

## FEATURES

- Improved Specifications Compared to LF155/156 Devices
- *Guaranteed* Low Offset Voltage 500 $\mu$ V Max.
- *Guaranteed* Low Offset Drift 5 $\mu$ V/ $^{\circ}$ C Max.
- *Guaranteed* Bias Current Fully Warmed-Up over Temperature
- OP-15: LF156 Speed with LF155 Power Dissipation
  - Guaranteed* Supply Current 4mA Max.
  - Guaranteed* Slew Rate 10V/ $\mu$ s Min.
- OP-16:
  - Guaranteed* Faster Slew Rate 18V/ $\mu$ s Min.
  - No High Frequency Oscillation at Cold Temperatures
- No Phase Reversal when Negative Common-Mode Limit is Exceeded

## APPLICATIONS

- Long Term Precision Integration
- Current to Voltage Conversion
- Medical Instrumentation—CAT Scanner
- High Speed, Precision Sample and Hold

## DESCRIPTION

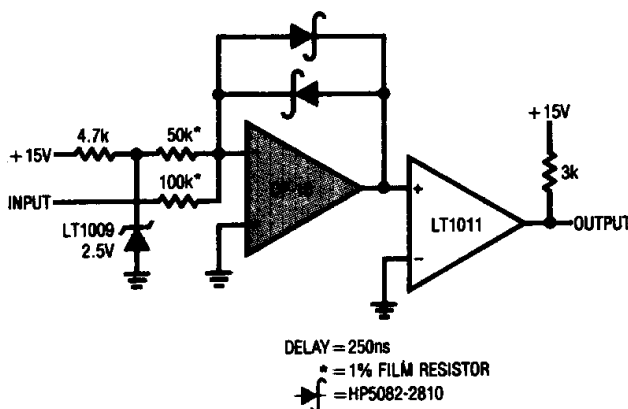
The OP-15/16 series devices feature distinct advantages over other JFET-input operational amplifiers, in particular compared to LF155/156 types.

The OP-15 has the speed of the LF156 design with the low power dissipation of the slower LF155. The OP-16 is considerably faster. Both devices offer offset voltages as low as 0.5mV, with guaranteed drift of 5 $\mu$ V/ $^{\circ}$ C. Input bias current at 125 $^{\circ}$ C is just a few nanoamperes.

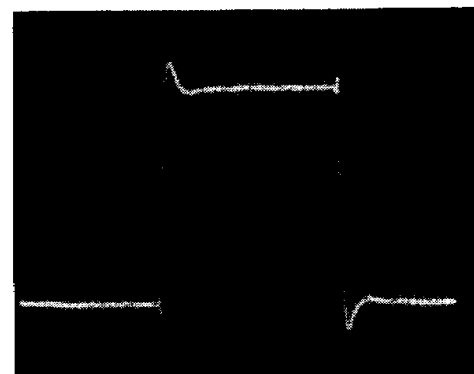
Other manufacturers' OP-15/16 (and LF155/156) exhibit phase reversal at the output when the negative common-mode limit at the input is exceeded; i.e., driving from -12V to -15V with  $\pm$ 15V supplies. This can cause lock-up in servo systems. As shown in the application section, Linear Technology's OP-15/16 does not have this problem due to unique phase reversal protection circuitry.

In addition, Linear's OP-16 is free from high frequency oscillation problems at cold temperatures, as is illustrated in the "Voltage Follower Small Signal Pulse Response" photo. For applications requiring higher performance, see the LT1022, LT1055 and LT1056 data sheets.

Fast, 12-Bit Current Comparator



Voltage Follower Small Signal Pulse Response  
 $T_A = -55^{\circ}\text{C}$



$C_L = 100\text{pF}$   
 VERTICAL SCALE = 20mV/DIV  
 HORIZONTAL SCALE = 0.2 $\mu$ s/DIV

# OP-15/OP-16

## ABSOLUTE MAXIMUM RATINGS

|                                       |                |
|---------------------------------------|----------------|
| Supply Voltage                        |                |
| A, B, E, F Grades                     | ± 22V          |
| C, G Grades                           | ± 18V          |
| Internal Power Dissipation            | 500mW          |
| Operating Temperature Range           |                |
| A, B, C Grades                        | -55°C to 125°C |
| E, F, G Grades                        | 0°C to 70°C    |
| Junction Temperature                  | 150°C          |
| Differential Input Voltage            |                |
| A, B, E, F Grades                     | ± 40V          |
| C, G Grades                           | ± 30V          |
| Input Voltage (Note 4)                |                |
| A, B, E, F Grades                     | ± 20V          |
| C, G Grades                           | ± 16V          |
| Output Short Circuit Duration         | Indefinite     |
| Storage Temperature Range             | -65°C to 150°C |
| Lead Temperature (Soldering, 10 sec.) | 300°C          |

