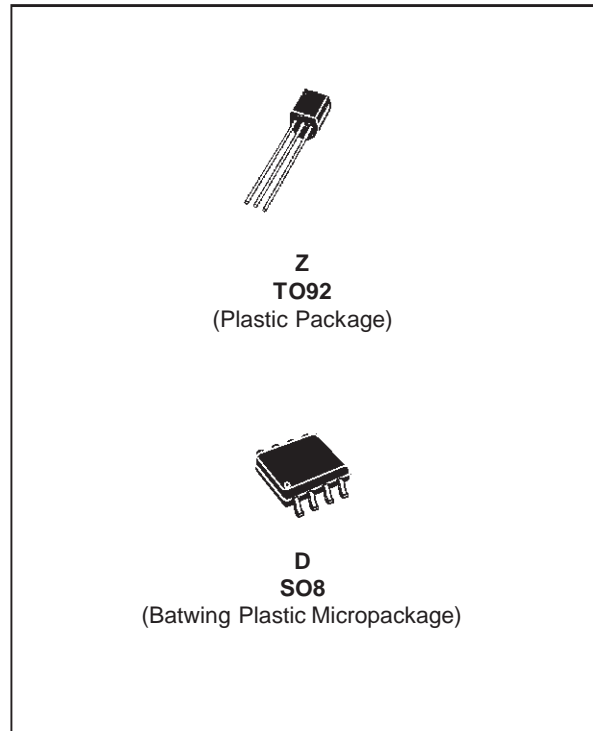


## PROGRAMMABLE VOLTAGE REFERENCE

- ADJUSTABLE OUTPUT VOLTAGE :  
 $V_{ref}$  to 36V
- SINK CURRENT CAPABILITY : 1 to 100mA
- TYPICAL OUTPUT IMPEDANCE :  $0.2\Omega$
- 0.4% AND 0.25% VOLTAGE PRECISION



### DESCRIPTION

The TL1431 is a programmable shunt voltage reference with guaranteed temperature stability over the entire temperature range of operation.

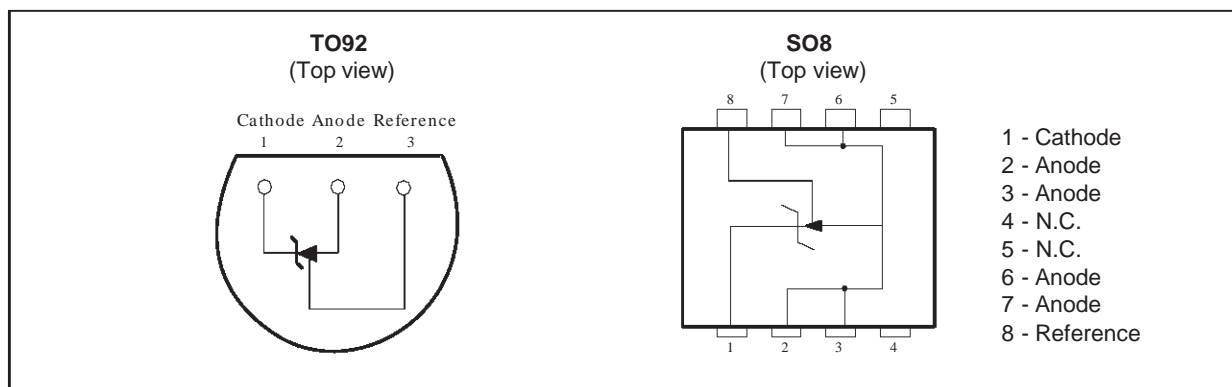
The output voltage may be set to any value between  $V_{ref}$  (approximately 2.5V) and 36V with two external resistors.

The TL1431 operates with a wide current range from 1 to 100mA with a typical dynamic impedance of  $0.2\Omega$ .

