

# LF155/LF156/LF256/LF257/LF355/LF356/LF357

## JFET Input Operational Amplifiers

### General Description

These are the first monolithic JFET input operational amplifiers to incorporate well matched, high voltage JFETs on the same chip with standard bipolar transistors (BI-FET™ Technology). These amplifiers feature low input bias and offset currents/low offset voltage and offset voltage drift, coupled with offset adjust which does not degrade drift or common-mode rejection. The devices are also designed for high slew rate, wide bandwidth, extremely fast settling time, low voltage and current noise and a low 1/f noise corner.

### Features

#### Advantages

- Replace expensive hybrid and module FET op amps
- Rugged JFETs allow blow-out free handling compared with MOSFET input devices
- Excellent for low noise applications using either high or low source impedance—very low 1/f corner
- Offset adjust does not degrade drift or common-mode rejection as in most monolithic amplifiers
- New output stage allows use of large capacitive loads (5,000 pF) without stability problems
- Internal compensation and large differential input voltage capability

### Applications

- Precision high speed integrators
- Fast D/A and A/D converters
- High impedance buffers
- Wideband, low noise, low drift amplifiers

- Logarithmic amplifiers
- Photocell amplifiers
- Sample and Hold circuits

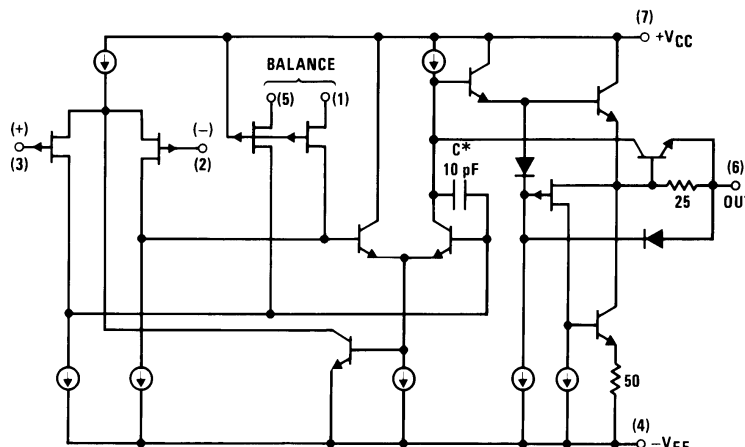
#### Common Features

- Low input bias current: 30pA
- Low Input Offset Current: 3pA
- High input impedance:  $10^{12}\Omega$
- Low input noise current:  $0.01 \text{ pA}/\sqrt{\text{Hz}}$
- High common-mode rejection ratio: 100 dB
- Large dc voltage gain: 106 dB

### Uncommon Features

|   | LF155/<br>LF355 | LF156/<br>LF256/<br>LF356 | LF257/<br>LF357<br>( $A_V=5$ ) | Units                        |
|---|-----------------|---------------------------|--------------------------------|------------------------------|
| ■ Extremely fast settling time to 0.01% | 4               | 1.5                       | 1.5                            | $\mu\text{s}$                |
| ■ Fast slew rate                        | 5               | 12                        | 50                             | $\text{V}/\mu\text{s}$       |
| ■ Wide gain bandwidth                   | 2.5             | 5                         | 20                             | MHz                          |
| ■ Low input noise voltage               | 20              | 12                        | 12                             | $\text{nV}/\sqrt{\text{Hz}}$ |

### Simplified Schematic



\*3pF in LF357 series.

