National Semiconductor

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LM614
Quad Operational Amplifier and Adjustable Reference

General Description

The LM614 consists of four op-amps and a programmable voltage reference in a 16-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 four wide output swing op-amps makes the LM614 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), initial tolerance (2.0%), and the ability to be programmed from 1.2V to 5.0V 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 new Super-Block™ family, the LM614 is a space-saving monolithic alternative to a multichip solution, offering a high level of integration without sacrificing performance.

Features

Op Amp

- Low operating current: 450µA
- Wide supply voltage range: 4V to 36V
- Wide common-mode range: V^- to (V^+− 1.8V)
- Wide differential input voltage: ±36V

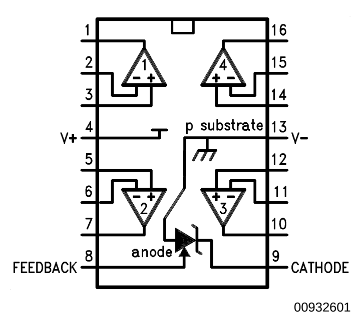
Reference

- Adjustable output voltage: 1.2V to 5.0V
- Initial tolerance: ±2.0%
- Wide operating current range: 17µA to 20mA
- Tolerant of load capacitance

Applications

- Transducer bridge driver and signal processing
- Process and mass flow control systems
- Power supply voltage monitor
- Buffered voltage references for A/D's

Connection Diagram



Ordering Information

Package	Temperature Range	Part Number	Package Marking	Transport Media	NSC Drawing
16-Pin Wide Body SOIC	0˚C to 70˚C	LM614CWM	LM614CWM	Rails	M16B
		LM614CWMX	LM614CWM	1k Units Tape and Reel	
	−40˚C to 85˚C	LM614IWM	LM614IWM	Rails	
		LM614IWMX	LM614IWM	1k Units Tape and Reel	

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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)
(Note 3)	−0.3V (Min)
Current through Any Input Pin &	
V_R Pin	±20 mA
Differential Input Voltage	
LM614I	±36V
LM614C	±32V
Storage Temperature Range	$-65°C \leq T_J \leq +150°C$
Maximum Junction Temperature	150˚C
Thermal Resistance,	
Junction-to-Ambient (Note 4)	150˚C
Soldering Information (Soldering,	
10 sec.)	220˚C
ESD Tolerance (Note 5)	±1kV

Operating Temperature Range

LM614I	$-40°C \leq T_J \leq +85°C$
LM614C	$0°C \leq T_J \leq +70°C$

Electrical Characteristics

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

Symbol	Parameter	Conditions	Typ (Note 6)	**LM614I LM614C Limits** (Note 7)	Units
I_S	Total Supply Current	$R_{LOAD} = \infty$,	450	1000	µA max
		$4V \leq V^+ \leq 36V$ (32V for LM614C)	**550**	**1070**	µA max
V_S	Supply Voltage Range		2.2	2.8	V min
			2.9	**3**	V min
			46	32	V max
			43	**32**	V max
OPERATIONAL AMPLIFIER					
V_{OS1}	V_{OS} Over Supply	$4V \leq V^+ \leq 36V$	1.5	5.0	mV max
		($4V \leq V^+ \leq 32V$ for LM614C)	**2.0**	**7.0**	mV max
V_{OS2}	V_{OS} Over V_{CM}	V_{CM} = 0V through V_{CM} =	1.0	5.0	mV max
		(V^+ − 1.8V), V^+ = 30V	**1.5**	**7.0**	mV max
$\frac{V_{OS3}}{\Delta T}$	Average V_{OS} Drift	(Note 7)	**15**		µV/˚C max
I_B	Input Bias Current		10	35	nA max
			11	**40**	nA max
I_{OS}	Input Offset Current		0.2	4	nA max
			0.3	**5**	nA max
$\frac{I_{OS1}}{\Delta T}$	Average Offset Drift Current		**4**		pA/˚C
R_{IN}	Input Resistance	Differential	1800		MΩ
		Common-Mode	3800		MΩ
C_{IN}	Input Capacitance	Common-Mode Input	5.7		pF
e_n	Voltage Noise	f = 100 Hz, Input Referred	74		$nV/\sqrt{Hz}$
I_n	Current Noise	f = 100 Hz, Input Referred	58		$fA/\sqrt{Hz}$
CMRR	Common-Mode Rejection Ratio	V^+ = 30V, $0V \leq V_{CM} \leq (V^+ - 1.8V)$,	95	75	dB min
		CMRR = 20 log ($\Delta V_{CM}/\Delta V_{OS}$)	**90**	**70**	dB min
PSRR	Power Supply Rejection Ratio	$4V \leq V^+ \leq 30V$, $V_{CM} = V^+/2$,	110	75	dB min
		PSRR = 20 log ($\Delta V^+/\Delta V_{OS}$)	**100**	**70**	dB min

Electrical Characteristics (Continued)

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

Symbol	Parameter	Conditions	Typ (Note 6)	LM614I LM614C Limits (Note 7)	Units
A_V	Open Loop Voltage Gain	R_L = 10 kΩ to GND, V^+ = 30V, 5V ≤ V_{OUT} ≤ 25V	500 **50**	94 **40**	V/mV min
SR	Slew Rate	V^+ = 30V (Note 8)	±0.70 **±0.65**	±0.50 **±0.45**	V/µs
GBW	Gain Bandwidth	C_L = 50 pF	0.8 **0.52**		MHz MHz
V_{O1}	Output Voltage Swing High	R_L = 10 kΩ to GND V^+ = 36V (32V for LM614C)	V^+ − 1.4 **V^+ − 1.6**	V^+ − 1.8 **V^+ − 1.9**	V min V min
V_{O2}	Output Voltage Swing Low	R_L = 10 kΩ to V^+ V^+ = 36V (32V for LM614C)	V^- + 0.8 **V^- + 0.9**	V^- + 0.95 **V^- + 1.0**	V max V max
I_{OUT}	Output Source	V_{OUT} = 2.5V, V_{+IN} = 0V, V_{-IN} = −0.3V	25 **15**	16 **13**	mA min mA min
I_{SINK}	Output Sink Current	V_{OUT} = 1.6V, V_{+IN} = 0V, V_{-IN} = 0.3V	17 **9**	13 **8**	mA min mA min
I_{SHORT}	Short Circuit Current	V_{OUT} = 0V, V_{+IN} = 3V, V_{-IN} = 2V, Source	30 **40**	50 **60**	mA max mA max
		V_{OUT} = 5V, V_{+IN} = 2V, V_{-IN} = 3V, Sink	30 **32**	70 **90**	mA max mA max
VOLTAGE REFERENCE					
V_R	Voltage Reference	(Note 9)	1.244	1.2191 1.2689 (±2.0%)	V min V max
$\frac{\Delta V_R}{\Delta T}$	Average Temperature Drift	(Note 10)	**10**	**150**	PPM/°C max
$\frac{\Delta V_R}{\Delta T_J}$	Hysteresis	(Note 11)	**3.2**		µV/°C
$\frac{\Delta V_R}{\Delta I_R}$	V_R Change with Current	$V_{R(100\ \mu A)} - V_{R(17\ \mu A)}$	0.05 **0.1**	1 **1.1**	mV max mV max
		$V_{R(10\ mA)} - V_{R(100\ \mu A)}$ (Note 12)	1.5 **2.0**	5 **5.5**	mV max mV max
R	Resistance	$\Delta V_{R(10 \to 0.1\ mA)}$/9.9 mA	**0.2**	**0.56**	Ω max
		$\Delta V_{R(100 \to 17\ \mu A)}$/83 µA	**0.6**	**13**	Ω max
$\frac{\Delta V_R}{\Delta V_{RO}}$	V_R Change with High V_{RO}	$V_{R(Vro\ =\ Vr)} - V_{R(Vro\ =\ 5.0V)}$ (3.76V between Anode and FEEDBACK)	2.5 **2.8**	7 **10**	mV max mV max
$\frac{\Delta V_R}{\Delta V^+}$	V_R Change with V^+ Change	$V_{R(V+\ =\ 5V)} - V_{R(V+\ =\ 36V)}$ (V^+ = 32V for LM614C)	0.1 **0.1**	1.2 **1.3**	mV max mV max
		$V_{R(V+\ =\ 5V)} - V_{R(V+\ =\ 3V)}$	0.01 **0.01**	1 **1.5**	mV max mV max
I_{FB}	FEEDBACK Bias Current	V_{ANODE} ≤ V_{FB} ≤ 5.06V	22 **29**	50 **55**	nA max nA max
e_n	Voltage Noise	BW = 10 Hz to 10 kHz,	30		μV_{RMS}

