

LM611 Operational Amplifier and Adjustable Reference

Check for Samples: [LM611](#)

FEATURES

OP AMP

- **Low Operating Current: 300 μ A (op amp)**
- **Wide Supply Voltage Range: 4V to 36V**
- **Wide Common-Mode Range: V^- to ($V^+ - 1.8V$)**
- **Wide Differential Input Voltage: $\pm 36V$**
- **Available in Low Cost 8-pin DIP**
- **Available in Plastic Package Rated for Military Temperature Range Operation**

REFERENCE

- **Adjustable Output Voltage: 1.2V to 6.3V**
- **Tight Initial Tolerance Available: $\pm 0.6\%$**
- **Wide Operating Current Range: 17 μ A to 20 mA**
- **Reference Floats Above Ground**
- **Tolerant of Load Capacitance**

APPLICATIONS

- **Transducer Bridge Driver**
- **Process and Mass Flow Control Systems**
- **Power Supply Voltage Monitor**
- **Buffered Voltage References for A/D's**

Connection Diagrams

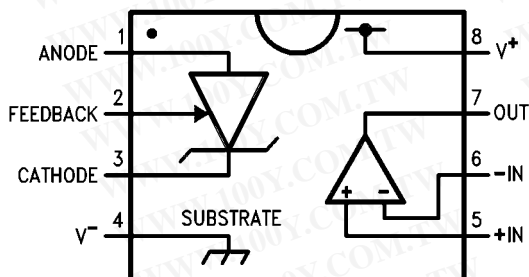


Figure 1. Hermetic Dual-In-Line Package

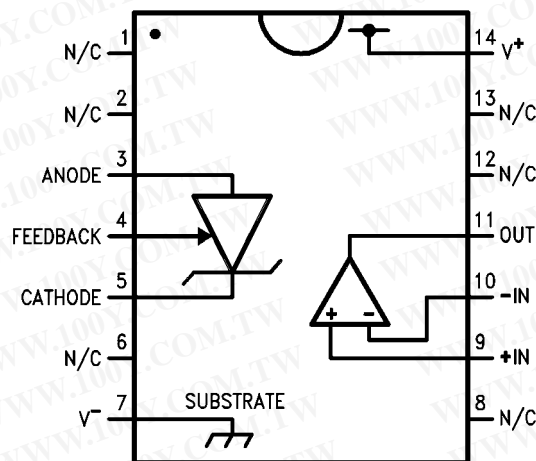


Figure 2. Plastic Surface Mount Narrow Package

DESCRIPTION

The LM611 consists of a single-supply op-amp and a programmable voltage reference in one space saving 8-pin package. The op-amp out-performs most single-supply op-amps by providing higher speed and bandwidth along with low supply current. This device was specifically designed to lower cost and board space requirements in transducer, test, measurement and data acquisition systems.

Combining a stable voltage reference with a wide output swing op-amp makes the LM611 ideal for single supply transducers, signal conditioning and bridge driving where large common-mode signals are common. The voltage reference consists of a reliable band-gap design that maintains low dynamic output impedance (1Ω typical), excellent initial tolerance (0.6%), and the ability to be programmed from 1.2V to 6.3V via two external resistors. The voltage reference is very stable even when driving large capacitive loads, as are commonly encountered in CMOS data acquisition systems.

As a member of TI's Super-Block family, the LM611 is a space-saving monolithic alternative to a multi-chip solution, offering a high level of integration without sacrificing performance.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.



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⁽¹⁾⁽²⁾

Voltage on Any Pins Except V_R (referred to V^- pin)	36V (Max)
See ⁽³⁾	-0.3V (Min)
Current through Any Input Pin and V_R Pin	± 20 mA
Differential Input Voltage	
Military and Industrial	± 36 V
Commercial	± 32 V
Storage Temperature Range	$-65^\circ\text{C} \leq T_J \leq +150^\circ\text{C}$
Maximum Junction Temperature	150°C
Thermal Resistance, Junction-to-Ambient ⁽⁴⁾	
N Package	100°C/W
D Package	150°C/W
Soldering Information Soldering (10 seconds)	
N Package	260°C
D Package	220°C
ESD Tolerance ⁽⁵⁾	± 1 kV

- (1) Absolute maximum ratings indicate limits beyond which damage to the component may occur. Electrical specifications do not apply when operating the device beyond its rated operating conditions.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
- (3) More accurately, it is excessive current flow, with resulting excess heating, that limits the voltages on all pins. When any pin is pulled a diode drop below V^- , a parasitic NPN transistor turns ON. No latch-up will occur as long as the current through that pin remains below the Maximum Rating. Operation is undefined and unpredictable when any parasitic diode or transistor is conducting.
- (4) Junction temperature may be calculated using $T_J = T_A + P_D \theta_{JA}$. The given thermal resistance is worst-case for packages in sockets in still air. For packages soldered to copper-clad board with dissipation from one op amp or reference output transistor, nominal θ_{JA} is 90°C/W for the N package and 135°C/W for the D package.
- (5) Human body model, 100 pF discharged through a 1.5 k Ω resistor.

Operating Temperature Range

LM611AI, LM611I, LM611BI	$-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
LM611AM, LM611M	$-55^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$
LM611C	$0^\circ\text{C} \leq T_J \leq 70^\circ\text{C}$

Electrical Characteristics⁽¹⁾

These specifications apply for $V^- = \text{GND} = 0\text{V}$, $V^+ = 5\text{V}$, $V_{\text{CM}} = V_{\text{OUT}} = 2.5\text{V}$, $I_{\text{R}} = 100\ \mu\text{A}$, FEEDBACK pin shorted to GND, unless otherwise specified. Limits in standard typeface are for $T_{\text{J}} = 25^\circ\text{C}$; limits in **boldface type** apply over the **Operating Temperature Range**.

Symbol	Parameter	Conditions	Typical ⁽²⁾	LM611AM LM611AI Limits ⁽³⁾	LM611M LM611BI LM611I LM611C Limits ⁽³⁾	Units
I_{S}	Total Supply Current	$R_{\text{LOAD}} = \infty$, $4\text{V} \leq V^+ \leq 36\text{V}$ (32V for LM611C)	210 221	300 320	350 370	μA max μA max
V_{S}	Supply Voltage Range		2.2 2.9	2.8 3	2.8 3	V min V min
			46 43	36 36	32 32	V max V max
OPERATIONAL AMPLIFIER						
V_{OS1}	V_{OS} Over Supply	$4\text{V} \leq V^+ \leq 36\text{V}$ ($4\text{V} \leq V^+ \leq 32\text{V}$ for LM611C)	1.5 2.0	3.5 6.0	5.0 7.0	mV max mV max
V_{OS2}	V_{OS} Over V_{CM}	$V_{\text{CM}} = 0\text{V}$ through $V_{\text{CM}} =$ ($V^+ - 1.8\text{V}$), $V^+ = 30\text{V}$, $V^- = 0\text{V}$	1.0 1.5	3.5 6.0	5.0 7.0	mV max mV max
$\frac{V_{\text{OS3}}}{\Delta T}$	Average V_{OS} Drift	See ⁽³⁾	15			$\mu\text{V}/^\circ\text{C}$ max
I_{B}	Input Bias Current		10 11	25 30	35 40	nA max nA max
I_{OS}	Input Offset Current		0.2 0.3	4 5	4 5	nA max nA max
$\frac{I_{\text{OS1}}}{\Delta T}$	Average Offset Drift Current		4			$\text{pA}/^\circ\text{C}$
R_{IN}	Input Resistance	Differential	1800			M Ω
		Common-Mode	3800			M Ω
C_{IN}	Input Capacitance	Common-Mode	5.7			pF
e_{n}	Voltage Noise	$f = 100\ \text{Hz}$, Input Referred	74			$\text{nV}/\sqrt{\text{Hz}}$
I_{n}	Current Noise	$f = 100\ \text{Hz}$, Input Referred	58			$\text{fA}/\sqrt{\text{Hz}}$
CMRR	Common-Mode Rejection-Ratio	$V^+ = 30\text{V}$, $0\text{V} \leq V_{\text{CM}} \leq (V^+ - 1.8\text{V})$ $\text{CMRR} = 20 \log (\Delta V_{\text{CM}}/\Delta V_{\text{OS}})$	95 90	80 75	75 70	dB min dB min
PSRR	Power Supply Rejection-Ratio	$4\text{V} \leq V^+ \leq 30\text{V}$, $V_{\text{CM}} = V^+/2$, $\text{PSRR} = 20 \log (\Delta V^+/\Delta V_{\text{OS}})$	110 100	80 75	75 70	dB min dB min
A_{V}	Open Loop Voltage Gain	$R_{\text{L}} = 10\ \text{k}\Omega$ to GND, $V^+ = 30\text{V}$, $5\text{V} \leq V_{\text{OUT}} \leq 25\text{V}$	500 50	100 40	94 40	V/mV min
SR	Slew Rate	$V^+ = 30\text{V}$ ⁽⁴⁾	0.70 0.65	0.55 0.45	0.50 0.45	V/ μs
GBW	Gain Bandwidth	$C_{\text{L}} = 50\ \text{pF}$	0.80 0.50			MHz
V_{O1}	Output Voltage Swing High	$R_{\text{L}} = 10\ \text{k}\Omega$ to GND $V^+ = 36\text{V}$ (32V for LM611C)	$V^+ - 1.4$ $V^+ - 1.6$	$V^+ - 1.7$ $V^+ - 1.9$	$V^+ - 1.8$ $V^+ - 1.9$	V min V min
V_{O2}	Output Voltage Swing Low	$R_{\text{L}} = 10\ \text{k}\Omega$ to V^+ $V^+ = 36\text{V}$ (32V for LM611C)	$V^- + 0.8$ $V^- + 0.9$	$V^- + 0.9$ $V^- + 1.0$	$V^- + 0.95$ $V^- + 1.0$	V max V max
I_{OUT}	Output Source Current	$V_{\text{OUT}} = 2.5\text{V}$, $V_{+\text{IN}} = 0\text{V}$, $V_{-\text{IN}} = -0.3\text{V}$	25 15	20 13	16 13	mA min mA min

- (1) Military RETS 611AMX electrical test specification is available on request. The LM611AMJ/883 can also be procured as a Standard Military Drawing.
- (2) Typical values in standard typeface are for $T_{\text{J}} = 25^\circ\text{C}$; values in **boldface type** apply for the full operating temperature range. These values represent the most likely parametric norm.
- (3) All limits are specified at room temperature (standard type face) or at operating temperature extremes (**bold face type**).
- (4) Slew rate is measured with op amp in a voltage follower configuration. For rising slew rate, the input voltage is driven from 5V to 25V, and the output voltage transition is sampled at 10V and 20V. For falling slew rate, the input voltage is driven from 25V to 5V, and output voltage transition is sampled at 20V and 10V.