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## Absolute Maximum Ratings (Note 1)

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

|   | LF155/6         | LF256/7/LF356B  | LF355/6/7       |
|---|-----------------|-----------------|-----------------|
| Supply Voltage  | ±22V            | ±22V            | ±18V            |
| Differential Input Voltage  | ±40V            | ±40V            | ±30V            |
| Input Voltage Range (Note 2)  | ±20V            | ±20V            | ±16V            |
| Output Short Circuit Duration   | Continuous      | Continuous      | Continuous      |
| $T_{JMAX}$  |                 |                 |                 |
| H-Package   | 150°C           | 115°C           | 115°C           |
| N-Package   |                 | 100°C           | 100°C           |
| M-Package   |                 | 100°C           | 100°C           |
| Power Dissipation at $T_A = 25^\circ\text{C}$ (Notes 1, 8)  |                 |                 |                 |
| H-Package (Still Air)   | 560 mW          | 400 mW          | 400 mW          |
| H-Package (400 LF/Min Air Flow)   | 1200 mW         | 1000 mW         | 1000 mW         |
| N-Package   |                 | 670 mW          | 670 mW          |
| M-Package   |                 | 380 mW          | 380 mW          |
| Thermal Resistance (Typical) $\theta_{JA}$  |                 |                 |                 |
| H-Package (Still Air)   | 160°C/W         | 160°C/W         | 160°C/W         |
| H-Package (400 LF/Min Air Flow)   | 65°C/W          | 65°C/W          | 65°C/W          |
| N-Package   |                 | 130°C/W         | 130°C/W         |
| M-Package   |                 | 195°C/W         | 195°C/W         |
| (Typical) $\theta_{JC}$   |                 |                 |                 |
| H-Package   | 23°C/W          | 23°C/W          | 23°C/W          |
| Storage Temperature Range   | -65°C to +150°C | -65°C to +150°C | -65°C to +150°C |
| Soldering Information (Lead Temp.)  |                 |                 |                 |
| Metal Can Package   |                 |                 |                 |
| Soldering (10 sec.)   | 300°C           | 300°C           | 300°C           |
| Dual-In-Line Package  |                 |                 |                 |
| Soldering (10 sec.)   | 260°C           | 260°C           | 260°C           |
| Small Outline Package   |                 |                 |                 |
| Vapor Phase (60 sec.)   |                 | 215°C           | 215°C           |
| Infrared (15 sec.)  |                 | 220°C           | 220°C           |
| See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices. |                 |                 |                 |
| ESD tolerance   |                 |                 |                 |
| (100 pF discharged through 1.5k $\Omega$ )  | 1000V           | 1000V           | 1000V           |

## DC Electrical Characteristics

(Note 3)

| Symbol                    | Parameter                                 | Conditions   | LF155/6 |     |     | LF256/7<br>LF356B |     |     | LF355/6/7 |     |     | Units                                  |
|---------------------------|---|--|---------|-----|-----|-------------------|-----|-----|-----------|-----|-----|--|
|                           |   |  | Min     | Typ | Max | Min               | Typ | Max | Min       | Typ | Max |  |
| $V_{OS}$                  | Input Offset Voltage                      | $R_S=50\Omega$ , $T_A=25^\circ\text{C}$<br>Over Temperature  |         | 3   | 5   |                   | 3   | 5   |           | 3   | 10  | mV<br>mV                               |
| $\Delta V_{OS}/\Delta T$  | Average TC of Input Offset Voltage        | $R_S=50\Omega$   |         | 5   |     |                   | 5   |     |           | 5   |     | $\mu\text{V}/^\circ\text{C}$           |
| $\Delta TC/\Delta V_{OS}$ | Change in Average TC with $V_{OS}$ Adjust | $R_S=50\Omega$ , (Note 4)                                    |         | 0.5 |     |                   | 0.5 |     |           | 0.5 |     | $\mu\text{V}/^\circ\text{C}$<br>per mV |
| $I_{OS}$                  | Input Offset Current                      | $T_J=25^\circ\text{C}$ , (Notes 3, 5)<br>$T_J \leq T_{HIGH}$ |         | 3   | 20  |                   | 3   | 20  |           | 3   | 50  | pA<br>nA                               |

