



# JM38510/11401/11402/11403/ 11404/11405/11406

JAN JFET-INPUT  
OPERATIONAL AMPLIFIERS

Precision Monolithics Inc.

T-79-15

## GENERAL DESCRIPTION

This data sheet covers the electrical requirements for a monolithic, low-power, internally-compensated JFET-input operational amplifier as specified in MIL-M-38510/114 for device types 01 to 06. Devices supplied to this data sheet are manufactured and tested at PMI's MIL-M-38510 certified facility and are listed in QPL-38510.

Complete device requirements will be found in MIL-M-38510 and MIL-M-38510/114 for Class B and Class S processed devices.

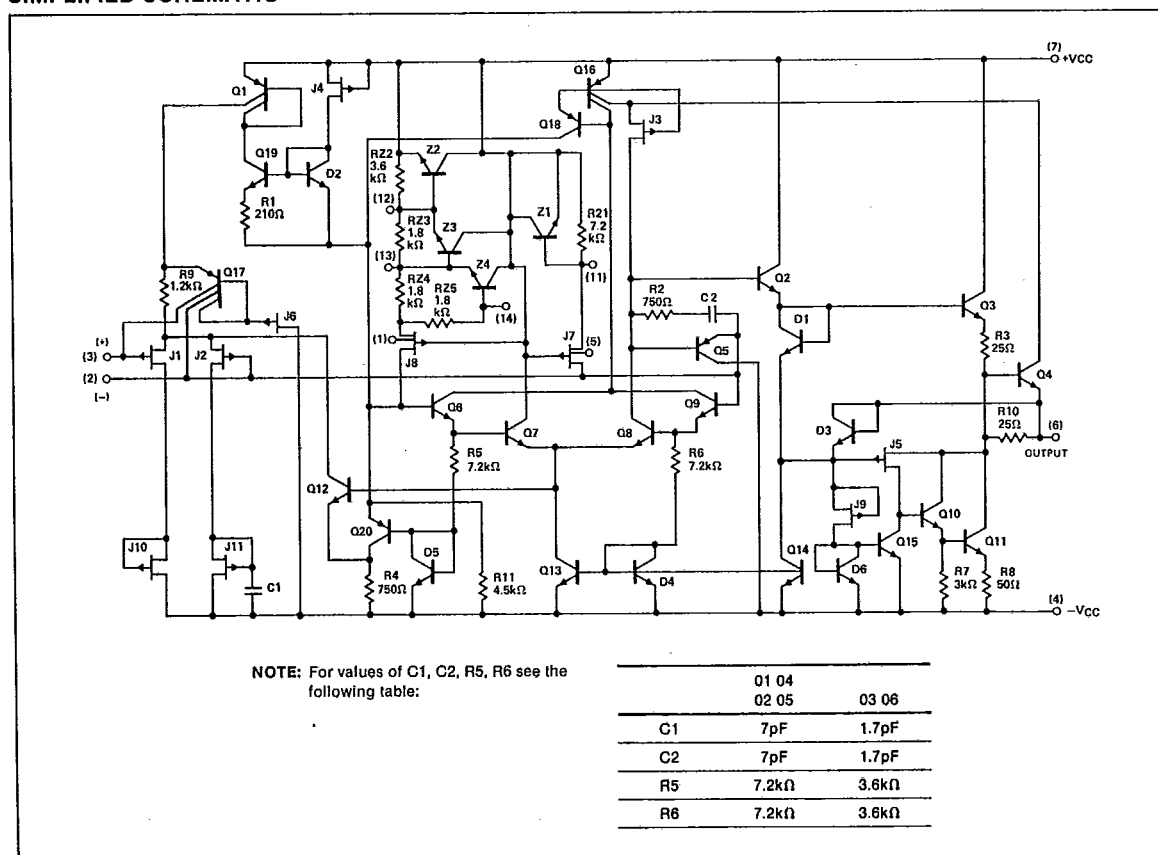
## GENERIC CROSS-REFERENCE INFORMATION

This cross-reference information is presented for the convenience of the user. The generic-industry types listed may not have identical

operational performance characteristics across the military temperature range or reliability factors equivalent to the MIL-M-38510 device.

| Military Device Type | Generic-Industry Type |
|----------------------|-----------------------|
| 01                   | LF-155                |
| 04                   | LF-155A               |
| 02                   | LF-156                |
| 05                   | LF-156A               |
| 03                   | LF-157                |
| 06                   | LF-157A               |

## SIMPLIFIED SCHEMATIC





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## ABSOLUTE MAXIMUM RATINGS

|                                      |                                    |
|--------------------------------------|------------------------------------|
| Supply Voltage Range                 | ±22V                               |
| Input Voltage Range (Note 1)         | ±20V                               |
| Differential Input Voltage Range     | ±40V                               |
| Lead Temperature (Soldering, 60 sec) | 300°C                              |
| Junction Temperature                 | $T_J = 175^\circ\text{C}$ (Note 3) |
| Storage Temperature Range            | -65°C to +150°C                    |
| Output Short-Circuit Duration        | Unlimited (Note 2)                 |

## NOTES:

1. The absolute maximum negative input voltage is equal to the negative power supply voltage.

2. Short circuit may be to ground to either supply. Rating applies to +125°C case temperature or +75°C ambient temperature.
3. For short-term test (in the specific burn-in and life test configuration when required and up to 168 hours maximum),  $T_J = 275^\circ\text{C}$ .

## RECOMMENDED OPERATING CONDITIONS

|                           |                 |
|---------------------------|-----------------|
| Supply Voltage Range      | ±5 to ±20 VDC   |
| Ambient Temperature Range | -55°C to +125°C |

**ELECTRICAL CHARACTERISTICS** at  $V_{CC}$  from ±5V to ±20V; source resistance = 50 ohm; ambient temperature range = -55°C to +125°C and figure 1, unless otherwise noted.