Electrical Characteristics (Continued)

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

Symbol	Parameter	Conditions	Typ (Note 6)	LM614I LM614C Limits (Note 7)	Units
		$V_{RO} = V_R$			

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: Input voltage above V^+ is allowed.

Note 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.

Note 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 comparator or reference output transistor, nominal θ_{jA} is 90˚C/W for the WM package.

Note 5: Human body model, 100 pF discharged through a 1.5 kΩ resistor.

Note 6: Typical values in standard typeface are for $T_J = 25^\circ C$; values in **boldface type** apply for the full operating temperature range. These values represent the most likely parametric norm.

Note 7: All limits are guaranteed at room temperature (standard type face) or at operating temperature extremes **(bold type face)**.

Note 8: 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 the output voltage transition is sampled at 20V and 10V.

Note 9: V_R is the Cathode-feedback voltage, nominally 1.244V.

Note 10: Average reference drift is calculated from the measurement of the reference voltage at 25˚C and at the temperature extremes. The drift, in ppm/˚C, is $10^6 \bullet \Delta V_R/(V_{R[25^\circ C]} \bullet \Delta T_J)$, where ΔV_R is the lowest value subtracted from the highest, $V_{R[25^\circ C]}$ is the value at 25˚C, and ΔT_J is the temperature range. This parameter is guaranteed by design and sample testing.

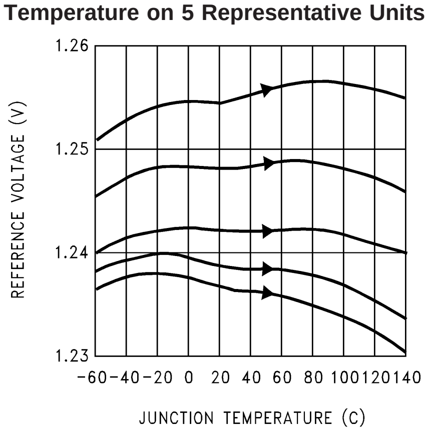
Note 11: Hysteresis is the change in V_R caused by a change in T_J, after the reference has been "dehysterized". To dehysterize the reference; that is minimize the hysteresis to the typical value, cycle its junction temperature in the following pattern, spiraling in toward 25˚C: 25˚C, 85˚C, −40˚C, 70˚C, 0˚C, 25˚C.

Note 12: Low contact resistance is required for accurate measurement.

Typical Performance Characteristics (Reference)

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

Reference Voltage vs. Temperature on 5 Representative Units



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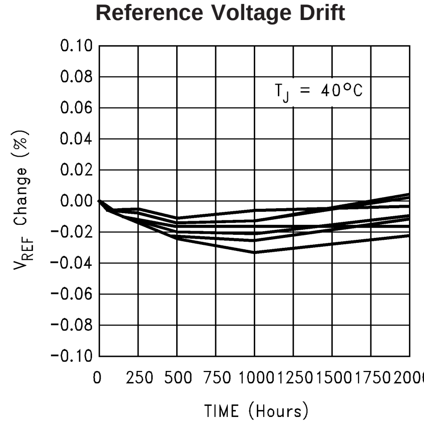
Reference Voltage Drift



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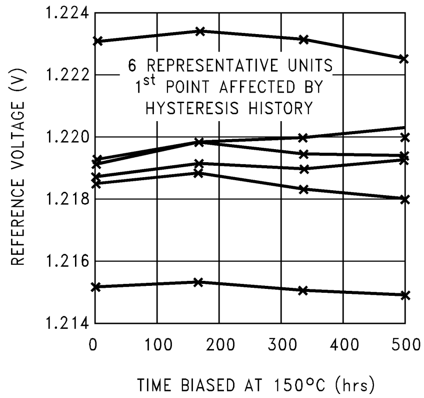
Typical Performance Characteristics (Reference) T_J = 25˚C, FEEDBACK pin shorted to V^- = 0V, unless otherwise noted (Continued)

Accelerated Reference Voltage Drift vs. Time



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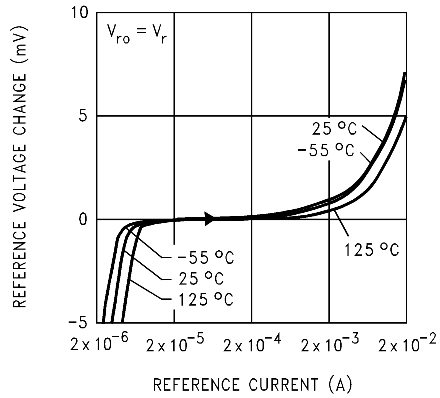
Reference Voltage vs. Current and Temperature



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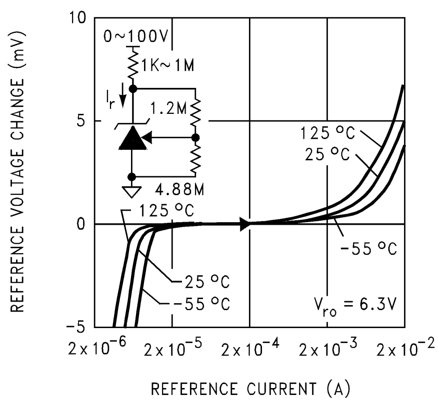
Reference Voltage vs. Current and Temperature



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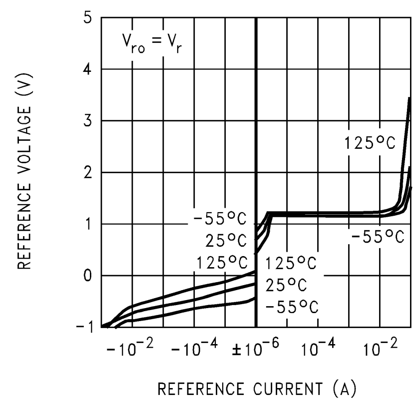
Reference Voltage vs. Reference Current