## DC Electrical Characteristics (Continued)

(Note 3)

| Symbol    | Parameter                       | Conditions  | LF155/6  |              |     | LF256/7<br>LF356B |                   |     | LF355/6/7 |              |     | Units        |
|-----------|---------------------------------|---|----------|--------------|-----|-------------------|-------------------|-----|-----------|--------------|-----|--------------|
|           |                                 |   | Min      | Typ          | Max | Min               | Typ               | Max | Min       | Typ          | Max |              |
| $I_B$     | Input Bias Current              | $T_J=25^\circ\text{C}$ , (Notes 3, 5)<br>$T_J \leq T_{HIGH}$  |          | 30           | 100 |                   | 30                | 100 |           | 30           | 200 | pA<br>nA     |
| $R_{IN}$  | Input Resistance                | $T_J=25^\circ\text{C}$  |          | $10^{12}$    |     |                   | $10^{12}$         |     |           | $10^{12}$    |     | $\Omega$     |
| $A_{VOL}$ | Large Signal Voltage Gain       | $V_S=\pm 15\text{V}$ , $T_A=25^\circ\text{C}$<br>$V_O=\pm 10\text{V}$ , $R_L=2\text{k}$<br>Over Temperature | 50       | 200          |     | 50                | 200               |     | 25        | 200          |     | V/mV<br>V/mV |
| $V_O$     | Output Voltage Swing            | $V_S=\pm 15\text{V}$ , $R_L=10\text{k}$<br>$V_S=\pm 15\text{V}$ , $R_L=2\text{k}$                           | $\pm 12$ | $\pm 13$     |     | $\pm 12$          | $\pm 13$          |     | $\pm 12$  | $\pm 13$     |     | V<br>V       |
| $V_{CM}$  | Input Common-Mode Voltage Range | $V_S=\pm 15\text{V}$  | $\pm 11$ | +15.1<br>-12 |     | $\pm 11$          | $\pm 15.1$<br>-12 |     | +10       | +15.1<br>-12 |     | V<br>V       |
| CMRR      | Common-Mode Rejection Ratio     |   | 85       | 100          |     | 85                | 100               |     | 80        | 100          |     | dB           |
| PSRR      | Supply Voltage Rejection Ratio  | (Note 6)  | 85       | 100          |     | 85                | 100               |     | 80        | 100          |     | dB           |

## DC Electrical Characteristics

$T_A = T_J = 25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$

| Parameter      | LF155 |     | LF355 |     | LF156/256/257/356B |     | LF356 |     | LF357 |     | Units |
|----------------|-------|-----|-------|-----|--------------------|-----|-------|-----|-------|-----|-------|
|                | Typ   | Max | Typ   | Max | Typ                | Max | Typ   | Max | Typ   | Max |       |
| Supply Current | 2     | 4   | 2     | 4   | 5                  | 7   | 5     | 10  | 5     | 10  | mA    |

## AC Electrical Characteristics

$T_A = T_J = 25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$

| Symbol   | Parameter                      | Conditions   | LF155/355    | LF156/256/<br>356B | LF156/256/356/<br>LF356B | LF257/357    | Units  |
|----------|--------------------------------|--|--------------|--------------------|--------------------------|--------------|--|
|          |                                |  | Typ          | Min                | Typ                      | Typ          |  |
| SR       | Slew Rate                      | LF155/6:<br>$A_V=1$ ,<br>LF357: $A_V=5$                    | 5            | 7.5                | 12                       |              | V/ $\mu\text{s}$<br>V/ $\mu\text{s}$             |
| GBW      | Gain Bandwidth Product         |  | 2.5          |                    | 5                        | 20           | MHz  |
| $t_s$    | Settling Time to 0.01%         | (Note 7)   | 4            |                    | 1.5                      | 1.5          | $\mu\text{s}$                                    |
| $e_n$    | Equivalent Input Noise Voltage | $R_S=100\Omega$<br>$f=100\text{ Hz}$<br>$f=1000\text{ Hz}$ | 25<br>20     |                    | 15<br>12                 | 15<br>12     | nV/ $\sqrt{\text{Hz}}$<br>nV/ $\sqrt{\text{Hz}}$ |
| $i_n$    | Equivalent Input Current Noise | $f=100\text{ Hz}$<br>$f=1000\text{ Hz}$                    | 0.01<br>0.01 |                    | 0.01<br>0.01             | 0.01<br>0.01 | pA/ $\sqrt{\text{Hz}}$<br>pA/ $\sqrt{\text{Hz}}$ |
| $C_{IN}$ | Input Capacitance              |  | 3            |                    | 3                        | 3            | pF   |

