

LM611

LM611 Operational Amplifier and Adjustable Reference

Datasheet.Directory



Literature Number: SNOSC08B

LM611

Operational Amplifier and Adjustable Reference

General 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 National'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.

Features

OP AMP

- Low operating current: 300 μA (op amp)
- Wide supply voltage range: 4V to 36V
- Wide common-mode range: V⁻ to (V⁺-1.8V)
- Wide differential input voltage: ±36V
- Available in low cost 8-pin DIP
- Available in plastic package rated for Military Temperature Range Operation

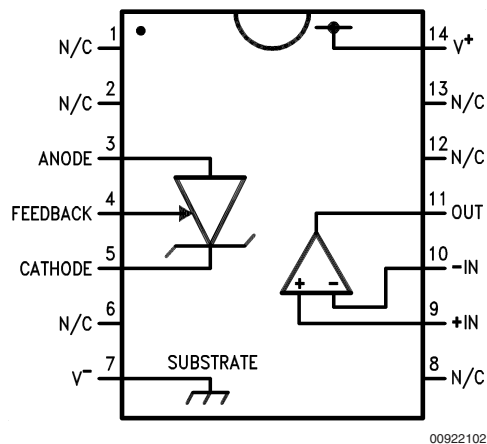
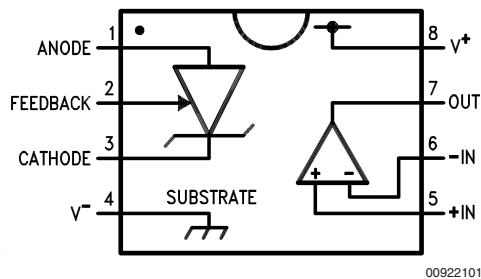
REFERENCE

- Adjustable output voltage: 1.2V to 6.3V
- Tight initial tolerance available: ±0.6%
- Wide operating current range: 17 μA 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



Super-Block™ is a trademark of National Semiconductor Corporation.

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Voltage on Any Pins Except V_R (referred to V^- pin) (Note 2)	36V (Max) -0.3V (Min)
Current through Any Input Pin and V_R Pin	± 20 mA
Differential Input Voltage Military and Industrial Commercial	± 36 V ± 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 (Note 3)	
N Package	100°C/W
M Package	150°C/W
Soldering Information Soldering (10 seconds)	
N Package	260°C
M Package	220°C
ESD Tolerance (Note 4)	± 1 kV

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

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

Symbol	Parameter	Conditions	Typical (Note 5)	LM611AM LM611AI Limits (Note 6)	LM611M LM611BI LM611I LM611C Limits (Note 6)	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	(Note 6)	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			$\text{M}\Omega$
		Common-Mode	3800			$\text{M}\Omega$
C_{IN}	Input Capacitance	Common-Mode	5.7			pF
e_n	Voltage Noise	$f = 100$ Hz, Input Referred	74			$\text{nV}/\sqrt{\text{Hz}}$
I_n	Current Noise	$f = 100$ Hz, Input Referred	58			$\text{fA}/\sqrt{\text{Hz}}$

Electrical Characteristics (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 (Note 5)	LM611AM	LM611M	Units
				LM611AI Limits (Note 6)	LM611BI LM611I LM611C Limits (Note 6)	
OPERATIONAL AMPLIFIER						
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	$V^+ = 30\text{V}$ (Note 7)	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
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	(Note 8)	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	(Note 9)	10	80	150	PPM/ $^\circ\text{C}$ max
$\frac{\Delta V_{\text{R}}}{\Delta T_{\text{J}}}$	Hysteresis	Hyst = $(V_{\text{ro}'} - V_{\text{ro}})/\Delta T_{\text{J}}$ (Note 10)	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
		$V_{\text{R}(10\ \text{mA})} - V_{\text{R}(100\ \mu\text{A})}$ (Note 11)	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

Electrical Characteristics (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 (Note 5)	LM611AM LM611AI Limits (Note 6)	LM611M LM611BI LM611I LM611C Limits (Note 6)	Units
VOLTAGE REFERENCE						
$\frac{\Delta V_{\text{R}}}{\Delta V^+}$	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}

Note 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.

Note 2: 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.

Note 3: Junction temperature may be calculated using $T_{\text{J}} = T_{\text{A}} + P_{\text{D}} \theta_{\text{JA}}$. 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 $90^\circ\text{C}/\text{W}$ for the N package and $135^\circ\text{C}/\text{W}$ for the M package.

Note 4: Human body model, 100 pF discharged through a 1.5 k Ω resistor.

Note 5: 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.

Note 6: All limits are guaranteed at room temperature (standard type face) or at operating temperature extremes (**bold face type**).

Note 7: 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.

Note 8: V_{R} is the cathode-feedback voltage, nominally 1.244V.

Note 9: 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 guaranteed by design and sample testing.

Note 10: Hysteresis is the change in V_{R} caused by a change in T_{J} , after the reference has been "dehysteresized". To dehysteresize 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 .

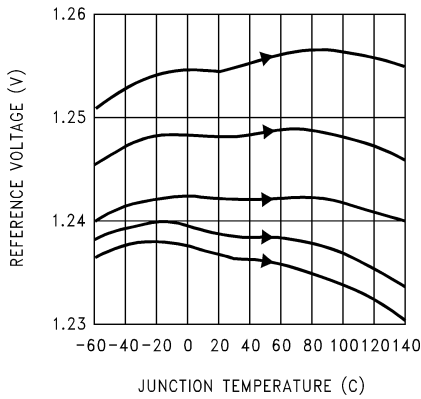
Note 11: Low contact resistance is required for accurate measurement.

Note 12: Military RETS 611AMX electrical test specification is available on request. The LM611AMJ/883 can also be procured as a Standard Military Drawing.

Typical Performance Characteristics (Reference)

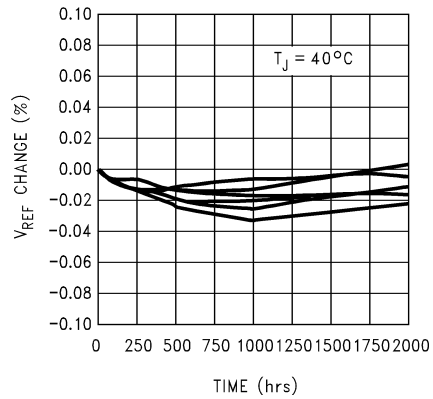
$T_J = 25^\circ\text{C}$, FEEDBACK pin shorted to $V^- = 0\text{V}$, unless otherwise noted