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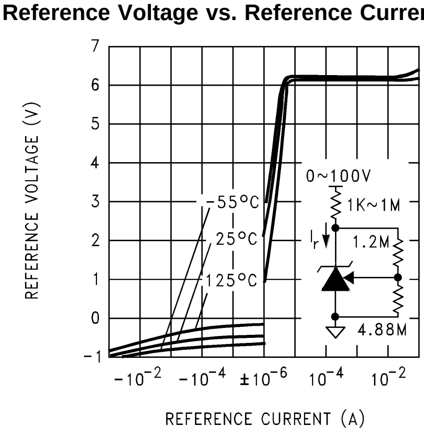
Reference Voltage vs. Reference Current



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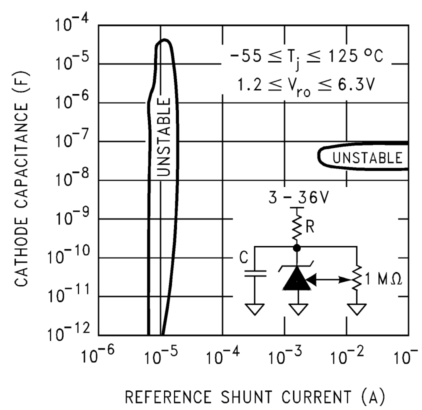
Reference AC Stability Range



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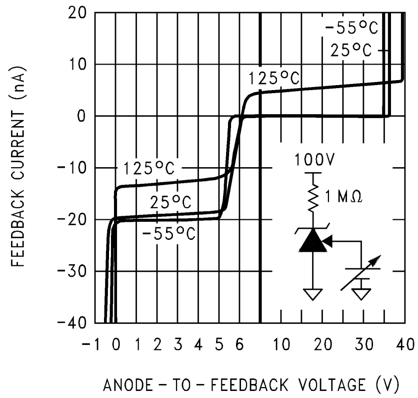
Typical Performance Characteristics (Reference)

T_J = 25˚C, FEEDBACK pin shorted to V^- = 0V, unless otherwise noted (Continued)

FEEDBACK Current vs. FEEDBACK-to-Anode Voltage



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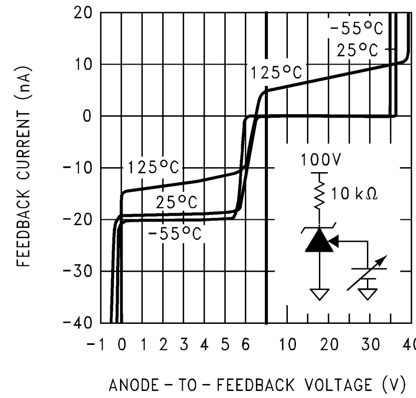
FEEDBACK Current vs. FEEDBACK-to-Anode Voltage



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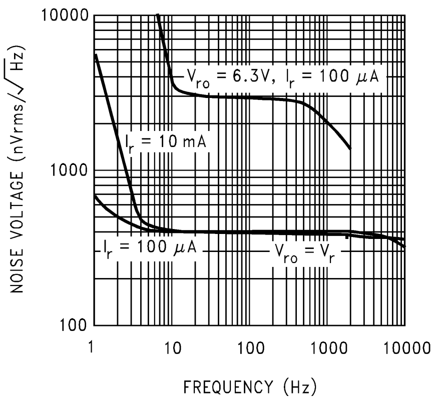
Reference Noise Voltage vs. Frequency



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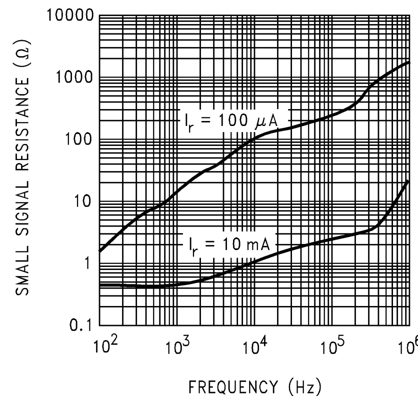
Reference Small-Signal Resistance vs. Frequency



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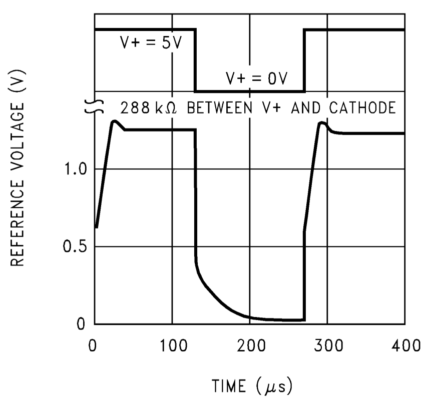
Reference Power-Up Time



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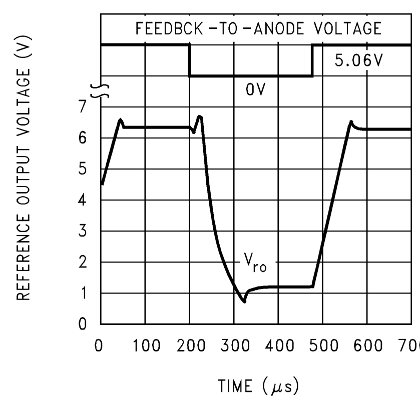
Reference Voltage with FEEDBACK Voltage Step



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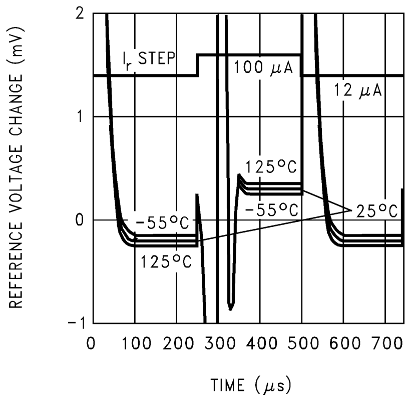
Typical Performance Characteristics (Reference) T_J = 25˚C, FEEDBACK pin shorted to V^- = 0V, unless otherwise noted (Continued)

Reference Voltage with 100~12 µA Current Step



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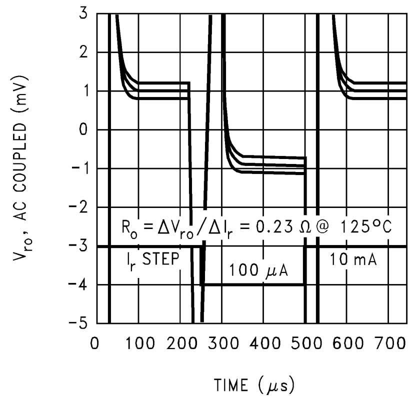
Reference Step Response for 100 µA ~ 10 mA Current Step



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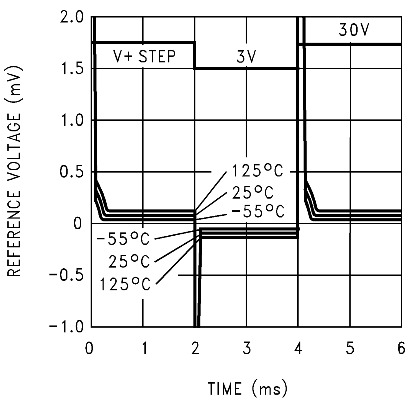
Reference Voltage Change with Supply Voltage Step