Electrical Characteristics⁽¹⁾ (continued)

These specifications apply for $V^- = \text{GND} = 0\text{V}$, $V^+ = 5\text{V}$, $V_{\text{CM}} = V_{\text{OUT}} = 2.5\text{V}$, $I_{\text{R}} = 100\ \mu\text{A}$, FEEDBACK pin shorted to GND, unless otherwise specified. Limits in standard typeface are for $T_{\text{J}} = 25^\circ\text{C}$; limits in **boldface type** apply over the **Operating Temperature Range**.

Symbol	Parameter	Conditions	Typical ⁽²⁾	LM611AM LM611AI Limits ⁽³⁾	LM611M LM611BI LM611I LM611C Limits ⁽³⁾	Units
I_{SINK}	Output Sink Current	$V_{\text{OUT}} = 1.6\text{V}$, $V_{+\text{IN}} = 0\text{V}$, $V_{-\text{IN}} = 0.3\text{V}$	17 9	14 8	13 8	mA min mA min
I_{SHORT}	Short Circuit Current	$V_{\text{OUT}} = 0\text{V}$, $V_{+\text{IN}} = 3\text{V}$, $V_{-\text{IN}} = 2\text{V}$, Source	30 40	50 60	50 60	mA max mA max
		$V_{\text{OUT}} = 5\text{V}$, $V_{+\text{IN}} = 2\text{V}$, $V_{-\text{IN}} = 3\text{V}$, Sink	30 32	60 80	70 90	mA max mA max
VOLTAGE REFERENCE						
V_{R}	Reference Voltage	See ⁽⁵⁾	1.244	1.2365 1.2515 ($\pm 0.6\%$)	1.2191 1.2689 ($\pm 2.0\%$)	V min V max
$\frac{\Delta V_{\text{R}}}{\Delta T_{\text{J}}}$	Average Temperature Drift	See ⁽⁶⁾	10	80	150	PPM/ $^\circ\text{C}$ max
$\frac{\Delta V_{\text{R}}}{\Delta T_{\text{J}}}$	Hysteresis	Hyst = $(V_{\text{ro}'} - V_{\text{ro}})/\Delta T_{\text{J}}$ ⁽⁷⁾	3.2			$\mu\text{V}/^\circ\text{C}$
$\frac{\Delta V_{\text{R}}}{\Delta I_{\text{R}}}$	V_{R} Change with Current	$V_{\text{R}(100\ \mu\text{A})} - V_{\text{R}(17\ \mu\text{A})}$	0.05 0.1	1 1.1	1 1.1	mV max mV max
		$V_{\text{R}(10\ \text{mA})} - V_{\text{R}(100\ \mu\text{A})}$ ⁽⁸⁾	1.5 2.0	5 5.5	5 5.5	mV max mV max
R	Resistance	$\Delta V_{\text{R}(10 \rightarrow 0.1\ \text{mA})}/9.9\ \text{mA}$ $\Delta V_{\text{R}(100 \rightarrow 17\ \mu\text{A})}/83\ \mu\text{A}$	0.2 0.6	0.56 13	0.56 13	Ω max Ω max
$\frac{\Delta V_{\text{R}}}{V_{\text{RO}}}$	V_{R} Change with High V_{RO}	$V_{\text{R}(V_{\text{ro}} = V_{\text{r}})} - V_{\text{R}(V_{\text{ro}} = 6.3\text{V})}$ (5.06V between Anode and FEEDBACK)	2.5 2.8	7 10	7 10	mV max mV max
$\frac{\Delta V_{\text{R}}}{\Delta V_{+}}$	V_{R} Change with V^+ Change	$V_{\text{R}(V_{+} = 5\text{V})} - V_{\text{R}(V_{+} = 36\text{V})}$ ($V^+ = 32\text{V}$ for LM611C)	0.1 0.1	1.2 1.3	1.2 1.3	mV max mV max
		$V_{\text{R}(V_{+} = 5\text{V})} - V_{\text{R}(V_{+} = 3\text{V})}$	0.01 0.01	1 1.5	1 1.5	mV max mV max
$\frac{\Delta V_{\text{R}}}{\Delta V_{\text{ANODE}}}$	V_{R} Change with V_{ANODE} Change	$V^+ = V^+ \text{ max}$, $\Delta V_{\text{R}} = V_{\text{R}}$ (@ $V_{\text{ANODE}} = V^- = \text{GND}$) - V_{R} (@ $V_{\text{ANODE}} = V^+ - 1.0\text{V}$)	0.7 3.3	1.5 3.0	1.6 3.0	mV max mV max
I_{FB}	FEEDBACK Bias Current	I_{FB} ; $V_{\text{ANODE}} \leq V_{\text{FB}} \leq 5.06\text{V}$	22 29	35 40	50 55	nA max nA max
e_{n}	V_{R} Noise	10 Hz to 10,000 Hz, $V_{\text{RO}} = V_{\text{R}}$	30			μV_{RMS}

(5) V_{R} is the cathode-feedback voltage, nominally 1.244V.

(6) Average reference drift is calculated from the measurement of the reference voltage at 25°C and at the temperature extremes. The drift, in ppm/ $^\circ\text{C}$, is $10^6 \cdot \Delta V_{\text{R}} / (V_{\text{R}[25^\circ\text{C}]} \cdot \Delta T_{\text{J}})$, where ΔV_{R} is the lowest value subtracted from the highest, $V_{\text{R}[25^\circ\text{C}]}$ is the value at 25°C , and ΔT_{J} is the temperature range. This parameter is ensured by design and sample testing.

(7) Hysteresis is the change in V_{R} caused by a change in T_{J} , after the reference has been “dehystereized”. To dehystereize the reference; that is minimize the hysteresis to the typical value, its junction temperature should be cycled in the following pattern, spiraling in toward 25°C : 25°C , 85°C , -40°C , 70°C , 0°C , 25°C .

(8) Low contact resistance is required for accurate measurement.

Typical Performance Characteristics (Reference)

$T_J = 25^\circ\text{C}$, FEEDBACK pin shorted to $V^- = 0\text{V}$, unless otherwise noted

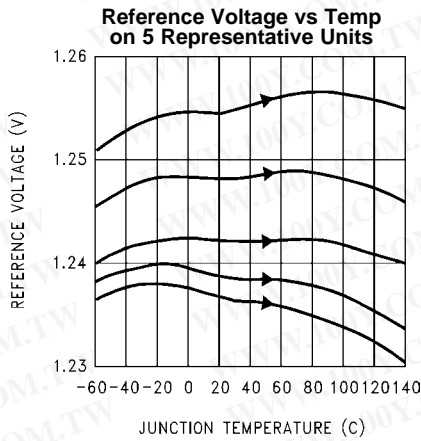


Figure 3.

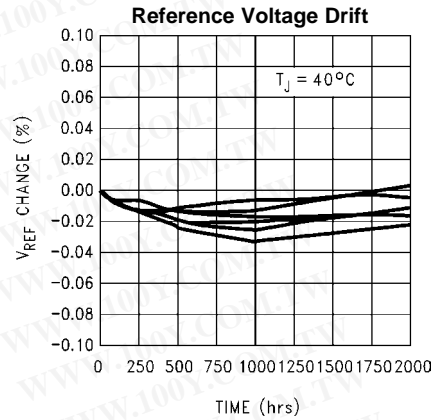


Figure 4.

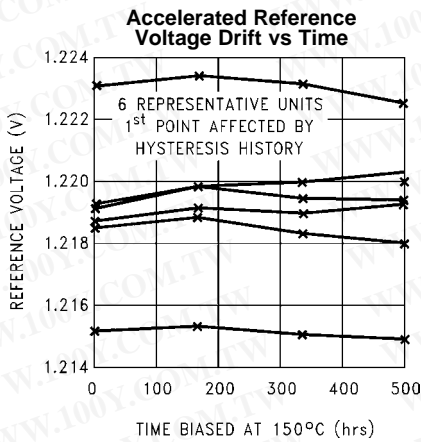


Figure 5.

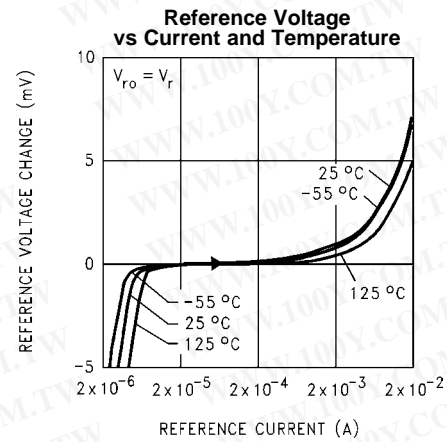


Figure 6.

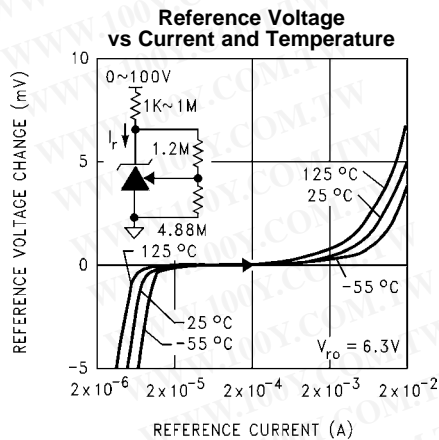


Figure 7.