Reference Voltage vs Temp on 5 Representative Units



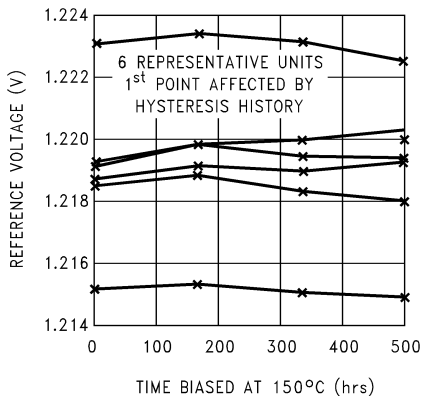
00922133

Reference Voltage Drift



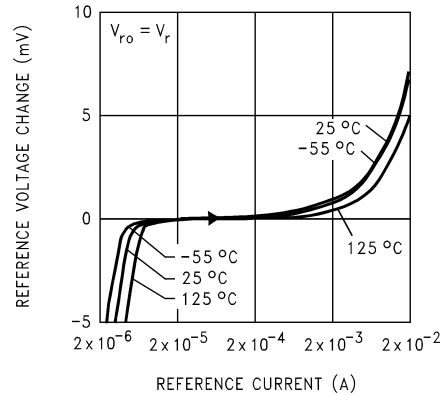
00922134

Accelerated Reference Voltage Drift vs Time



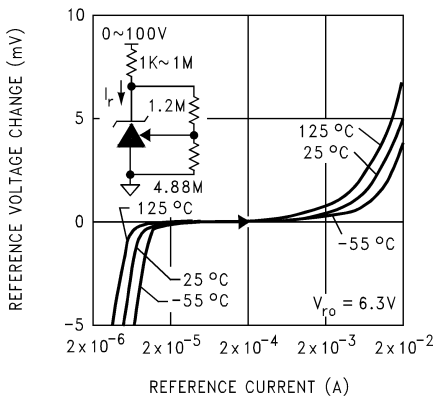
00922135

Reference Voltage vs Current and Temperature



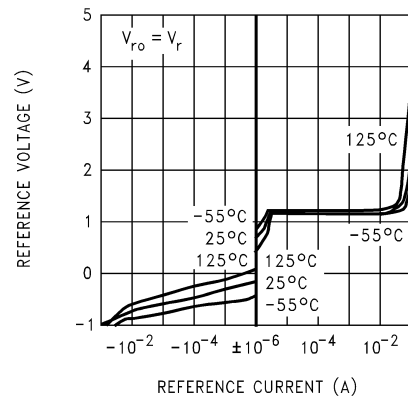
00922136

Reference Voltage vs Current and Temperature



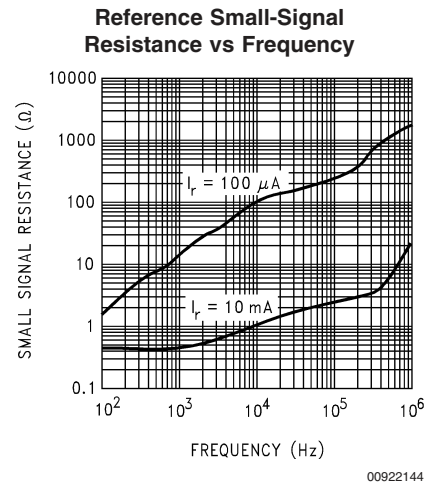
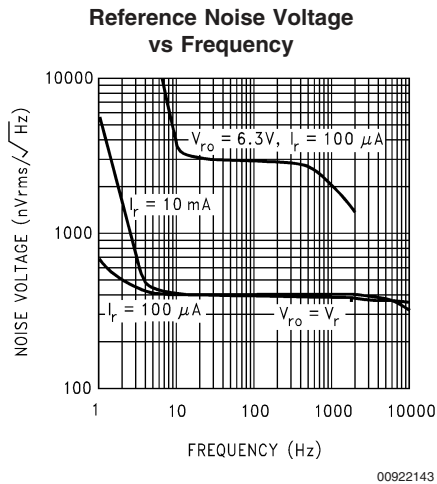
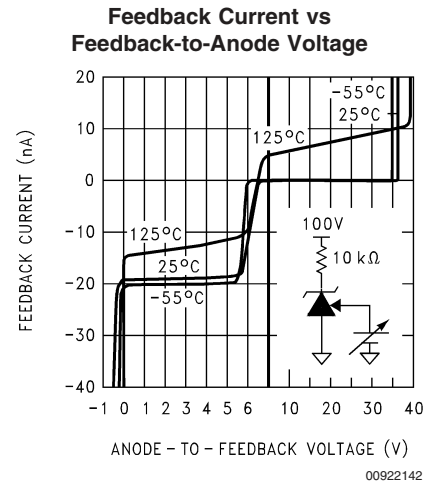
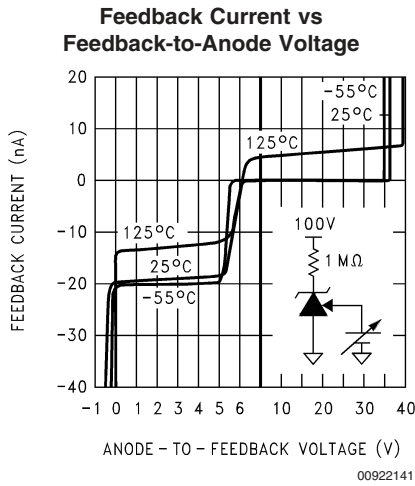
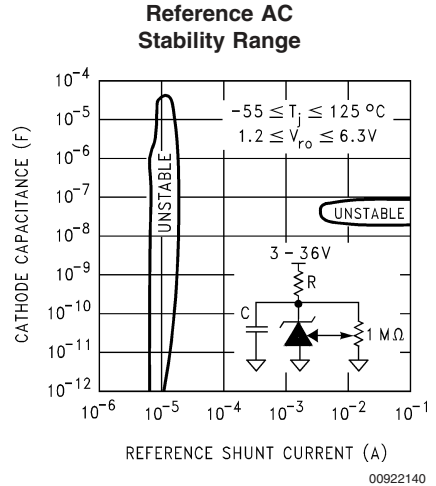
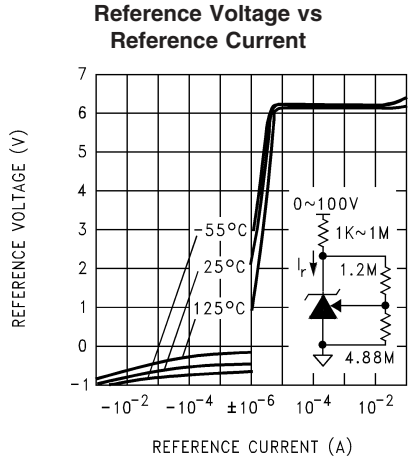
00922137

Reference Voltage vs Reference Current

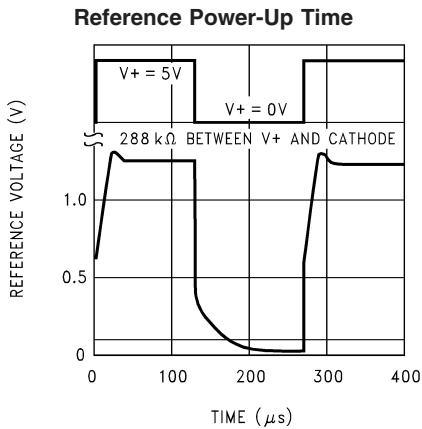


00922138

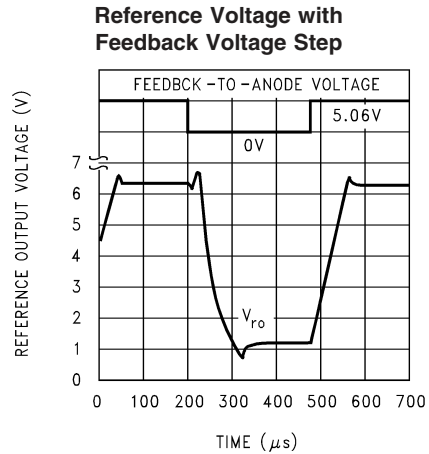
Typical Performance Characteristics (Reference) $T_J = 25^\circ\text{C}$, FEEDBACK pin shorted to $V^- = 0\text{V}$, unless otherwise noted (Continued)