## PACKAGE/ORDER INFORMATION

| TOP VIEW                                |  | ORDER PART NUMBER   |          |
|---|--|---|----------|
| <p>H PACKAGE<br/>METAL CAN</p>          |  | OP-15AH   | OP-16AH  |
|   |  | OP-15BH   | OP-16BH  |
|   |  | OP-15CH   | OP-16CH  |
|   |  | OP-15EH   | OP-16EH  |
|   |  | OP-15FH   | OP-16FH  |
|   |  | OP-15GH   | OP-16GH  |
| TOP VIEW                                |  |   |          |
| <p>NB PACKAGE<br/>8 PIN PLASTIC DIP</p> |  | OP-15GN8  | OP-16GN8 |
|   |  | $V_{OS}$ is adjusted with a potentiometer ranging from 10k to 1M. The wiper is connected to $V^+$ |          |

## ELECTRICAL CHARACTERISTICS $V_S = \pm 15V, T_A = 25^\circ C$ unless otherwise noted.

| SYMBOL    | PARAMETER                    | CONDITIONS   | OP-15A/E<br>OP-16A/E |           |       | OP-15B/F<br>OP-16B/F |           |       | OP-15C/G<br>OP-16C/G |           |       | UNITS                              |
|-----------|------------------------------|--|----------------------|-----------|-------|----------------------|-----------|-------|----------------------|-----------|-------|------------------------------------|
|           |                              |  | MIN                  | TYP       | MAX   | MIN                  | TYP       | MAX   | MIN                  | TYP       | MAX   |                                    |
| $V_{OS}$  | Input Offset Voltage         | $R_S = 50\Omega$   | —                    | 0.2       | 0.5   | —                    | 0.4       | 1.0   | —                    | 0.5       | 3.0   | mV                                 |
| $I_{OS}$  | Input Offset Current         | $T_I = 25^\circ C$ (Note 1)<br>Warmed-Up OP-15<br>OP-16      | —                    | 3         | 10    | —                    | 6         | 20    | —                    | 12        | 50    | pA                                 |
|           |                              |  | —                    | 5         | 22    | —                    | 10        | 40    | —                    | 20        | 100   | pA                                 |
|           |                              |  | —                    | 5         | 25    | —                    | 10        | 50    | —                    | 20        | 125   | pA                                 |
| $I_B$     | Input Bias Current           | $T_I = 25^\circ C$ (Note 1)<br>Warmed-Up OP-15<br>OP-16      | —                    | ± 15      | ± 50  | —                    | ± 30      | ± 100 | —                    | ± 60      | ± 200 | pA                                 |
|           |                              |  | —                    | ± 18      | ± 110 | —                    | ± 40      | ± 200 | —                    | ± 80      | ± 400 | pA                                 |
|           |                              |  | —                    | ± 20      | ± 130 | —                    | ± 40      | ± 250 | —                    | ± 80      | ± 500 | pA                                 |
| $R_{IN}$  | Input Resistance             |  | —                    | $10^{12}$ | —     | —                    | $10^{12}$ | —     | —                    | $10^{12}$ | —     | $\Omega$                           |
| $A_{VOL}$ | Large Signal Voltage Gain    | $R_L \geq 2k\Omega$<br>$V_O = \pm 10V$                       | 100                  | 240       | —     | 75                   | 220       | —     | 50                   | 200       | —     | V/mV                               |
| $V_O$     | Output Voltage Swing         | $R_L = 10k\Omega$<br>$R_L = 2k\Omega$                        | ± 12                 | ± 13      | —     | ± 12                 | ± 13      | —     | ± 12                 | ± 13      | —     | V                                  |
|           |                              |  | ± 11                 | ± 12.7    | —     | ± 11                 | ± 12.7    | —     | ± 11                 | ± 12.7    | —     | V                                  |
| $I_S$     | Supply Current               | OP-15<br>OP-16   | —                    | 2.7       | 4.0   | —                    | 2.7       | 4.0   | —                    | 2.8       | 5.0   | mA                                 |