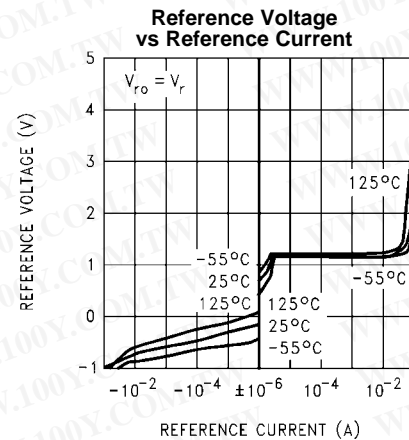


Figure 8.

Typical Performance Characteristics (Reference) (continued)

$T_J = 25^\circ\text{C}$, FEEDBACK pin shorted to $V^- = 0\text{V}$, unless otherwise noted

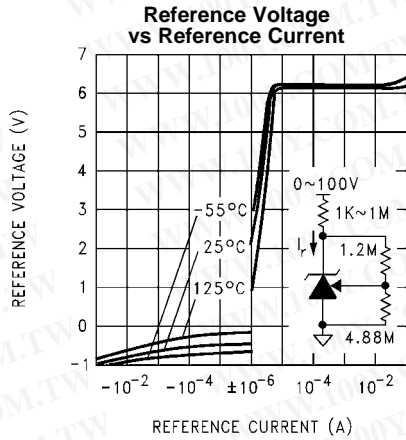


Figure 9.

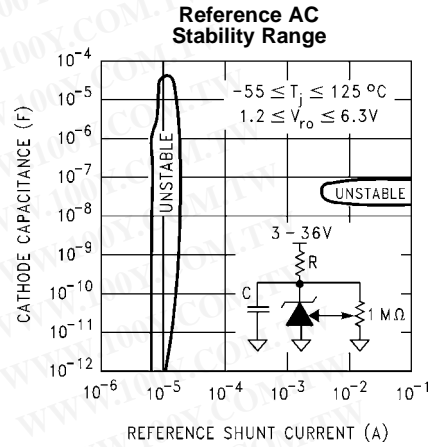


Figure 10.

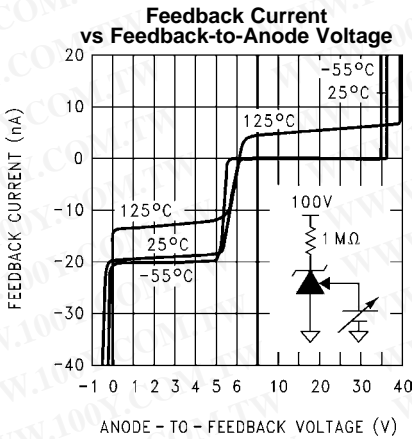


Figure 11.

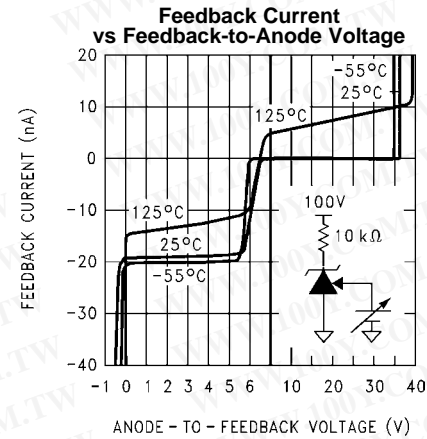


Figure 12.

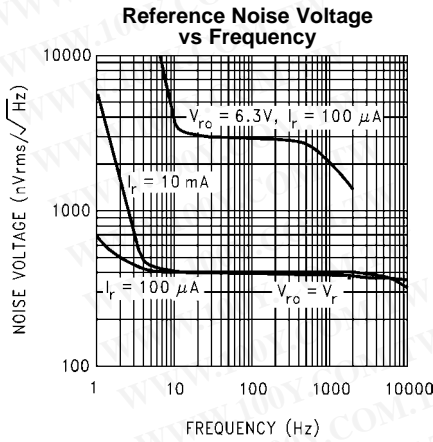


Figure 13.

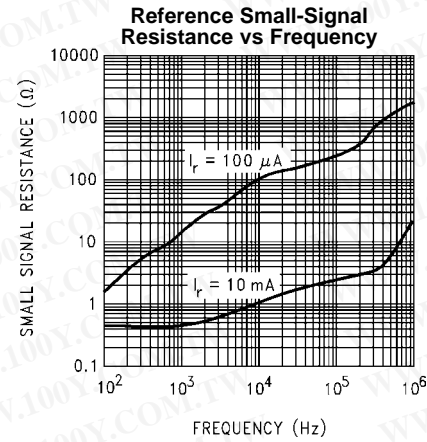


Figure 14.

Typical Performance Characteristics (Reference) (continued)

$T_J = 25^\circ\text{C}$, FEEDBACK pin shorted to $V^- = 0\text{V}$, unless otherwise noted

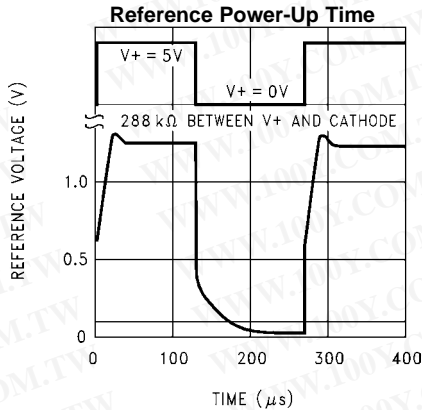


Figure 15.

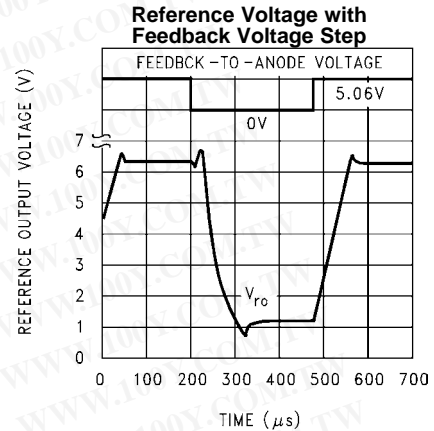


Figure 16.

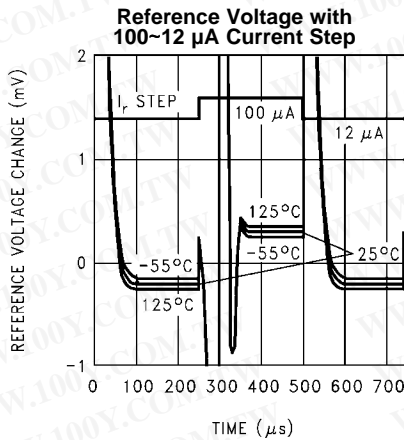


Figure 17.

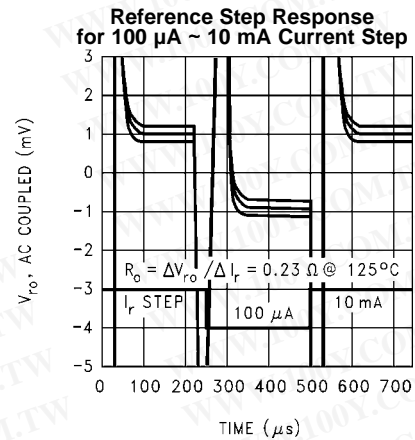


Figure 18.

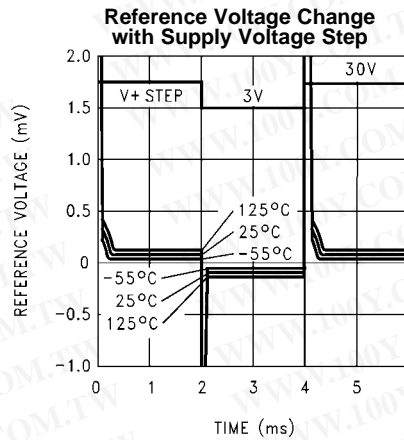


Figure 19.

Typical Performance Characteristics (Op Amps)

$V^+ = 5V$, $V^- = GND = 0V$, $V_{CM} = V^+/2$, $V_{OUT} = V^+/2$, $T_J = 25^\circ C$, unless otherwise noted

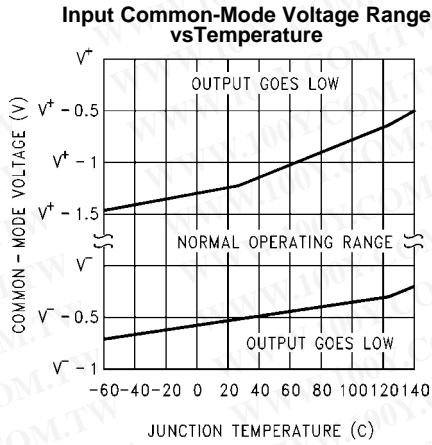


Figure 20.

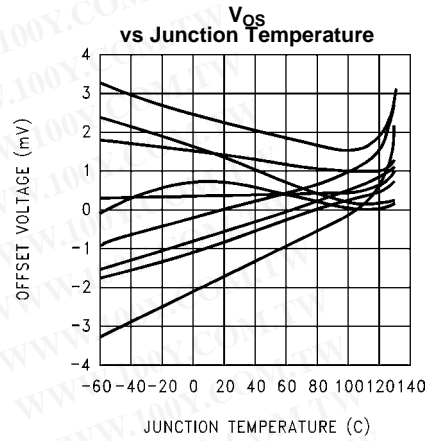


Figure 21.

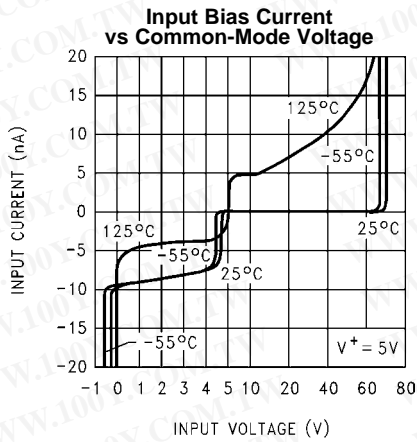


Figure 22.