| PARAMETER                                                   | SYMBOL                           | CONDITIONS                                                                                               | 01 LIMITS |      | 04 LIMITS |      | UNITS                        |
|-------------------------------------------------------------|----------------------------------|----------------------------------------------------------------------------------------------------------|-----------|------|-----------|------|------------------------------|
|                                                             |                                  |                                                                                                          | MIN       | MAX  | MIN       | MAX  |                              |
| Input Offset Voltage                                        | $V_{IO}$                         | $\pm V_{CC} = \pm 5V, V_{CM} = 0V$<br>$T_A = 25^\circ\text{C}$                                           | -5        | 5    | -2        | 2    | mV                           |
|                                                             |                                  | $\pm V_{CC} = \pm 20V$<br>$V_{CM} = \pm 15V, 0V$<br>$-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$ | -7        | 7    | -2.5      | 2.5  |                              |
| Input Offset Voltage Temperature Sensitivity                | $\frac{\Delta V_{IO}}{\Delta T}$ | $\pm V_{CC} = \pm 20V$<br>$V_{CM} = 0V$                                                                  | -30       | 30   | -10       | 10   | $\mu\text{V}/^\circ\text{C}$ |
| Input Offset Current                                        | $I_{IO}$                         | $\pm V_{CC} = \pm 20V, V_{CM} = 0V,$<br>$T_J = 25^\circ\text{C}$                                         | -20       | 20   | -20       | 20   | pA                           |
|                                                             |                                  | $T_J = 125^\circ\text{C}$                                                                                | -20       | 20   | -20       | 20   | nA                           |
| Input Bias Current<br>(Note 1)<br>(Note 2)<br>(Note 3)      | $+I_{IB}$                        | $\pm V_{CC} = \pm 20V, V_{CM} = +15V$<br>$T_J = 25^\circ\text{C}$                                        | -100      | 3500 | -100      | 3500 | pA                           |
|                                                             |                                  | $t \leq 25\text{ms}$<br>$T_J = 125^\circ\text{C}$                                                        | -10       | 60   | -10       | 60   | nA                           |
|                                                             | $-I_{IB}$                        | $\pm V_{CC} = \pm 15V, V_{CM} = +10V$<br>$T_J = 25^\circ\text{C}$                                        | -100      | 300  | -100      | 300  | pA                           |
|                                                             |                                  | $t \leq 25\text{ms}$<br>$T_J = 125^\circ\text{C}$                                                        | -10       | 50   | -10       | 50   | nA                           |
|                                                             |                                  | $\pm V_{CC} = \pm 20V, -15V \leq V_{CM} \leq 0V$<br>$T_J = 25^\circ\text{C}$                             | -100      | 100  | -100      | 100  | pA                           |
|                                                             |                                  | $t \leq 25\text{ms}$<br>$T_J = 125^\circ\text{C}$                                                        | -10       | 50   | -10       | 50   | nA                           |
| Power Supply Rejection Ratio                                | +PSRR                            | $+V_{CC} = 10V, -V_{CC} = -20V$                                                                          | 85        | —    | 85        | —    | dB                           |
|                                                             | -PSRR                            | $+V_{CC} = 20V, -V_{CC} = -10V$                                                                          | —         | —    | —         | —    | —                            |
| Input Voltage Common-Mode Rejection (Note 4)                | CMR                              | $\pm V_{CC} = \pm 20V$<br>$V_{IN} = \pm 15V$                                                             | 85        | —    | 85        | —    | dB                           |
| Adjustment for Input Offset Voltage                         | $V_{IO} \text{ ADJ (+)}$         | $\pm V_{CC} = \pm 20V$                                                                                   | +8        | —    | +8        | —    | mV                           |
|                                                             | $V_{IO} \text{ ADJ (-)}$         | $\pm V_{CC} = \pm 20V$                                                                                   | —         | -8   | —         | -8   | mV                           |
| Output Short-Circuit Current (for Positive Output) (Note 5) | $I_{OS(+)}$                      | $\pm V_{CC} = \pm 15V$<br>$t \leq 25\text{ms}$<br>(Short Circuit to Ground)                              | -50       | —    | -50       | —    | mA                           |
| Output Short-Circuit Current (for Negative Output) (Note 5) | $I_{OS(-)}$                      | $\pm V_{CC} = \pm 15V$<br>$t \leq 25\text{ms}$<br>(Short Circuit to Ground)                              | —         | 50   | —         | 50   | mA                           |
| Supply Current                                              | $I_{CC}$                         | $T_A = -55^\circ\text{C}$                                                                                | —         | 11   | —         | 11   | mA                           |
|                                                             |                                  | $\pm V_{CC} = \pm 15V, T_A = +25^\circ\text{C}$                                                          | —         | 4    | —         | 4    |                              |
|                                                             |                                  | $T_A = +125^\circ\text{C}$                                                                               | —         | 4    | —         | 4    |                              |
| Output Voltage Swing (Maximum)                              | $V_{OP}$                         | $\pm V_{CC} = \pm 20V, R_L = 10k\Omega$                                                                  | ±16       | —    | ±16       | —    | V                            |
|                                                             |                                  | $\pm V_{CC} = \pm 20V, R_L = 2k\Omega$                                                                   | ±15       | —    | ±15       | —    |                              |
| Open-Loop Voltage Gain (Single Ended) (Note 6)              | $A_{VS(+)}$<br>$A_{VS(-)}$       | $\pm V_{CC} = \pm 20V, V_{OUT} = \pm 15V$<br>$R_L = 2k\Omega, T_A = 25^\circ\text{C}$                    | 50        | —    | 50        | —    | V/mV                         |
|                                                             |                                  | $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$                                                     | 25        | —    | 25        | —    |                              |
| Open-Loop Voltage Gain (Single Ended) (Note 6)              | $A_{VS}$                         | $\pm V_{CC} = \pm 5V$<br>$R_L = 2k\Omega$<br>$V_{OUT} = \pm 2V$                                          | 10        | —    | 10        | —    | V/mV                         |

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OPERATIONAL AMPLIFIERS/BUFFERS