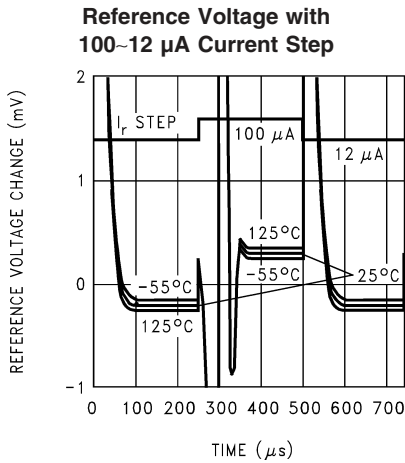
Typical Performance Characteristics (Reference) $T_J = 25^\circ\text{C}$, FEEDBACK pin shorted to $V^- = 0\text{V}$, unless otherwise noted (Continued)



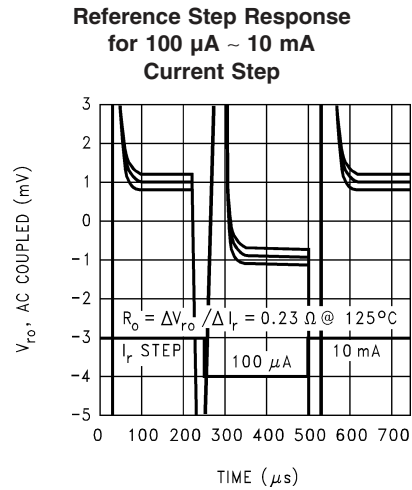
00922145



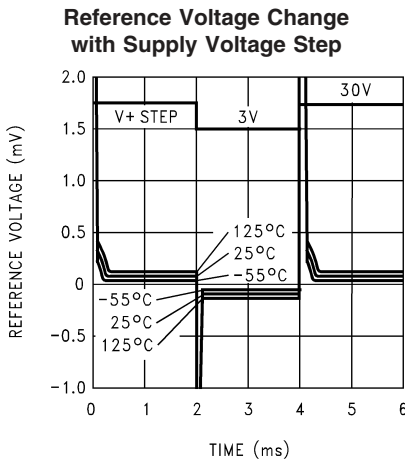
00922146



00922147



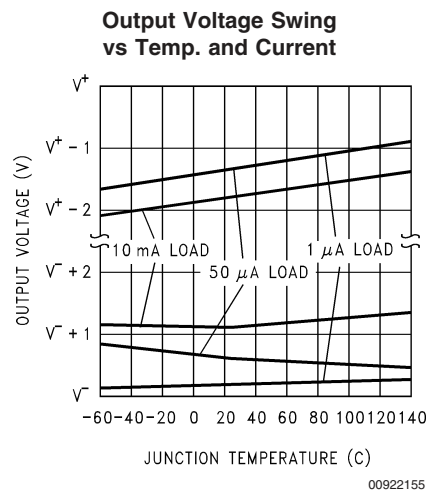
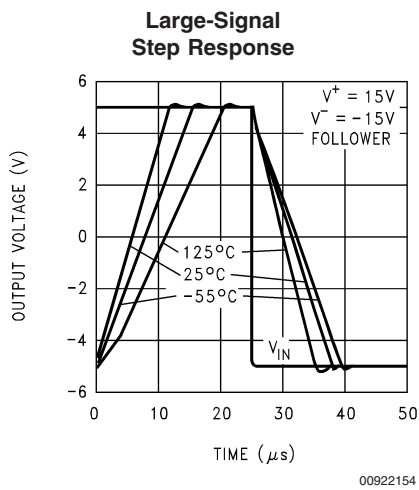
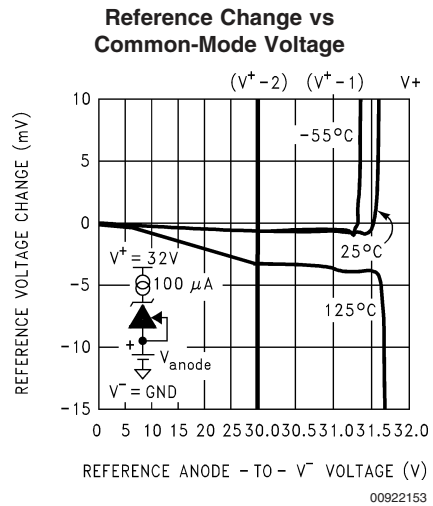
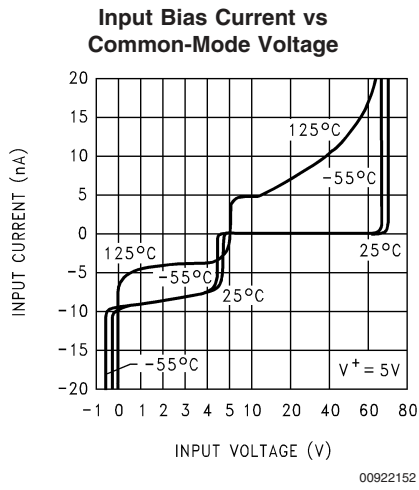
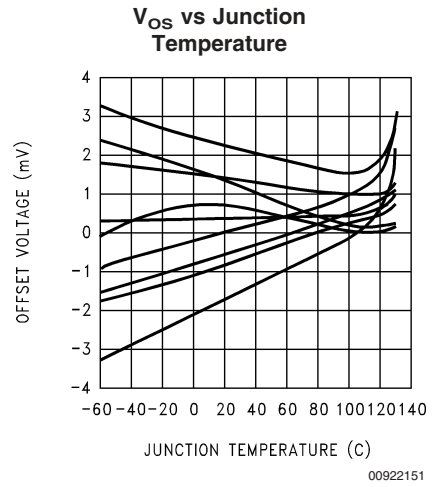
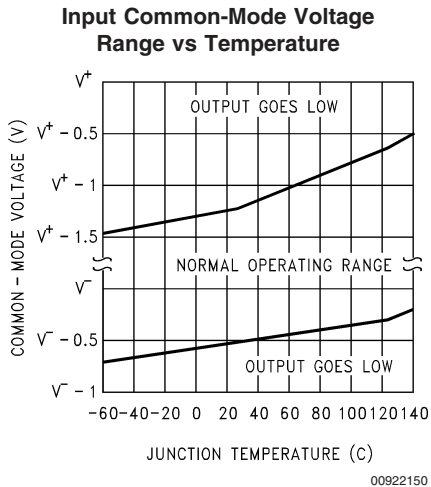
00922148