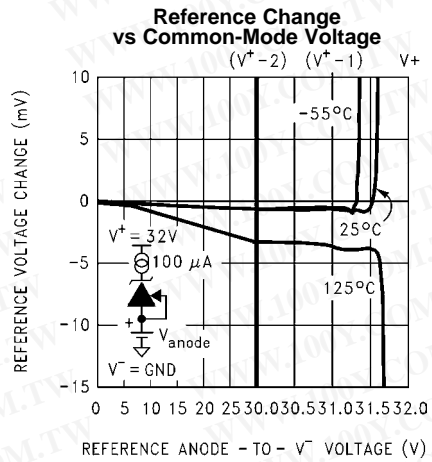


Figure 23.

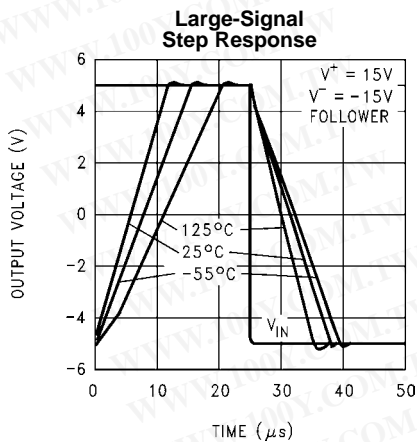


Figure 24.

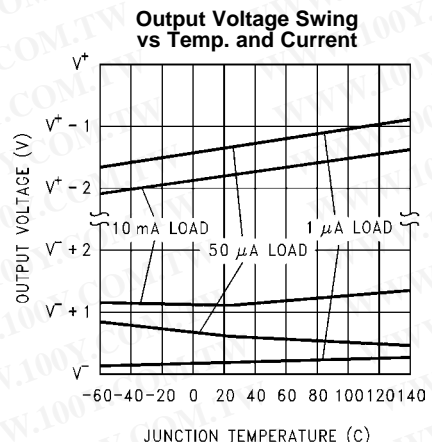


Figure 25.

Typical Performance Characteristics (Op Amps) (continued)

$V^+ = 5V$, $V^- = GND = 0V$, $V_{CM} = V^+/2$, $V_{OUT} = V^+/2$, $T_J = 25^\circ C$, unless otherwise noted

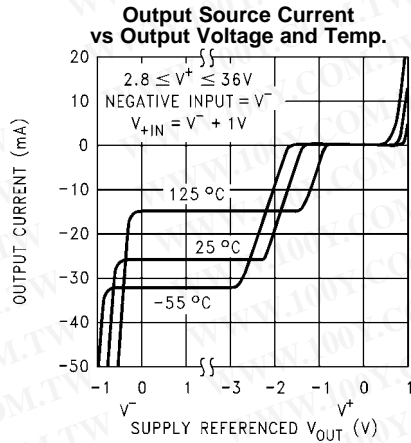


Figure 26.

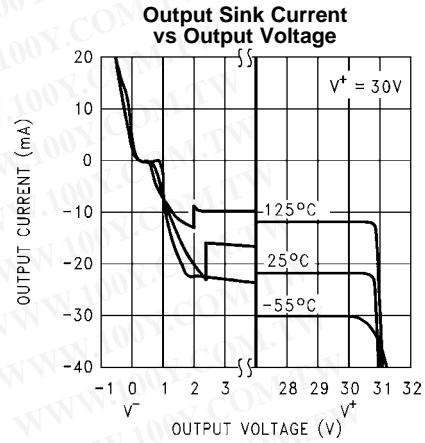


Figure 27.

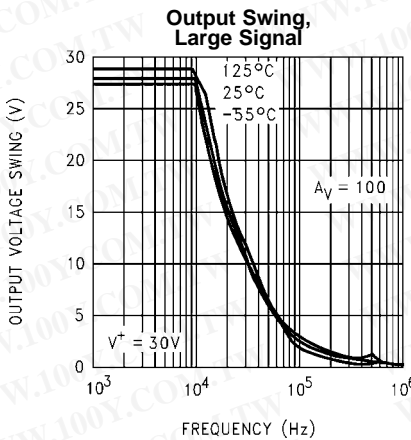


Figure 28.

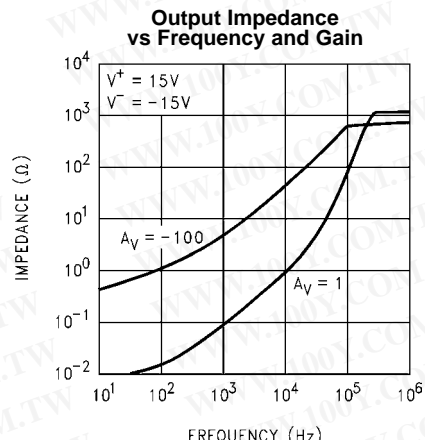


Figure 29.

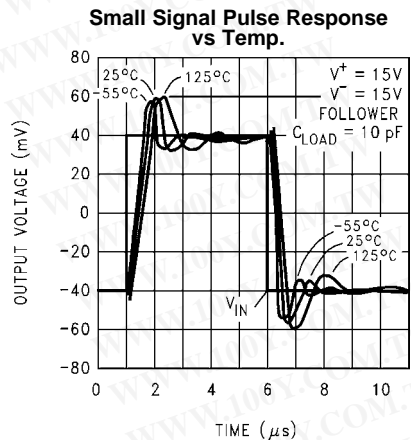


Figure 30.

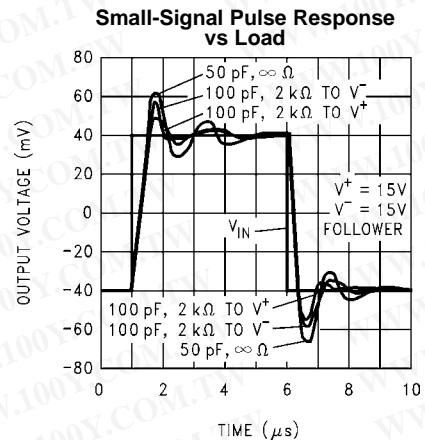


Figure 31.

Typical Performance Characteristics (Op Amps) (continued)

$V^+ = 5V, V^- = GND = 0V, V_{CM} = V^+/2, V_{OUT} = V^+/2, T_J = 25^\circ C$, unless otherwise noted

Op Amp Voltage Noise vs Frequency

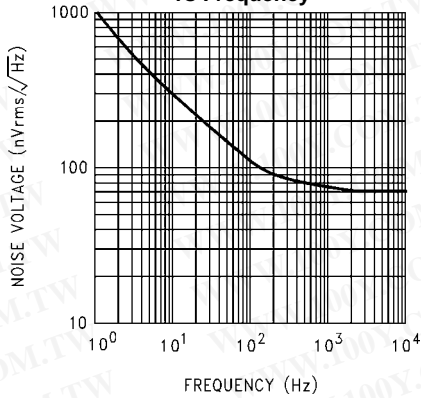


Figure 32.

Op Amp Current Noise vs Frequency

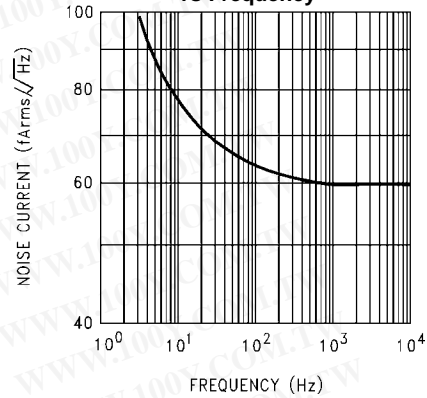


Figure 33.

Small-Signal Voltage Gain vs Frequency and Temperature

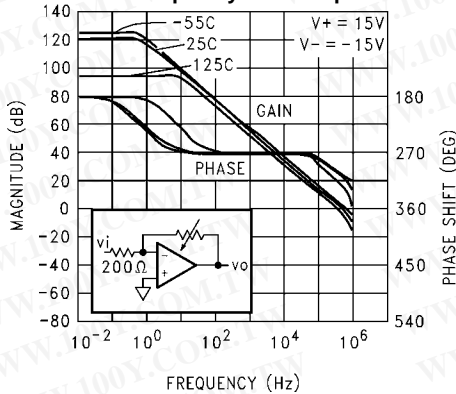


Figure 34.

Small-Signal Voltage Gain vs Frequency and Load

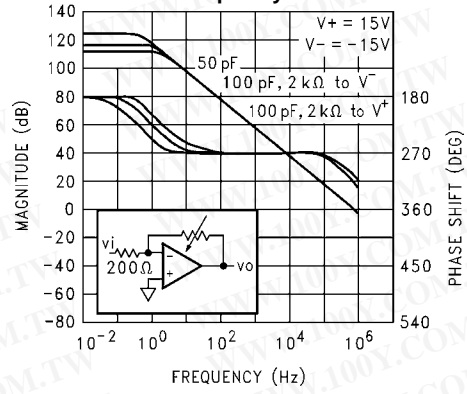


Figure 35.

Follower Small-Signal Frequency Response

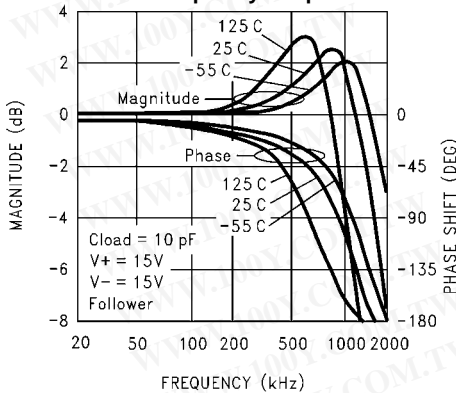


Figure 36.

