National Semiconductor

November 1995

LM6317
120 MHz, Fast Settling, Low Power, Voltage Feedback Amplifier

General Description

The LM6317 is a high speed, unity-gain stable voltage feedback amplifier that consumes only 40 mW of quiescent power. Operating at ±5V power supply, the LM6317 provides excellent AC performance such as 120 MHz of unity-gain bandwidth, 1500V/µs of slew rate, and 80 dB of SFDR.

The LM6317 has the slew characteristic of a current feedback amplifier; yet it can be used in all traditional amplifier configurations. The high output current and good stability with capacitive load of LM6317 makes it ideal for driving cables. With its unity-gain stability, fast settling time and low output impedance, the LM6317 can be used to buffer A/D converters. The LM6317 also has very low input voltage and current noise, high CMRR and PSRR, desirable in precision applications such as ATE systems.

Features (Typical unless otherwise noted)

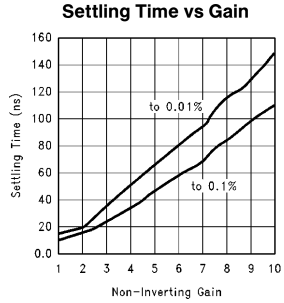
- Easy to use voltage feedback topology
- Unity-gain stability
- Wide unity-gain bandwidth 120 MHz
- Fast slew rate 1100V/µs
- Fast settling time
  - — 0.1% 12 ns
  - — 0.01% 18 ns
- Low SFDR @ 1 MHz Driving 100Ω 80 dB
- High output current 60 mA
- High CMRR and PSRR 80 dB, 74 dB
- Low supply current 4 mA
- Specified for ±5V operation

Applications

- Active filters
- A/D Converter buffers
- Video cable drivers
- Communication systems
- Portable systems
- Ultrasound equipment
- ATE systems

Typical Performance

Settling Time vs Gain



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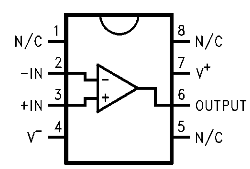
Connection Diagram

8-Pin DIP/SO



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Top View

Ordering Information

Package	Temperature Range Industrial −40°C to +85°C	Transport Media	NSC Drawing
8-Pin DIP	LM6317IN	Rails	N08E
8-Pin Small Outline	LM6317IM	Rails	M08A
	LM6317IMX	2.5k Tape and Reel	

Absolute Maximum Ratings (Note 1)

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

ESD Tolerance (Note 2)	
Human Body Model	1.5 kV
Machine Model	200V
Supply Voltage ($V^+ - V^-$)	12V
Differentfial Input Voltage	10V
Output Current (Note 3)	±60 mA
Storage Temperature Range	−65°C to +150°C
Maximum Junction Temperature (Note 4)	150°C

Operating Ratings (Note 1)

Supply Voltage	$\pm 2.3V \leq V_S \leq \pm 6V$
Junction Temperature Range	$-40°C \leq T_J \leq +85°C$
Thermal Resistance (θ_{JA})	
N Package, 8-Pin Molded DIP	110°C/W
M Package, 8-Pin Surface Mount	170°C/W

±5V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_J = 25°C$, $V^+ = +5V$, $V^- = -5V$, $V_{CM} = 0V$, and $R_L = 100\Omega$. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Typ (Note 5)	Limit (Note 6)	Units
V_{OS}	Input Offset Voltage		0.3	5 **7**	mV max
TC V_{OS}	Input Offset Voltage Average Drift		8		μV/°C
I_B	Input Bias Current		3	12 **22**	μA max
I_{OS}	Input Offset Current		0.2	2 **4**	μA max
R_{IN}	Input Resistance	Differential	2		MΩ
		Common	1		
C_{IN}	Input Capacitance	Differential	1		pF
		Common	1		
R_O	Open Loop Output Resistance		0.02		Ω
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 1.5V$	80	62 **57**	dB min
PSRR	Power Supply Rejection Ratio	$V_S = \pm 5V$ to $\pm 4.5V$	74	60 **52**	dB min
A_V	Large Signal Voltage Gain	$V_{OUT} = \pm 1V$ $R_L = 1\ k\Omega$	70	55 **50**	dB min
		$V_{OUT} = \pm 1V$ $R_L = 100\Omega$	67	53 **48**	
V_{CM}	Input Common-Mode Voltage Range	CMRR = 60 dB	3.2	2.6 **2.3**	V min
			−3.2	−2.6 **−2.3**	V max