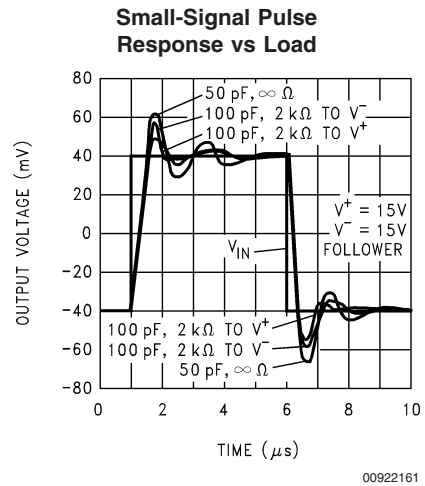
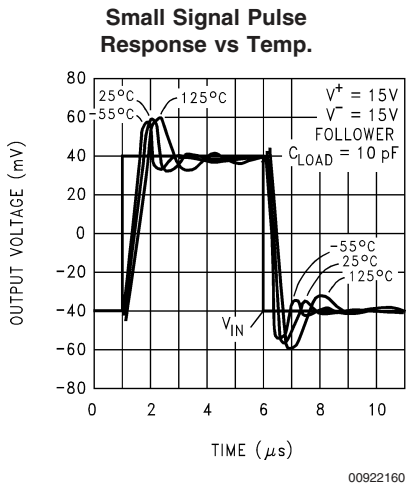
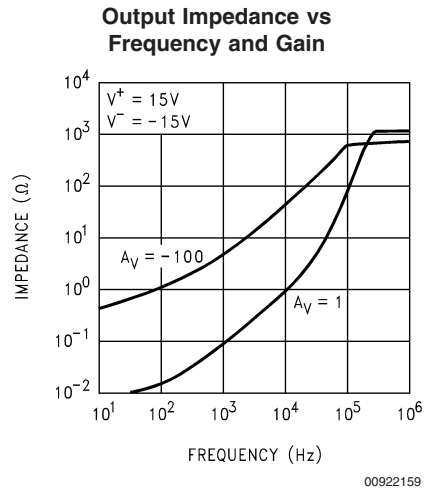
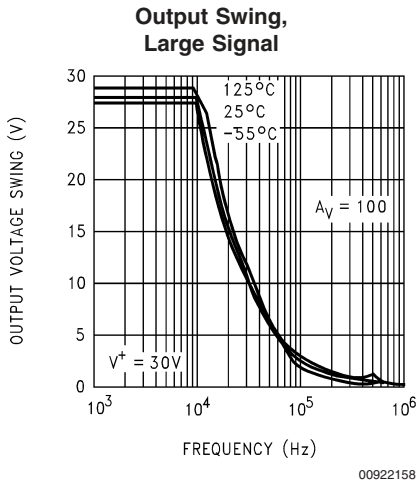
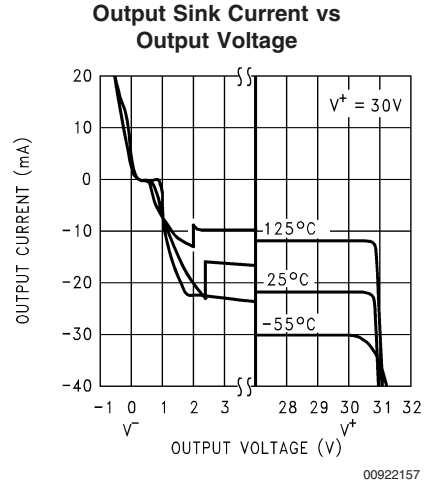
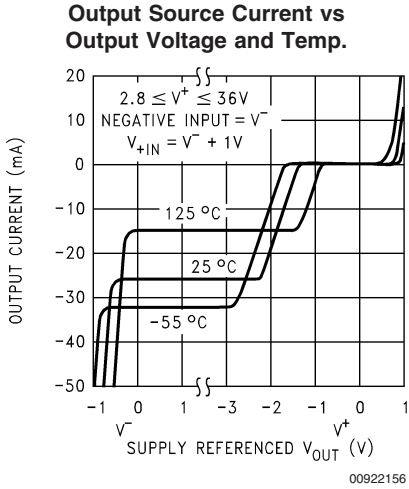
00922149

Typical Performance Characteristics (Op Amps)

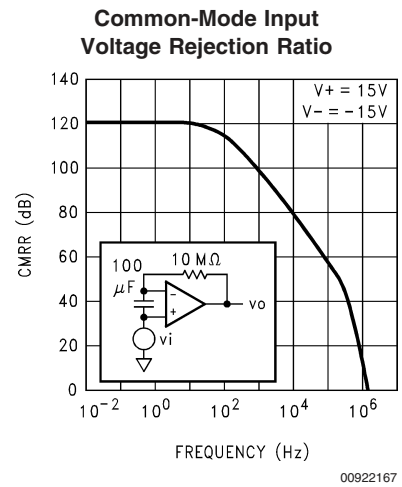
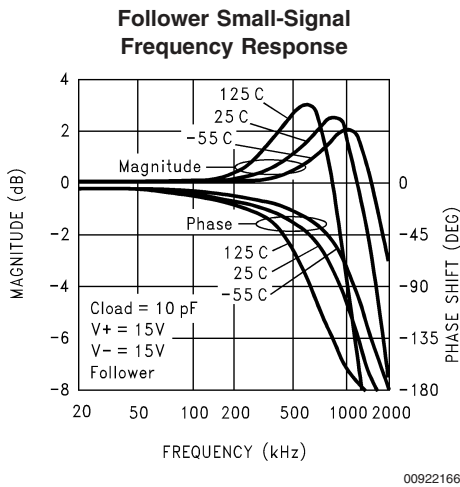
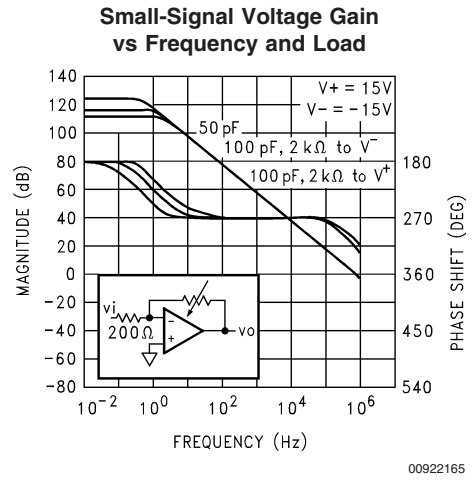
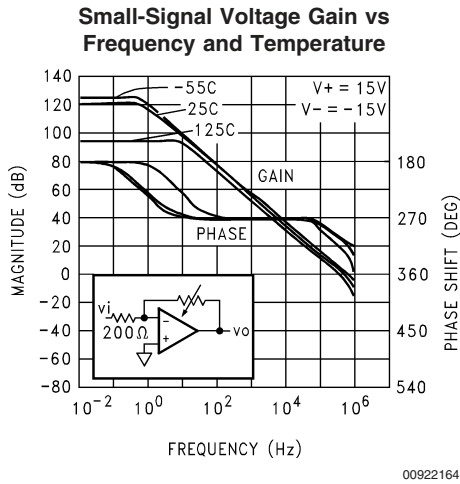
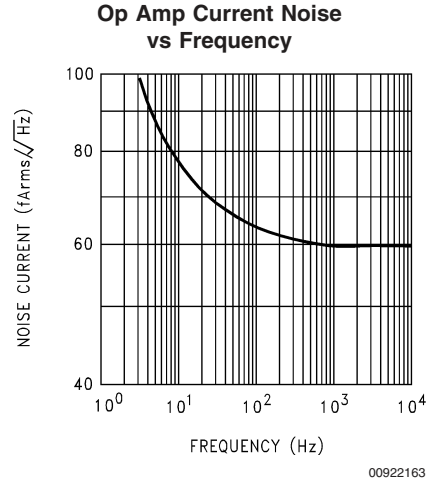
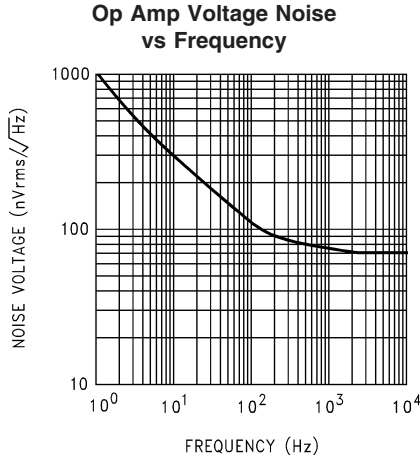
$V^+ = 5V$, $V^- = GND = 0V$, $V_{CM} = V^+/2$, $V_{OUT} = V^+/2$, $T_J = 25^\circ C$, unless otherwise noted