|           |                              |  | —                    | 4.6       | 7.0   | —                    | 4.6       | 7.0   | —                    | 4.8       | 8.0   | mA                                 |
| SR        | Slew Rate                    | $A_{VCL} = +1$ OP-15<br>OP-16                                | 10                   | 13        | —     | 7.5                  | 11        | —     | 5                    | 9         | —     | V/ $\mu s$                         |
|           |                              |  | 18                   | 20        | —     | 12                   | 18        | —     | 9                    | 16        | —     | V/ $\mu s$                         |
| GBW       | Gain Bandwidth Product       | (Note 3) OP-15<br>OP-16                                      | 4.0                  | 6.0       | —     | 3.5                  | 5.7       | —     | 3.0                  | 5.4       | —     | MHz                                |
|           |                              |  | —                    | 8.0       | —     | —                    | 7.6       | —     | —                    | 7.2       | —     | MHz                                |
|           | Settling Time (Note 2)       | to 0.01% OP-15<br>to 0.10%                                   | —                    | 4.5       | —     | —                    | 4.5       | —     | —                    | 4.7       | —     | $\mu s$                            |
|           |                              |  | —                    | 1.2       | —     | —                    | 1.2       | —     | —                    | 1.3       | —     | $\mu s$                            |
|           |                              | to 0.01% OP-16<br>to 0.10%                                   | —                    | 3.8       | —     | —                    | 3.8       | —     | —                    | 4.0       | —     | $\mu s$                            |
|           |                              |  | —                    | 0.9       | —     | —                    | 0.9       | —     | —                    | 1.0       | —     | $\mu s$                            |
|           | Input Voltage Range          |  | ± 10.5               | —         | —     | ± 10.5               | —         | —     | ± 10.3               | —         | —     | V                                  |
| CMRR      | Common-Mode Rejection Ratio  | $V_{CM} = \pm 10.5V$<br>$V_{CM} = \pm 10.3V$                 | 86                   | 100       | —     | 86                   | 100       | —     | 82                   | 96        | —     | dB                                 |
| PSRR      | Power Supply Rejection Ratio | $V_S = \pm 10V$ to $\pm 18V$<br>$V_S = \pm 10V$ to $\pm 15V$ | —                    | 10        | 51    | —                    | 10        | 51    | —                    | 10        | 80    | $\mu V/V$<br>$\mu V/V$             |
| $e_n$     | Input Noise Voltage Density  | $f_0 = 100Hz$<br>$f_0 = 1000Hz$                              | —                    | 20        | —     | —                    | 20        | —     | —                    | 20        | —     | nV/ $\sqrt{Hz}$<br>nV/ $\sqrt{Hz}$ |
|           |                              |  | —                    | 15        | —     | —                    | 15        | —     | —                    | 15        | —     | nV/ $\sqrt{Hz}$                    |
| $i_n$     | Input Noise Current Density  | $f_0 = 100Hz$<br>$f_0 = 1000Hz$                              | —                    | 0.01      | —     | —                    | 0.01      | —     | —                    | 0.01      | —     | pA/ $\sqrt{Hz}$<br>pA/ $\sqrt{Hz}$ |
|           |                              |  | —                    | 0.01      | —     | —                    | 0.01      | —     | —                    | 0.01      | —     | pA/ $\sqrt{Hz}$                    |
| $C_{IN}$  | Input Capacitance            |  | —                    | 3         | —     | —                    | 3         | —     | —                    | 3         | —     | pF                                 |

