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# LM158QML

## Low Power Dual Operational Amplifiers

### General Description

The LM158 series consists of two independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, dc gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM158 series can be directly operated off of the standard +5V power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional  $\pm 15V$  power supplies.

### Unique Characteristics

- In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage.
- The unity gain cross frequency is temperature compensated.
- The input bias current is also temperature compensated.

### Advantages

- Two internally compensated op amps
- Eliminates need for dual supplies
- Allows direct sensing near Gnd and  $V_O$  also goes to Gnd
- Compatible with all forms of logic
- Power drain suitable for battery operation

### Features

- Available with radiation guarantee
  - High Dose Rate 100 krad(Si)
  - ELDRS Free 100 krad(Si)
- Internally frequency compensated for unity gain
- Large dc voltage gain: 100 dB
- Wide bandwidth (unity gain): 1 MHz (temperature compensated)
- Wide power supply range:
  - Single supply: 3V to 32V
  - or dual supplies:  $\pm 1.5V$  to  $\pm 16V$
- Very low supply current drain (500  $\mu A$ ) – essentially independent of supply voltage
- Low input offset voltage: 2 mV
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Large output voltage swing: 0V to  $V^+ - 1.5V$

### Ordering Information

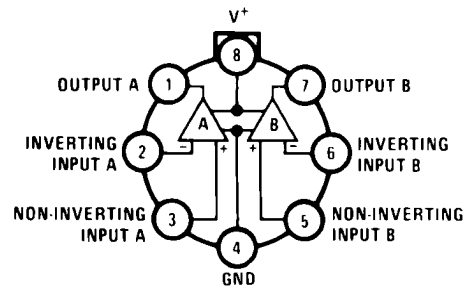
| NS Part Number                                      | SMD Part Number                 | NS Package Number | Package Description |
|-----------------------------------------------------|---------------------------------|-------------------|---------------------|
| LM158H/883                                          |                                 | H08C              | 8LD T0–99 Metal Can |
| LM158J/883                                          | 5962–8771001PA                  | J08A              | 8LD Ceramic DIP     |
| LM158H-SMD                                          | 5962–8771001GA                  | H08C              | 8LD T0–99 Metal Can |
| LM158AH/883                                         | 5962–8771002GA                  | H08C              | 8LD T0–99 Metal Can |
| LM158AJ/883                                         | 5962–8771002PA                  | J08A              | 8LD Ceramic DIP     |
| LM158AWG/883                                        | 5962–8771002QXA                 | WG10A             | 10LD Ceramic SOIC   |
| LM158AHRQMLV<br>HIGH DOSE RATE ONLY (Note 11)       | 5962R8771002VGA<br>100 krad(Si) | H08C              | 8LD T0–99 Metal Can |
| LM158AJ-QMLV                                        | 5962–8771002VPA                 | J08A              | 8LD Ceramic DIP     |
| LM158AJRQMLV<br>HIGH DOSE RATE ONLY (Note 11)       | 5962R8771002VPA<br>100 krad(Si) | J08A              | 8LD Ceramic DIP     |
| LM158AWGRQMLV<br>HIGH DOSE RATE ONLY (Note 11)      | 5962R8771002VXA<br>100 krad(Si) | WG10A             | 10LD Ceramic SOIC   |
| LM158A MDR<br>HIGH DOSE RATE ONLY DIE (Notes 1, 11) | 5962R8771002V9A<br>100 krad(Si) |                   |                     |
| LM158AHLQMLV<br>ELDRS FREE ONLY (Note 12)           | 5962R8771003VGA<br>100 krad(Si) | H08C              | 8LD T0–99 Metal Can |
| LM158AJRLQMLV<br>ELDRS FREE ONLY (Note 12)          | 5962R8771003VPA<br>100 krad(Si) | J08A              | 8LD Ceramic DIP     |

| NS Part Number                                         | SMD Part Number                 | NS Package Number | Package Description |
|--------------------------------------------------------|---------------------------------|-------------------|---------------------|
| LM158AWGRLQMLV<br><b>ELDRS FREE ONLY</b> (Note 12)     | 5962R8771003VXA<br>100 krad(Si) | WG10A             | 10LD Ceramic SOIC   |
| LM158A MDE<br><b>ELDRS FREE ONLY DIE</b> (Notes 1, 12) | 5962R8771003V9A<br>100 krad(Si) |                   |                     |

Note 1: FOR ADDITIONAL DIE INFORMATION, PLEASE VISIT THE HI REL WEB SITE AT: [www.national.com/analog/space/level\\_die](http://www.national.com/analog/space/level_die)

## Connection Diagrams

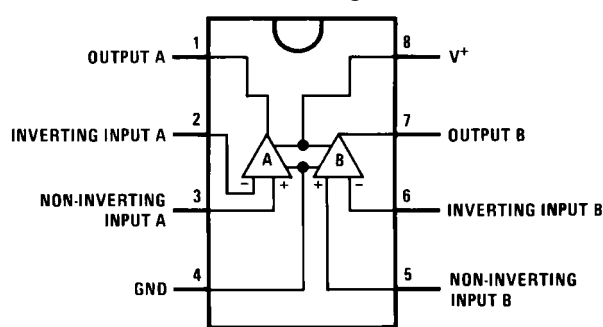
**Metal Can Package**



20150201

**Top View**  
See NS Package Number H08C

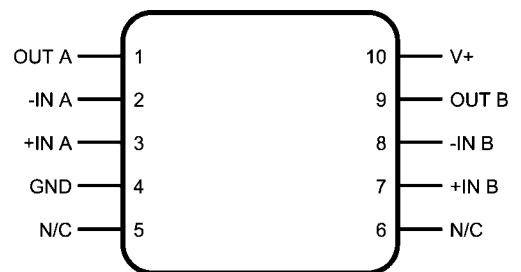
**DIP Package**



20150204

**Top View**  
See NS Package Number J08A

**10LD Ceramic SOIC**

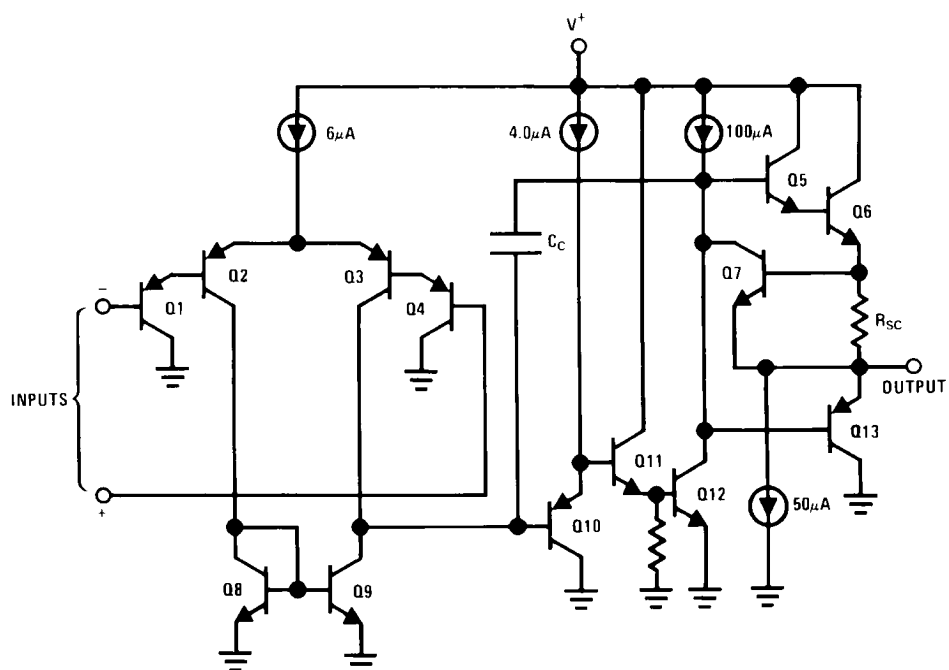


20150202

**Top View**  
See NS Package Number WG10A

# Schematic Diagram

(Each Amplifier)



20150203

## Absolute Maximum Ratings (Note 2)

|                                                         |                                          |
|---------------------------------------------------------|------------------------------------------|
| Supply Voltage, $V^+$                                   | $32V_{DC}$                               |
| Differential Input Voltage                              | $32V_{DC}$                               |
| Input Voltage                                           | $-0.3V_{DC}$ to $+32V_{DC}$              |
| Power Dissipation (Note 3)                              | 830 mW                                   |
| Output Short-Circuit to GND (Note 4)<br>(One Amplifier) | Continuous                               |
| $V^+ \leq 15V_{DC}$ and $T_A = 25^\circ C$              |                                          |
| Maximum Junction Temperature ( $T_{Jmax}$ )             | $150^\circ C$                            |
| Input Current ( $V_I < -0.3V$ ) (Note 5)                | 50 mA                                    |
| Operating Temperature Range                             | $-55^\circ C \leq T_A \leq +125^\circ C$ |
| Storage Temperature Range                               | $-65^\circ C \leq T_A \leq +150^\circ C$ |
| Lead Temperature (Soldering, 10 seconds)                |                                          |
| Metal Can                                               | $300^\circ C$                            |
| Ceramic DIP                                             | $260^\circ C$                            |
| Ceramic SOIC                                            | $260^\circ C$                            |
| Thermal Resistance                                      |                                          |
| $\theta_{JA}$                                           |                                          |
| Metal Can (Still Air)                                   | $155^\circ C/W$                          |
| Metal Can (500LF/Min Air Flow)                          | $80^\circ C/W$                           |
| Ceramic DIP (Still Air)                                 | $132^\circ C/W$                          |
| Ceramic DIP (500LF/Min Air Flow)                        | $81^\circ C/W$                           |
| Ceramic SOIC (Still Air)                                | $195^\circ C/W$                          |
| Ceramic SOIC (500LF/Min Air Flow)                       | $131^\circ C/W$                          |
| $\theta_{JC}$                                           |                                          |
| Metal Can                                               | $42^\circ C/W$                           |
| Ceramic DIP                                             | $23^\circ C/W$                           |
| Ceramic SOIC                                            | $33^\circ C/W$                           |
| Package Weight                                          |                                          |
| Metal Can                                               | 1,000mg                                  |
| Ceramic DIP                                             | 1,100mg                                  |
| Ceramic SOIC                                            | 220mg                                    |
| ESD Tolerance (Note 8)                                  | 250V                                     |