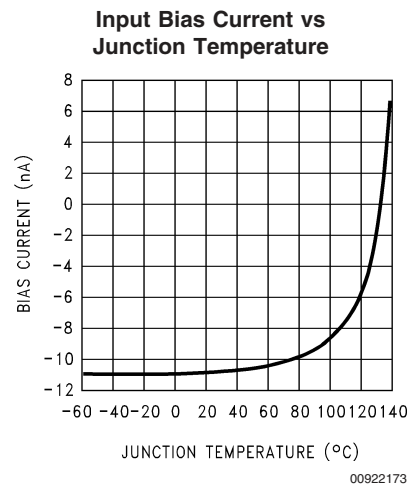
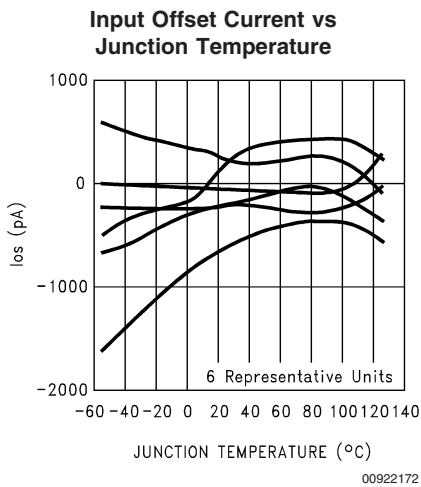
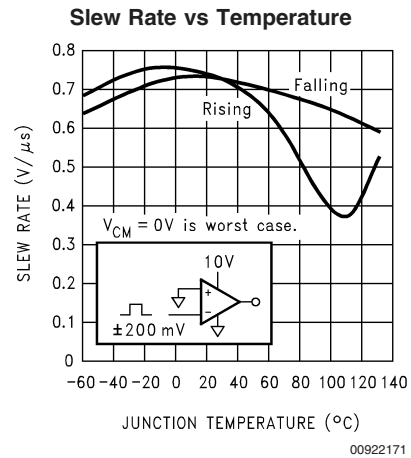
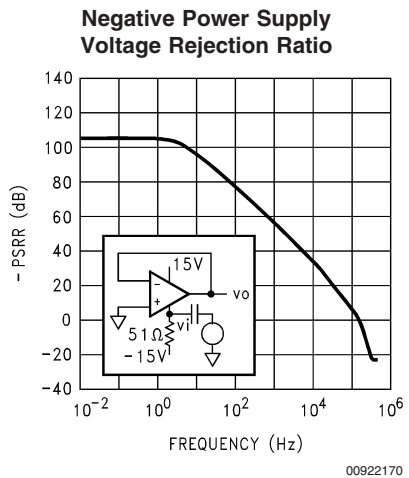
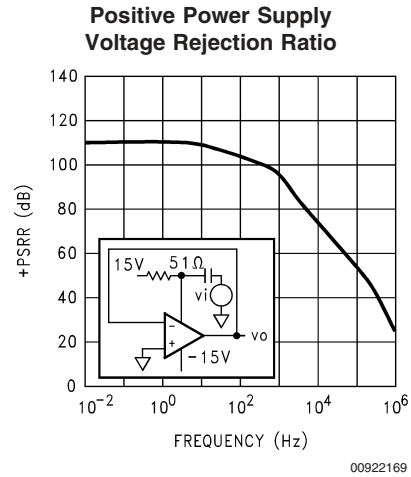
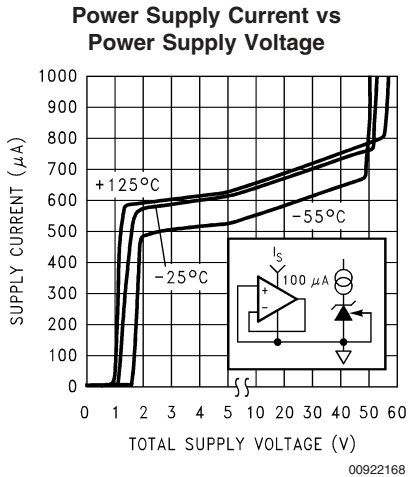
Typical Performance Characteristics (Op Amps) $V^+ = 5V, V^- = GND = 0V, V_{CM} = V^+/2, V_{OUT} = V^+/2, T_J = 25^\circ C$, unless otherwise noted (Continued)



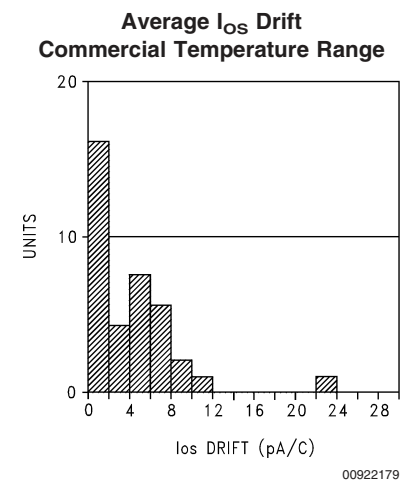
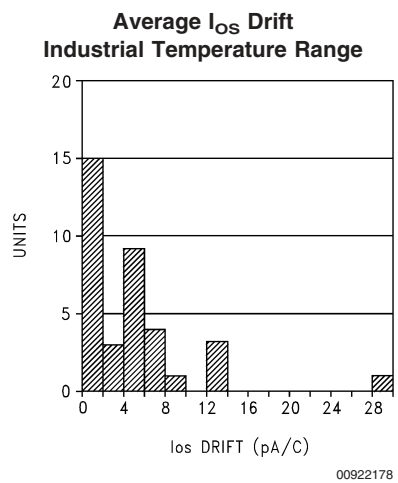
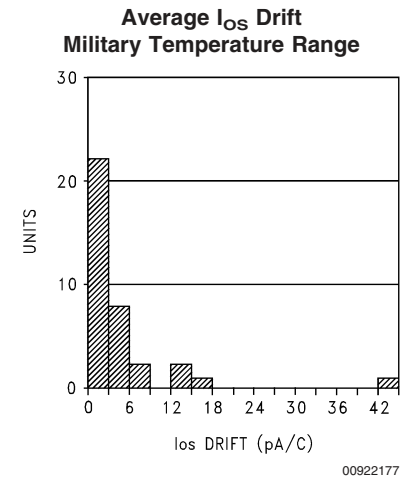
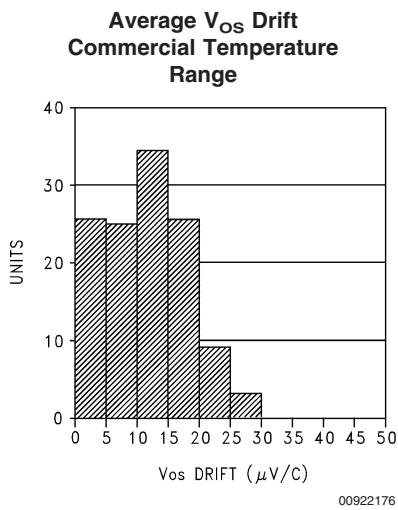
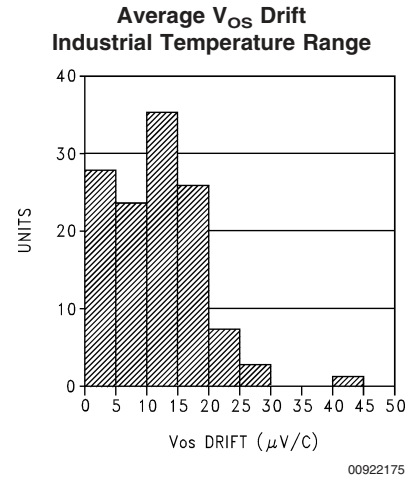
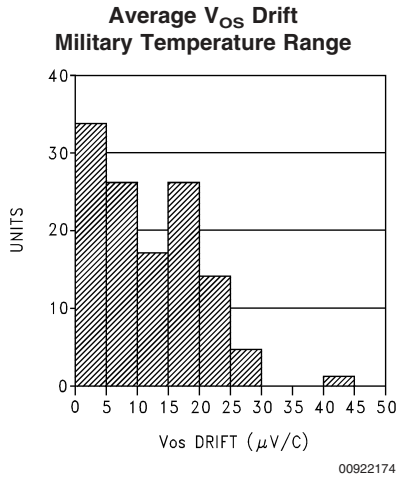
Typical Performance Characteristics (Op Amps) $V^+ = 5V$, $V^- = GND = 0V$, $V_{CM} = V^+/2$, $V_{OUT} = V^+/2$, $T_J = 25^\circ C$, unless otherwise noted (Continued)