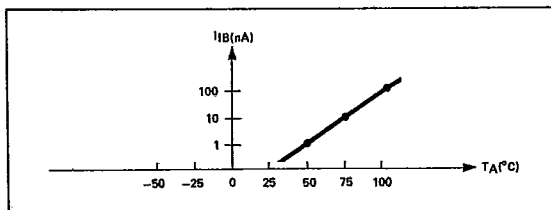
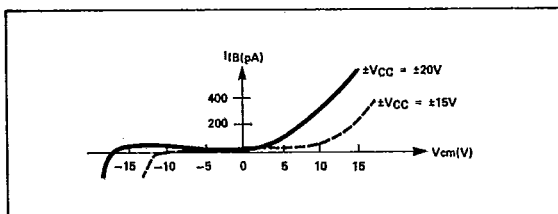
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**ELECTRICAL CHARACTERISTICS** at  $V_{CC}$  from  $\pm 5V$  to  $\pm 20V$ ; source resistance = 50 ohm; ambient temperature range =  $-55^{\circ}C$  to  $+125^{\circ}C$  and figure 1, unless otherwise noted. (Continued)

| PARAMETER                           | SYMBOL                    | CONDITIONS                                                                                                                              | 01 LIMITS |      | 04 LIMITS |      | UNITS         |
|-------------------------------------|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-----------|------|-----------|------|---------------|
|                                     |                           |                                                                                                                                         | MIN       | MAX  | MIN       | MAX  |               |
| Transient Response Rise Time        | $TR_{(tr)}$               | $\pm V_{CC} = \pm 15V$ , $R_L = 2k\Omega$ , $A_V = 1$<br>$C_L = 100pF$ , See Figure 2<br>$V_{IN} = 50mV$                                | —         | 150  | —         | 150  | ns            |
| Transient Response Overshoot        | $TR_{(os)}$               | $\pm V_{CC} = \pm 15V$ , $R_L = 2k\Omega$ , $A_V = 1$<br>$C_L = 100pF$ , See Figure 2<br>$V_{IN} = 50mV$                                | —         | 40   | —         | 40   | %             |
| Slew Rate                           | $SR_{(+)}$ and $SR_{(-)}$ | $V_{IN} = \pm 5V$ , $\pm V_{CC} = \pm 15V$<br>$A_V = 1$ , See Figure 2<br>$T_A = 25^{\circ}C$<br>$T_A = -55^{\circ}C$ , $+125^{\circ}C$ | 2         | —    | 3         | —    | $V/\mu s$     |
|                                     |                           |                                                                                                                                         | 1         | —    | 1.5       | —    |               |
| Settling Time                       | $ts_{(+)}$ and $ts_{(-)}$ | $\pm V_{CC} = \pm 15V$ (0.1% error)<br>$T_A = 25^{\circ}C$ , $A_V = -1$<br>See Figure 3                                                 | —         | 4000 | —         | 4000 | ns            |
| Noise (Referred to Input) Broadband | $N_I(BB)$                 | $\pm V_{CC} = \pm 20V$ , $T_A = 25^{\circ}C$<br>Bandwidth = 5kHz                                                                        | —         | 10   | —         | 10   | $\mu V_{rms}$ |
| Noise (Referred to Input) Popcorn   | $N_I(PC)$                 | $\pm V_{CC} = \pm 20V$ , $T_A = 25^{\circ}C$<br>Bandwidth = 5kHz                                                                        | —         | 40   | —         | 40   | $\mu V_{pk}$  |

#### NOTES:

- Bias currents are actually junction leakage currents which double (approximately) for each  $10^{\circ}C$  increase in junction temperature  $T_J$ . Measurement of bias current is specified at  $T_J$  rather than  $T_A$ , since normal warm-up thermal transients will affect the bias currents. The measurements for bias currents must be made within 25ms or 5 loop time constants after power is first applied to the device for test. Measurement at  $T_A = -55^{\circ}C$  is not necessary since expected values are too small for typical test systems.
- Bias current is sensitive to power supply voltage, common-mode voltage and temperature as shown by the following typical curves:



- Negative  $I_B$  minimum limits reflect the characteristics of device with bias current compensation.
- CMR is calculated from  $V_{IO}$  measurements at  $V_{CM} = +15V$  and  $-15V$ .
- Continuous limits shall be considerably lower. Protection for shorts to either supply exists providing that  $T_J(max) \leq 175^{\circ}C$ .
- Because of thermal feedback effects from output to input, open-loop gain is not guaranteed to be linear or positive over the operating range. These requirements, if needed, should be specified by the user in additional procurement documents.

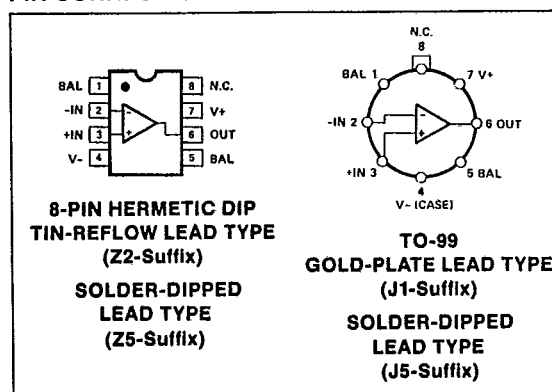
#### CASE OUTLINE

Per MIL-M-38510, Appendix C, Case Outline A-1 (8 Lead Can), Package Type Designator "G"; and Appendix C, Case Outline D-4 (8 Lead Dual-in-Line) Package Type Designator "P".

#### POWER AND THERMAL CHARACTERISTICS

| Package                            | Case outline | Maximum allowable power dissipation | Maximum $\theta_{JA}-C$ | Maximum $\theta_{JA}-A$ |
|------------------------------------|--------------|-------------------------------------|-------------------------|-------------------------|
| 8 Lead Can (TO-99)                 | G            | 330mW at $T_A = 125^{\circ}C$       | 40^{\circ}C/W           | 150^{\circ}C/W          |
| 8 Lead Hermetic DIP (Dual-in-Line) | P            | 417mW at $T_A = 125^{\circ}C$       | 50^{\circ}C/W           | 120^{\circ}C/W          |

#### PIN CONNECTIONS





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**ELECTRICAL CHARACTERISTICS** at  $V_{CC}$  from  $\pm 5V$  to  $\pm 20V$ ; source resistance = 50 ohm; ambient temperature range =  $-55^{\circ}C$  to  $+125^{\circ}C$  and figure 1, unless otherwise noted.