## Quality Conformance Inspection

Mil-Std-883, Method 5005 - Group A

| Subgroup | Description         | Temp °C |
|----------|---------------------|---------|
| 1        | Static tests at     | +25     |
| 2        | Static tests at     | +125    |
| 3        | Static tests at     | -55     |
| 4        | Dynamic tests at    | +25     |
| 5        | Dynamic tests at    | +125    |
| 6        | Dynamic tests at    | -55     |
| 7        | Functional tests at | +25     |
| 8A       | Functional tests at | +125    |
| 8B       | Functional tests at | -55     |
| 9        | Switching tests at  | +25     |
| 10       | Switching tests at  | +125    |
| 11       | Switching tests at  | -55     |
| 12       | Settling time at    | +25     |
| 13       | Settling time at    | +125    |
| 14       | Settling time at    | -55     |

# LM158 Electrical Characteristics SMD 5962–8771001

## DC Parameters

The following conditions apply, unless otherwise specified. All voltages referenced to device ground.

| Symbol       | Parameter                    | Conditions                                                   | Notes              | Min  | Max  | Units   | Sub-groups |
|--------------|------------------------------|--------------------------------------------------------------|--------------------|------|------|---------|------------|
| $I_{CC}$     | Power Supply Current         | $+V_{CC} = 5V, R_L = 100K, V_O = 1.4V$                       |                    |      | 1.2  | mA      | 1, 2, 3    |
|              |                              | $+V_{CC} = 30V, R_L = 100K, V_O = 1.4V$                      |                    |      | 3.0  | mA      | 1          |
|              |                              |                                                              |                    |      | 4.0  | mA      | 2, 3       |
| $V_{OH}$     | Output Voltage High          | $+V_{CC} = 30V, R_L = 2K\Omega$                              |                    | 26   |      | V       | 1, 2, 3    |
|              |                              | $+V_{CC} = 30V, R_L = 10K\Omega$                             |                    | 27   |      | V       | 1, 2, 3    |
| $V_{OL}$     | Output Voltage Low           | $+V_{CC} = 30V, R_L = 10K\Omega$                             |                    |      | 20   | mV      | 1, 2, 3    |
|              |                              | $+V_{CC} = 30V, I_{Sink} = 1\mu A$                           |                    |      | 20   | mV      | 1, 2, 3    |
|              |                              | $+V_{CC} = 5V, R_L = 10K\Omega$                              |                    |      | 20   | mV      | 1, 2, 3    |
| $I_{Sink}$   | Output Sink Current          | $+V_{CC} = 15V, V_O = 200mV, +V_I = 0V, -V_I = +65mV$        |                    | 12   |      | $\mu A$ | 1          |
|              |                              | $+V_{CC} = 15V, V_O = 2V, +V_I = 0V, -V_I = +65mV$           |                    | 10   |      | mA      | 1          |
|              |                              |                                                              |                    | 5.0  |      | mA      | 2, 3       |
| $I_{Source}$ | Output Source Current        | $+V_{CC} = 15V, V_O = 2V, +V_I = 0V, -V_I = -65mV$           |                    |      | -20  | mA      | 1          |
|              |                              |                                                              |                    |      | -10  | mA      | 2, 3       |
| $I_{OS}$     | Short Circuit Current        | $+V_{CC} = 5V, V_O = 0V$                                     |                    | -60  |      | mA      | 1          |
| $V_{IO}$     | Input Offset Voltage         | $+V_{CC} = 30V, V_{CM} = 0V, R_S = 50\Omega, V_O = 1.4V$     |                    | -5.0 | 5.0  | mV      | 1          |
|              |                              |                                                              |                    | -7.0 | 7.0  | mV      | 2, 3       |
|              |                              | $+V_{CC} = 30V, V_{CM} = 28.5V, R_S = 50\Omega, V_O = 1.4V$  |                    | -5.0 | 5.0  | mV      | 1          |
|              |                              | $+V_{CC} = 30V, V_{CM} = 28V, R_S = 50\Omega, V_O = 1.4V$    |                    | -7.0 | 7.0  | mV      | 2, 3       |
|              |                              | $+V_{CC} = 5V, V_{CM} = 0V, R_S = 50\Omega, V_O = 1.4V$      |                    | -5.0 | 5.0  | mV      | 1          |
|              |                              |                                                              |                    | -7.0 | 7.0  | mV      | 2, 3       |
| CMRR         | Common Mode Rejection Ratio  | $+V_{CC} = 30V, R_S = 50\Omega, V_I = 0V \text{ to } 28.5V,$ |                    | 70   |      | dB      | 1          |
| $\pm I_{IB}$ | Input Bias Current           | $+V_{CC} = 5V, V_{CM} = 0V$                                  | (Note 6)           | -150 | -1.0 | nA      | 1          |
|              |                              |                                                              | (Note 6)           | -300 | -1.0 | nA      | 2, 3       |
| $I_{IO}$     | Input Offset Current         | $+V_{CC} = 5V, V_{CM} = 0V$                                  |                    | -30  | 30   | nA      | 1          |
|              |                              |                                                              |                    | -100 | 100  | nA      | 2, 3       |
| PSRR         | Power Supply Rejection Ratio | $+V_{CC} = 5V \text{ to } 30V, V_{CM} = 0V$                  |                    | 65   |      | dB      | 1          |
| $V_{CM}$     | Common Mode Voltage Range    | $+V_{CC} = 30V$                                              | (Note 7), (Note 9) |      | 28.5 | V       | 1          |
|              |                              |                                                              | (Note 7), (Note 9) |      | 28.0 | V       | 2, 3       |
| $V_{Diff}$   | Differential Input Voltage   |                                                              | (Note 10)          |      | 32   | V       | 1, 2, 3    |
| $A_{VS}$     | Large Signal Gain            | $+V_{CC} = 15V, R_L = 2K\Omega, V_O = 1V \text{ to } 11V$    |                    | 50   |      | V/mV    | 4          |
|              |                              |                                                              |                    | 25   |      | V/mV    | 5, 6       |

# LM158A Electrical Characteristics SMD 5962–8771002, High Dose Rate

## DC Parameters

The following conditions apply, unless otherwise specified. All voltages referenced to device ground.

| Symbol       | Parameter                    | Conditions                                                   | Notes        | Min  | Max  | Units   | Sub-groups |
|--------------|------------------------------|--------------------------------------------------------------|--------------|------|------|---------|------------|
| $I_{CC}$     | Power Supply Current         | $+V_{CC} = 5V, R_L = 100K, V_O = 1.4V$                       |              |      | 1.2  | mA      | 1, 2, 3    |
|              |                              | $+V_{CC} = 30V, R_L = 100K, V_O = 1.4V$                      |              |      | 3.0  | mA      | 1          |
|              |                              |                                                              |              |      | 4.0  | mA      | 2, 3       |
| $V_{OH}$     | Output Voltage High          | $+V_{CC} = 30V, R_L = 2K\Omega$                              |              | 26   |      | V       | 1, 2, 3    |
|              |                              | $+V_{CC} = 30V, R_L = 10K\Omega$                             |              | 27   |      | V       | 1, 2, 3    |
| $V_{OL}$     | Output Voltage Low           | $+V_{CC} = 30V, R_L = 10K\Omega$                             |              |      | 40   | mV      | 1          |
|              |                              |                                                              |              |      | 100  | mV      | 2, 3       |
|              |                              | $+V_{CC} = 30V, I_{Sink} = 1\mu A$                           |              |      | 40   | mV      | 1          |
|              |                              |                                                              |              |      | 100  | mV      | 2, 3       |
|              |                              | $+V_{CC} = 5V, R_L = 10K\Omega$                              |              |      | 40   | mV      | 1          |
|              |                              |                                                              |              |      | 100  | mV      | 2, 3       |
| $I_{Sink}$   | Output Sink Current          | $+V_{CC} = 15V, V_O = 200mV, +V_I = 0V, -V_I = +65mV$        |              | 12   |      | $\mu A$ | 1          |
|              |                              | $+V_{CC} = 15V, V_O = 2V, +V_I = 0V, -V_I = +65mV$           |              | 10   |      | mA      | 1          |
|              |                              |                                                              |              | 5.0  |      | mA      | 2, 3       |
| $I_{Source}$ | Output Source Current        | $+V_{CC} = 15V, V_O = 2V, +V_I = 0V, -V_I = -65mV$           |              |      | -20  | mA      | 1          |
|              |                              |                                                              |              |      | -10  | mA      | 2, 3       |
| $I_{OS}$     | Short Circuit Current        | $+V_{CC} = 5V, V_O = 0V$                                     |              | -60  |      | mA      | 1          |
| $V_{IO}$     | Input Offset Voltage         | $+V_{CC} = 30V, V_{CM} = 0V, R_S = 50\Omega, V_O = 1.4V$     |              | -2.0 | 2.0  | mV      | 1          |
|              |                              |                                                              |              | -4.0 | 4.0  | mV      | 2, 3       |
|              |                              | $+V_{CC} = 30V, V_{CM} = 28.5V, R_S = 50\Omega, V_O = 1.4V$  |              | -2.0 | 2.0  | mV      | 1          |
|              |                              | $+V_{CC} = 30V, V_{CM} = 28V, R_S = 50\Omega, V_O = 1.4V$    |              | -4.0 | 4.0  | mV      | 2, 3       |
|              |                              |                                                              |              | -2.0 | 2.0  | mV      | 1          |
| CMRR         | Common Mode Rejection Ratio  | $+V_{CC} = 30V, R_S = 50\Omega, V_I = 0V \text{ to } 28.5V,$ |              | 70   |      | dB      | 1          |
|              |                              |                                                              |              |      |      |         |            |
| $\pm I_{IB}$ | Input Bias Current           | $+V_{CC} = 5V, V_{CM} = 0V$                                  | (Note 6)     | -50  | -1.0 | nA      | 1          |
|              |                              |                                                              | (Note 6)     | -100 | -1.0 | nA      | 2, 3       |
| $I_{IO}$     | Input Offset Current         | $+V_{CC} = 5V, V_{CM} = 0V$                                  |              | -10  | 10   | nA      | 1          |
|              |                              |                                                              |              | -30  | 30   | nA      | 2, 3       |
| PSRR         | Power Supply Rejection Ratio | $+V_{CC} = 5V \text{ to } 30V, V_{CM} = 0V$                  |              | 65   |      | dB      | 1          |
| $V_{CM}$     | Common Mode Voltage Range    | $+V_{CC} = 30V$                                              | (Notes 7, 9) |      | 28.5 | V       | 1          |
|              |                              |                                                              | (Notes 7, 9) |      | 28.0 | V       | 2, 3       |
| $V_{Diff}$   | Differential Input Voltage   |                                                              | (Note 10)    |      | 32   | V       | 1, 2, 3    |
| $A_{VS}$     | Large Signal Gain            | $+V_{CC} = 15V, R_L = 2K\Omega, V_O = 1V \text{ to } 11V$    |              | 50   |      | V/mV    | 4          |
|              |                              |                                                              |              | 25   |      | V/mV    | 5, 6       |