Common-Mode Input Voltage Rejection Ratio

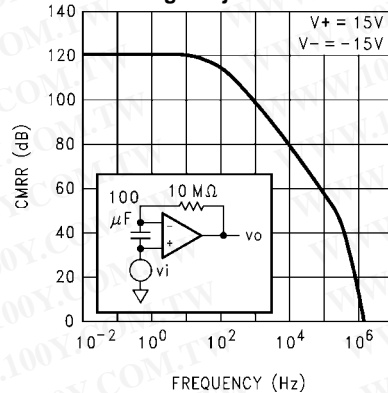


Figure 37.

Typical Performance Characteristics (Op Amps) (continued)

$V^+ = 5V$, $V^- = GND = 0V$, $V_{CM} = V^+/2$, $V_{OUT} = V^+/2$, $T_J = 25^\circ C$, unless otherwise noted

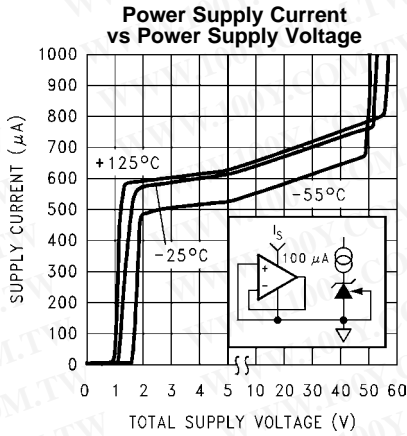


Figure 38.

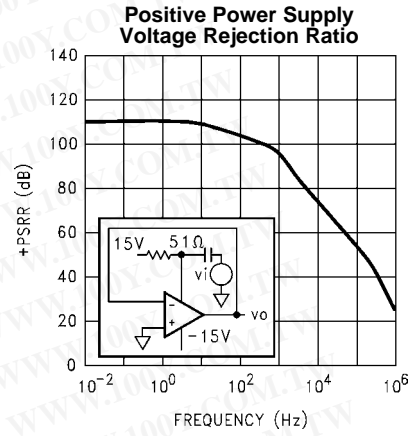


Figure 39.

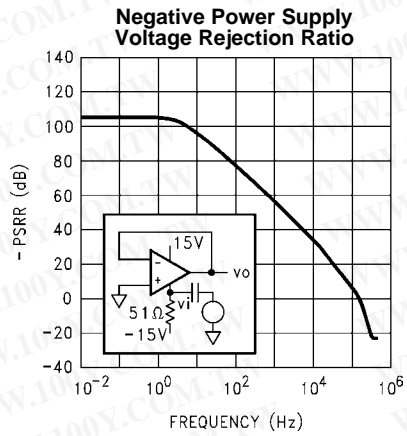


Figure 40.

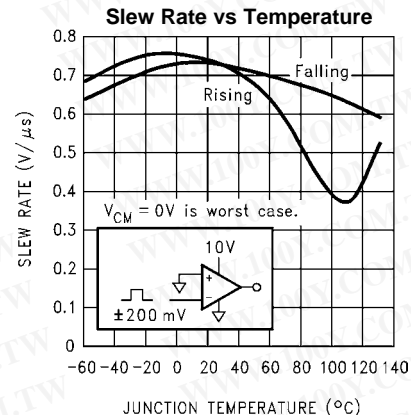


Figure 41.

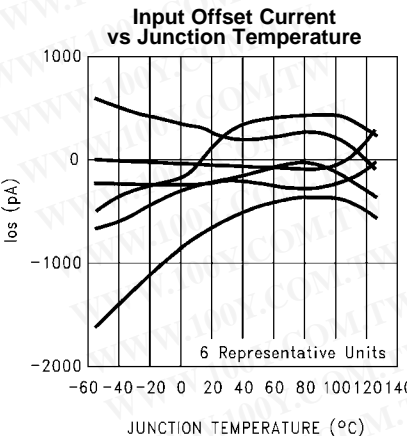


Figure 42.

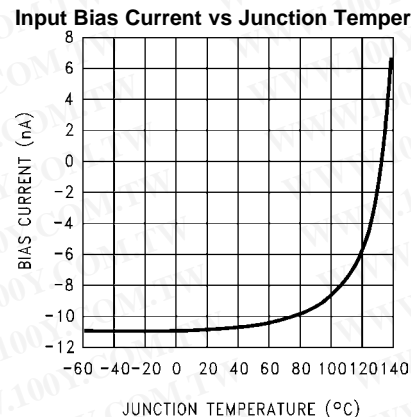
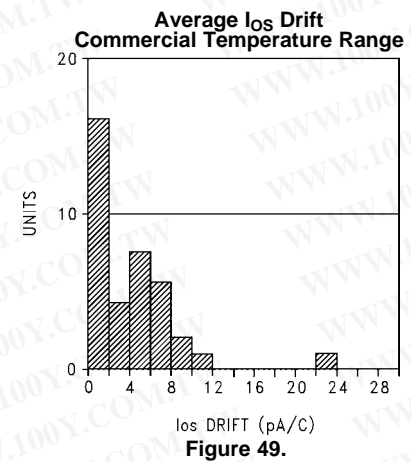
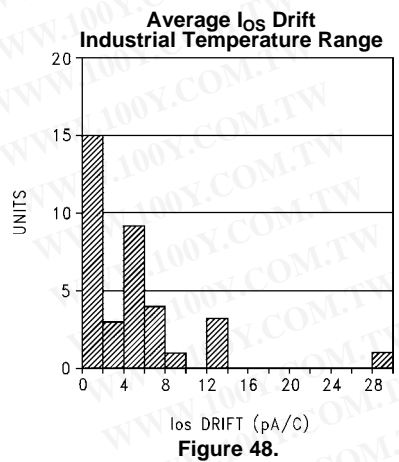
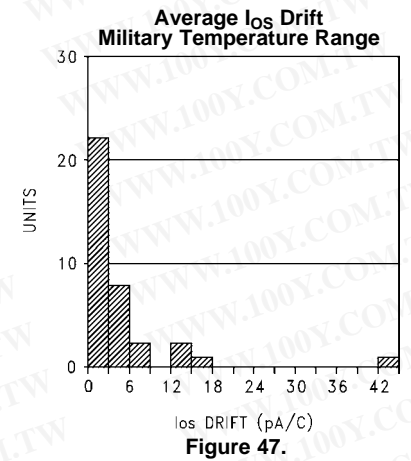
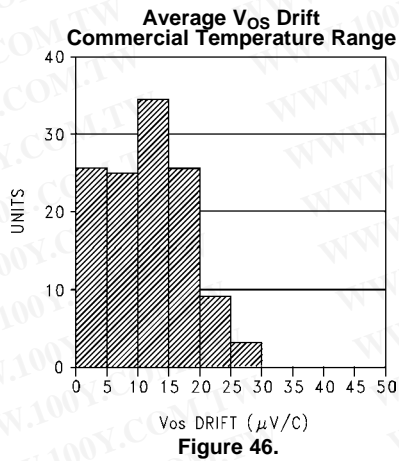
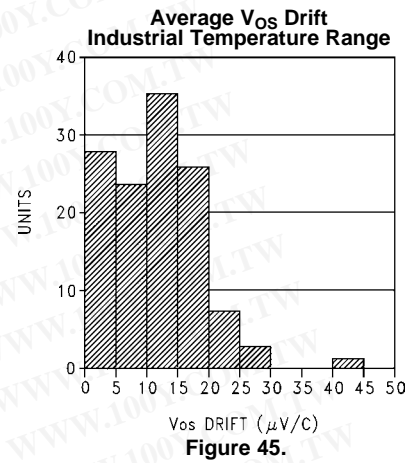
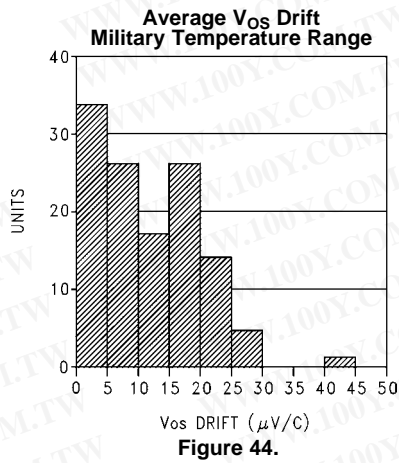


Figure 43.

Typical Performance Distributions



Typical Performance Distributions (continued)

Voltage Reference Broad-Band Noise Distribution

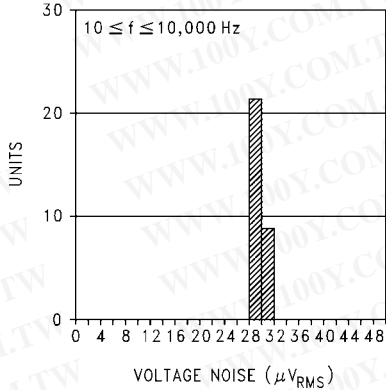


Figure 50.

Op Amp Voltage Noise Distribution

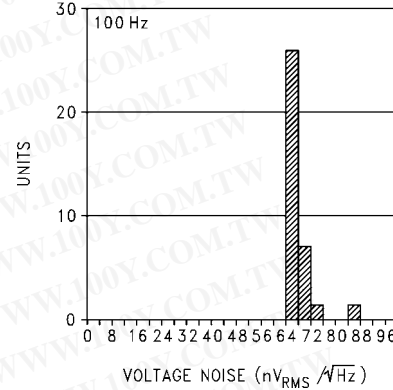


Figure 51.

Op Amp Current Noise Distribution

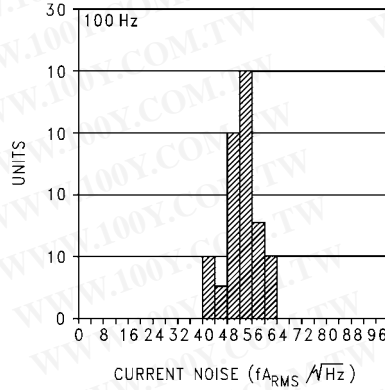


Figure 52.