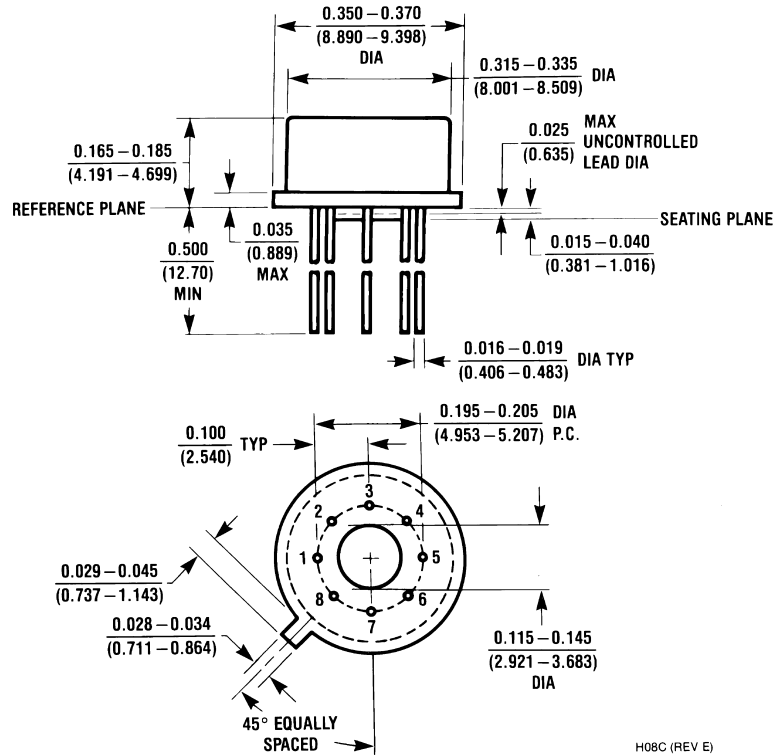
## Notes for Electrical Characteristics

**Note 1:** The maximum power dissipation for these devices must be derated at elevated temperatures and is dictated by  $T_{JMAX}$ ,  $\theta_{JA}$ , and the ambient temperature,  $T_A$ . The maximum available power dissipation at any temperature is  $P_D=(T_{JMAX}-T_A)/\theta_{JA}$  or the  $25^\circ\text{C}$   $P_{DMAX}$ , whichever is less.

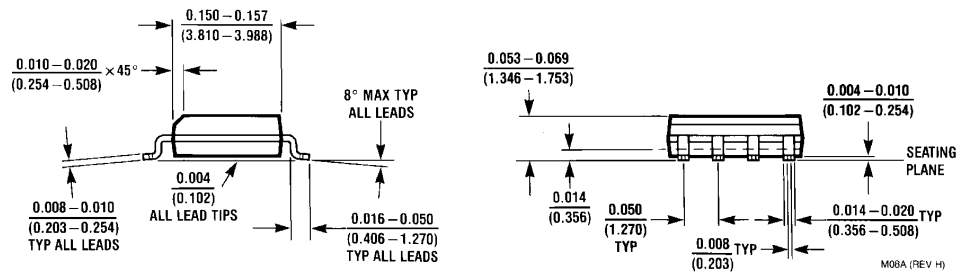
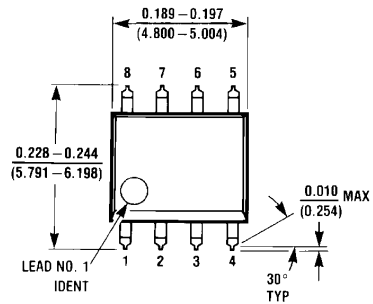
**Note 2:** Unless otherwise specified the absolute maximum negative input voltage is equal to the negative power supply voltage.