## SMD 5962–8771002, High Dose Rate DC Drift Parameters

The following conditions apply, unless otherwise specified. All voltages referenced to device ground.  
Delta calculations are performed on QMLV devices at Group B, Subgroup 5 only.

| Symbol       | Parameter            | Conditions                                                       | Notes    | Min  | Max | Units | Sub-groups |
|--------------|----------------------|------------------------------------------------------------------|----------|------|-----|-------|------------|
| $V_{IO}$     | Input Offset Voltage | $+V_{CC} = 30V, V_{CM} = 0V,$<br>$R_S = 50\Omega, V_O = 1.4V$    |          | -0.5 | 0.5 | mV    | 1          |
|              |                      | $+V_{CC} = 30V, V_{CM} = 28.5V,$<br>$R_S = 50\Omega, V_O = 1.4V$ |          | -0.5 | 0.5 | mV    | 1          |
|              |                      | $+V_{CC} = 5V, V_{CM} = 0V,$<br>$R_S = 50\Omega, V_O = 1.4V$     |          | -0.5 | 0.5 | mV    | 1          |
| $\pm I_{IB}$ | Input Bias Current   | $+V_{CC} = 5V, V_{CM} = 0V$                                      | (Note 6) | -10  | 10  | nA    | 1          |

## SMD 5962–8771002, High Dose Rate 100K Post Radiation Limits @ +25°C (Note 11) DC Parameters

The following conditions apply, unless otherwise specified. All voltages referenced to device ground.

| Symbol       | Parameter            | Conditions                                                       | Notes         | Min  | Max  | Units | Sub - groups |
|--------------|----------------------|------------------------------------------------------------------|---------------|------|------|-------|--------------|
| $V_{IO}$     | Input Offset Voltage | $+V_{CC} = 30V, V_{CM} = 0V,$<br>$R_S = 50\Omega, V_O = 1.4V$    | (Note 11)     | -4.0 | 4.0  | mV    | 1            |
|              |                      | $+V_{CC} = 30V, V_{CM} = 28.5V,$<br>$R_S = 50\Omega, V_O = 1.4V$ | (Note 11)     | -4.0 | 4.0  | mV    | 1            |
|              |                      | $+V_{CC} = 5V, V_{CM} = 0V,$<br>$R_S = 50\Omega, V_O = 1.4V$     | (Note 11)     | -4.0 | 4.0  | mV    | 1            |
| $\pm I_{IB}$ | Input Bias Current   | $+V_{CC} = 5V, V_{CM} = 0V$                                      | (Notes 6, 11) | -60  | -1.0 | nA    | 1            |
| $I_{CC}$     | Power Supply Current | $+V_{CC} = 5V, R_L = 100K,$<br>$V_O = 1.4V$                      | (Note 11)     |      | 1.5  | mA    | 1            |



# LM158A Electrical Characteristics SMD 5962–8771003 ELDRS Free Only

## DC Parameters

The following conditions apply, unless otherwise specified. All voltages referenced to device ground.

| Symbol       | Parameter                    | Conditions                                                   | Notes              | Min  | Max  | Units   | Sub-groups |
|--------------|------------------------------|--------------------------------------------------------------|--------------------|------|------|---------|------------|
| $I_{CC}$     | Power Supply Current         | $+V_{CC} = 5V, R_L = 100K, V_O = 1.4V$                       |                    |      | 1.2  | mA      | 1, 2, 3    |
|              |                              | $+V_{CC} = 30V, R_L = 100K, V_O = 1.4V$                      |                    |      | 3.0  | mA      | 1,         |
|              |                              |                                                              |                    |      | 4.0  |         | 2, 3       |
| $V_{OH}$     | Output Voltage High          | $+V_{CC} = 30V, R_L = 2K\Omega$                              |                    | 26   |      | V       | 1, 2, 3    |
|              |                              | $+V_{CC} = 30V, R_L = 10K\Omega$                             |                    | 27   |      | V       | 1, 2, 3    |
| $V_{OL}$     | Output Voltage Low           | $+V_{CC} = 30V, R_L = 10K\Omega$                             |                    |      | 40   | mV      | 1          |
|              |                              |                                                              |                    |      | 100  | mV      | 2, 3       |
|              |                              | $+V_{CC} = 30V, I_{Sink} = 1\mu A$                           |                    |      | 40   | mV      | 1          |
|              |                              |                                                              |                    |      | 100  | mV      | 2, 3       |
|              |                              | $+V_{CC} = 5V, R_L = 10K\Omega$                              |                    |      | 40   | mV      | 1          |
|              |                              |                                                              |                    |      | 100  | mV      | 2, 3       |
| $I_{Sink}$   | Output Sink Current          | $+V_{CC} = 15V, V_O = 200mV, +V_I = 0V, -V_I = +65mV$        |                    | 12   |      | $\mu A$ | 1          |
|              |                              | $+V_{CC} = 15V, V_O = 2V, +V_I = 0V, -V_I = +65mV$           |                    | 10   |      | mA      | 1          |
|              |                              |                                                              |                    | 5.0  |      | mA      | 2, 3       |
| $I_{Source}$ | Output Source Current        | $+V_{CC} = 15V, V_O = 2V, +V_I = 0V, -V_I = -65mV$           |                    |      | -20  | mA      | 1          |
|              |                              |                                                              |                    |      | -10  | mA      | 2, 3       |
| $I_{OS}$     | Short Circuit Current        | $+V_{CC} = 5V, V_O = 0V$                                     |                    | -60  |      | mA      | 1          |
| $V_{IO}$     | Input Offset Voltage         | $+V_{CC} = 30V, V_{CM} = 0V, R_S = 50\Omega, V_O = 1.4V$     |                    | -2.0 | 2.0  | mV      | 1          |
|              |                              |                                                              |                    | -4.0 | 4.0  | mV      | 2, 3       |
|              |                              | $+V_{CC} = 30V, V_{CM} = 28.5V, R_S = 50\Omega, V_O = 1.4V$  |                    | -2.0 | 2.0  | mV      | 1          |
|              |                              | $+V_{CC} = 30V, V_{CM} = 28V, R_S = 50\Omega, V_O = 1.4V$    |                    | -4.0 | 4.0  | mV      | 2, 3       |
|              |                              | $+V_{CC} = 5V, V_{CM} = 0V, R_S = 50\Omega, V_O = 1.4V$      |                    | -2.0 | 2.0  | mV      | 1          |
|              |                              |                                                              |                    | -4.0 | 4.0  | mV      | 2, 3       |
| CMRR         | Common Mode Rejection Ratio  | $+V_{CC} = 30V, R_S = 50\Omega, V_I = 0V \text{ to } 28.5V,$ |                    | 70   |      | dB      | 1          |
| $\pm I_{IB}$ | Input Bias Current           | $+V_{CC} = 5V, V_{CM} = 0V$                                  | (Note 6)           | -50  | -1.0 | nA      | 1          |
|              |                              |                                                              | (Note 6)           | -100 | -1.0 | nA      | 2, 3       |
| $I_{IO}$     | Input Offset Current         | $+V_{CC} = 5V, V_{CM} = 0V$                                  |                    | -10  | 10   | nA      | 1          |
|              |                              |                                                              |                    | -30  | 30   | nA      | 2, 3       |
| PSRR         | Power Supply Rejection Ratio | $+V_{CC} = 5V \text{ to } 30V, V_{CM} = 0V$                  |                    | 65   |      | dB      | 1          |
| $V_{CM}$     | Common Mode Voltage Range    | $+V_{CC} = 30V$                                              | (Note 7), (Note 9) |      | 28.5 | V       | 1          |
|              |                              |                                                              | (Note 7), (Note 9) |      | 28.0 | V       | 2, 3       |
| $V_{Diff}$   | Differential Input Voltage   |                                                              | (Note 10)          |      | 32   | V       | 1, 2, 3    |
| $A_{VS}$     | Large Signal Gain            | $+V_{CC} = 15V, R_L = 2K\Omega, V_O = 1V \text{ to } 11V$    |                    | 50   |      | V/mV    | 4          |
|              |                              |                                                              |                    | 25   |      | V/mV    | 5, 6       |

## SMD 5962–8771003, ELDRS Free Only DC Drift Parameters

The following conditions apply, unless otherwise specified. All voltages referenced to device ground.  
Delta calculations are performed on QMLV devices at Group B, Subgroup 5 only.