APPLICATION INFORMATION

VOLTAGE REFERENCE

Reference Biasing

The voltage reference is of a shunt regulator topology that models as a simple zener diode. With current I_r flowing in the 'forward' direction there is the familiar diode transfer function. I_r flowing in the reverse direction forces the reference voltage to be developed from cathode to anode. The applied voltage to the cathode may range from a diode drop below V^- to the reference voltage or to the avalanche voltage of the parallel protection diode, nominally 7V. A 6.3V reference with $V^+ = 3V$ is allowed.

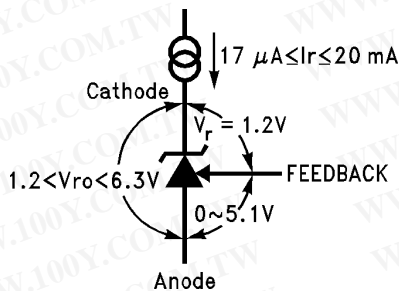


Figure 53. Voltages Associated with Reference (Current Source I_r is External)

The reference equivalent circuit reveals how V_r is held at the constant 1.2V by feedback, and how the FEEDBACK pin passes little current.

To generate the required reverse current, typically a resistor is connected from a supply voltage higher than the reference voltage. Varying that voltage, and so varying I_r , has small effect with the equivalent series resistance of less than an ohm at the higher currents. Alternatively, an active current source, such as the LM134 series, may generate I_r .

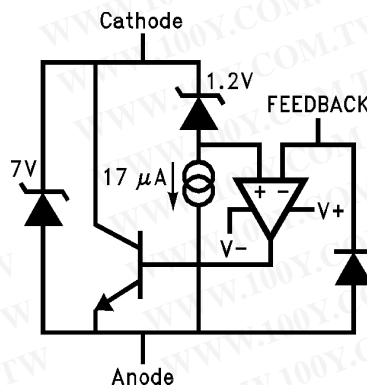


Figure 54. Reference Equivalent Circuit

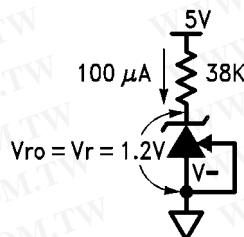


Figure 55. 1.2V Reference

Capacitors in parallel with the reference are allowed. See the [Reference AC Stability Range curve](#) for capacitance values—from 20 μA to 3 mA any capacitor value is stable. With the reference's wide stability range with resistive and capacitive loads, a wide range of RC filter values will perform noise filtering.

Adjustable Reference

The FEEDBACK pin allows the reference output voltage, V_{ro} , to vary from 1.24V to 6.3V. The reference attempts to hold V_r at 1.24V. If V_r is above 1.24V, the reference will conduct current from Cathode to Anode; FEEDBACK current always remains low. If FEEDBACK is connected to Anode, then $V_{ro} = V_r = 1.24\text{V}$. For higher voltages FEEDBACK is held at a constant voltage above Anode—say 3.76V for $V_{ro} = 5\text{V}$. Connecting a resistor across the constant V_r generates a current $I=R1/V_r$ flowing from Cathode into FEEDBACK node. A Thevenin equivalent 3.76V is generated from FEEDBACK to Anode with $R2=3.76/I$. Keep I greater than one thousand times larger than FEEDBACK bias current for $<0.1\%$ error— $I \geq 32 \mu\text{A}$ for the military grade over the military temperature range ($I \geq 5.5 \mu\text{A}$ for a 1% untrimmed error for a commercial part.)

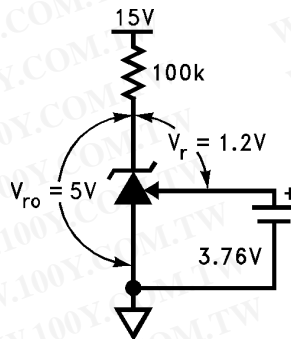
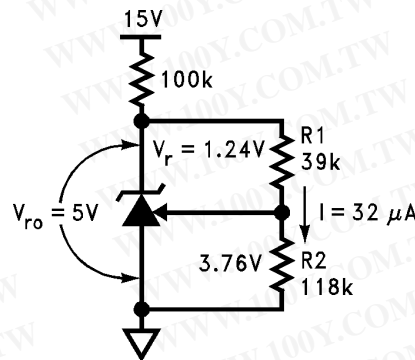


Figure 56. Thevenin Equivalent of Reference with 5V Output



$$R1 = Vr/I = 1.24/32\mu = 39k$$

$$R2 = R1 \{(Vro/Vr) - 1\} = 39k \{(5/1.24) - 1\} = 118k$$

Figure 57. Resistors R1 and R2 Program Reference Output Voltage to be 5V

Understanding that V_r is fixed and that voltage sources, resistors, and capacitors may be tied to the FEEDBACK pin, a range of V_r temperature coefficients may be synthesized.

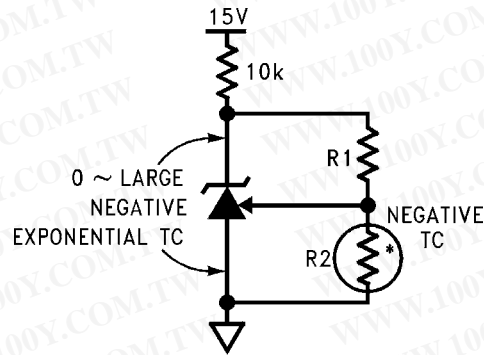


Figure 58. Output Voltage has Negative Temperature Coefficient (TC) if R2 has Negative TC

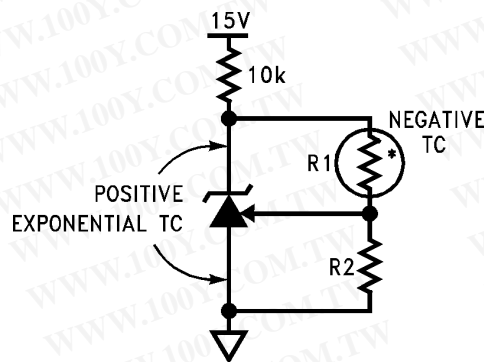


Figure 59. Output Voltage has Positive TC if R1 has Negative TC

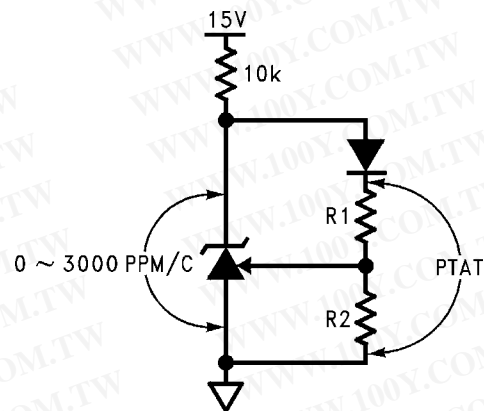
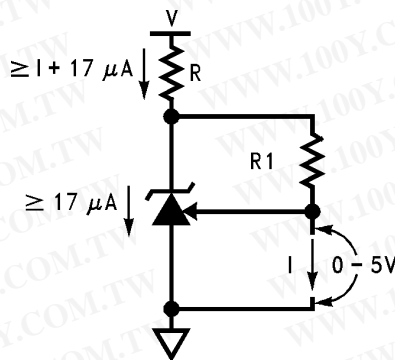


Figure 60. Diode in Series with R1 Causes Voltage Across R1 and R2 to be Proportional to Absolute Temperature (PTAT)

Connecting a resistor across Cathode-to-FEEDBACK creates a 0 TC current source, but a range of TCs may be synthesized.



$$I = Vr/R1 = 1.24/R1$$

Figure 61. Current Source is Programmed by R1

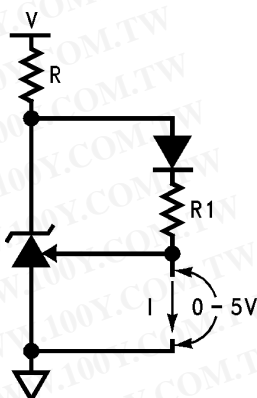


Figure 62. Proportional-to-Absolute-Temperature Current Source

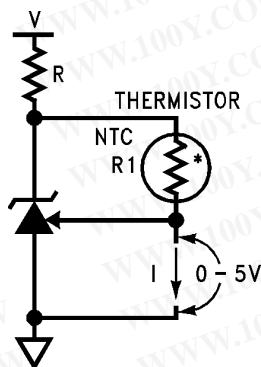


Figure 63. Negative -TC Current Source

Hysteresis

The reference voltage depends, slightly, on the thermal history of the die. Competitive micro-power products vary—always check the data sheet for any given device. Do not assume that no specification means no hysteresis.

OPERATIONAL AMPLIFIER

The amp or the reference may be biased in any way with no effect on the other, except when a substrate diode conducts (see ⁽¹⁾ under [Electrical Characteristics](#)). The amp may have inputs outside the common-mode range, may be operated as a comparator, or have all terminals floating with no effect on the reference (tying inverting input to output and non-inverting input to V^- on unused amp is preferred). Choosing operating points that cause oscillation, such as driving too large a capacitive load, is best avoided.

Op Amp Output Stage

The op amp, like the LM124 series, has a flexible and relatively wide-swing output stage. There are simple rules to optimize output swing, reduce cross-over distortion, and optimize capacitive drive capability:

1. **Output Swing:** Unloaded, the 42 μA pull-down will bring the output within 300 mV of V^- over the military temperature range. If more than 42 μA is required, a resistor from output to V^- will help. Swing across any load may be improved slightly if the load can be tied to V^+ , at the cost of poorer sinking open-loop voltage gain.
2. **Cross-over Distortion:** The LM611 has lower cross-over distortion (a 1 V_{BE} deadband versus 3 V_{BE} for the LM124), and increased slew rate as shown in the [Typical Performance Characteristics curves](#). A resistor pull-up or pull-down will force class-A operation with only the PNP or NPN output transistor conducting, eliminating cross-over distortion.
3. **Capacitive Drive:** Limited by the output pole caused by the output resistance driving capacitive loads, a pull-down resistor conducting 1 mA or more reduces the output stage NPN r_e until the output resistance is that of the current limit 25 Ω . 200 pF may then be driven without oscillation.