| PARAMETER                                                   | SYMBOL                             | CONDITIONS                                                                                                                                                        | 02 LIMITS            |              | 05 LIMITS            |              | UNITS             |
|-------------------------------------------------------------|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|--------------|----------------------|--------------|-------------------|
|                                                             |                                    |                                                                                                                                                                   | MIN                  | MAX          | MIN                  | MAX          |                   |
| Input Offset Voltage                                        | $V_{IO}$                           | $\pm V_{CC} = \pm 5V$ , $V_{CM} = 0V$<br>$T_A = 25^{\circ}C$<br>$\pm V_{CC} = \pm 20V$<br>$V_{CM} = \pm 15V$ , $0V$<br>$-55^{\circ}C \leq T_A \leq +125^{\circ}C$ | -5                   | 5            | -2                   | 2            | mV                |
| Input Offset Voltage Temperature Sensitivity                | $\frac{\Delta V_{IO}}{\Delta T}$   | $\pm V_{CC} = \pm 20V$<br>$V_{CM} = 0V$                                                                                                                           | -30                  | 30           | -10                  | 10           | $\mu V/^{\circ}C$ |
| Input Offset Current                                        | $I_{IO}$                           | $\pm V_{CC} = \pm 20V$ , $V_{CM} = 0V$ ,<br>$T_J = 25^{\circ}C$<br>$T_J = 125^{\circ}C$                                                                           | -20                  | 20           | -20                  | 20           | pA<br>nA          |
| Input Bias Current<br>(Note 1)<br>(Note 2)<br>(Note 3)      | $+I_{IB}$                          | $\pm V_{CC} = \pm 20V$ , $V_{CM} = +15V$<br>$T_J = 25^{\circ}C$                                                                                                   | -100                 | 3500         | -100                 | 3500         | pA                |
|                                                             |                                    | $t \leq 25ms$ , $T_J = 125^{\circ}C$                                                                                                                              | -10                  | 60           | -10                  | 60           | nA                |
|                                                             | $-I_{IB}$                          | $\pm V_{CC} = \pm 15V$ , $V_{CM} = +10V$<br>$T_J = 25^{\circ}C$                                                                                                   | -100                 | 300          | -100                 | 300          | pA                |
|                                                             |                                    | $t \leq 25ms$ , $T_J = 125^{\circ}C$                                                                                                                              | -10                  | 50           | -10                  | 50           | nA                |
|                                                             |                                    | $\pm V_{CC} = \pm 20V$ , $-15V \leq V_{CM} \leq 0V$<br>$T_J = 25^{\circ}C$                                                                                        | -100                 | 100          | -100                 | 100          | pA                |
|                                                             |                                    | $t \leq 25ms$ , $T_J = 125^{\circ}C$                                                                                                                              | -10                  | 50           | -10                  | 50           | nA                |
| Power Supply Rejection Ratio                                | +PSRR<br>-PSRR                     | $+V_{CC} = 10V$ , $-V_{CC} = -20V$<br>$+V_{CC} = 20V$ , $-V_{CC} = -10V$                                                                                          | 85                   | —            | 85                   | —            | dB                |
| Input Voltage Common-Mode Rejection (Note 4)                | CMR                                | $\pm V_{CC} = \pm 20V$<br>$V_{IN} = \pm 15V$                                                                                                                      | 85                   | —            | 85                   | —            | dB                |
| Adjustment for Input Offset Voltage                         | $V_{IO} ADJ(+)$<br>$V_{IO} ADJ(-)$ | $\pm V_{CC} = \pm 20V$<br>$\pm V_{CC} = \pm 20V$                                                                                                                  | +8<br>—              | —<br>-8      | +8<br>—              | —<br>-8      | mV                |
| Output Short-Circuit Current (for Positive Output) (Note 5) | $I_{OS(+)}$                        | $\pm V_{CC} = \pm 15V$<br>$t \leq 25ms$<br>(Short Circuit to Ground)                                                                                              | -50                  | —            | -50                  | —            | mA                |
| Output Short-Circuit Current (for Negative Output) (Note 5) | $I_{OS(-)}$                        | $\pm V_{CC} = \pm 15V$<br>$t \leq 25ms$<br>(Short Circuit to Ground)                                                                                              | —                    | 50           | —                    | 50           | mA                |
| Supply Current                                              | $I_{CC}$                           | $T_A = -55^{\circ}C$<br>$\pm V_{CC} = \pm 15V$ , $T_A = +25^{\circ}C$<br>$T_A = +125^{\circ}C$                                                                    | —<br>—<br>—          | 11<br>7<br>7 | —<br>—<br>—          | 11<br>7<br>7 | mA                |
| Output Voltage Swing (Maximum)                              | $V_{OP}$                           | $\pm V_{CC} = \pm 20V$ , $R_L = 10k\Omega$<br>$\pm V_{CC} = \pm 20V$ , $R_L = 2k\Omega$                                                                           | $\pm 16$<br>$\pm 15$ | —<br>—       | $\pm 16$<br>$\pm 15$ | —<br>—       | V                 |
| Open-Loop Voltage Gain (Single Ended) (Note 6)              | $A_{VS(+)}$<br>$A_{VS(-)}$         | $\pm V_{CC} = \pm 20V$ , $V_{OUT} = \pm 15V$<br>$R_L = 2k\Omega$ , $T_A = 25^{\circ}C$<br>$-55^{\circ}C \leq T_A \leq +125^{\circ}C$                              | 50<br>25             | —<br>—       | 50<br>25             | —<br>—       | V/mV              |
| Open-Loop Voltage Gain (Single Ended) (Note 6)              | $A_{VS}$                           | $\pm V_{CC} = \pm 5V$<br>$R_L = 2k\Omega$<br>$V_{OUT} = \pm 2V$                                                                                                   | 10                   | —            | 10                   | —            | V/mV              |
| Transient Response Rise Time                                | $TR_{(tr)}$                        | $\pm V_{CC} = \pm 15V$ , $R_L = 2k\Omega$ , $A_V = 1$<br>$C_L = 100pF$ , See Figure 2<br>$V_{IN} = 50mV$                                                          | —                    | 100          | —                    | 100          | ns                |
| Transient Response Overshoot                                | $TR_{(os)}$                        | $\pm V_{CC} = \pm 15V$ , $R_L = 2k\Omega$ , $A_V = 1$<br>$C_L = 100pF$ , See Figure 2<br>$V_{IN} = 50mV$                                                          | —                    | 40           | —                    | 40           | %                 |
| Slew Rate                                                   | $SR(+)$<br>and<br>$SR(-)$          | $V_{IN} = \pm 5V$ , $\pm V_{CC} = \pm 15V$<br>$A_V = 1$ , See Figure 2<br>$T_A = 25^{\circ}C$<br>$T_A = -55^{\circ}C$ , $+125^{\circ}C$                           | 7.5<br>5             | —<br>—       | 10<br>7              | —<br>—       | V/ $\mu s$        |
| Settling Time                                               | $ts(+)$<br>and<br>$ts(-)$          | $\pm V_{CC} = \pm 15V$ (0.1% error)<br>$T_A = 25^{\circ}C$ , $A_V = -1$<br>See Figure 3                                                                           | —                    | 4000         | —                    | 4000         | ns                |