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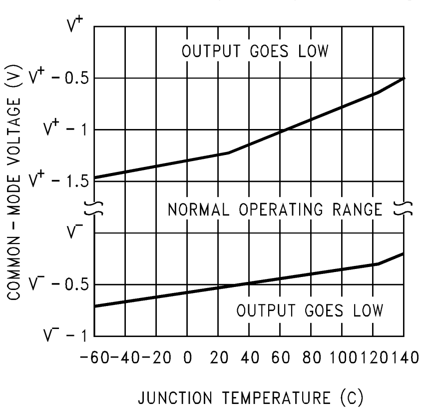
Typical Performance Characteristics (Op Amps) V^+ = 5V, V^- = GND = 0V, V_{CM} = V^+/2, V_{OUT} = V^+/2, T_J = 25˚C, unless otherwise noted

Input Common-Mode Voltage Range vs. Temperature



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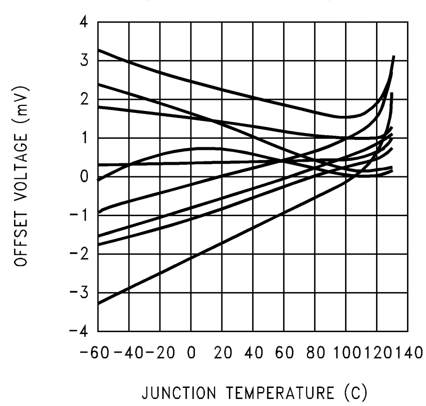
V_{OS} vs. Junction Temperature on 9 Representative Units



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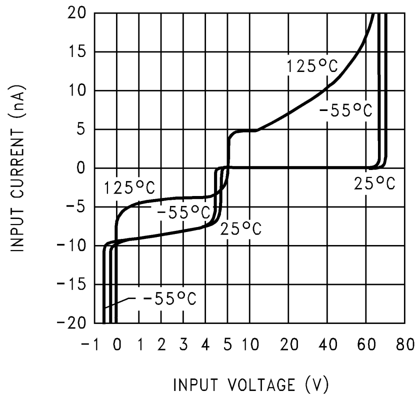
Typical Performance Characteristics (Op Amps) $V^+ = 5V$, $V^- = GND = 0V$, $V_{CM} = V^+/2$, $V_{OUT} = V^+/2$, $T_J = 25^\circ C$, unless otherwise noted (Continued)

Input Bias Current vs. Common-Mode Voltage



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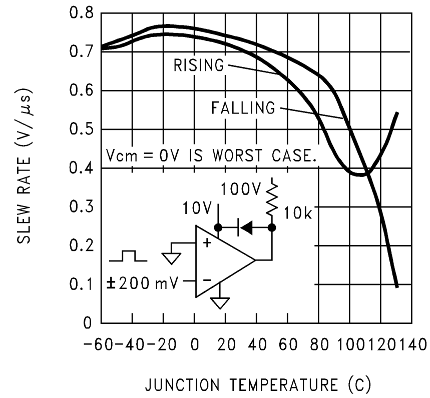
Slew Rate vs. Temperature and Output Sink Current



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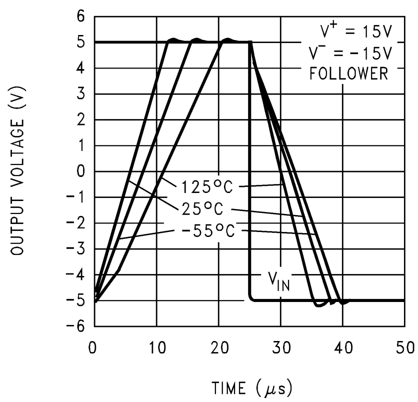
Large-Signal Step Response



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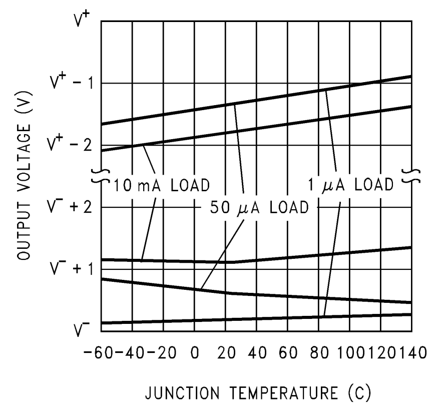
Output Voltage Swing vs. Temp. and Current



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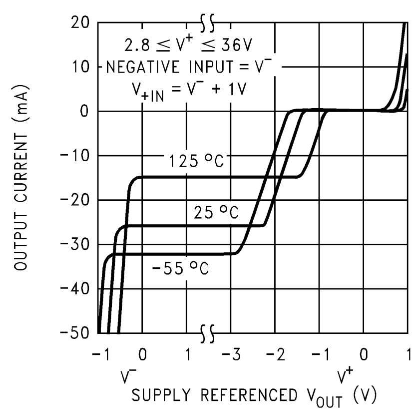
Output Source Current vs. Output Voltage and Temp.



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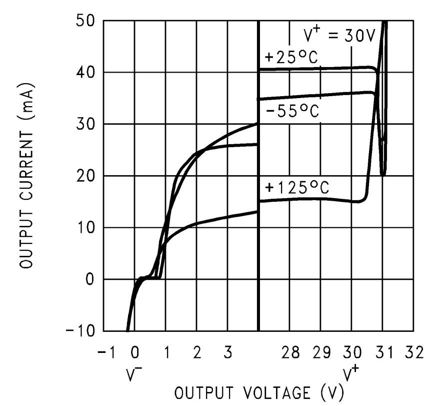
Output Sink Current vs. Output Voltage and Temp.



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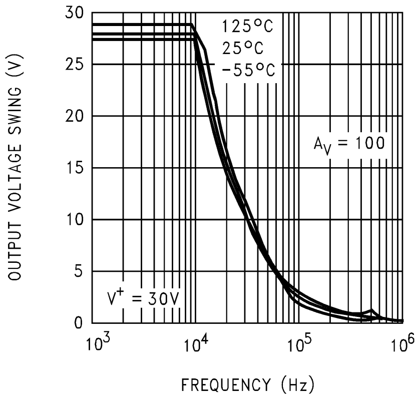
Typical Performance Characteristics (Op Amps) $V^+ = 5V$, $V^- = GND = 0V$, $V_{CM} = V^+/2$, $V_{OUT} = V^+/2$, $T_J = 25^\circ C$, unless otherwise noted (Continued)

Output Swing, Large Signal



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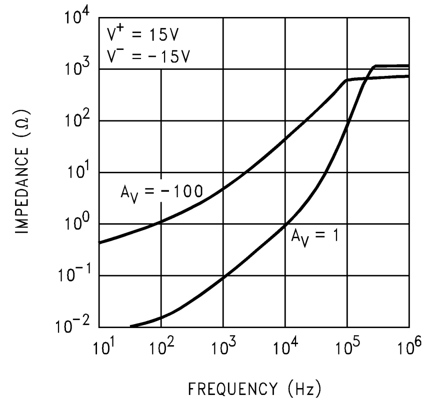
Output Impedance vs. Frequency and Gain



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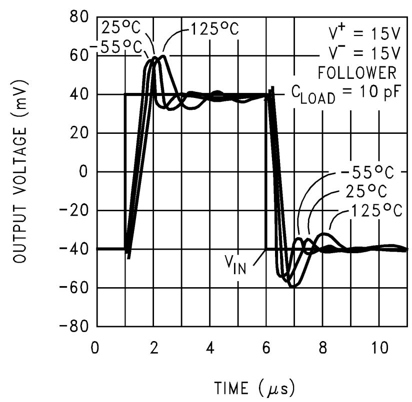
Small-Signal Pulse Response vs. Temp.