| Symbol       | Parameter            | Conditions                                                       | Notes    | Min  | Max | Units | Sub-groups |
|--------------|----------------------|------------------------------------------------------------------|----------|------|-----|-------|------------|
| $V_{IO}$     | Input Offset Voltage | $+V_{CC} = 30V, V_{CM} = 0V,$<br>$R_S = 50\Omega, V_O = 1.4V$    |          | -0.5 | 0.5 | mV    | 1          |
|              |                      | $+V_{CC} = 30V, V_{CM} = 28.5V,$<br>$R_S = 50\Omega, V_O = 1.4V$ |          | -0.5 | 0.5 | mV    | 1          |
|              |                      | $+V_{CC} = 5V, V_{CM} = 0V,$<br>$R_S = 50\Omega, V_O = 1.4V$     |          | -0.5 | 0.5 | mV    | 1          |
| $\pm I_{IB}$ | Input Bias Current   | $+V_{CC} = 5V, V_{CM} = 0V$                                      | (Note 6) | -10  | 10  | nA    | 1          |

## SMD 5962–8771003, ELDRS Free Only 100K Post Radiation Limits @ +25°C (Note 12) DC Parameters

The following conditions apply, unless otherwise specified. All voltages referenced to device ground.

| Symbol       | Parameter            | Conditions                                                       | Notes         | Min  | Max  | Units | Sub - groups |
|--------------|----------------------|------------------------------------------------------------------|---------------|------|------|-------|--------------|
| $V_{IO}$     | Input Offset Voltage | $+V_{CC} = 30V, V_{CM} = 0V,$<br>$R_S = 50\Omega, V_O = 1.4V$    | (Note 12)     | -4.0 | 4.0  | mV    | 1            |
|              |                      | $+V_{CC} = 30V, V_{CM} = 28.5V,$<br>$R_S = 50\Omega, V_O = 1.4V$ | (Note 12)     | -4.0 | 4.0  | mV    | 1            |
|              |                      | $+V_{CC} = 5V, V_{CM} = 0V,$<br>$R_S = 50\Omega, V_O = 1.4V$     | (Note 12)     | -4.0 | 4.0  | mV    | 1            |
| $\pm I_{IB}$ | Input Bias Current   | $+V_{CC} = 5V, V_{CM} = 0V$                                      | (Notes 6, 12) | -60  | -1.0 | nA    | 1            |

**Note 2:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

**Note 3:** The maximum power dissipation must be derated at elevated temperatures and is dictated by  $T_{Jmax}$  (maximum junction temperature),  $\theta_{JA}$  (package junction to ambient thermal resistance), and  $T_A$  (ambient temperature). The maximum allowable power dissipation at any temperature is  $P_{Dmax} = (T_{Jmax} - T_A) / \theta_{JA}$  or the number given in the Absolute Maximum Ratings, whichever is lower.

**Note 4:** Short circuits from the output to  $V^+$  can cause excessive heating and eventual destruction. When considering short circuits to ground, the maximum output current is approximately 40 mA independent of the magnitude of  $V^+$ . At values of supply voltage in excess of +15V, continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

**Note 5:** This input current will only exist when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistors becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also lateral NPN parasitic transistor action on the IC chip. This transistor action can cause the output voltages of the op amps to go to the  $V^+$  voltage level (or to ground for a large overdrive) for the time duration that an input is driven negative. This is not destructive and normal output states will re-establish when the input voltage, which was negative, again returns to a value greater than -0.3V (at 25°C).

**Note 6:** The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.

**Note 7:** The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3V (at 25°C). The upper end of the common-mode voltage range is  $V^+ - 1.5V$  (at 25°C), but either or both inputs can go to +32V without damage, independent of the magnitude of  $V^+$ .

**Note 8:** Human body model, 1.5 k $\Omega$  in series with 100 pF.

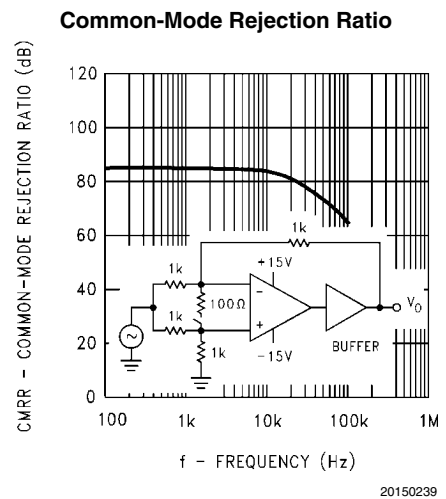
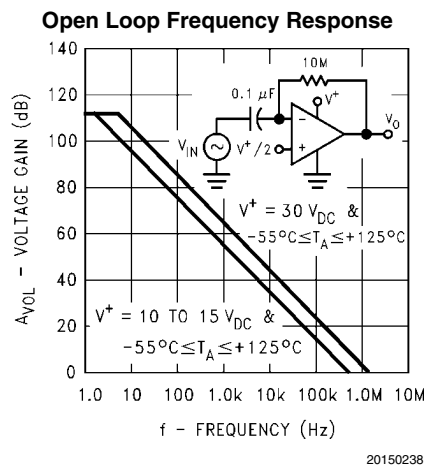
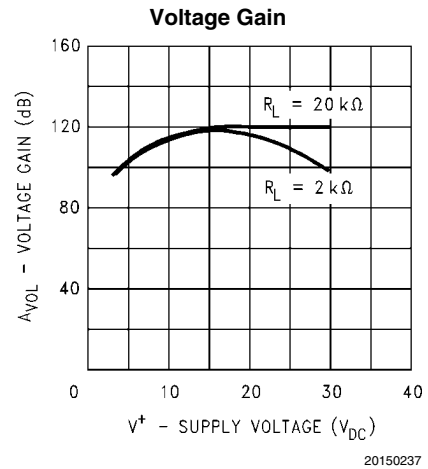
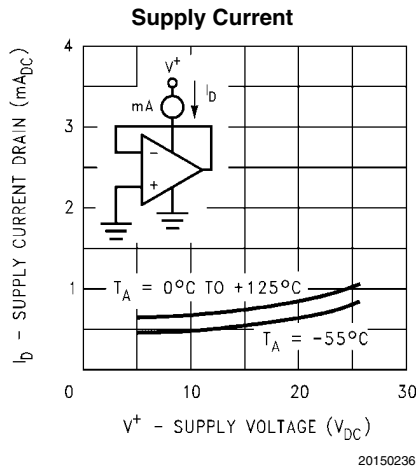
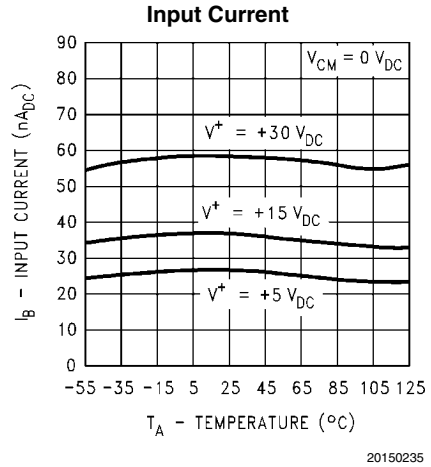
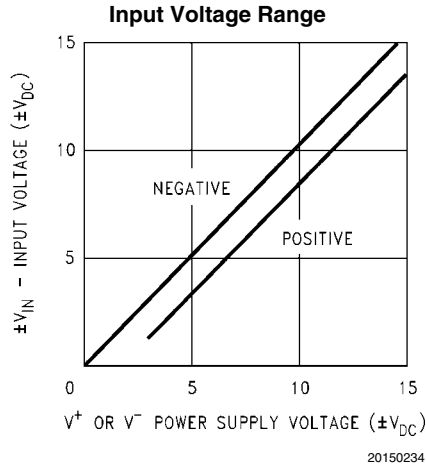
**Note 9:** Guaranteed by input offset voltage.

**Note 10:** Guaranteed parameter not tested.

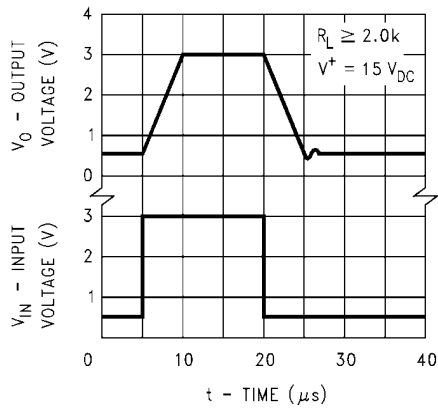
**Note 11:** Pre and post irradiation limits are identical to those listed under AC and DC electrical characteristics except as listed in the Post Radiation Limits Table. These parts may be dose rate sensitive in a space environment and demonstrate enhanced low dose rate sensitivity. Radiation end point limits for the noted parameters are guaranteed only for the conditions as specified in MIL-STD-883, per Test Method 1019, Condition A.

**Note 12:** Pre and post irradiation limits are identical to those listed under AC and DC electrical characteristics except as listed in the Post Radiation Limits Table. These parts may be sensitive in a high dose environment. Low dose rate testing has been performed on a wafer-by-wafer basis, per Test Method 1019, Condition D of MIL-STD-883, with no enhanced low dose rate sensitivity (ELDRS).