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 (Continued)



Typical Performance Distributions



Typical Performance Distributions (Continued)

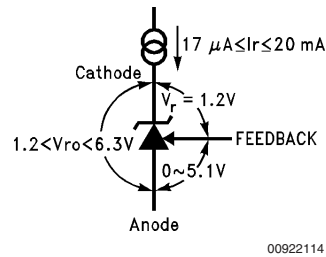
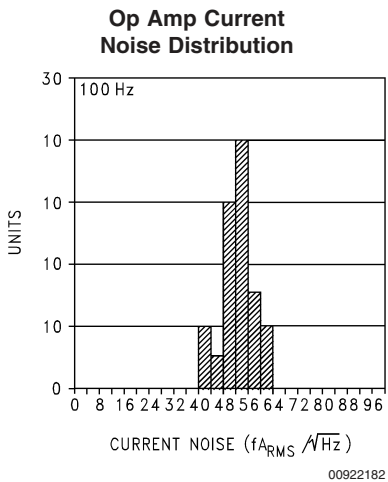
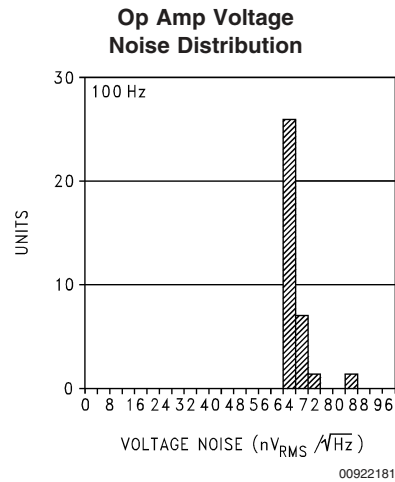
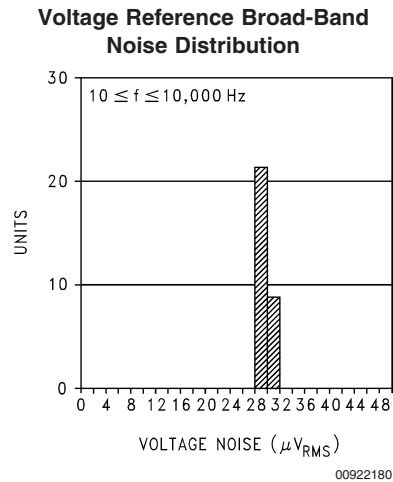


FIGURE 1. Voltages Associated with Reference (Current I_r is External)

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 .

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.

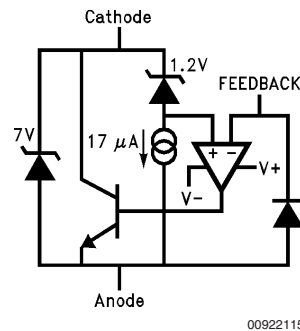


FIGURE 2. Reference Equivalent Circuit

Application Information (Continued)

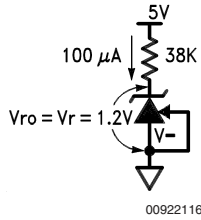


FIGURE 3. 1.2V Reference

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 $V_{ro} = V_r = 1.24V$. For higher voltages FEEDBACK is held at a constant voltage above Anode—say 3.76V for $V_{ro} = 5V$. 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— $I \geq 32 \mu A$ for the military grade over the military temperature range ($I \geq 5.5 \mu A$ for a 1% untrimmed error for a commercial part.)

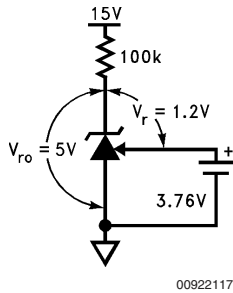
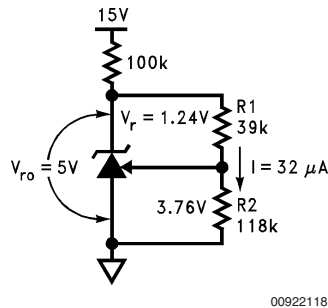


FIGURE 4. Thevenin Equivalent of Reference with 5V Output



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

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

FIGURE 5. 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.

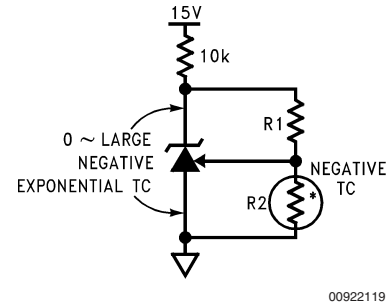


FIGURE 6. Output Voltage has Negative Temperature Coefficient (TC) if R2 has Negative TC

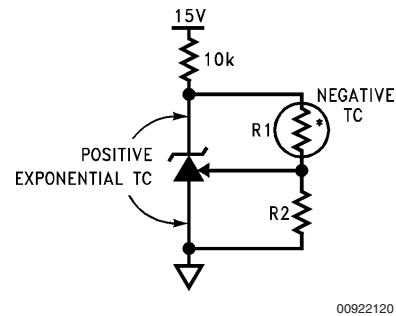


FIGURE 7. Output Voltage has Positive TC if R1 has Negative TC

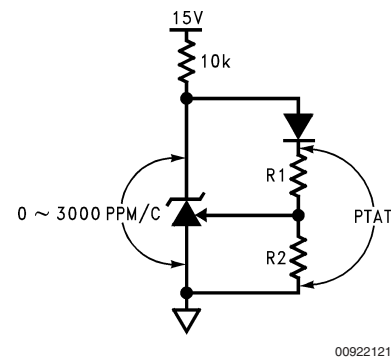
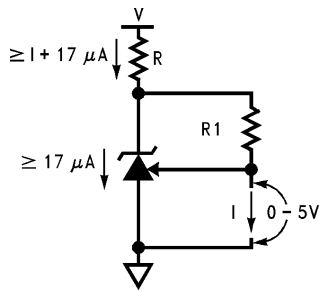