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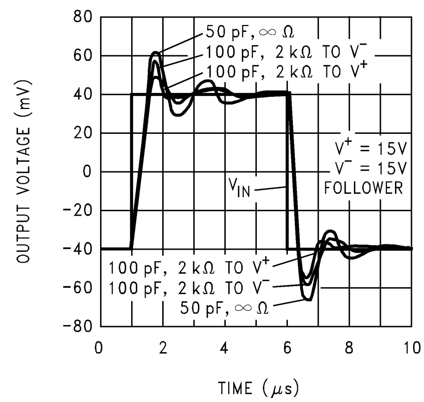
Small-Signal Pulse Response vs. Load



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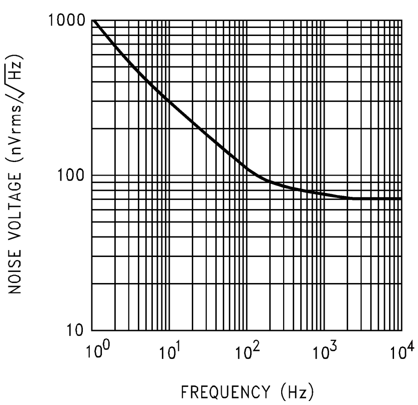
Op Amp Voltage Noise vs. Frequency



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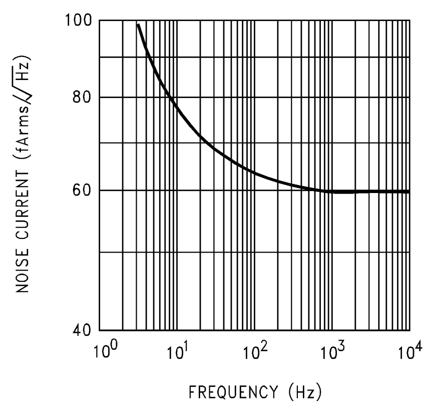
Op Amp Current Noise vs. Frequency



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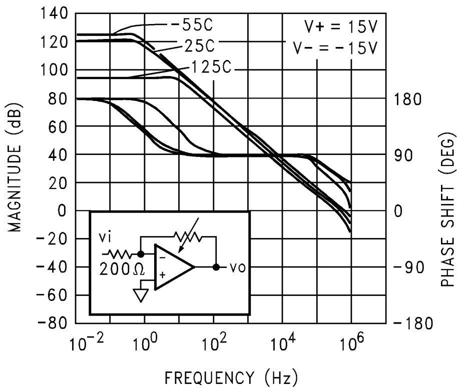
Typical Performance Characteristics (Op Amps) $V^+ = 5V$, $V^- = GND = 0V$, $V_{CM} = V^+/2$, $V_{OUT} = V^+/2$, $T_J = 25^\circ C$, unless otherwise noted (Continued)

Small-Signal Voltage Gain vs. Frequency and Temperature



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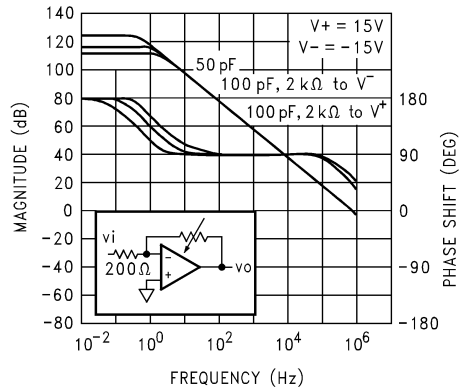
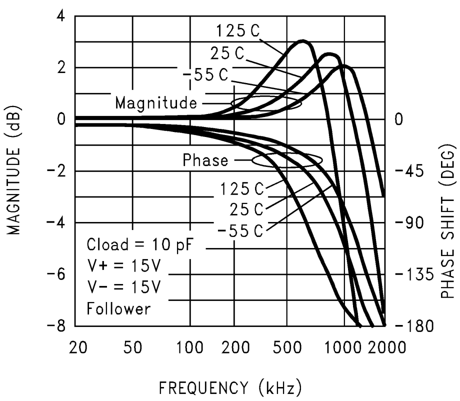
Small-Signal Voltage Gain vs. Frequency and Load



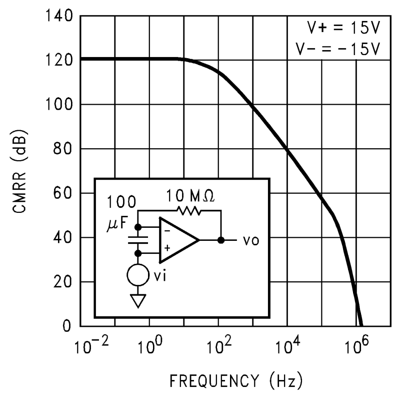
00932679

Follower Small-Signal Frequency Response



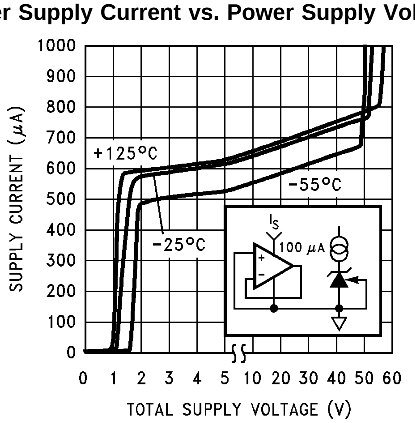
00932680

Common-Mode Input Voltage Rejection Ratio



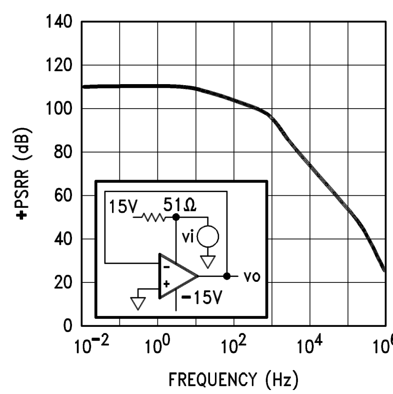
00932681

Power Supply Current vs. Power Supply Voltage



00932607

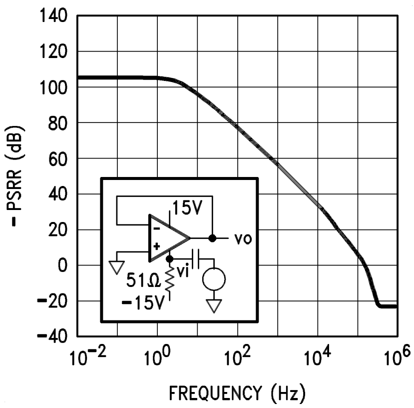
Positive Power Supply Voltage Rejection Ratio



00932621

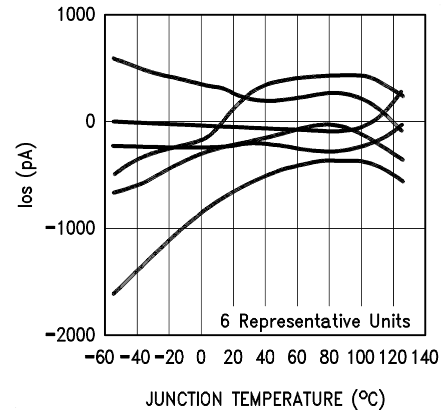
Typical Performance Characteristics (Op Amps) $V^+ = 5V$, $V^- = GND = 0V$, $V_{CM} = V^+/2$, $V_{OUT} = V^+/2$, $T_J = 25^\circ C$, unless otherwise noted (Continued)