## Typical Performance Characteristics

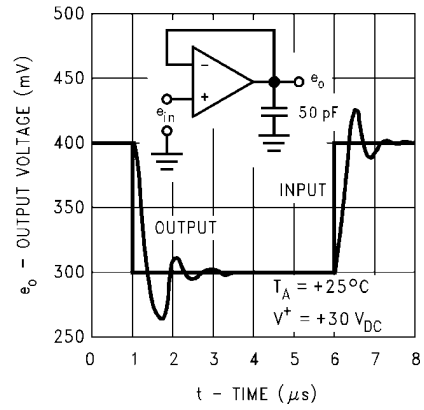


Voltage Follower Pulse Response



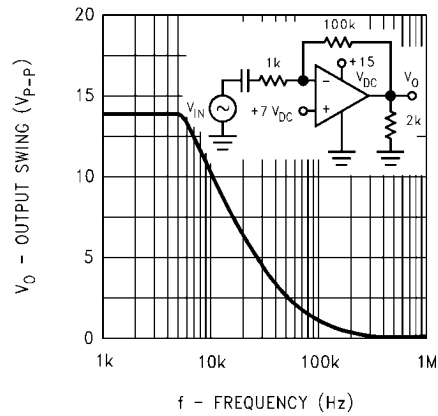
20150240

Voltage Follower Pulse Response (Small Signal)



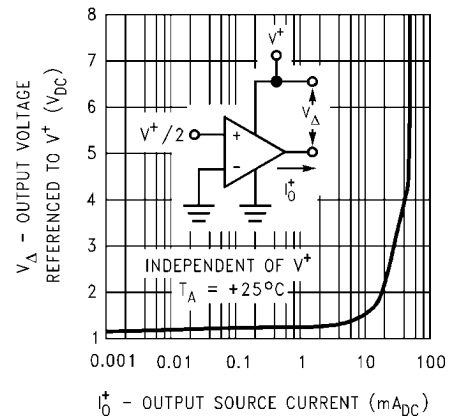
20150241

Large Signal Frequency Response



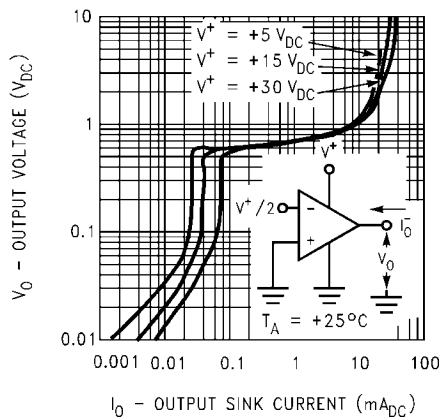
20150242

Output Characteristics Current Sourcing



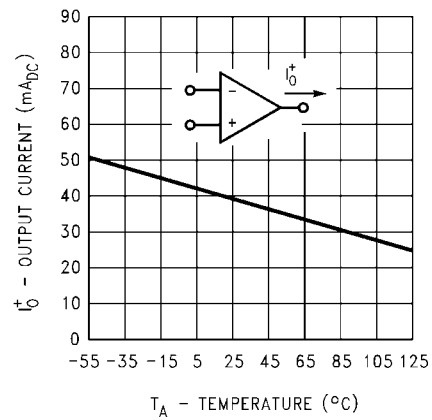
20150243

Output Characteristics Current Sinking



20150244

Current Limiting



20150245

## Application Hints

The LM158 series are op amps which operate with only a single power supply voltage, have true-differential inputs, and remain in the linear mode with an input common-mode voltage of  $0 V_{DC}$ . These amplifiers operate over a wide range of power supply voltage with little change in performance characteristics. At  $25^{\circ}\text{C}$  amplifier operation is possible down to a minimum supply voltage of  $2.3 V_{DC}$ .

Precautions should be taken to insure that the power supply for the integrated circuit never becomes reversed in polarity or that the unit is not inadvertently installed backwards in a test socket as an unlimited current surge through the resulting forward diode within the IC could cause fusing of the internal conductors and result in a destroyed unit.

Large differential input voltages can be easily accommodated and, as input differential voltage protection diodes are not needed, no large input currents result from large differential input voltages. The differential input voltage may be larger than  $V^+$  without damaging the device. Protection should be provided to prevent the input voltages from going negative more than  $-0.3 V_{DC}$  (at  $25^{\circ}\text{C}$ ). An input clamp diode with a resistor to the IC input terminal can be used.

To reduce the power supply current drain, the amplifiers have a class A output stage for small signal levels which converts to class B in a large signal mode. This allows the amplifiers to both source and sink large output currents. Therefore both NPN and PNP external current boost transistors can be used to extend the power capability of the basic amplifiers. The output voltage needs to raise approximately 1 diode drop above ground to bias the on-chip vertical PNP transistor for output current sinking applications.

For ac applications, where the load is capacitively coupled to the output of the amplifier, a resistor should be used, from the output of the amplifier to ground to increase the class A bias current and prevent crossover distortion. Where the load is directly coupled, as in dc applications, there is no crossover distortion.

Capacitive loads which are applied directly to the output of the amplifier reduce the loop stability margin. Values of 50 pF can be accommodated using the worst-case non-inverting unity gain connection. Large closed loop gains or resistive isolation should be used if larger load capacitance must be driven by the amplifier.

The bias network of the LM158 establishes a drain current which is independent of the magnitude of the power supply voltage over the range of  $3 V_{DC}$  to  $30 V_{DC}$ .

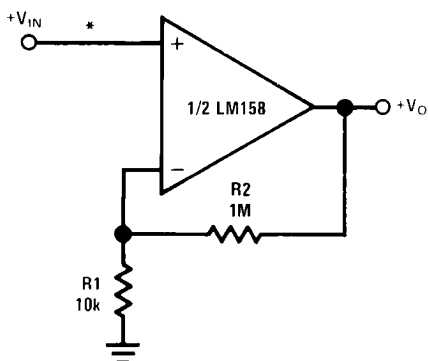
Output short circuits either to ground or to the positive power supply should be of short time duration. Units can be destroyed, not as a result of the short circuit current causing metal fusing, but rather due to the large increase in IC chip dissipation which will cause eventual failure due to excessive junction temperatures. Putting direct short-circuits on more than one amplifier at a time will increase the total IC power dissipation to destructive levels, if not properly protected with external dissipation limiting resistors in series with the output leads of the amplifiers. The larger value of output source current which is available at  $25^{\circ}\text{C}$  provides a larger output current capability at elevated temperatures (see typical performance characteristics) than a standard IC op amp.

The circuits presented in the section on typical applications emphasize operation on only a single power supply voltage. If complementary power supplies are available, all of the standard op amp circuits can be used. In general, introducing a pseudo-ground (a bias voltage reference of  $V^+/2$ ) will allow operation above and below this value in single power supply systems. Many application circuits are shown which take advantage of the wide input common-mode voltage range which includes ground. In most cases, input biasing is not required and input voltages which range to ground can easily be accommodated.

## Typical Single-Supply Applications

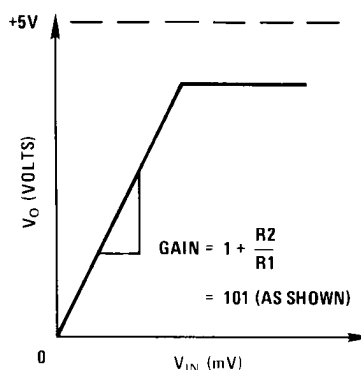
( $V^+ = 5.0 V_{DC}$ )

### Non-Inverting DC Gain (0V Output)



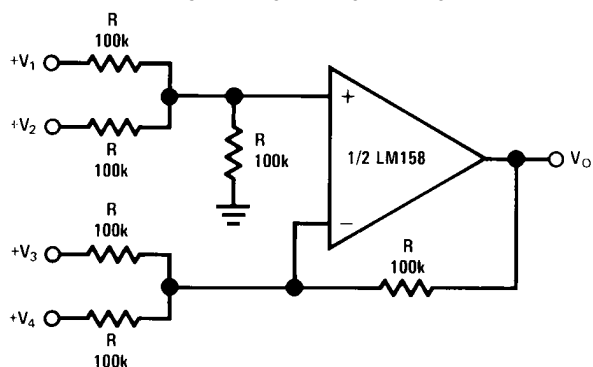
20150206

\*R not needed due to temperature independent  $I_{IN}$



20150207

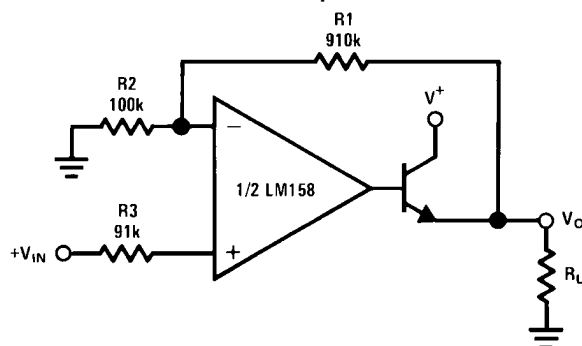
### DC Summing Amplifier ( $V_{IN'S} \geq 0 V_{DC}$ and $V_O \geq 0 V_{DC}$ )



20150208

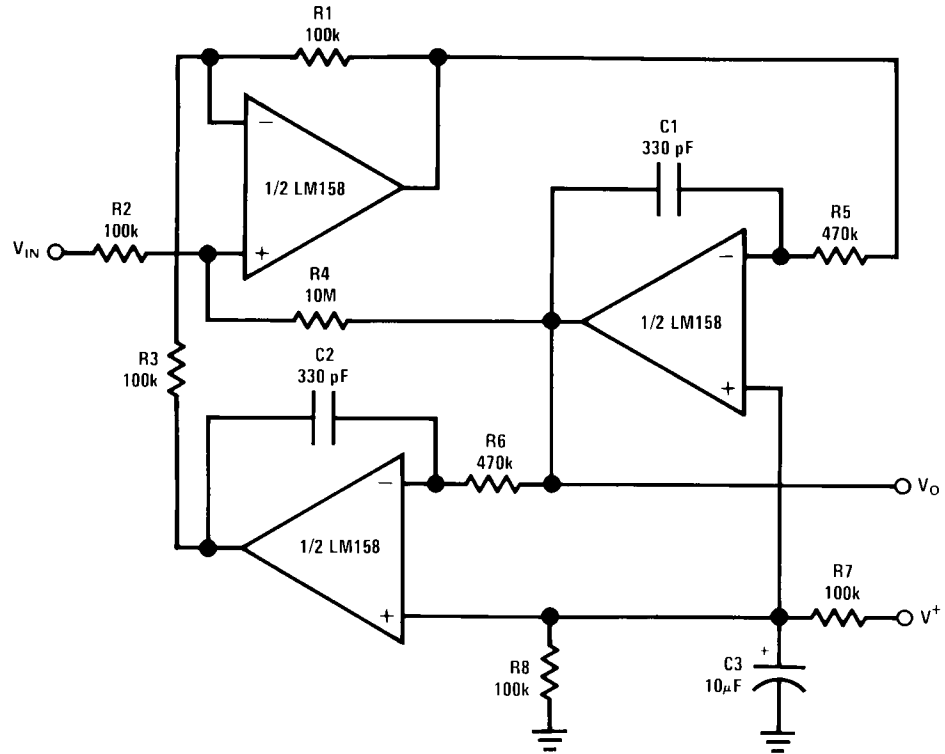
Where:  $V_O = V_1 + V_2 - V_3 - V_4$   
 $(V_1 + V_2) \geq (V_3 + V_4)$  to keep  $V_O > 0 V_{DC}$