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OPERATIONAL AMPLIFIERS/BUFFERS



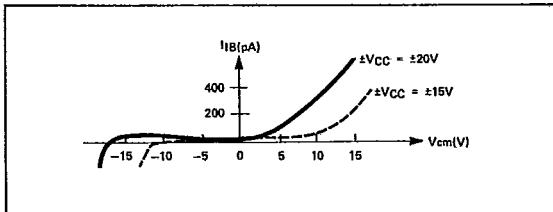
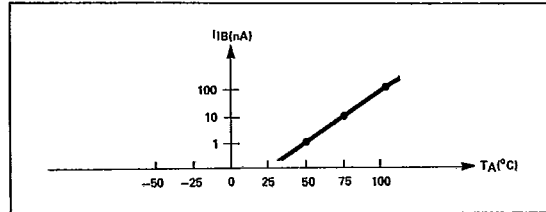
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**ELECTRICAL CHARACTERISTICS** at  $V_{CC}$  from  $\pm 5V$  to  $\pm 20V$ ; source resistance = 50 ohm; ambient temperature range =  $-55^{\circ}C$  to  $+125^{\circ}C$  and figure 1, unless otherwise noted. (Continued)

| PARAMETER                              | SYMBOL    | CONDITIONS                                                       | 02 LIMITS |     | 05 LIMITS |     | UNITS         |
|----------------------------------------|-----------|------------------------------------------------------------------|-----------|-----|-----------|-----|---------------|
|                                        |           |                                                                  | MIN       | MAX | MIN       | MAX |               |
| Noise (Referred to Input)<br>Broadband | $N_I(BB)$ | $\pm V_{CC} = \pm 20V$ , $T_A = 25^{\circ}C$<br>Bandwidth = 5kHz | —         | 10  | —         | 10  | $\mu V_{rms}$ |
| Noise (Referred to Input)<br>Popcorn   | $N_I(PC)$ | $\pm V_{CC} = \pm 20V$ , $T_A = 25^{\circ}C$<br>Bandwidth = 5kHz | —         | 40  | —         | 40  | $\mu V_{pk}$  |

**NOTES:**

- Bias currents are actually junction leakage currents which double (approximately) for each  $10^{\circ}C$  increase in junction temperature  $T_J$ . Measurement of bias current is specified at  $T_J$  rather than  $T_A$ , since normal warm-up thermal transients will affect the bias currents. The measurements for bias currents must be made within 25ms or 5 loop time constants after power is first applied to the device for test. Measurement at  $T_A = -55^{\circ}C$  is not necessary since expected values are too small for typical test systems.
- Bias current is sensitive to power supply voltage, common-mode voltage and temperature as shown by the following typical curves:



- Negative  $I_B$  minimum limits reflect the characteristics of device with bias current compensation.
- CMR is calculated from  $V_{IO}$  measurements at  $V_{CM} = +15V$  and  $-15V$ .
- Continuous limits shall be considerably lower. Protection for shorts to either supply exists providing that  $T_J(max) \leq 175^{\circ}C$ .
- Because of thermal feedback effects from output to input, open-loop gain is not guaranteed to be linear or positive over the operating range. These requirements, if needed, should be specified by the user in additional procurement documents.

**ORDERING INFORMATION**

| JAN SLASH SHEET  | PMI DEVICE      |
|------------------|-----------------|
| JM38510/11401BGC | PM155J1/38510   |
| JM38510/11401BGA | PM155J5/38510   |
| JM38510/11401BPB | PM155Z2/38510   |
| JM38510/11401BPA | PM155Z5/38510   |
| JM38510/11404BGC | PM155AJ1/38510  |
| JM38510/11404BGA | PM155AJ5/38510  |
| JM38510/11404BPB | PM155AZ2/38510  |
| JM38510/11404BPA | PM155AZ5/38510  |
| JM38510/11402BGC | PM156J1/38510   |
| JM38510/11402BGA | PM156J5/38510   |
| JM38510/11402BPB | PM156Z2/38510   |
| JM38510/11402BPA | PM156Z5/38510   |
| JM38510/11401SGA | PM155SJ5/38510  |
| JM38510/11402SGA | PM156SJ5/38510* |
| JM38510/11404SGA | PM155SAJ5/38510 |
| JM38510/11405SGA | PM156SAJ5/38510 |

| JAN SLASH SHEET  | PMI DEVICE     |
|------------------|----------------|
| JM38510/11405BGC | PM156AJ1/38510 |
| JM38510/11405BGA | PM156AJ5/38510 |
| JM38510/11405BPB | PM156AZ2/38510 |
| JM38510/11405BPA | PM156AZ5/38510 |
| JM38510/11403BGC | PM157J1/38510  |
| JM38510/11403BGA | PM157J5/38510  |
| JM38510/11403BPB | PM157Z2/38510  |
| JM38510/11403BPA | PM157Z5/38510  |
| JM38510/11406BGC | PM157AJ1/38510 |
| JM38510/11406BGA | PM157AJ5/38510 |
| JM38510/11406BPB | PM157AZ2/38510 |
| JM38510/11406BPA | PM157AZ5/38510 |

\* Undergoing Part 1 qualification as of 1/90.



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**ELECTRICAL CHARACTERISTICS** at  $V_{CC}$  from  $\pm 5V$  to  $\pm 20V$ ; source resistance = 50 ohm; ambient temperature range =  $-55^{\circ}C$  to  $+125^{\circ}C$  and figure 1, unless otherwise noted.