**ELECTRICAL CHARACTERISTICS**  $V_S = \pm 15V, -55^\circ C \leq T_A \leq 125^\circ C$  unless otherwise noted.

| SYMBOL            | PARAMETER  | CONDITIONS  | OP-15A<br>OP-16A |       |      | OP-15B<br>OP-16B |       |      | OP-15C<br>OP-16C |        |      | UNITS |       |
|-------------------|--|---|------------------|-------|------|------------------|-------|------|------------------|--------|------|-------|-------|
|                   |  |   | MIN              | TYP   | MAX  | MIN              | TYP   | MAX  | MIN              | TYP    | MAX  |       |       |
| V <sub>OS</sub>   | Input Offset Voltage                                     | R <sub>S</sub> = 50Ω  | ●                | —     | 0.4  | 0.9              | —     | 0.7  | 2.0              | —      | 0.9  | 4.5   | mV    |
| TCV <sub>OS</sub> | Average Input Offset Voltage Drift Without External Trim | R <sub>P</sub> = 100kΩ  | ●                | —     | 2    | 5                | —     | 3    | 10               | —      | 4    | 15    | μV/°C |
|                   |  |   | ●                | —     | 2    | —                | —     | 3    | —                | —      | 4    | —     | μV/°C |
| I <sub>OS</sub>   | Input Offset Current                                     | T <sub>J</sub> = 125°C (Note 1)<br>T <sub>A</sub> = 125°C, Warmed-Up OP-15<br>OP-16 | ●                | —     | 0.6  | 4.0              | —     | 0.8  | 6.0              | —      | 1.0  | 9.0   | nA    |
|                   |  |   | ●                | —     | 0.8  | 7.0              | —     | 1.2  | 11               | —      | 1.5  | 17    | nA    |
|                   |  |   | ●                | —     | 1.0  | 8.5              | —     | 1.3  | 14.5             | —      | 1.7  | 22    | nA    |
| I <sub>B</sub>    | Input Bias Current                                       | T <sub>J</sub> = 125°C (Note 1)<br>T <sub>A</sub> = 125°C, Warmed-Up OP-15<br>OP-16 | ●                | —     | ±1.2 | ±5.0             | —     | ±1.5 | ±7.5             | —      | ±1.8 | ±10   | nA    |
|                   |  |   | ●                | —     | ±1.7 | ±9.0             | —     | ±2.2 | ±14              | —      | ±2.7 | ±19   | nA    |
|                   |  |   | ●                | —     | ±2.0 | ±11              | —     | ±2.5 | ±18              | —      | ±3.0 | ±25   | nA    |
|                   | Input Voltage Range                                      |   | ●                | ±10.4 | —    | —                | ±10.4 | —    | —                | ±10.25 | —    | —     | V     |
| CMRR              | Common-Mode Rejection Ratio                              | V <sub>CM</sub> = ±10.4V  | ●                | 85    | 97   | —                | 85    | 97   | —                | —      | —    | —     | dB    |
|                   |  | V <sub>CM</sub> = ±10.25V   | ●                | —     | —    | —                | —     | —    | —                | 80     | 93   | —     | dB    |
| PSRR              | Power Supply Rejection Ratio                             | V <sub>S</sub> = ±10V to ±18V   | ●                | —     | 15   | 57               | —     | 15   | 57               | —      | —    | —     | μV/V  |
|                   |  | V <sub>S</sub> = ±10V to ±15V   | ●                | —     | —    | —                | —     | —    | —                | —      | 23   | 100   | μV/V  |
| A <sub>VOL</sub>  | Large Signal Voltage Gain                                | R <sub>L</sub> ≥ 2kΩ<br>V <sub>O</sub> = ±10V                                       | ●                | 35    | 120  | —                | 30    | 110  | —                | 25     | 100  | —     | V/mV  |
| V <sub>O</sub>    | Output Voltage Swing                                     | R <sub>L</sub> ≥ 10kΩ   | ●                | ±12   | ±13  | —                | ±12   | ±13  | —                | ±12    | ±13  | —     | V     |