### Power Amplifier



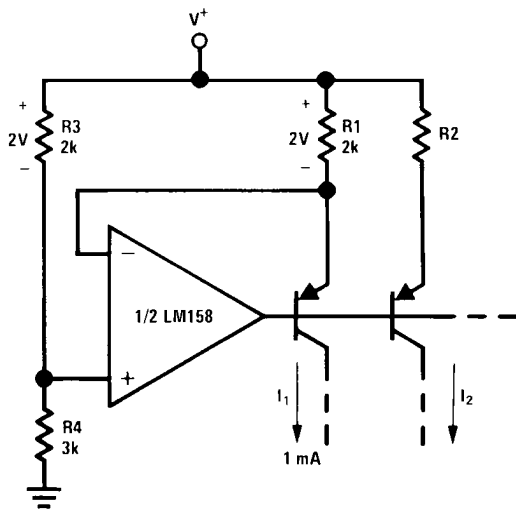
20150209

$V_O = 0 V_{DC}$  for  $V_{IN} = 0 V_{DC}$   
 $A_V = 10$

**"BI-QUAD" RC Active Bandpass Filter**

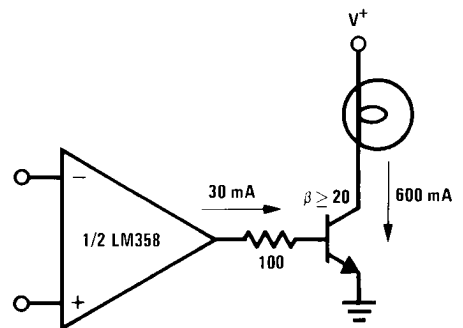
20150210

$f_o = 1 \text{ kHz}$   
 $Q = 50$   
 $A_v = 100 \text{ (40 dB)}$

**Fixed Current Sources**

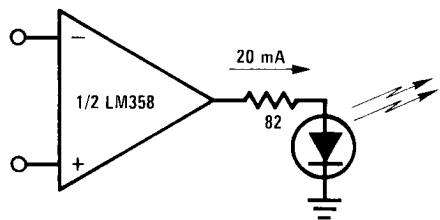
20150211

$$I_2 = \left( \frac{R_1}{R_2} \right) I_1$$

**Lamp Driver**

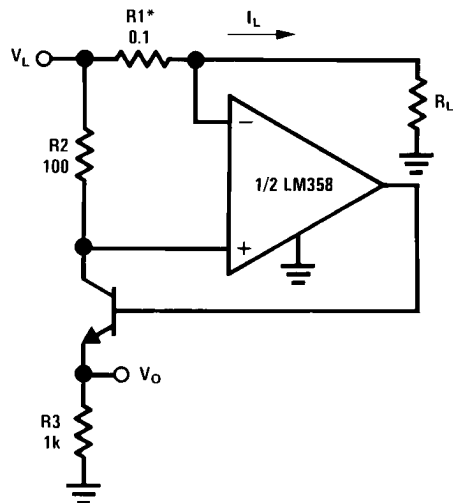
20150212

LED Driver



20150213

Current Monitor

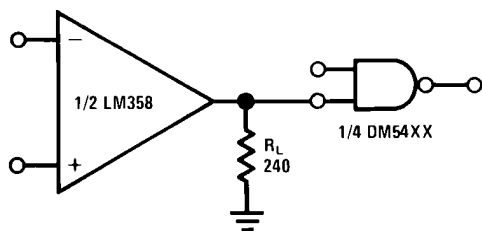


20150214

$$V_O = \frac{1V(I_L)}{1A}$$

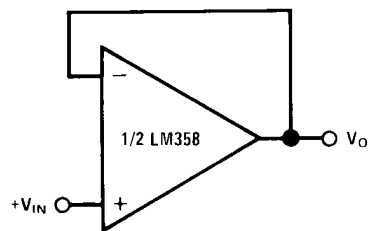
\*(Increase  $R_1$  for  $I_L$  small) $V_L \leq V^+ - 2V$ 