Op Amp Input Stage

The lateral PNP input transistors, unlike those of most op amps, have BV_{EBO} equal to the absolute maximum supply voltage. Also, they have no diode clamps to the positive supply nor across the inputs. These features make the inputs look like high impedances to input sources producing large differential and common-mode voltages.

Typical Applications

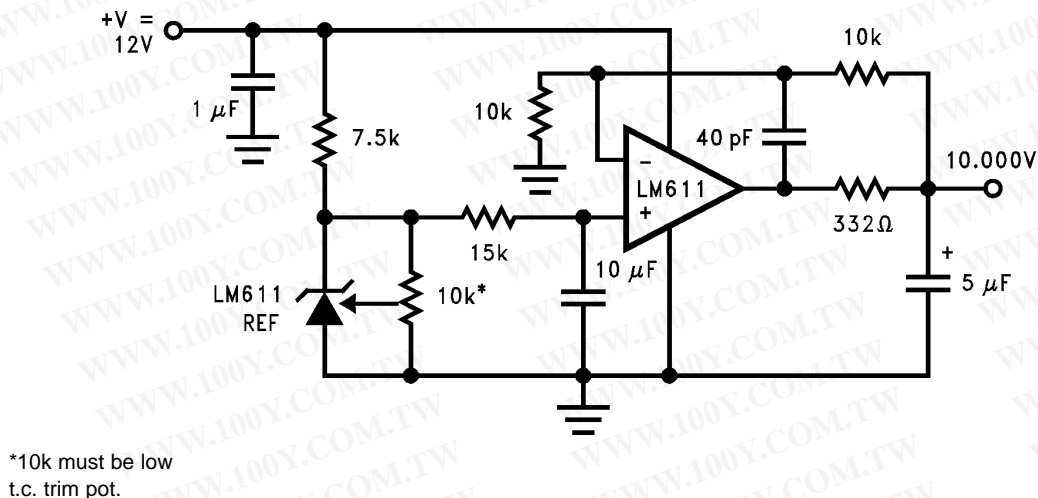


Figure 64. Ultra Low Noise 10.000V Reference.
Total Output Noise is Typically 14 μV_{RMS} .
Adjust the 10k pot for 10.000V.

(1) Absolute maximum ratings indicate limits beyond which damage to the component may occur. Electrical specifications do not apply when operating the device beyond its rated operating conditions.

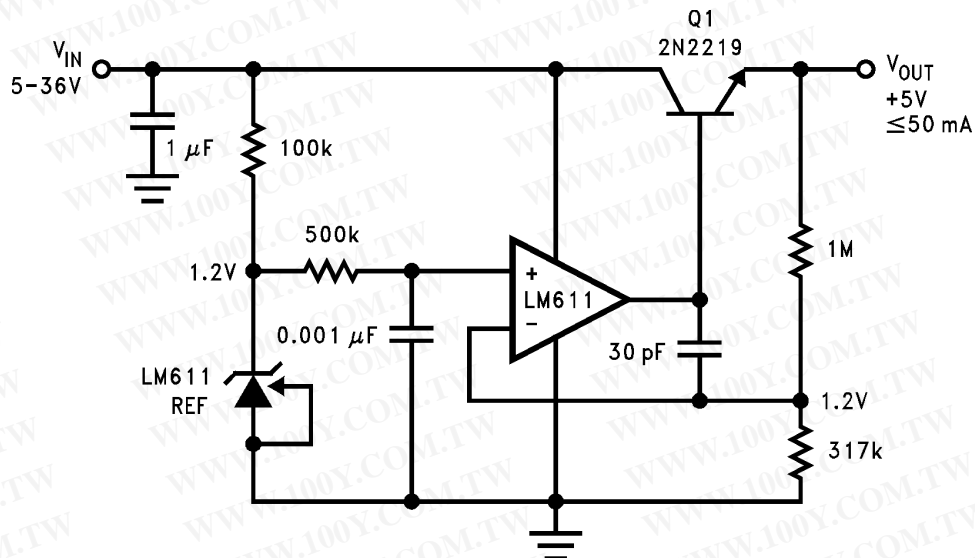
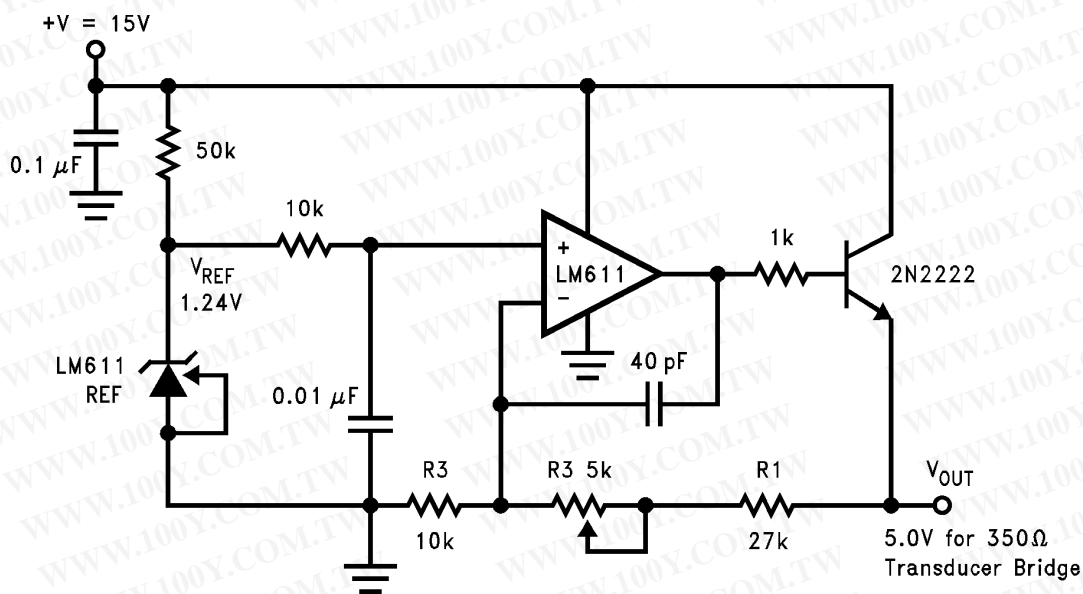


Figure 65. Simple Low Quiescent Drain Voltage Regulator. Total Supply Current is approximately 320 μ A when $V_{IN} = 5V$, and output has no load.



$V_{OUT} = (R1/R2 + 1) V_{REF}$.
 R1, R2 should be 1% metal film.
 R3 should be low t.c. trim pot.

Figure 66. Slow Rise-Time Upon Power-Up, Adjustable Transducer Bridge Driver. Rise-time is approximately 0.5 ms.

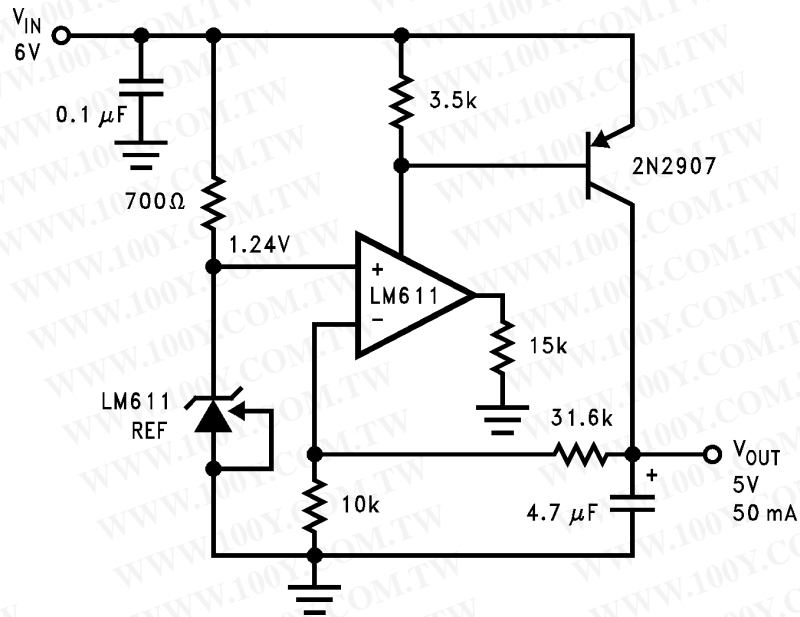


Figure 67. Low Drop-Out Voltage Regulator Circuit. Drop out voltage is typically 0.2V.

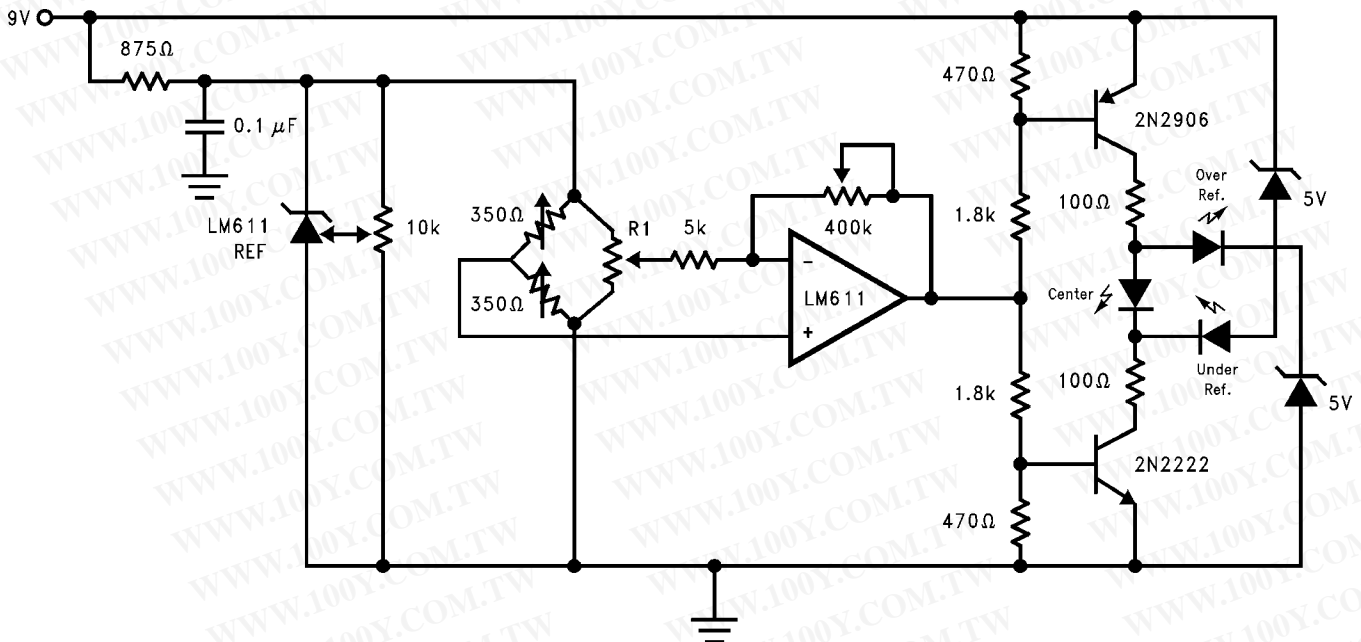


Figure 68. Nulling Bridge Detection System. Adjust sensitivity via 400 kΩ pot. Null offset with R1, and bridge drive with the 10k pot.