Negative Power Supply Voltage Rejection Ratio



00932622

Input Offset Current vs. Junction Temperature



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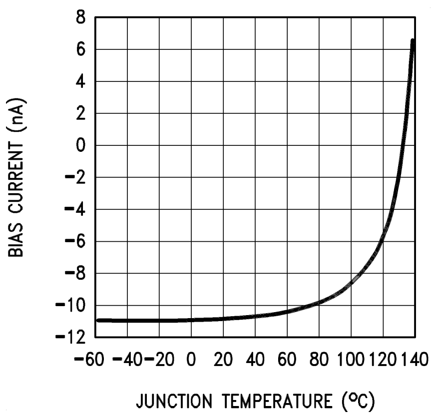
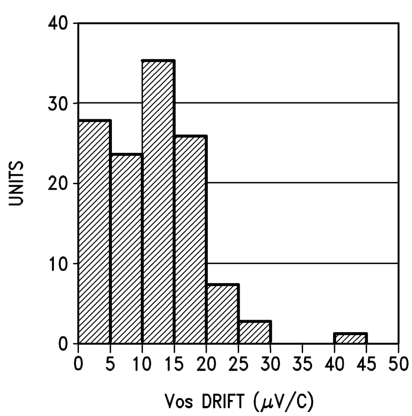
Input Bias Current vs. Junction Temperature



00932638

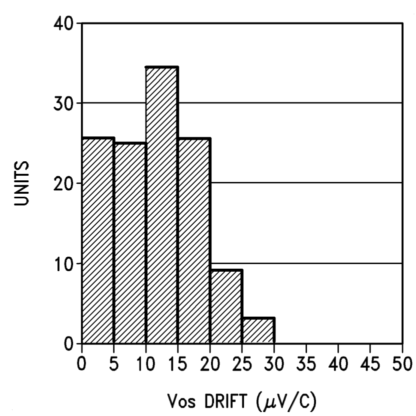
Typical Performance Distributions

Average V_{OS} Drift Industrial Temperature Range



00932630

Average V_{OS} Drift Commercial Temperature Range



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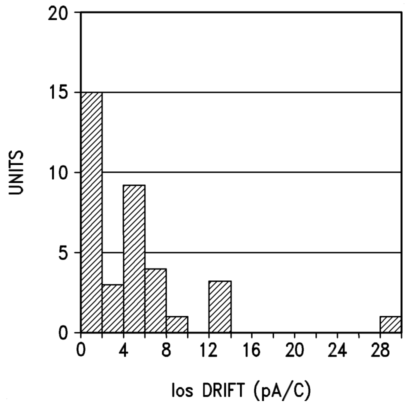
Typical Performance Distributions (Continued)

Average I_{OS} Drift Industrial Temperature Range



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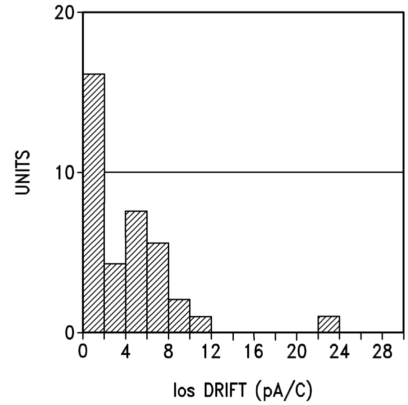
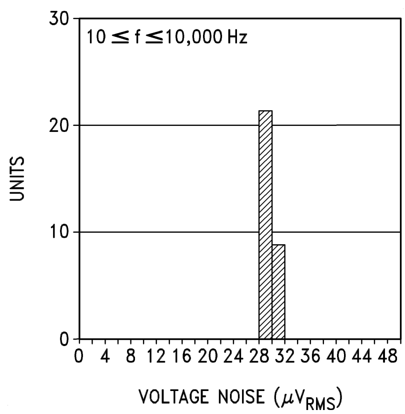
Average I_{OS} Drift Commercial Temperature Range



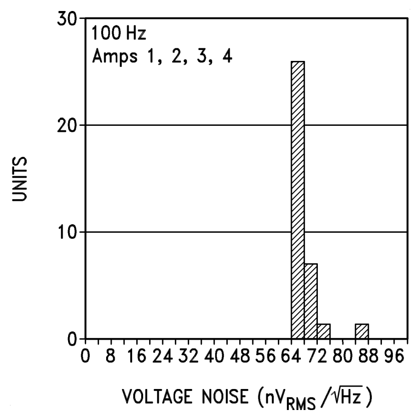
00932634

Voltage Reference Broad-BandNoise Distribution



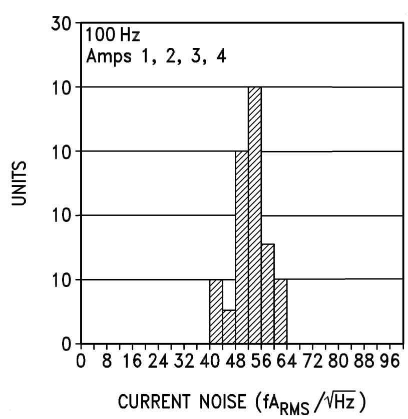
00932635

Op Amp Voltage Noise Distribution



00932636

Op Amp Current Noise Distribution



00932637

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 cathode may swing from a diode drop below V^- to the reference voltage or to the avalanche voltage of the parallel protection diode, nominally 7V. A 5.0V reference with V^+ = 3V is allowed.

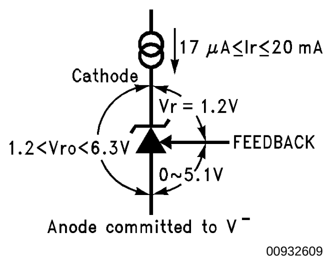


FIGURE 1. Voltages Associated with Reference (Current Source I_r is External)

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.

Adjustable Reference

The FEEDBACK pin allows the reference output voltage, V_{ro}, to vary from 1.24V to 5.0V. 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 $I = V_r/R1$ flowing from Cathode into FEEDBACK node. A Thevenin equivalent 3.76V is generated from FEEDBACK to Anode with R2=3.76/I. For a 1% error, use R1 such that I is greater than one hundred times the FEEDBACK bias current. For example, keep I ≥ 5.5µA.

Capacitors in parallel with the reference are allowed. See the Reference AC Stability Range typical 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.

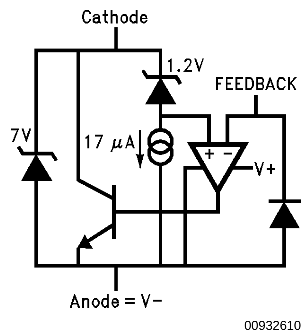


FIGURE 2. Reference Equivalent Circuit

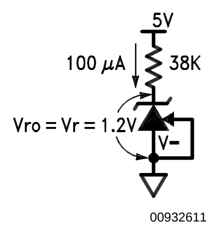


FIGURE 3. 1.2V Reference

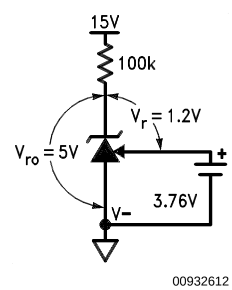
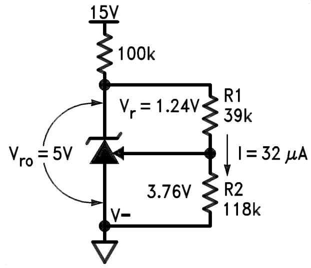


FIGURE 4. Thevenin Equivalent of Reference with 5V Output

Application Information (Continued)



00932613

R1 = Vr/I = 1.24/32µ = 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.