Driving TTL



20150215

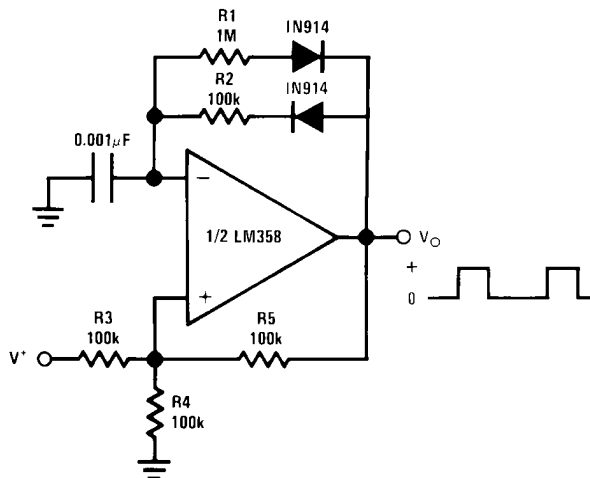
Voltage Follower



20150217

$$V_O = V_{IN}$$

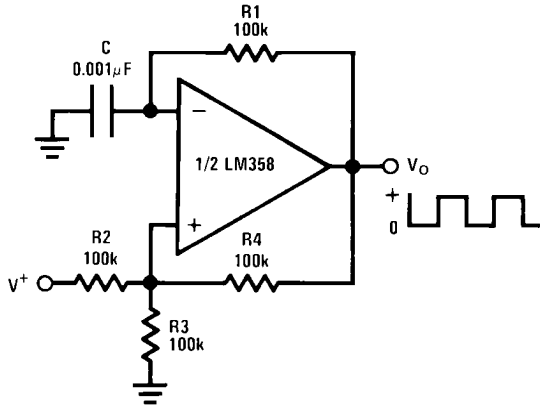
Pulse Generator



20150216

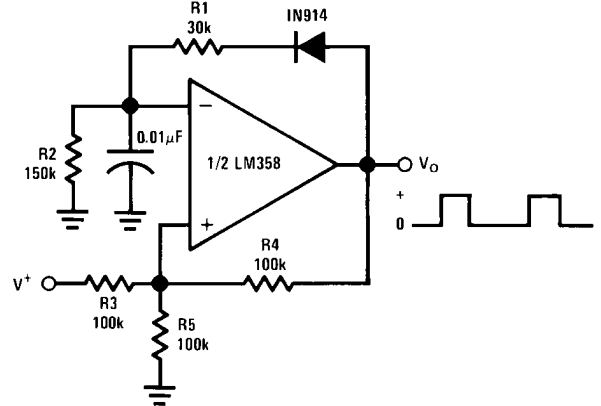


### Squarewave Oscillator



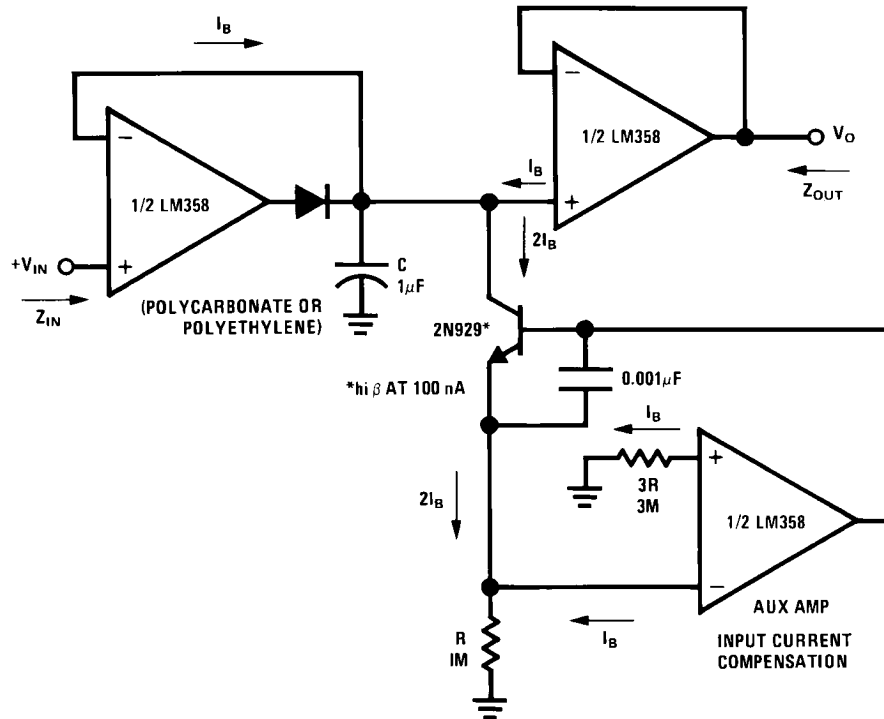
20150218

### Pulse Generator



20150219

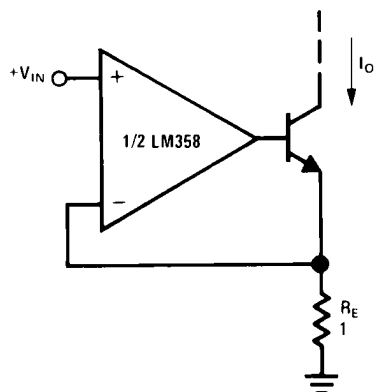
### Low Drift Peak Detector



20150220

HIGH  $Z_{IN}$   
LOW  $Z_{OUT}$

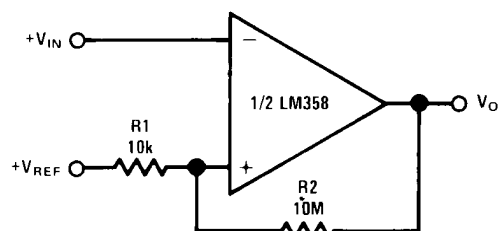
## High Compliance Current Sink



20150221

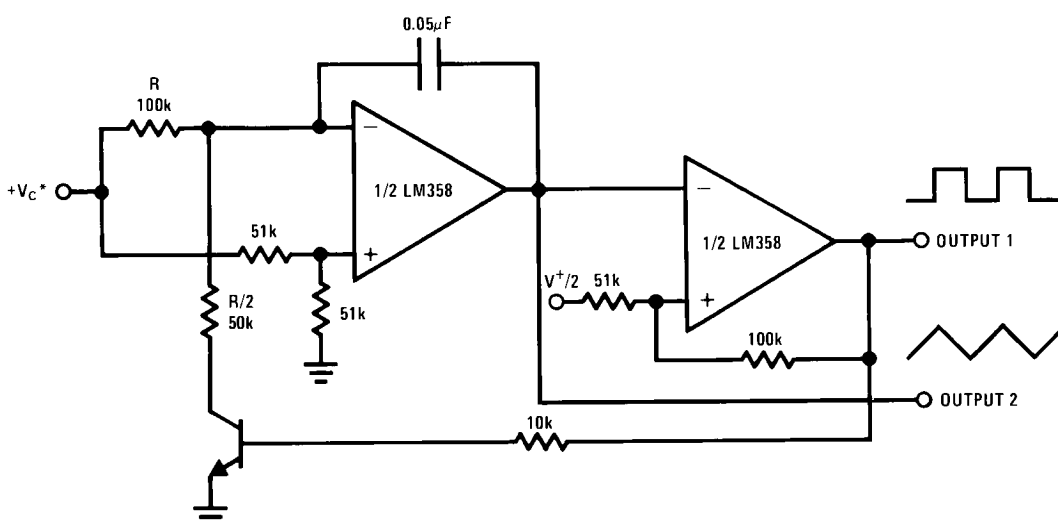
$I_O = 1 \text{ amp/volt } V_{IN}$   
(Increase  $R_E$  for  $I_O$  small)

## Comparator with Hysteresis



20150222

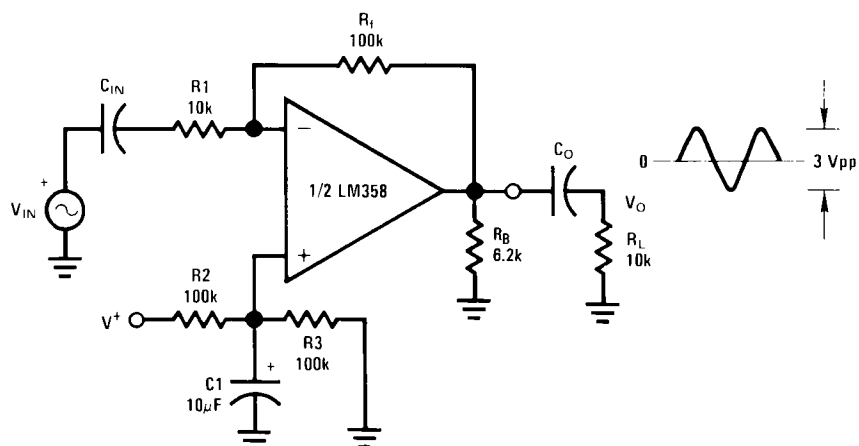
## Voltage Controlled Oscillator (VCO)



20150223

\*WIDE CONTROL VOLTAGE RANGE:  $0 V_{DC} \leq V_C \leq 2 (V^+ - 1.5V_{DC})$

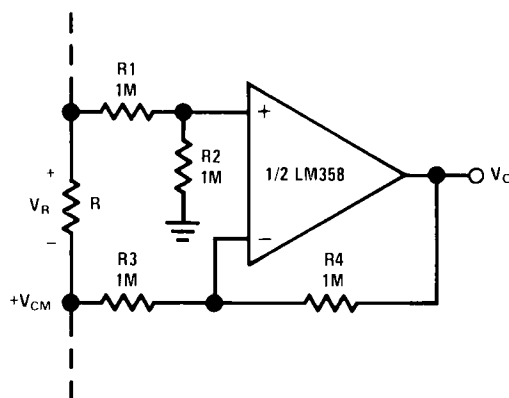
## AC Coupled Inverting Amplifier



20150224

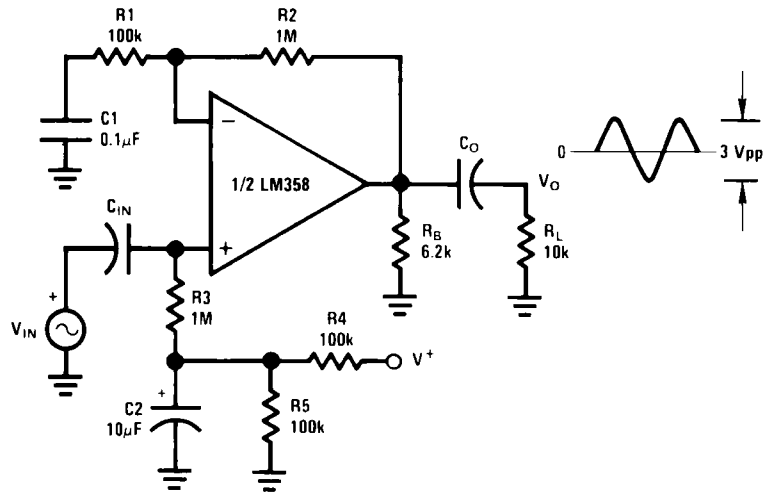
$$A_V = \frac{R_f}{R_1} \quad (\text{As shown, } A_V = 10)$$

## Ground Referencing a Differential Input Signal



20150225

## AC Coupled Non-Inverting Amplifier

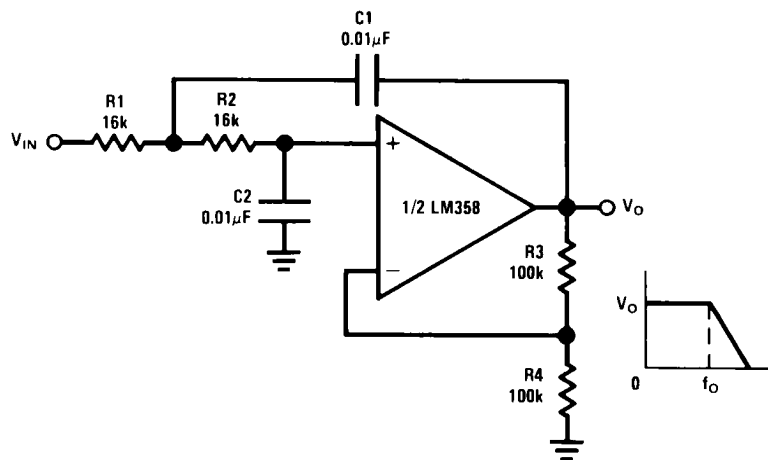


20150226

$$A_V = 1 + \frac{R_2}{R_1}$$

 $A_V = 11$  (As Shown)

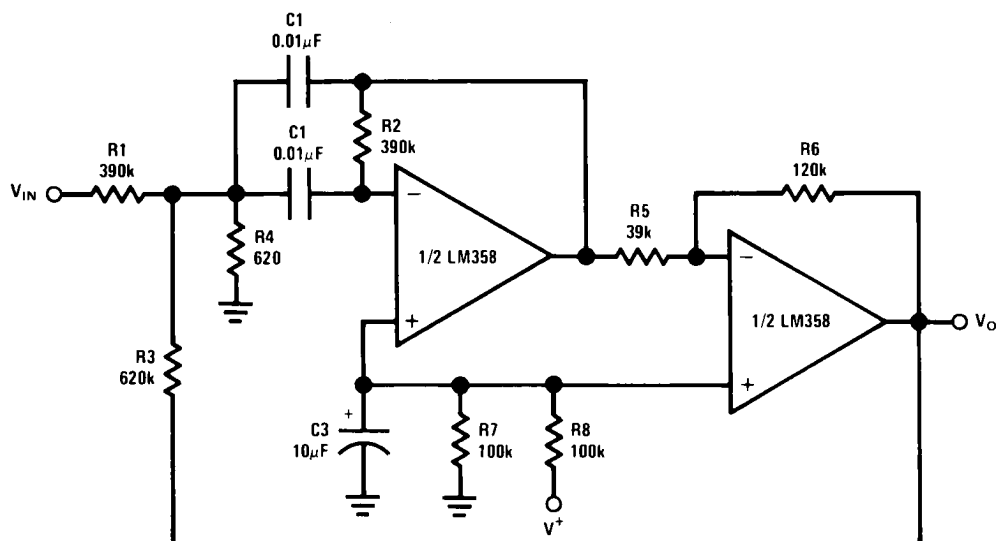
## DC Coupled Low-Pass RC Active Filter



20150227

 $f_o = 1 \text{ kHz}$   
 $Q = 1$   
 $A_V = 2$

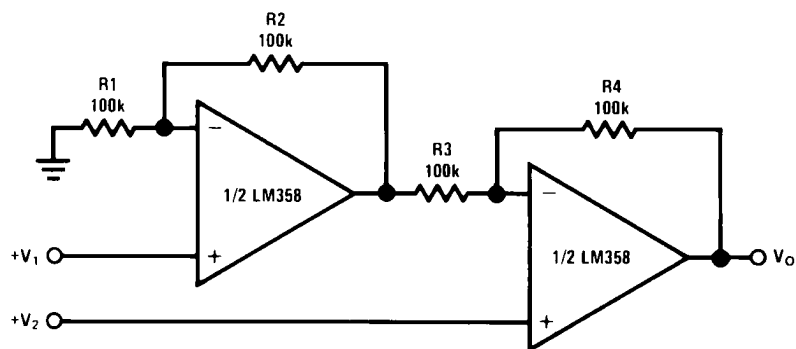
## Bandpass Active Filter



20150228

$f_o = 1 \text{ kHz}$   
 $Q = 25$

## High Input Z, DC Differential Amplifier



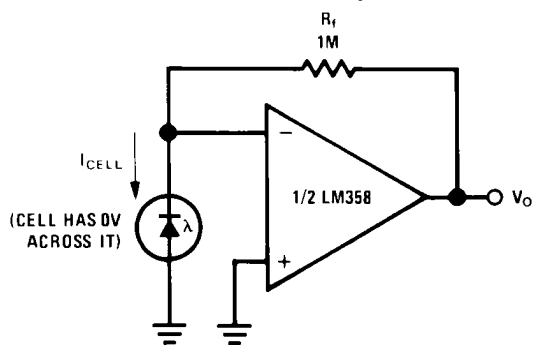
20150229

For  $\frac{R1}{R2} = \frac{R4}{R3}$  (CMRR depends on this resistor ratio match)