FIGURE 8. Diode in Series with R1 Causes Voltage Across R1 and R2 to be Proportional to Absolute Temperature (PTAT)

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

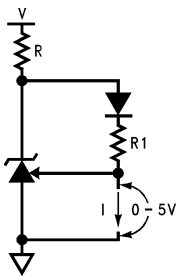
Application Information (Continued)



00922122

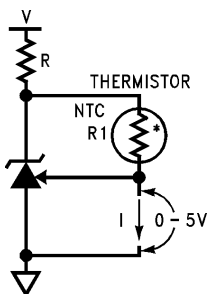
$$I = V_r/R1 = 1.24/R1$$

FIGURE 9. Current Source is Programmed by R1



00922123

FIGURE 10. Proportional-to-Absolute-Temperature Current Source



00922124

FIGURE 11. 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 Guaranteed Electrical Characteristics Note 1). 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

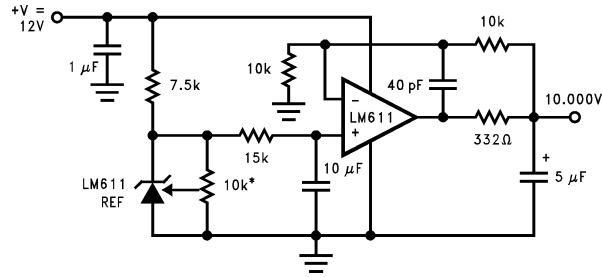
The op amp, like the LM124 series, has a flexible and relatively wide-swing output stage. There are simple rules to optimize output swing, reduce cross-over distortion, and optimize capacitive drive capability:

1. Output Swing: Unloaded, the $42 \mu\text{A}$ pull-down will bring the output within 300 mV of V^- over the military temperature range. If more than $42 \mu\text{A}$ 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 characteristic 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_o until the output resistance is that of the current limit 25Ω . 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.

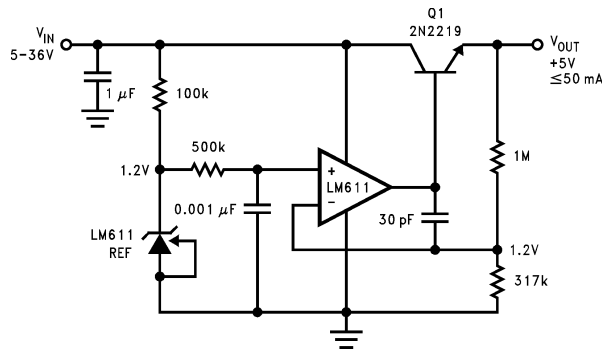
Typical Applications



00922128

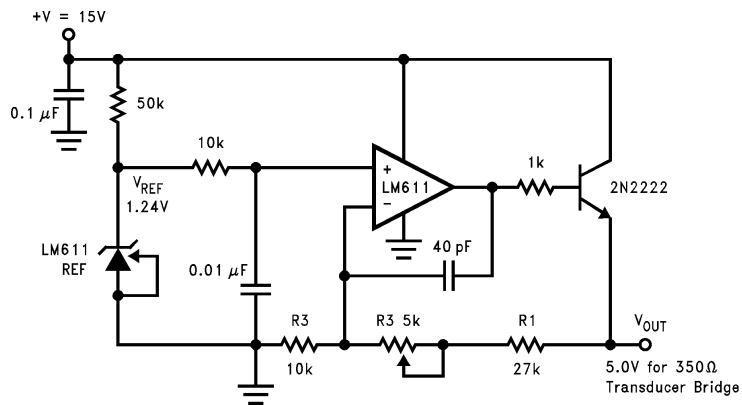
*10k must be low
t.c. trim pot.

FIGURE 12. Ultra Low Noise 10.00V Reference.
Total Output Noise is Typically $14 \mu\text{V}_{\text{RMS}}$.
Adjust the 10k pot for 10.000V.



00922130

FIGURE 13. Simple Low Quiescent Drain Voltage Regulator. Total Supply Current is approximately $320 \mu\text{A}$ when $V_{\text{IN}} = 5\text{V}$, and output has no load.

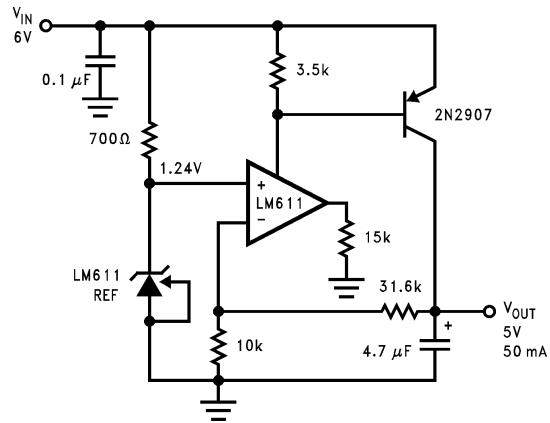


00922129

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

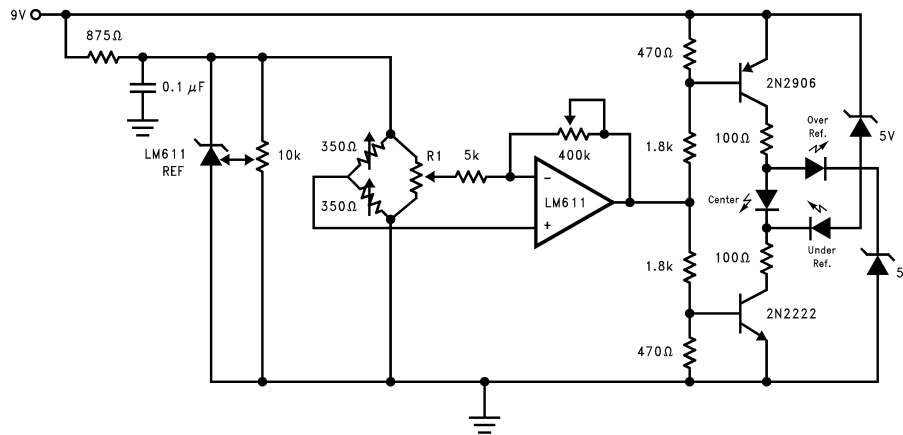
**FIGURE 14. Slow Rise-Time Upon Power-Up,
Adjustable Transducer Bridge Driver.**
Rise-time is approximately 0.5 ms.

Typical Applications (Continued)



00922131

FIGURE 15. Low Drop-Out Voltage Regulator Circuit. Drop out voltage is typically 0.2V.