| PARAMETER                                                         | SYMBOL                           | CONDITIONS                                                                                     | 03 LIMITS |      | 06 LIMITS |      | UNITS             |
|-------------------------------------------------------------------|----------------------------------|------------------------------------------------------------------------------------------------|-----------|------|-----------|------|-------------------|
|                                                                   |                                  |                                                                                                | MIN       | MAX  | MIN       | MAX  |                   |
| Input Offset Voltage                                              | $V_{IO}$                         | $\pm V_{CC} = \pm 5V, V_{CM} = 0V$<br>$T_A = 25^{\circ}C$                                      | -5        | 5    | -2        | 2    | mV                |
|                                                                   |                                  | $\pm V_{CC} = \pm 20V$<br>$V_{CM} = \pm 15V, 0V$<br>$-55^{\circ}C \leq T_A \leq +125^{\circ}C$ | -7        | 7    | -2.5      | 2.5  |                   |
| Input Offset Voltage Temperature Sensitivity                      | $\frac{\Delta V_{IO}}{\Delta T}$ | $\pm V_{CC} = \pm 20V$<br>$V_{CM} = 0V$                                                        | -30       | 30   | -10       | 10   | $\mu V/^{\circ}C$ |
| Input Offset Current                                              | $I_{IO}$                         | $\pm V_{CC} = \pm 20V, V_{CM} = 0V$<br>$T_J = 25^{\circ}C$                                     | -20       | 20   | -20       | 20   | pA                |
|                                                                   |                                  | $T_J = 125^{\circ}C$                                                                           | -20       | 20   | -20       | 20   | nA                |
| Input Bias Current<br>(Note 1)<br>(Note 2)<br>(Note 3)            | $+I_{IB}$                        | $\pm V_{CC} = \pm 20V, V_{CM} = +15V$<br>$T_J = 25^{\circ}C$                                   | -100      | 3500 | -100      | 3500 | pA                |
|                                                                   |                                  | $t \leq 25ms, T_J = 125^{\circ}C$                                                              | -10       | 60   | -10       | 60   | nA                |
|                                                                   | $-I_{IB}$                        | $\pm V_{CC} = \pm 15V, V_{CM} = +10V$<br>$T_J = 25^{\circ}C$                                   | -100      | 300  | -100      | 300  | pA                |
|                                                                   |                                  | $t \leq 25ms, T_J = 125^{\circ}C$                                                              | -10       | 50   | -10       | 50   | nA                |
|                                                                   |                                  | $\pm V_{CC} = \pm 20V, -15V \leq V_{CM} \leq 0V$<br>$T_J = 25^{\circ}C$                        | -100      | 100  | -100      | 100  | pA                |
|                                                                   |                                  | $t \leq 25ms, T_J = 125^{\circ}C$                                                              | -10       | 50   | -10       | 50   | nA                |
| Power Supply Rejection Ratio                                      | $+PSRR$<br>$-PSRR$               | $+V_{CC} = 10V, -V_{CC} = -20V$                                                                | 85        | —    | 85        | —    | dB                |
|                                                                   |                                  | $+V_{CC} = 20V, -V_{CC} = -10V$                                                                | —         | —    | —         | —    |                   |
| Input Voltage Common-Mode Rejection (Note 4)                      | CMR                              | $\pm V_{CC} = \pm 20V$<br>$V_{IN} = \pm 15V$                                                   | 85        | —    | 85        | —    | dB                |
| Adjustment for Input Offset Voltage                               | $V_{IO ADJ (+)}$                 | $\pm V_{CC} = \pm 20V$                                                                         | +8        | —    | +8        | —    | mV                |
|                                                                   | $V_{IO ADJ (-)}$                 | $\pm V_{CC} = \pm 20V$                                                                         | —         | -8   | —         | -8   |                   |
| Output Short-Circuit Current<br>(for Positive Output) (Note 5)    | $I_{OS(+)}$                      | $\pm V_{CC} = \pm 15V$<br>$t \leq 25ms$<br>(Short Circuit to Ground)                           | -50       | —    | -50       | —    | mA                |
|                                                                   |                                  |                                                                                                |           |      |           |      |                   |
| Output Short-Circuit Current<br>(for Negative Output)<br>(Note 5) | $I_{OS(-)}$                      | $\pm V_{CC} = \pm 15V$<br>$t \leq 25ms$<br>(Short Circuit to Ground)                           | —         | 50   | —         | 50   | mA                |
|                                                                   |                                  |                                                                                                |           |      |           |      |                   |
| Supply Current                                                    | $I_{CC}$                         | $T_A = -55^{\circ}C$                                                                           | —         | 11   | —         | 11   | mA                |
|                                                                   |                                  | $\pm V_{CC} = \pm 15V, T_A = +25^{\circ}C$                                                     | —         | 7    | —         | 7    |                   |
|                                                                   |                                  | $T_A = +125^{\circ}C$                                                                          | —         | 7    | —         | 7    |                   |
| Output Voltage Swing<br>(Maximum)                                 | $V_{OP}$                         | $\pm V_{CC} = \pm 20V, R_L = 10k\Omega$                                                        | $\pm 16$  | —    | $\pm 16$  | —    | V                 |
|                                                                   |                                  | $\pm V_{CC} = \pm 20V, R_L = 2k\Omega$                                                         | $\pm 15$  | —    | $\pm 15$  | —    |                   |
| Open-Loop Voltage Gain<br>(Single Ended) (Note 6)                 | $A_{VS(+)}$<br>$A_{VS(-)}$       | $\pm V_{CC} = \pm 20V, V_{OUT} = \pm 15V$<br>$R_L = 2k\Omega, T_A = 25^{\circ}C$               | 50        | —    | 50        | —    | V/mV              |
|                                                                   |                                  | $-55^{\circ}C \leq T_A \leq +125^{\circ}C$                                                     | 25        | —    | 25        | —    |                   |
| Open-Loop Voltage Gain<br>(Single Ended) (Note 6)                 | $A_{VS}$                         | $\pm V_{CC} = \pm 5V$<br>$R_L = 2k\Omega$<br>$V_{OUT} = \pm 2V$                                | 10        | —    | 10        | —    | V/mV              |

5  
OPERATIONAL AMPLIFIERS/BUFFERS

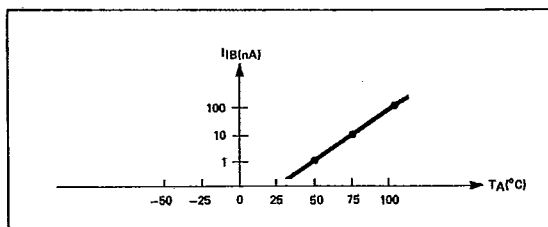
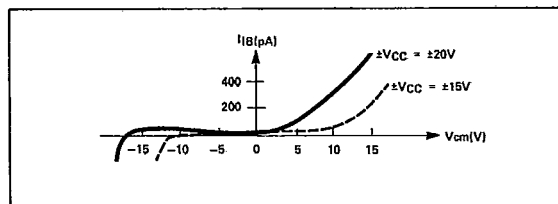
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**ELECTRICAL CHARACTERISTICS** at  $V_{CC}$  from  $\pm 5V$  to  $\pm 20V$ ; source resistance = 50 ohm; ambient temperature range =  $-55^\circ C$  to  $+125^\circ C$  and figure 1, unless otherwise noted. (Continued)