$$V_O = 1 + \frac{R4}{R3} (V_2 - V_1)$$

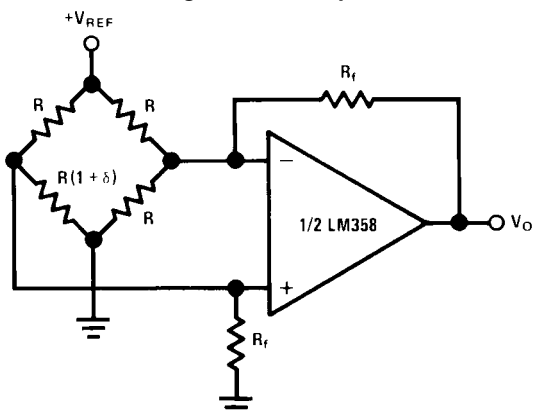
As Shown:  $V_O = 2 (V_2 - V_1)$

## Photo Voltaic-Cell Amplifier



20150230

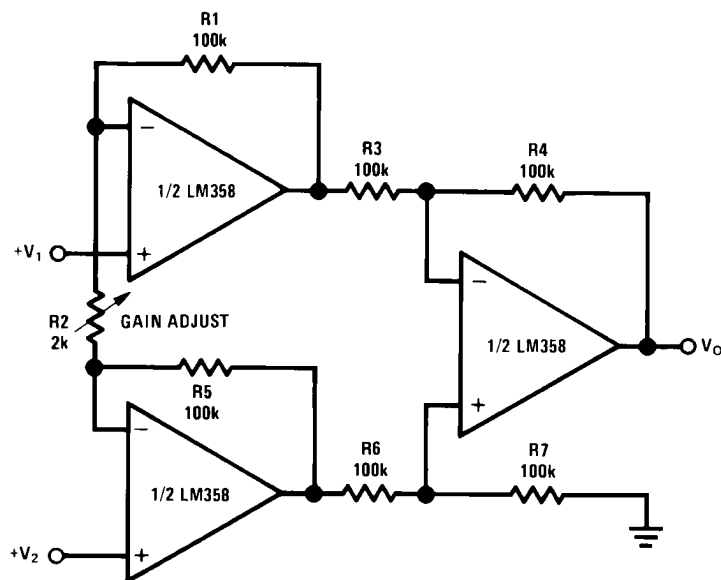
## Bridge Current Amplifier



20150233

For  $\delta \ll 1$  and  $R_f \gg R$ 

$$V_O \approx V_{REF} \left( \frac{\delta}{2} \right) \frac{R_f}{R}$$

High Input Z Adjustable-Gain  
DC Instrumentation Amplifier

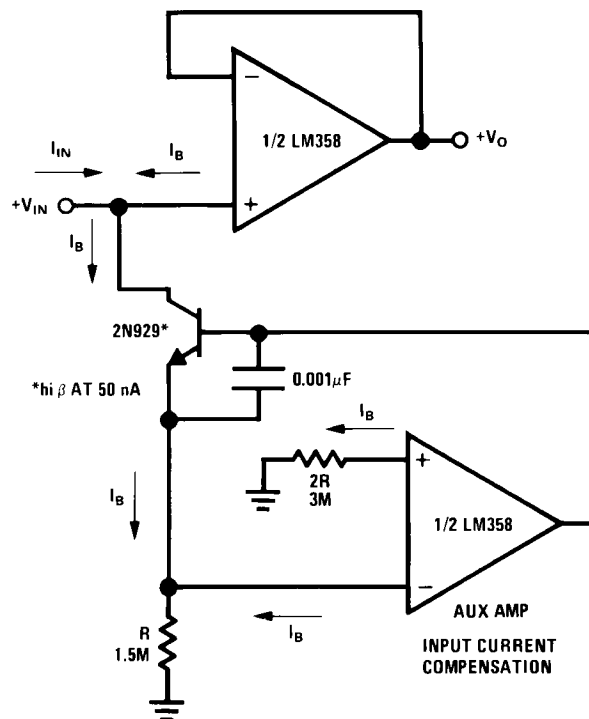
20150231

If  $R_1 = R_5$  &  $R_3 = R_4 = R_6 = R_7$  (CMRR depends on match)

$$V_O = 1 + \frac{2R_1}{R_2} (V_2 - V_1)$$

As shown  $V_O = 101 (V_2 - V_1)$

### Using Symmetrical Amplifiers to Reduce Input Current (General Concept)



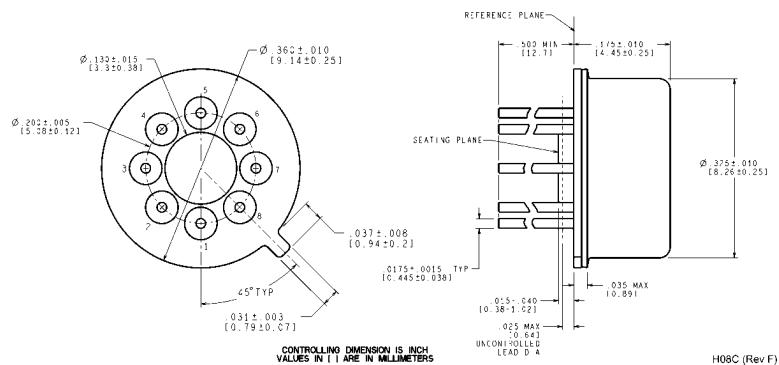
20150232

## Revision History

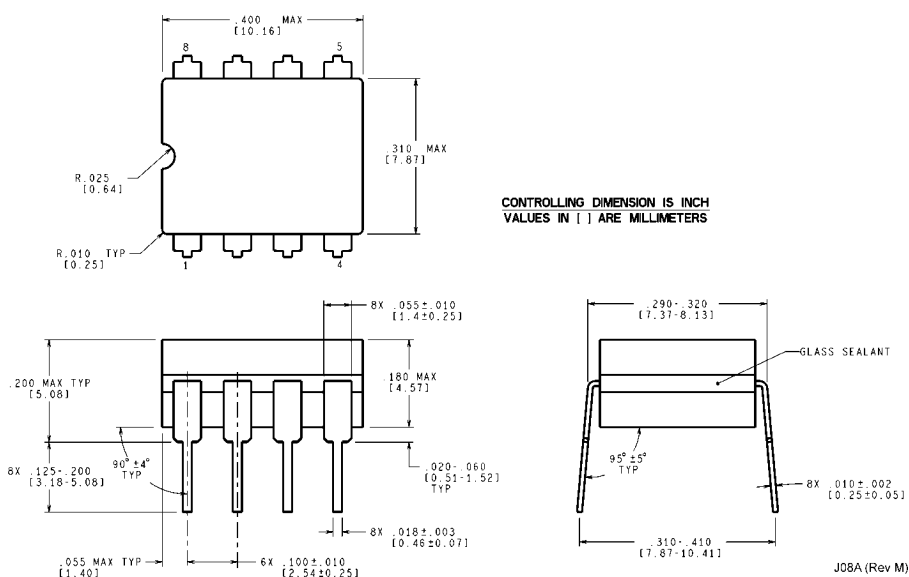
| Date Released | Revision | Section                                                              | Originator  | Changes                                                                                                                                                                                               |
|---------------|----------|----------------------------------------------------------------------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 07/12/05      | A        | New release to corporate format.                                     | L. Lytle    | 2 MDS datasheets converted into one Corporate datasheet format. MNLM158-X-RH Rev 1C1 & MNLM158-X Rev 1A1 will be archived.                                                                            |
| 01/09/06      | B        | Typical Single-Supply Applications                                   | R. Malone   | Correct an equation From: $V1 + V2 + V3 + V4$<br>To: $V1 + V2 - V3 - V4$ (right after art -08, pg 12). Reason: To reflect same correction made in commercial data sheet. Revision A will be archived. |
| 01/27/06      | C        | Features, Ordering Information Table and Post Radiation Electrical's | Larry McGee | Added reference to radiation, NSID's to Ordering Table and Post Rad limits for 100k                                                                                                                   |
| 10/05/06      | D        | Connection Diagram, page 2                                           | R. Malone   | Corrected typo title for Ceramic SOIC. Revision C will be Archived                                                                                                                                    |
| 08/21/08      | E        | Features, Ordering Information, Electrical Sections and Notes.       | Larry McGee | Added reference to ELDRS, NSID's to Ordering Table, and ELDRS Electricals. Deleted 50k Rad NSID's and Post Rad table. Revision D will be Archived.                                                    |
| 01/13/09      | F        | Ordering Information, ELDRS Electrical Section, Notes 11 and 12      | Larry McGee | Deleted NSID's LM158AH-QMLV and LM158AWG-QMLV code K. Changed DC and Post Rad ELDRS Electricals. Changed Notes 11 and 12 wording. Revision E will be Archived.                                        |



# Physical Dimensions inches (millimeters) unless otherwise noted



**Metal Can Package (H)**  
**NS Package Number H08C**



**CERDIP Package (J)**  
**NS Package Number J08A**

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## Notes

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