±5V DC Electrical Characteristics (Continued) Unless otherwise specified, all limits guaranteed for T_J = 25°C, V^+ = +5V, V^- = −5V, V_{CM} = 0V, and R_L = 100Ω. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Typ (Note 5)	Limit (Note 6)	Units
V_O	Output Swing	R_L = 1 kΩ	3.5	3 **2.6**	V min
			−3.5	−3 **−2.6**	V max
		R_L = 100Ω	3	2.5 **2.3**	V min
			−3	−2.5 **−2.3**	V max
I_S	Supply Current		4	6 **7**	mA max

±5V AC Electrical Characteristics

Unless otherwise specified, T_J = 25°C, V^+ = +5V, V^- = 5V, A_V = 1, and R_L = 100Ω

Symbol	Parameter	Conditions	Typ (Note 5)	Units
SR	Slew Rate	5V Step	1100	V/µs
		5V Step, A_V = −1, R_L = 500Ω	750	
	Unity-Gain Bandwidth	A_V = −1, R_L = 500Ω	120	MHz
	−3 dB Frequency	A_V = +2	80	MHz
θ_m	Phase Margin	A_V = −1, R_L = 500Ω	60	°
t_s	Settling Time	0.1%, 2V Step	12	ns
		0.01%, 2V Step	18	
e_n	Input-Referred Voltage Noise	f = 100 kHz	4.2	$\frac{nV}{\sqrt{Hz}}$
i_n	Input-Referred Current Noise	f = 100 kHz	2	$\frac{pA}{\sqrt{Hz}}$

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics.

Note 2: Human body model, 1.5 kΩ in series with 100 pF. Machine model, 200Ω in series with 100 pF.

Note 3: Applies to both single-supply and split-supply operation. Sourcing and sinking more than 60 mA at the output may adversely affect reliability.

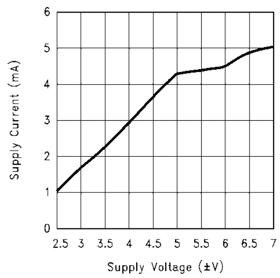
Note 4: The maximum power dissipation is a function of $T_{J(max)}$, θ_{JA}, and T_A. The maximum allowable power dissipation at any ambient temperature is P_D = $(T_{J(max)}-T_A)/\theta_{JA}$. All numbers apply for packages soldered directly into a PC board.

Note 5: Typical values represent the most likely parametric norm.

Note 6: All limits are guaranteed by testing or statistical analysis.

Typical Performance Characteristics
Unless otherwise noted, $T_A = 25°C$, $V_S = \pm 5V$

Supply Current vs Supply Voltage



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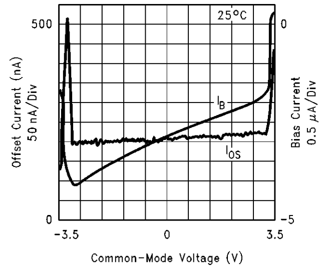
I_B and I_{OS} vs Common-Mode Voltage



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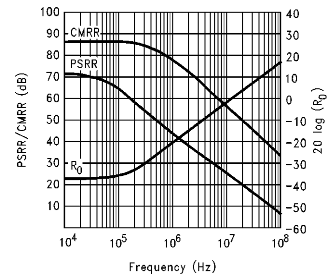
PSRR, CMRR, and Closed Loop R_O



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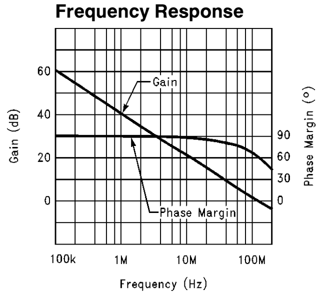
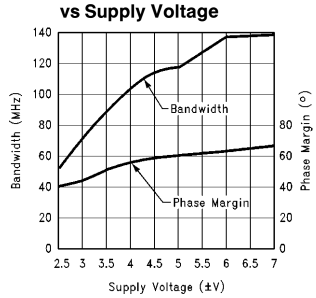
Open Loop Frequency Response