2

**ELECTRICAL CHARACTERISTICS**  $V_S = \pm 15V, 0^\circ C \leq T_A \leq 70^\circ C$  unless otherwise noted.

| SYMBOL            | PARAMETER  | CONDITIONS  | OP-15E<br>OP-16E |       |       | OP-15F<br>OP-16F |       |       | OP-15G<br>OP-16G |        |       | UNITS |       |
|-------------------|--|---|------------------|-------|-------|------------------|-------|-------|------------------|--------|-------|-------|-------|
|                   |  |   | MIN              | TYP   | MAX   | MIN              | TYP   | MAX   | MIN              | TYP    | MAX   |       |       |
| V <sub>OS</sub>   | Input Offset Voltage                                     | R <sub>S</sub> = 50Ω  | ●                | —     | 0.3   | 0.75             | —     | 0.55  | 1.5              | —      | 0.7   | 3.8   | mV    |
| TCV <sub>OS</sub> | Average Input Offset Voltage Drift Without External Trim | R <sub>P</sub> = 100kΩ  | ●                | —     | 2     | 5                | —     | 3     | 10               | —      | 4     | 15    | μV/°C |
|                   |  |   | ●                | —     | 2     | —                | —     | 3     | —                | —      | 4     | —     | μV/°C |
| I <sub>OS</sub>   | Input Offset Current                                     | T <sub>J</sub> = 70°C (Note 1)<br>T <sub>A</sub> = 70°C, Warmed-Up OP-15<br>OP-16 | ●                | —     | 0.04  | 0.30             | —     | 0.06  | 0.45             | —      | 0.08  | 0.65  | nA    |
|                   |  |   | ●                | —     | 0.06  | 0.55             | —     | 0.08  | 0.80             | —      | 0.10  | 1.2   | nA    |
|                   |  |   | ●                | —     | 0.07  | 0.70             | —     | 0.10  | 1.1              | —      | 0.15  | 1.7   | nA    |
| I <sub>B</sub>    | Input Bias Current                                       | T <sub>J</sub> = 70°C (Note 1)<br>T <sub>A</sub> = 70°C, Warmed-Up OP-15<br>OP-16 | ●                | —     | ±0.10 | ±0.40            | —     | ±0.12 | ±0.60            | —      | ±0.14 | ±0.80 | nA    |
|                   |  |   | ●                | —     | ±0.13 | ±0.75            | —     | ±0.16 | ±1.1             | —      | ±0.19 | ±1.5  | nA    |
|                   |  |   | ●                | —     | ±0.15 | ±0.90            | —     | ±0.20 | ±1.4             | —      | ±0.25 | ±2.0  | nA    |
|                   | Input Voltage Range                                      |   | ●                | ±10.4 | —     | —                | ±10.4 | —     | —                | ±10.25 | —     | —     | V     |
| CMRR              | Common-Mode Rejection Ratio                              | V <sub>CM</sub> = ±10.4V  | ●                | 85    | 98    | —                | 85    | 98    | —                | —      | —     | —     | dB    |
|                   |  | V <sub>CM</sub> = ±10.25V   | ●                | —     | —     | —                | —     | —     | —                | 80     | 94    | —     | dB    |
| PSRR              | Power Supply Rejection Ratio                             | V <sub>S</sub> = ±10V to ±18V   | ●                | —     | 13    | 57               | —     | 13    | 57               | —      | —     | —     | μV/V  |
|                   |  | V <sub>S</sub> = ±10V to ±15V   | ●                | —     | —     | —                | —     | —     | —                | —      | 20    | 100   | μV/V  |
| A <sub>VO</sub>   | Large Signal Voltage Gain                                | R <sub>L</sub> ≥ 2kΩ<br>V <sub>O</sub> = ±10V                                     | ●                | 65    | 200   | —                | 50    | 180   | —                | 35     | 160   | —     | V/mV  |
| V <sub>O</sub>    | Output Voltage Swing                                     | R <sub>L</sub> ≥ 10kΩ   | ●                | ±12   | ±13   | —                | ±12   | ±13   | —                | ±12    | ±13   | —     | V     |

The ● denotes the specifications which apply over full operating temperature range.

For MIL-STD components, please refer to LTC 883C data sheet for test listing and parameters.

**Note 1:** Input bias current is specified for two different conditions. The T<sub>J</sub> specification is with the junction at ambient temperature; the warmed-up specification is with the device operating in a warmed-up condition at the ambient temperature specified. I<sub>B</sub> and I<sub>OS</sub> are measured at V<sub>CM</sub> = 0.

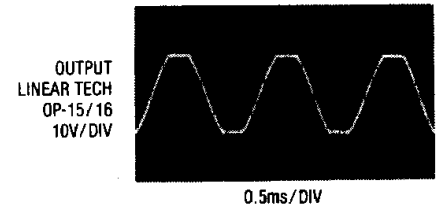
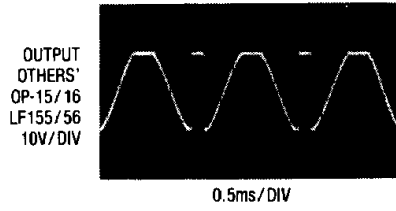
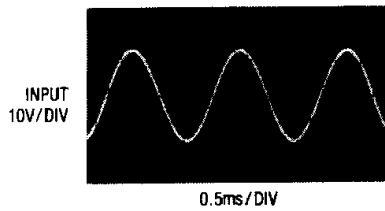
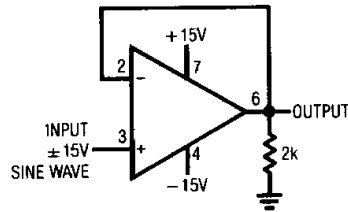
**Note 2:** Settling time is defined here for a unity gain inverter connection using 2kΩ resistors. It is the time required for the error voltage (the voltage at the inverting input pin on the amplifier) to settle to within a specified percentage of its final value from the time a 10V step input is applied to the inverter.

