the appropriate device grade. However, any part can be adjusted to a tighter tolerance, or to slightly different voltage, using the fine trim circuit in Figure 2. The table in Figure 2 lists the trim range for different values of R in the figure, and also shows the effect on temperature coefficient.

*Figure 1. MX581 Basic Connection*
High-Precision, 10V Reference

Voltage Temperature Coefficient

The temperature characteristic of the MX581 consistently follows an “S-curve” (see Typical Operating Characteristics). A five-point 100% test guarantees compliance with -55°C to +125°C specifications and a three-point 100% test guarantees 0°C to +70°C specifications.

The voltage change specifications in the Electrical Characteristics table state the maximum deviation over temperature from the reference’s initial value at +25°C, as well as drift in ppm/°C. By adding the maximum deviation for a given device to its initial tolerance, the total error is quickly determined.

Output Current

The MX581 is unique in that it can sink as well as source current. The circuit is also protected for output shorts to either +VS or GND. The output voltage versus current characteristic is shown in the Typical Operating Characteristics. For applications that require the MX581 to sink current, maintain a load capacitance of 10nF or greater for proper operation.

Dynamic Performance

The turn-on characteristic and settling performance of the MX581 are shown in the Typical Operating Characteristics. Both coarse and fine transient response is shown. The reference typically settles to 1mV within 180μs after power is applied.

Applications Information

Precision High-CURRENT Reference

A npn power transistor, or Darlington, is easily connected to the MX581 to greatly increase its output current. The circuit of Figure 3 provides a +10V output at up to 4A. If the load has a significant capacitive component, compensation capacitor, C1, should be added. If the load is purely resistive, high-frequency supply rejection is improved without C1.

Low Input Voltage

Although line regulation is specified from 12.5V to 40V, the MX581 can operate with a +12V ±5% input by adding a resistor as shown in Figure 4. The resistor reduces the current that must be supplied from VOUT. Note that the resistor cannot be used at higher input voltages since, as the supply increases, it sources more current than VOUT can sink.
High-Precision, 10V Reference

Current Limiter
By adding a single resistor as shown in Figure 5, the MX581 is turned into a precision current limiter for applications where the driving voltage is 12.5V to 40V. The programmed current ranges from 0.75mA to 5mA.

Negative 10V Reference
Where a -10V reference is required, the MX581 can be connected as a two-terminal device and biased like a zener diode. The circuit is shown in Figure 6. +Vs and vout are connected to the system's analog ground and the MX581's GND pin is connected, through a resistor, to the negative supply. With 1mA flowing in the reference, the output voltage is typically 2mV greater than what is obtained with the conventional, positive hook-up.

When using the 2-terminal connection, the load and the bias resistor must be selected so that the current flowing in the reference is maintained between 1mA and 5mA. The operating temperature range for this connection is limited to -55°C to +85°C.

Reference for CMOS DACs and ADCs
The MX581 is well suited for use with a wide variety of digital-to-analog converters, especially CMOS DACs. Figure 7 shows a circuit in which an MX7533 10-bit DAC outputs 0 to -10V when using a +10V reference. For a positive DAC output, the MX581 is configured as a 2-terminal -10V reference (Figure 6) and connected to the DAC's VREF input.

In Figure 8, an MX7574 CMOS ADC uses an MX581 for its -10V reference input. The input range for the ADC is 0 to +10V.
High-Precision, 10V Reference

Figure 9. MX581 Microprocessor Interface

Chip Topography

TRANSISTOR COUNT: 72
SUBSTRATE CONNECTED TO GND

3 Lead TO-39 (VR)
θJA = 150°C/W
θJC = 15°C/W
High-Precision, 10V Reference

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to www.maxim-ic.com/packages.)

INCHES    MILLIMETERS
DIM      MIN    MAX    MIN    MAX
A   0.053    0.069   1.35   1.75
A1  0.004    0.010 0.15    0.25
B   0.014    0.019 0.35    0.49
C   0.007    0.010 0.19    0.25
\( \varepsilon \)  0.050 BSC 1.27 BSC
E   0.150    0.157 3.80    4.00
H  0.228    0.244 5.85    6.20
L  0.016    0.050 0.40    1.27

VARIATIONS:

INCHES    MILLIMETERS
DIM      MIN    MAX    MIN    MAX    N    MS012
D    0.189    0.197 4.80    5.00  8    AA
D    0.337    0.344 8.55    8.75 14    AB
D    0.386    0.394 9.80   10.00 16    AC

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. LEADS TO BE COPLANAR WITHIN 0.10mm (.004").
4. CONTROLLING DIMENSION: MILLIMETERS.
5. MEETS JEDEC MS012.
6. N = NUMBER OF PINS.

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