Simplified Schematic Diagrams

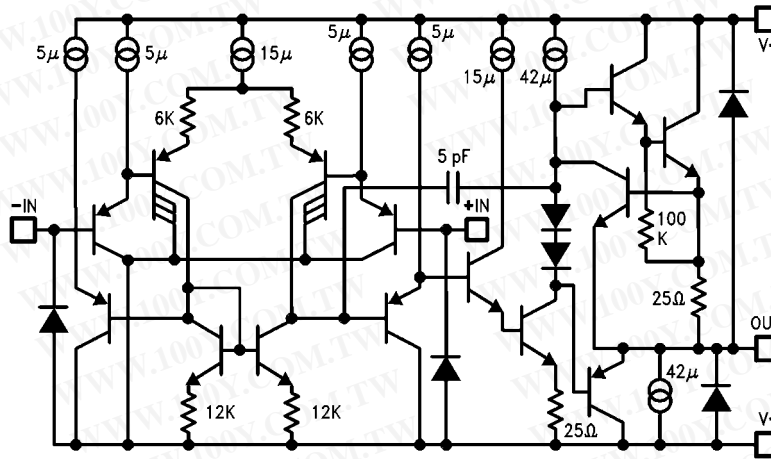


Figure 69. Op Amp

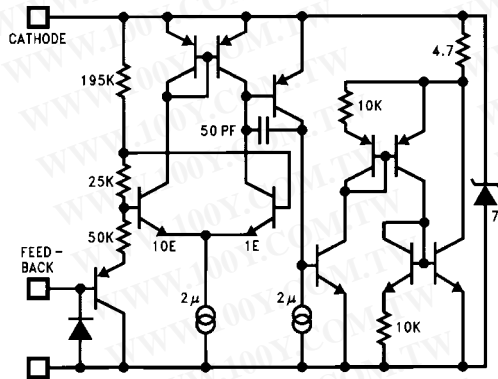


Figure 70. Reference

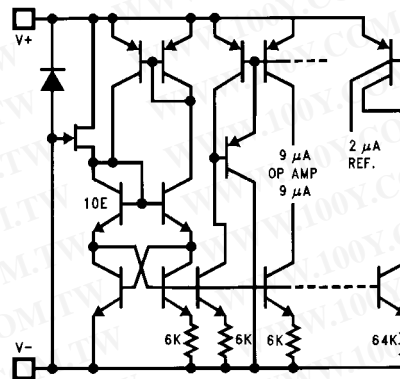


Figure 71. Bias

REVISION HISTORY

Changes from Revision B (March 2013) to Revision C

Page

- Changed layout of National Data Sheet to TI format 21

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
LM611CM	ACTIVE	SOIC	D	14	55	TBD	Call TI	Call TI	0 to 70	LM611CM	Samples
LM611CM/NOPB	ACTIVE	SOIC	D	14	55	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	LM611CM	Samples
LM611CMX	ACTIVE	SOIC	D	14	2500	TBD	Call TI	Call TI	0 to 70	LM611CM	Samples
LM611CMX/NOPB	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	LM611CM	Samples
LM611IM	ACTIVE	SOIC	D	14	55	TBD	Call TI	Call TI	-40 to 85	LM611IM	Samples
LM611IM/NOPB	ACTIVE	SOIC	D	14	55	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	LM611IM	Samples
LM611IMX	ACTIVE	SOIC	D	14	2500	TBD	Call TI	Call TI	-40 to 85	LM611IM	Samples
LM611IMX/NOPB	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	LM611IM	Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

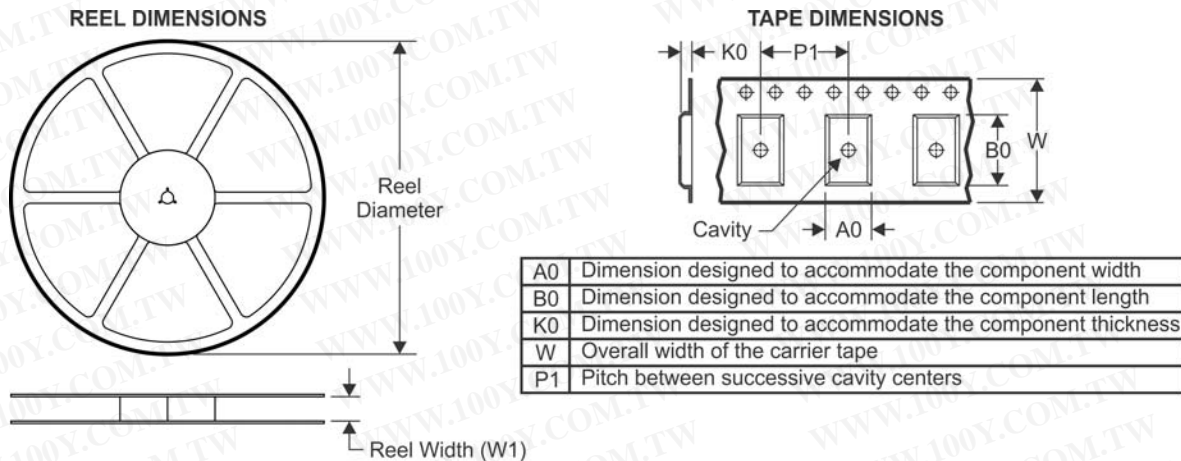
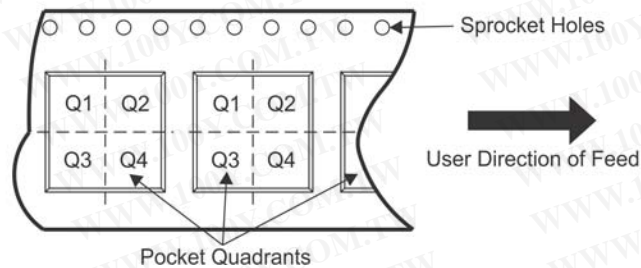
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

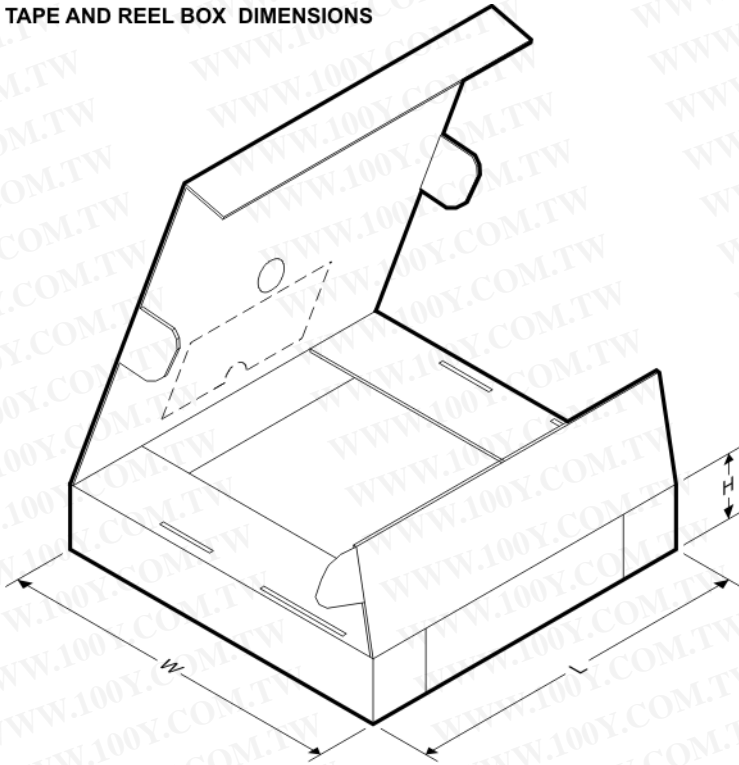
Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM611CMX	SOIC	D	14	2500	330.0	16.4	6.5	9.35	2.3	8.0	16.0	Q1
LM611CMX/NOPB	SOIC	D	14	2500	330.0	16.4	6.5	9.35	2.3	8.0	16.0	Q1
LM611IMX	SOIC	D	14	2500	330.0	16.4	6.5	9.35	2.3	8.0	16.0	Q1
LM611IMX/NOPB	SOIC	D	14	2500	330.0	16.4	6.5	9.35	2.3	8.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM611CMX	SOIC	D	14	2500	367.0	367.0	35.0
LM611CMX/NOPB	SOIC	D	14	2500	367.0	367.0	35.0
LM611IMX	SOIC	D	14	2500	367.0	367.0	35.0
LM611IMX/NOPB	SOIC	D	14	2500	367.0	367.0	35.0

勝特力材料 886-3-5753170
勝特力电子(上海) 86-21-34970699
勝特力电子(深圳) 86-755-83298787
Http://www.100y.com.tw

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

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

TI E2E Community

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2013, Texas Instruments Incorporated