Bandwidth vs Supply Voltage



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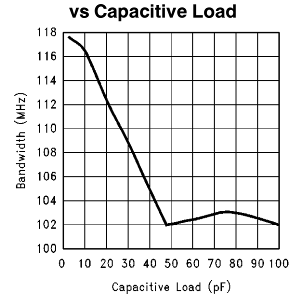
Bandwidth vs Capacitive Load



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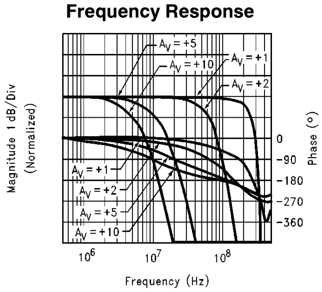
Non-Inverting Frequency Response



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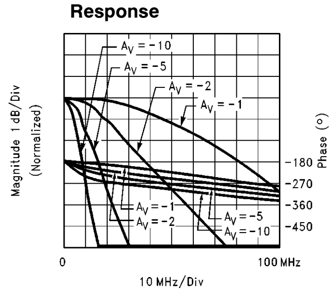
Inverting Frequency Response



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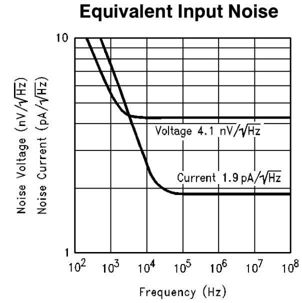
Equivalent Input Noise



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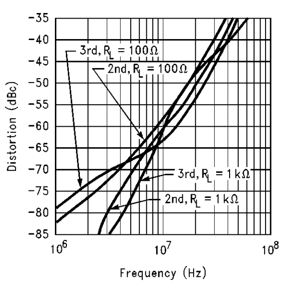
2nd and 3rd Harmonic Distortion



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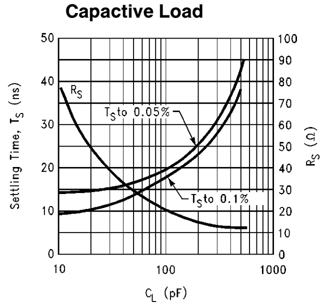
Settling Time vs Capactive Load



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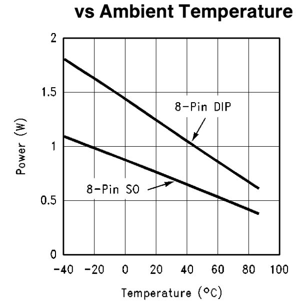
Maximum Power Dissipation vs Ambient Temperature



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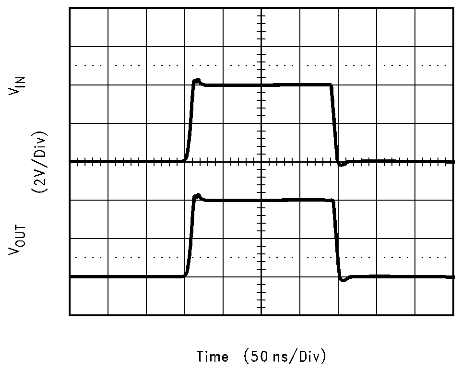
Typical Performance Characteristics Unless otherwise noted, $T_A = 25°C$, $V_S = \pm 5V$ (Continued)

Large Signal Pulse Response ($A_V = +1$)



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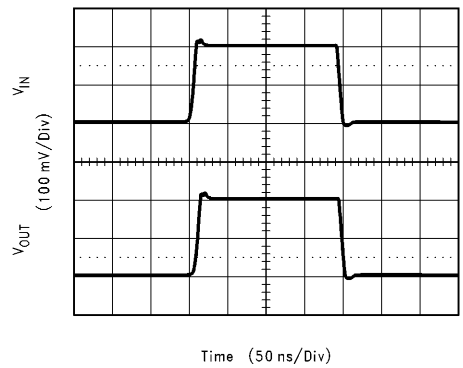
Small Signal Pulse Response ($A_V = +1$)