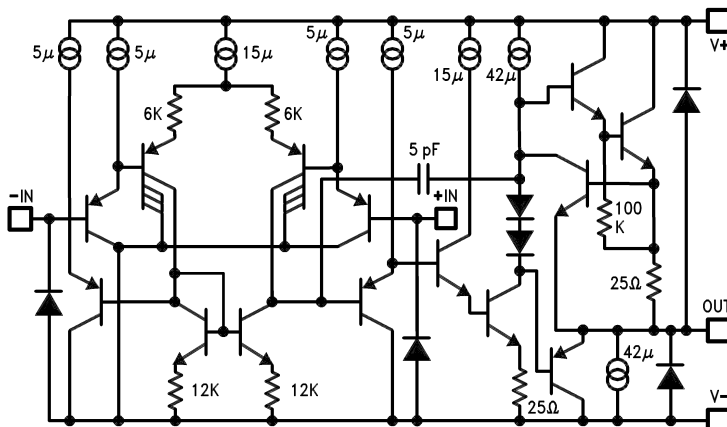


00922132

FIGURE 16. Nulling Bridge Detection System. Adjust sensitivity via 400 k Ω pot. Null offset with R1, and bridge drive with the 10k pot.

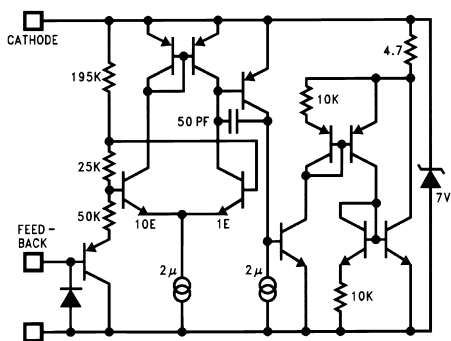
Simplified Schematic Diagrams

Op Amp



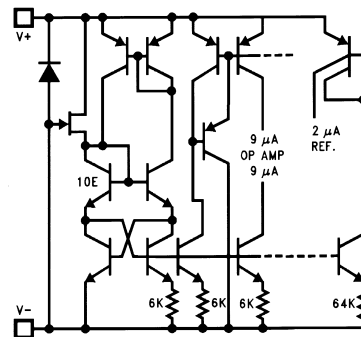
00922103

Reference



00922191

Bias



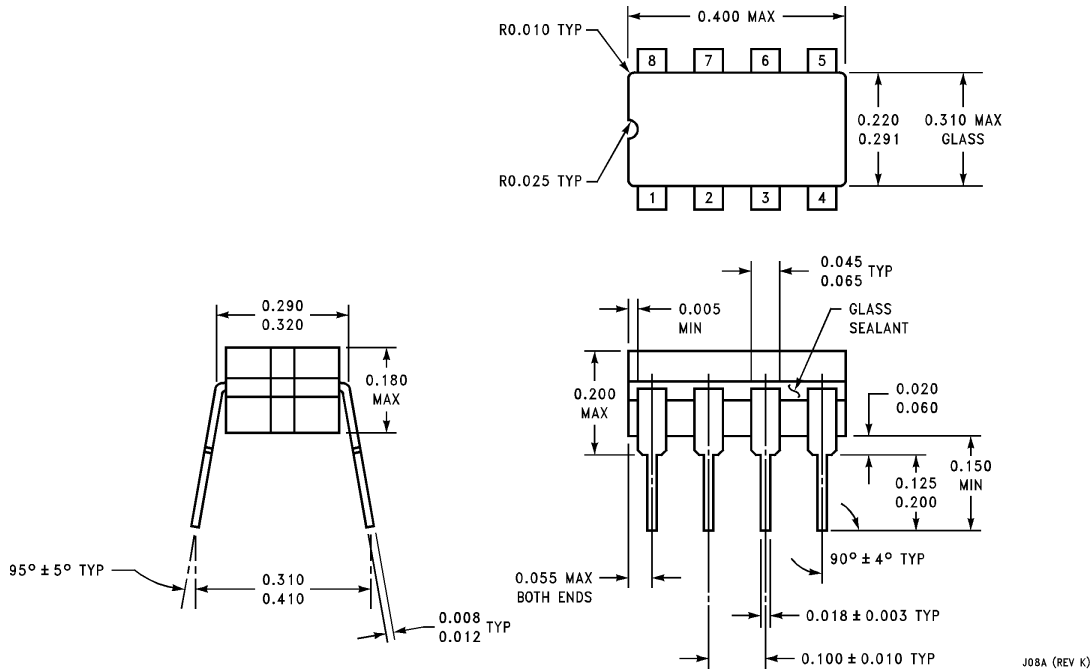
00922192

Ordering Information

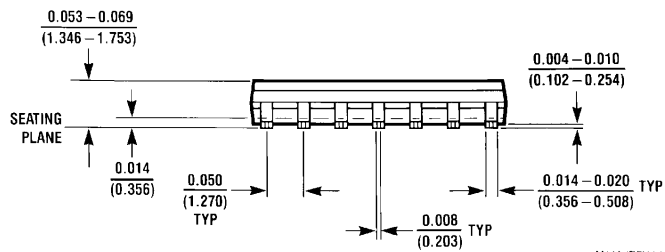
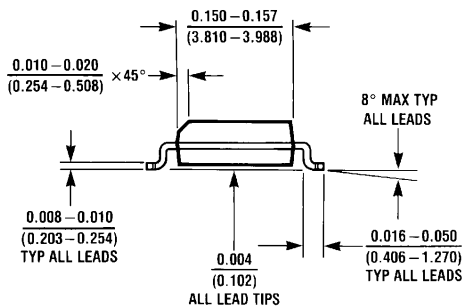
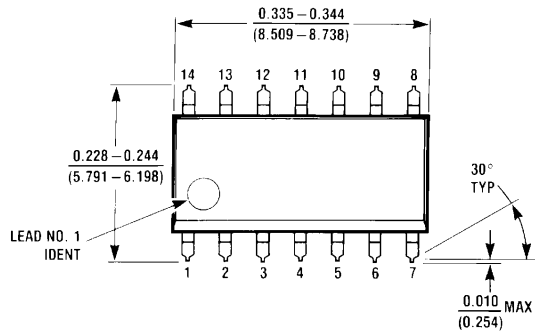
Reference Tolerance & V_{OS}	Temperature Range			Package	NSC Drawing
	Military $-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$	Industrial $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$	Commercial $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$		
$\pm 0.6\%$ @ 80 ppm/ $^{\circ}\text{C}$ max $V_{OS} = 3.5\text{ mV}$ max	LM611AMJ/883 (Note 12)	—	—	8-pin ceramic DIP	J08A
$\pm 2.0\%$ @ 150 ppm/ $^{\circ}\text{C}$ max $V_{OS} = 5\text{ mV}$ max	—	LM611IM LM611IMX	LM611CM LM611CMX	14-pin Narrow Surface Mount	M14A

Physical Dimensions inches (millimeters)

unless otherwise noted



Hermetic Dual-In-Line Package (J)
Order Number LM611AMJ/883
NS Package Number J08A



Plastic Surface Mount Narrow Package (0.15) (M)
Order Number LM611CM, LM611CMX, LM611IM or LM611IMX
NS Package Number M14A

Notes

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

BANNED SUBSTANCE COMPLIANCE

National Semiconductor certifies that the products and packing materials meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no "Banned Substances" as defined in CSP-9-111S2.



National Semiconductor
Americas Customer
Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959

www.national.com

National Semiconductor
Europe Customer Support Center
Fax: +49 (0) 180-530 85 86
Email: europa.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor
Asia Pacific Customer
Support Center
Email: ap.support@nsc.com

National Semiconductor
Japan Customer Support Center
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

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

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

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI 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 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. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

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 Mobile Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

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
Transportation and Automotive	www.ti.com/automotive
Video and Imaging	www.ti.com/video

TI E2E Community Home Page

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2011, Texas Instruments Incorporated