**Note 3:** Unless otherwise stated, these test conditions apply:

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

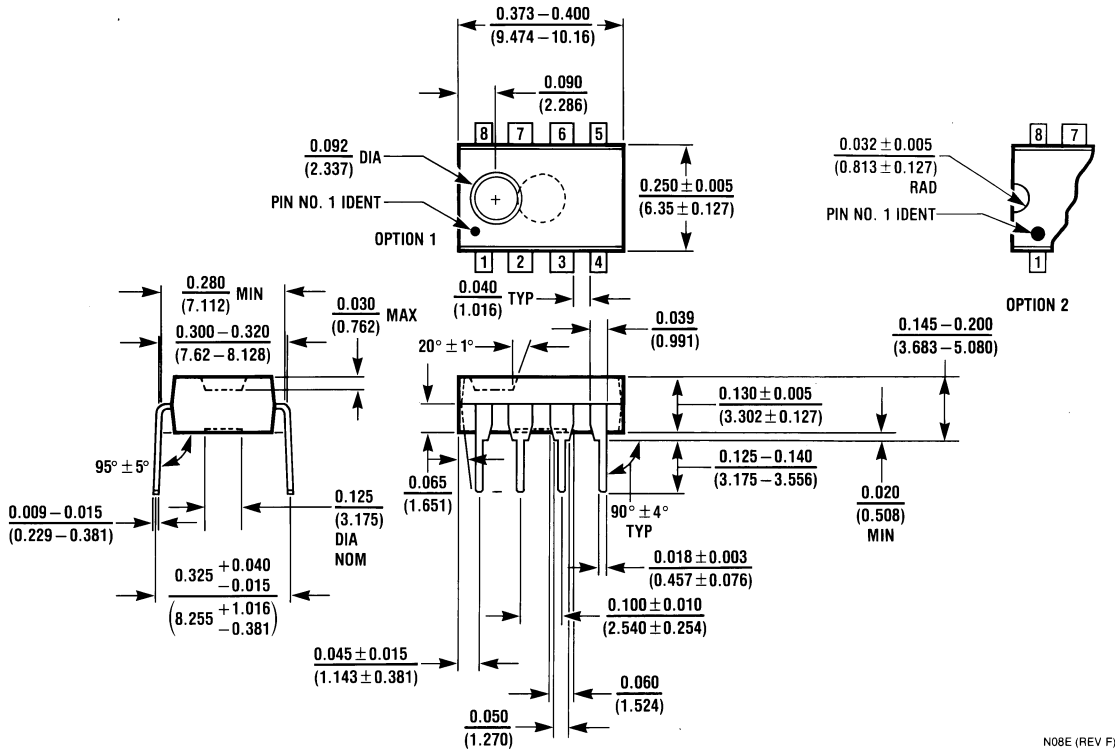


**Metal Can Package (H)**  
 Order Number LF155H, LF156H, LF256H, LF257H, LF356BH, LF356H or LF357H  
 NS Package Number H08C



**Small Outline Package (M)**  
 Order Number LF356M or LF356MX  
 NS Package Number M08A

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



**Molded Dual-In-Line Package (N)**  
**Order Number LF356N**  
**NS Package Number N08E**

N08E (REV F)

**LF155/LF156/LF256/LF257/LF355/LF356/LF357 JFET Input Operational Amplifiers**

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