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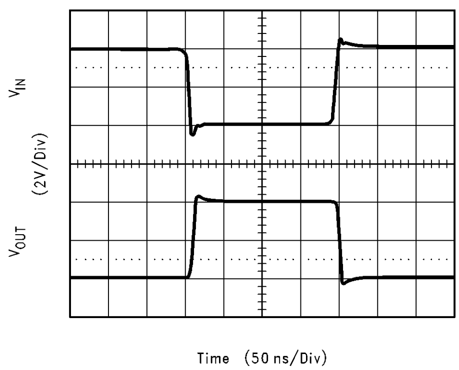
Large Signal Pulse Response ($A_V = -1$)



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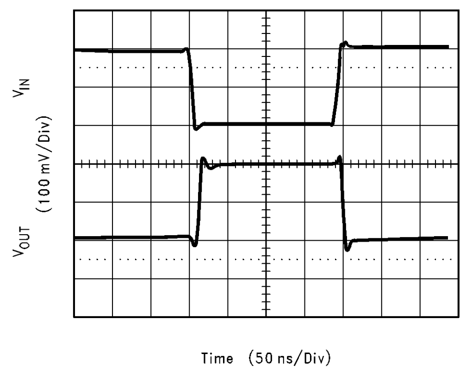
Small Signal Pulse Response ($A_V = -1$)



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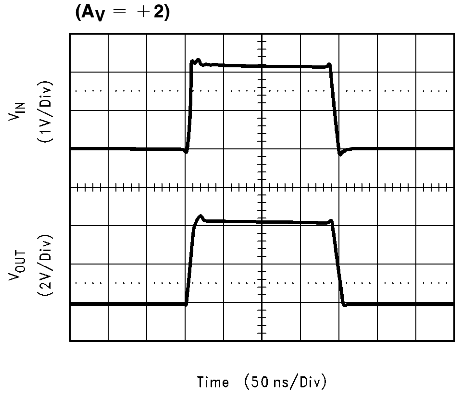
Large Signal Pulse Response ($A_V = +2$)



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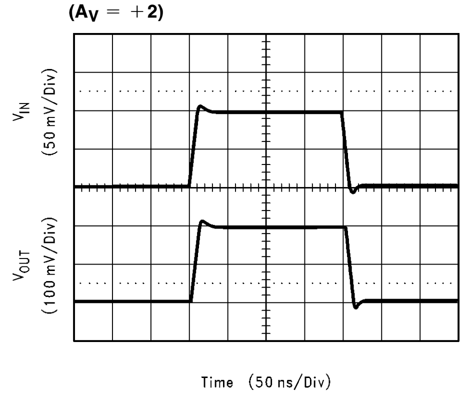
Small Signal Pulse Response ($A_V = +2$)



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Application Notes

Using the LM6317

LIMITS AND PRECAUTIONS

The absolute maximum supply voltage which may be applied to the LM6317 is 12V. Designers should not design for more than 10V nominal, and carefully check supply tolerances under all conditions so that the voltages do not exceed the maximum.

DIFFERENTIAL INPUT VOLTAGE

Differential input voltage is the difference in voltage between the non-inverting (+) input and the inverting (−) input of the op amp. The absolute maximum differential input for the LM6317 is 10V across the inputs. This limit also applies when there is no power supplied to the op amp. This may not be a problem in most conventional op amp designs, however, designers should avoid using the LM6317 as comparators or forcing the inputs to different voltages. In some designs, diodes protection may be needed between the inputs, as shown in *Figure 1*.

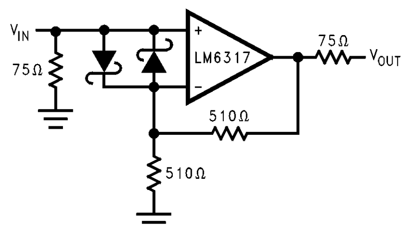

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FIGURE 1. Input Protection for LM6317

Layout Consideration

PRINTED CIRCUIT BOARDS AND HIGH SPEED OP AMPS

There are many things to consider when designing PC boards for high speed op amps. Without proper caution, it is very easy and frustrating to have excessive ringing, oscillation and other degraded AC performance in high speed circuits. As a rule, the signal traces should be short and wide to provide low inductance and low impedance paths. Any unused board space needs be grounded to reduce stray signal pickup. Critical components should also be grounded at a common point to eliminate voltage drop. Sockets add capacitance to the board and can affect frequency performance. It is better to solder the amplifier directly into the PC board without using any socket.