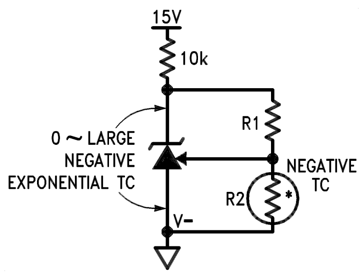


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FIGURE 6. Output Voltage has Negative Temperature Coefficient (TC) if R2 has Negative TC

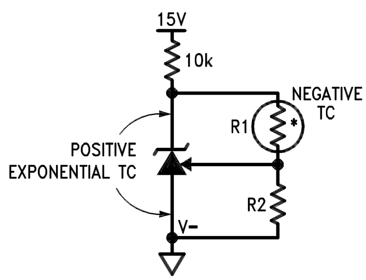

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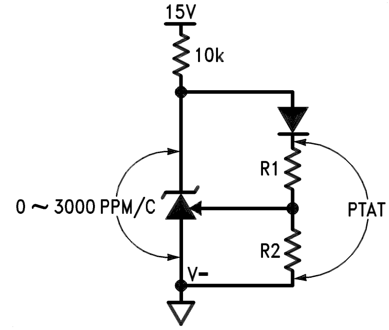
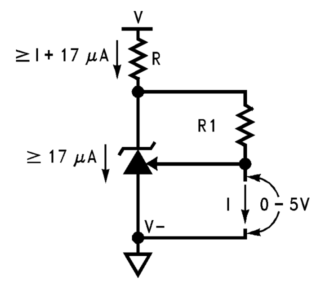
FIGURE 7. Output Voltage has Positive TC if R1 has Negative TC



00932616

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.



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I = Vr/R1 = 1.24/R1

FIGURE 9. Current Source is Programmed by R1

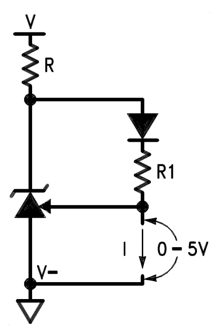

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FIGURE 10. Proportional-to-Absolute-Temperature Current Source

Application Information (Continued)

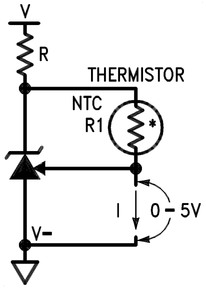


FIGURE 11. Negative-TC Current Source

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 AMPLIFIERS

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

Op Amp Output Stage

These op amps, like their LM124 series, have flexible and relatively wide-swing output stages. There are simple rules to optimize output swing, reduce cross-over distortion, and optimize capacitive drive capability:

1. Output Swing: Unloaded, the 42µA pull-down will bring the output within 300 mV of V^- over the military temperature range. If more than 42µA 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 LM614 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_e until the output resistance is that of the current limit 25Ω. 200pF may then be driven without oscillation.

Op Amp Input Stage

The lateral PNP input transistors, unlike 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

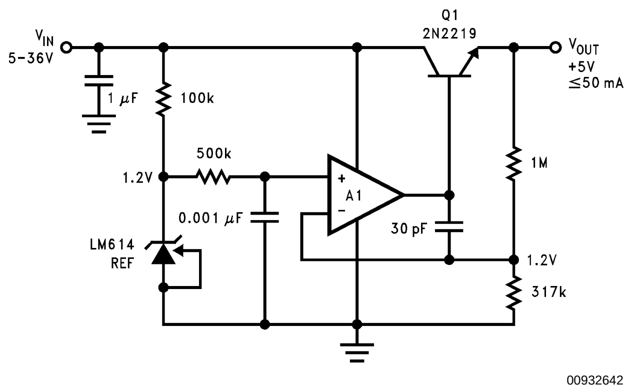
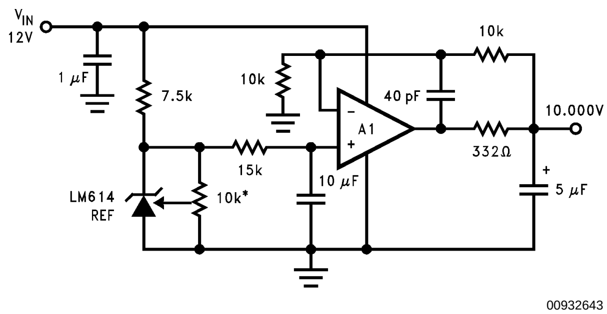
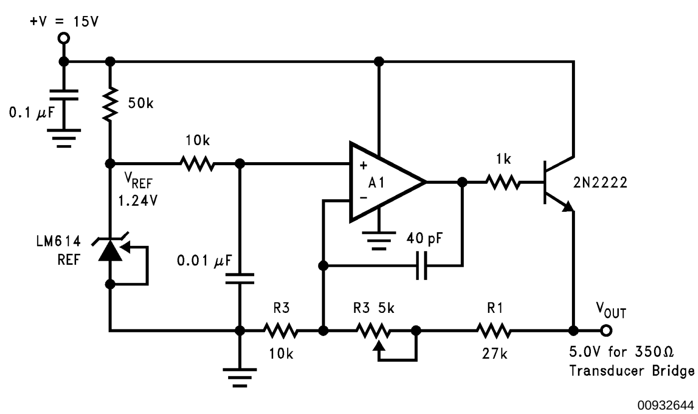


FIGURE 12. Simple Low Quiescent Drain Voltage Regulator. Total supply current approximately 320µA, when V_{IN} = +5V.



*10k must be low
t.c. trimpot.

FIGURE 13. Ultra Low Noise 10.00V Reference. Total output noise is typically $14\mu V_{RMS}$.



$V_{OUT} = (R_1 /Pe + 1)\ V_{REF}$
R_1, R_2 should be 1% metal film
P_β should be low T.C. trim pot

FIGURE 14. Slow Rise Time Upon Power-Up, Adjustable Transducer Bridge Driver. Rise time is approximately 1ms.

Typical Applications (Continued)