| PARAMETER                           | SYMBOL                    | CONDITIONS                                                                                                                        | 03 LIMITS |        | 06 LIMITS |        | UNITS         |
|-------------------------------------|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------|-----------|--------|-----------|--------|---------------|
|                                     |                           |                                                                                                                                   | MIN       | MAX    | MIN       | MAX    |               |
| Transient Response Rise Time        | $TR_{(tr)}$               | $\pm V_{CC} = \pm 15V$ , $R_L = 2k\Omega$ , $A_V = 5$<br>$C_L = 100pF$ , See Figure 2<br>$V_{IN} = 50mV$                          | —         | 450    | —         | 450    | ns            |
| Transient Response Overshoot        | $TR_{(os)}$               | $\pm V_{CC} = \pm 15V$ , $R_L = 2k\Omega$ , $A_V = 5$<br>$C_L = 100pF$ , See Figure 2<br>$V_{IN} = 50mV$                          | —         | 25     | —         | 25     | %             |
| Slew Rate                           | $SR_{(+)}$ and $SR_{(-)}$ | $V_{IN} = \pm 1V$ , $\pm V_{CC} = \pm 15V$<br>$A_V = 5$ , See Figure 2<br>$T_A = 25^\circ C$<br>$T_A = -55^\circ C, +125^\circ C$ | 30<br>20  | —<br>— | 40<br>25  | —<br>— | $V/\mu s$     |
|                                     |                           |                                                                                                                                   |           |        |           |        |               |
| Settling Time                       | $ts_{(+)}$ and $ts_{(-)}$ | $\pm V_{CC} = \pm 15V$ (0.1% error)<br>$T_A = 25^\circ C$ , $A_V = -5$<br>See Figure 3                                            | —         | 800    | —         | 800    | ns            |
| Noise (Referred to Input) Broadband | $N_{I(BB)}$               | $\pm V_{CC} = \pm 20V$ , $T_A = 25^\circ C$<br>Bandwidth = 5kHz                                                                   | —         | 10     | —         | 10     | $\mu V_{rms}$ |
| Noise (Referred to Input) Popcorn   | $N_{I(PC)}$               | $\pm V_{CC} = \pm 20V$ , $T_A = 25^\circ C$<br>Bandwidth = 5kHz                                                                   | —         | 40     | —         | 40     | $\mu V_{pk}$  |

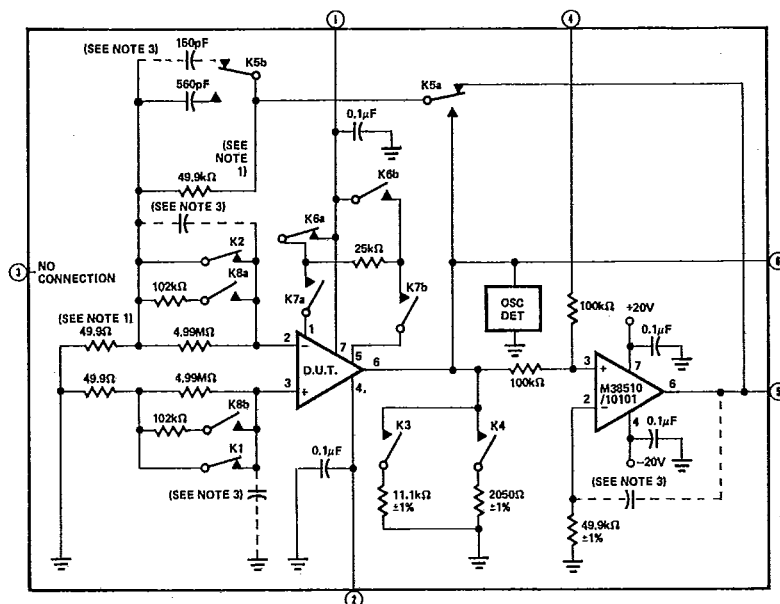
**NOTES:**

1. Bias currents are actually junction leakage currents which double (approximately) for each  $10^\circ C$  increase in junction temperature  $T_J$ . Measurement of bias current is specified at  $T_J$  rather than  $T_A$ , since normal warm-up thermal transients will affect the bias currents. The measurements for bias currents must be made within 25ms or 5 loop time constants after power is first applied to the device for test. Measurement at  $T_A = -55^\circ C$  is not necessary since expected values are too small for typical test systems.
2. Bias current is sensitive to power supply voltage, common-mode voltage and temperature as shown by the following typical curves:



3. Negative  $I_B$  minimum limits reflect the characteristics of device with bias current compensation.
4. CMR is calculated from  $V_{IO}$  measurements at  $V_{CM} = +15V$  and  $-15V$ .
5. Continuous limits shall be considerably lower. Protection for shorts to either supply exists providing that  $T_J(max) \leq 175^\circ C$ .
6. Because of thermal feedback effects from output to input, open-loop gain is not guaranteed to be linear or positive over the operating range. These requirements, if needed, should be specified by the user in additional procurement documents.

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## NOTES:

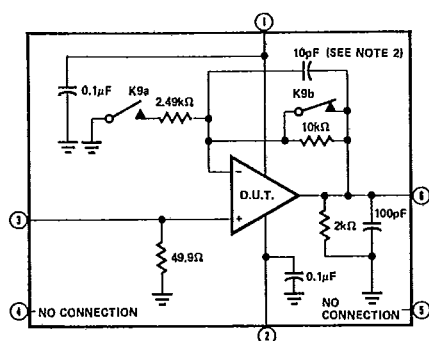
1. All resistors are  $\pm 0.1\%$  tolerance and all capacitors are  $\pm 10\%$  tolerance, unless otherwise specified.
2. Precautions shall be taken to prevent damage to the D.U.T. during insertion into socket and change of state of relays (i.e. disable voltage supplies, current limit  $\pm V_{CC}$ , etc.).
3. Compensation capacitors should be added as required for test circuit stability. Two general methods for stability compensation exist. One method is with a capacitor for nulling amp feedback. The other method is with a capacitor in parallel with the  $49.9k\Omega$  closed-loop feedback resistor. Both methods should not be used simultaneously. Proper wiring procedures shall be followed to prevent unwanted coupling and oscillations, etc. Loop response and

settling time shall be consistent with the test rate such that any value has settled for at least five loop time constants before the value is measured.