USING PROBES

Active (FET) probes are ideal for taking high frequency measurements because they have wide bandwidth, high input impedance and low input capacitance. However, the probe ground leads provide a long ground loop that will produce errors in measurement. Instead, the probes can be grounded directly by removing the ground leads and probe jackets and using scope probe jacks.

COMPONENTS SELECTION AND FEEDBACK RESISTOR

It is important in high speed applications to keep all component leads short because wires are inductive at high frequency. For discrete components, choose carbon composition-type resistors and mica-type capacitors. Surface mount components are preferred over decrete components for minimum inductive effect.

Large values of feedback resistors can couple with parasitic capacitance and cause undersirable effects such as ringing or oscillation in high speed amplifiers. Feedback resistor value around 1 kΩ is recommended.

COMPENSATION FOR INPUT CAPACITANCE

The combination of an amplifier's input capacitance with the gain setting resistors adds a pole that can cause peaking or oscillation. To solve this problem, a feedback capacitor with a value

$$C_F > (R_G \times C_{IN})/R_F$$

can be used to cancel that pole. The value of C_{IN} can be found in the DC Electrical Characteristics Table of the datasheet. *Figure 2* illustrates the compensation circuit.

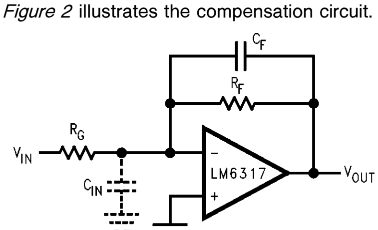

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FIGURE 2. Compensating for Input Capacitance

Power Supply Bypassing

Bypassing the power supply is necessary to maintain low power supply impedance across frequency. Both positive and negative power supplies should be bypassed individually by placing 0.01 μF creramic capacitors directly to power supply pins and 2.2 μF tantalum capacitors close to the power supply pins.

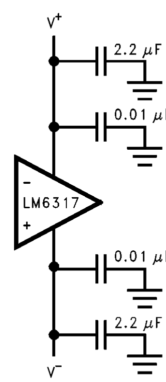

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FIGURE 3. Power Supply Bypassing

Application Notes (Continued)

Termination

In high frequency applications, reflections occur if signals are not properly terminated. To minimize reflection, coaxial cable with matching characteristic impedance to the signal source should be used. The other end of the cable should be terminated with the same value terminator or resistor. For the commonly used cables. RG59 has 75Ω characteristics impedance, and RG58 has 50Ω characteristics impedance.

Driving Capacitive Loads

Amplifiers driving capacitive loads can oscillate or have ringing at the output. To eliminate oscillation or reduce ringing, an isolation resistor can be placed as shown below in *Figure 4*. The combination of the isolation resistor and the load capacitor froms a pole to incease stability by adding more phase margin to the overall system. The desired performance depends on the value of the isolation resistor; the bigger the isolation resistor, the more damped the pulse response becomes. A 50Ω isolation resistor is recommended for initial evaluation.

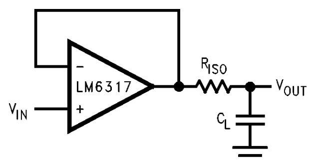

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FIGURE 4. Driving Capacitive Load

Other High Speed and Video Amplifiers

National Semiconductor has an extensive line of high speed amplifiers, with a range of operating voltage from 3V single supply to ±15V, and a range of package types, such as the space saving SOT23-5 TinyPak™ (3.05mm × 3.00mm × 1.43mm - about the size of a grain of rice) and a wide SO-8 for better power dissipation.