**Note 3:** Sample tested.

**Note 4:** Unless otherwise specified, the absolute maximum negative input voltage is equal to the negative power supply voltage.

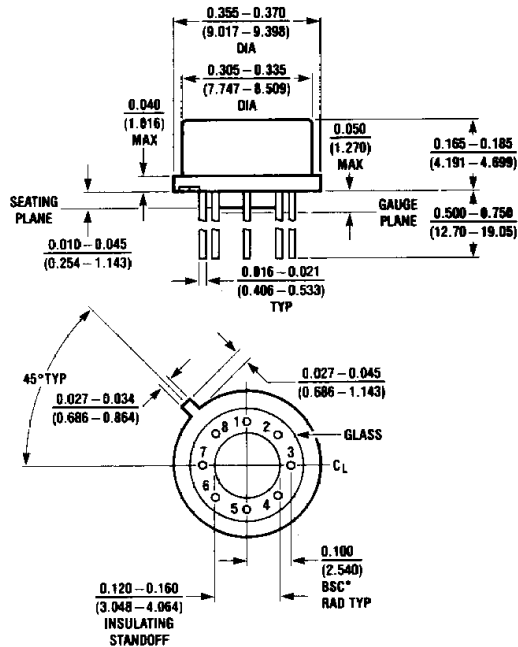
# APPLICATIONS

## Voltage Follower with Input Exceeding the Negative Common-Mode Range



# PACKAGE DESCRIPTION

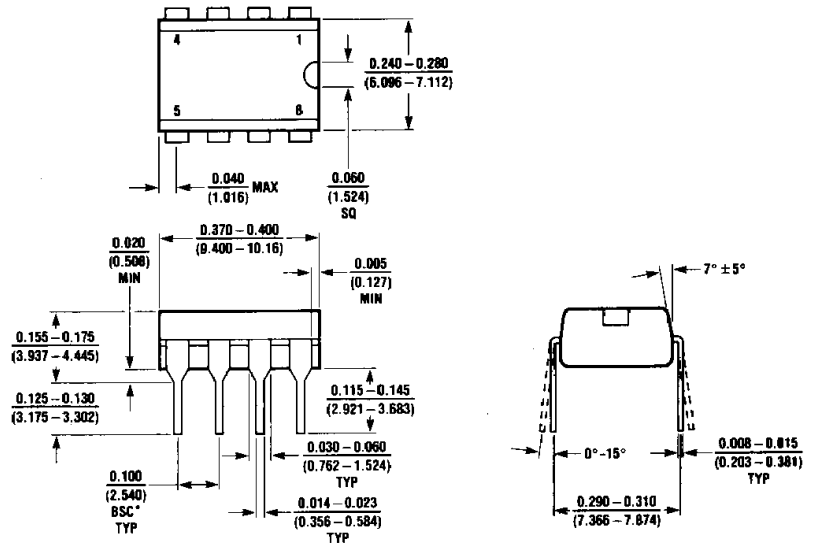
## H Package Metal Can



NOTE: DIMENSIONS IN INCHES

|            |                 |               |
|------------|-----------------|---------------|
| $T_{jmax}$ | $\theta_{j\mu}$ | $\theta_{jc}$ |
| 150°C      | 150°C/W         | 45°C/W        |

## N8 Package 8 Lead Plastic



NOTE: DIMENSIONS IN INCHES UNLESS OTHERWISE NOTED  
\*LEADS WITHIN 0.007 OF TRUE POSITION (TP) AT GAUGE PLANE

|            |                 |
|------------|-----------------|
| $T_{jmax}$ | $\theta_{j\mu}$ |
| 100°C      | 130°C/W         |