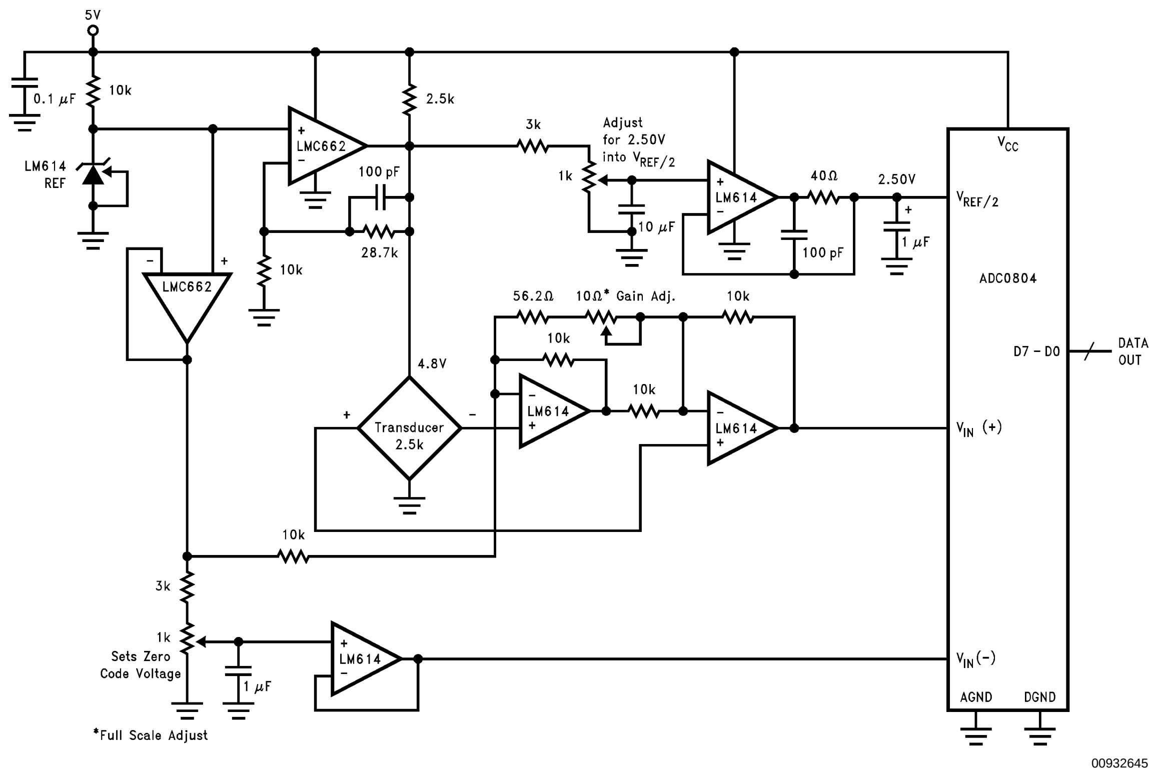
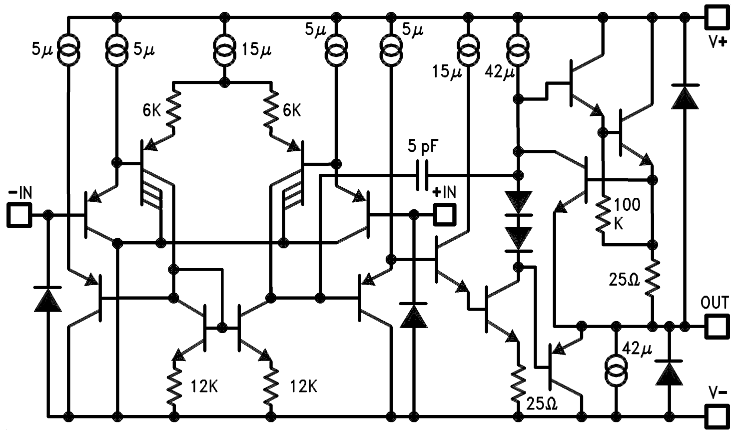


FIGURE 15. Transducer Data Acquisition System. Set zero code voltage, then adjust 10Ω gain adjust pot for full scale.

Simplified Schematic Diagrams

Op Amp



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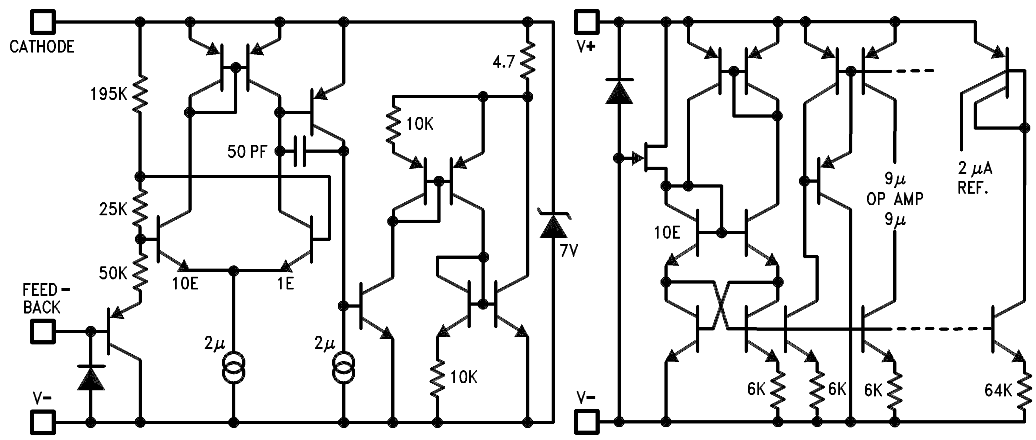
Reference / Bias



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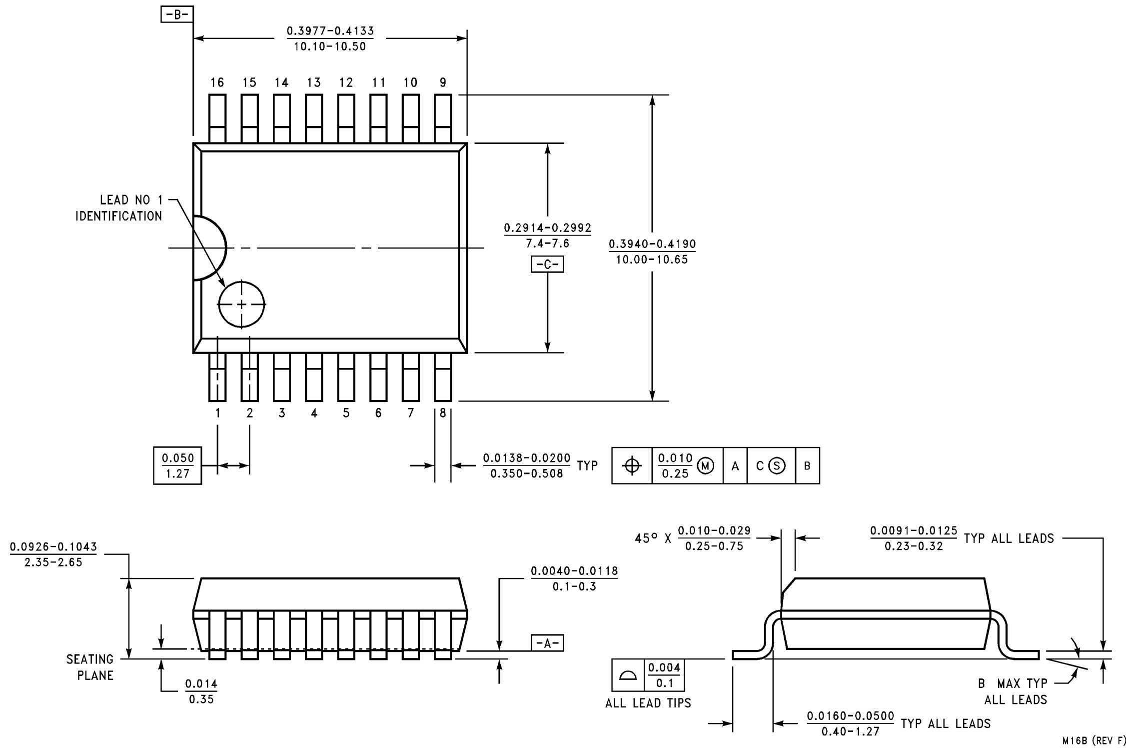
Physical Dimensions inches (millimeters) unless otherwise noted



16-Lead Molded Small Outline Package (WM)
NS Package Number M16B

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