4. Adequate settling time should be allowed such that each parameter has settled to within 5% of its final value.
5. All relays are shown in the normal de-energized state.
6. The nulling amplifier shall be a M38510/10101XXX. Saturation of the nulling amplifier is not allowed on tests where the E (Pin 5) value is measured.
7. The load resistors  $2050\Omega$  and  $11.1k\Omega$  yield effective load resistances of  $2k\Omega$  and  $10k\Omega$  respectively.
8. Any oscillation greater than 300mV in amplitude (peak-to-peak) shall be cause for device failure.

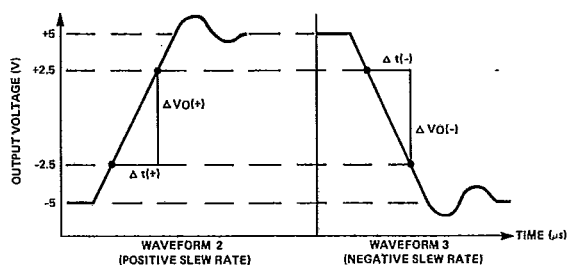
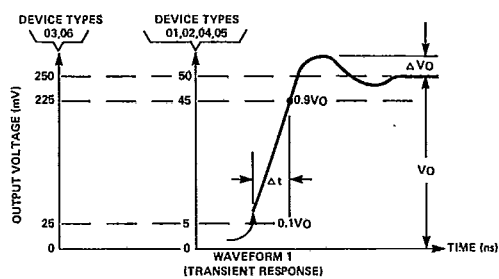
Figure 1. Test Circuit for Static Tests

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**NOTES:**

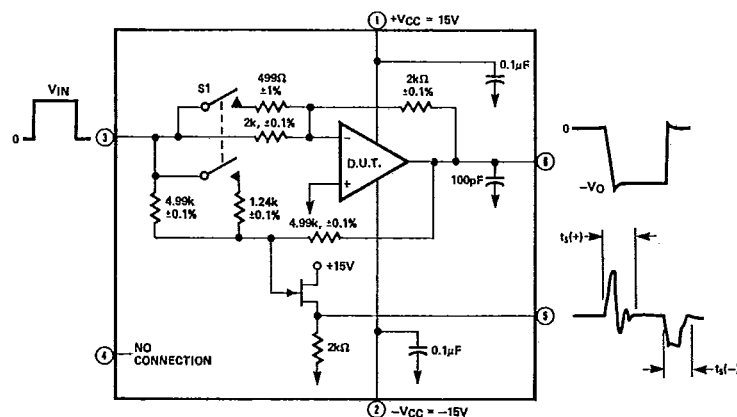
1. Resistors are  $\pm 1.0\%$  tolerance and capacitors are  $\pm 10\%$  tolerance.
2. This capacitance includes the actual measured value with stray and wire capacitance.
3. Precautions shall be taken to prevent damage to the D.U.T. during insertion into socket and in applying power.



| PARAMETER SYMBOL | DEVICE TYPE              | INPUT PULSE SIGNAL AT $t_r \leq 50\text{ns}$ | OUTPUT PULSE SIGNAL      | EQUATION                                         |
|------------------|--------------------------|----------------------------------------------|--------------------------|--------------------------------------------------|
| TR ( $t_r$ )     | ALL                      | +50mV                                        | WAVEFORM 1               | TR ( $t_r$ ) = $\Delta t$                        |
| TR ( $O_S$ )     | ALL                      | +50mV                                        | WAVEFORM 1               | TR ( $O_S$ ) = $100 \cdot \Delta V_O / V_{O1}$ % |
| SR (+)           | 01, 02, 04, 05<br>03, 06 | -5V to +5V STEP<br>-1V to +1V STEP           | WAVEFORM 2<br>WAVEFORM 2 | SR (+) = $\Delta V_{O1} / \Delta t (+)$          |
| SR (-)           | 01, 02, 04, 05<br>03, 06 | +5V to -5V STEP<br>-1V to +1V STEP           | WAVEFORM 3<br>WAVEFORM 3 | SR (-) = $\Delta V_{O1} (-) / \Delta t (-)$      |

**Figure 2. Test Circuit for Transient Response and Slew Rate.**

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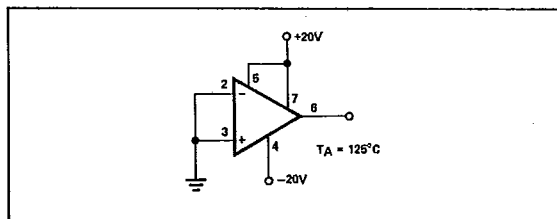
**NOTES:**

1. Resistors are  $\pm 1.0\%$  and capacitors are  $\pm 10\%$ , unless otherwise specified.
2. Precaution shall be taken to prevent damage to the D.U.T. during insertion into socket and in applying power.
3. For device types 01, 02, 04 and 05, S1 is open,  $A_V = -1$  and  $V_{IN} = 10V$ .
4. For device types 03 and 06, S1 is closed,  $A_V = -5$  and  $V_{IN} = 2V$ .
5. Settling time,  $t_s$  measured on Pin 5, is the interval during which the summing node is not nulled within the specified accuracy referred to the output.

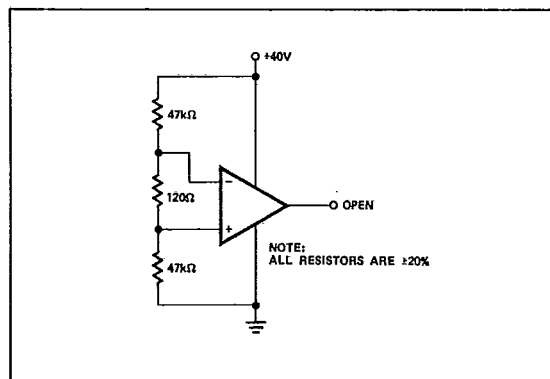
### Figure 3. Test Circuit for Settling Time

## BURN-IN

Devices supplied by PMI have been subjected to burn-in per Method 1015 of MIL-STD-883 using test condition C with circuit shown on Figure 4 or test condition F using circuit shown on Figure 5.



**Figure 4. Test Circuit, Burn-In (Steady-State Power and Reverse Bias) and Operating Life Test**



**Figure 5. Accelerated Burn-In and Life Test Circuit**

## OPERATIONAL AMPLIFIERS/BUFFERS