This op amp line includes -

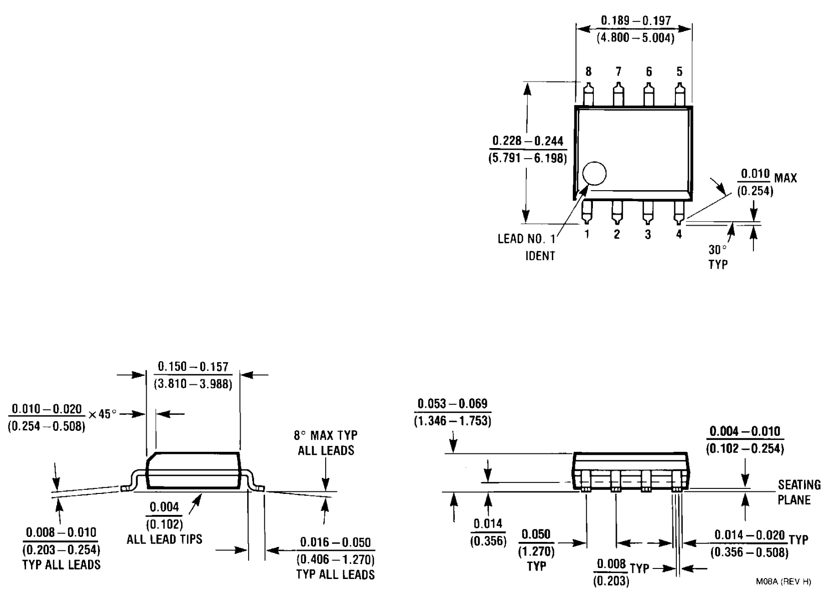
LM6171 100 MHz low distortion amplifier with greater than 3000V/μs slew rate. Voltage feedback design draws only 2.5 mA. Specified at ±15V and ±5V supplies.

LM7131 TinyPak (SOT23-5) video amplifier with 70 MHz gain bandwidth. Specified at 3V, 5V and ±5V supplies.

LM7171 200 MHz voltage feedback amplifier with 100 mA output current and 4000V/μs slew rate. Supply current of 6.5 mA. Specified at ±15V and ±5V supplies.

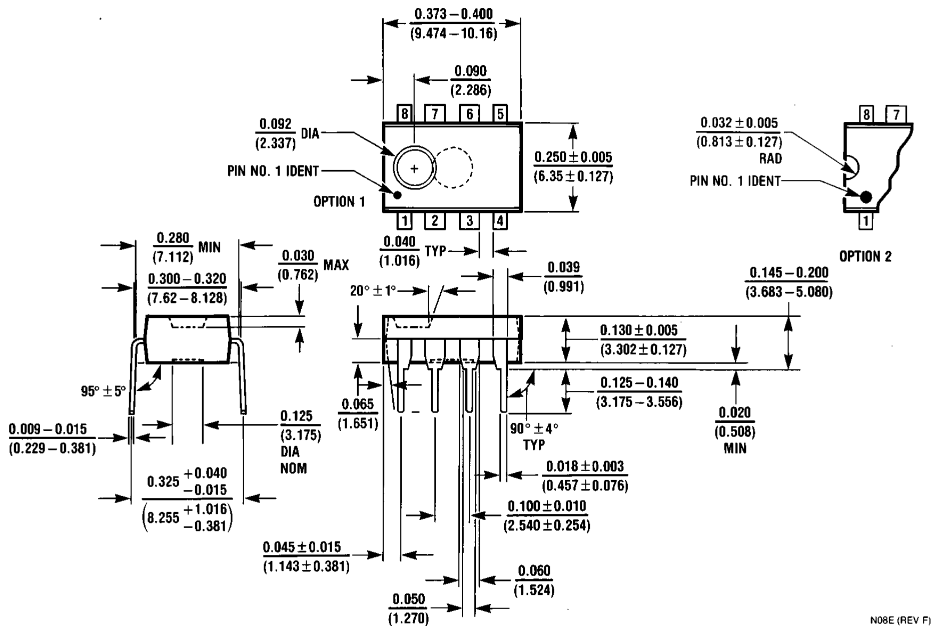
Information on these parts is available from your National Semiconductor representative.

Physical Dimensions inches (millimeters) unless otherwise noted



8-Pin Small Outline
Order Number LM6317IM or LM6317IMX
NSC Package Number M08A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



8-Pin DIP
Order Number LM6317IN
NSC Package Number N08E

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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.

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