### ORDER CODES

| Part number | Temperature Range | Package |   |
|-------------|-------------------|---------|---|
|             |                   | Z       | D |
| TL1431C/AC  | -20°C, +70°C      | •       | • |
| TL1431I/AI  | -40°C, +105°C     | •       | • |

### PIN CONNECTIONS



**ABSOLUTE MAXIMUM RATINGS**

| Symbol            | Parameter   | Value                     | Unit |
|-------------------|---|---------------------------|------|
| V <sub>KA</sub>   | Cathode to Anode Voltage                                      | 37                        | V    |
| I <sub>K</sub>    | Continuous Cathode Current Range                              | -100 to +150              | mA   |
| I <sub>ref</sub>  | Reference Input Current Range                                 | -0.05 to +10              | mA   |
| T <sub>oper</sub> | Operating Free-air Temperature Range TL1431C/AC<br>TL1431I/AI | -20 to +70<br>-40 to +105 | °C   |
| T <sub>stg</sub>  | Storage Temperature Range                                     | -65 to +150               | °C   |

**OPERATING CONDITIONS**

| Symbol          | Parameter                | Value                  | Unit |
|-----------------|--------------------------|------------------------|------|
| V <sub>KA</sub> | Cathode to Anode Voltage | V <sub>ref</sub> to 36 | V    |
| I <sub>K</sub>  | Cathode Current          | 1 to 100               | mA   |

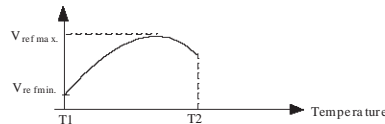
**ELECTRICAL CHARACTERISTICS**

T<sub>amb</sub> = 25°C (unless otherwise specified)

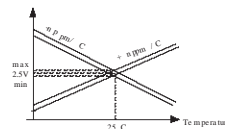
| Symbol                                 | Parameter   | TL1431C |       |          | TL1431AC |       |          | Unit   |
|--|---|---------|-------|----------|----------|-------|----------|--------|
|  |   | Min.    | Typ.  | Max.     | Min.     | Typ.  | Max.     |        |
| V <sub>ref</sub>                       | Reference Input Voltage - (figure 1)<br>V <sub>KA</sub> = V <sub>ref</sub> , I <sub>K</sub> = 10mA<br>T <sub>amb</sub> = 25°C   | 2.490   | 2.500 | 2.510    | 2.493    | 2.500 | 2.507    | V      |
| ΔV <sub>ref</sub>                      | Reference Input Voltage Deviation Over Temperature Range - (figure 1, note1)<br>V <sub>KA</sub> = V <sub>ref</sub> , I <sub>K</sub> = 10mA, T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>  |         | 3     | 20       |          | 3     | 20       | mV     |
| $\frac{\Delta V_{ref}}{\Delta T}$      | Temperature Coefficient of Reference Input Voltage - (note 2)<br>V <sub>KA</sub> = V <sub>ref</sub> , I <sub>K</sub> = 10mA, T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>                 |         | ±13   | ±90      |          | ±13   | ±90      | ppm/°C |
| $\frac{\Delta V_{ref}}{\Delta V_{KA}}$ | Ratio of Change in Reference Input Voltage to Change in Cathode to Anode Voltage - (figure 2)<br>I <sub>K</sub> = 10mA, ΔV <sub>KA</sub> = 36V to 3V  | -2      | -1.1  |          | -2       | -1.1  |          | mV/V   |
| I <sub>ref</sub>                       | Reference Input Current - (figure 2)<br>I <sub>K</sub> = 10mA, R <sub>1</sub> = 10kΩ, R <sub>2</sub> = ∞<br>T <sub>amb</sub> = 25°C<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>       |         | 1.5   | 2.5<br>3 |          | 1.5   | 2.5<br>3 | μA     |
| ΔI <sub>ref</sub>                      | Reference Input Current Deviation Over Temperature Range - (figure 2)<br>I <sub>K</sub> = 10mA, R <sub>1</sub> = 10kΩ, R <sub>2</sub> = ∞<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub> |         | 0.2   | 1.2      |          | 0.2   | 1.2      | μA     |
| I <sub>min</sub>                       | Minimum Cathode Current for Regulation - (figure 1)<br>V <sub>KA</sub> = V <sub>ref</sub>   |         | 0.5   | 1        |          | 0.5   | 0.6      | mA     |
| I <sub>off</sub>                       | Off-State Cathode Current - (figure 3)  |         | 180   | 500      |          | 180   | 500      | nA     |
| Z <sub>KA</sub>                        | Dynamic Impedance - (figure 1, note 3)<br>V <sub>KA</sub> = V <sub>ref</sub> , ΔI <sub>K</sub> = 1 to 100mA, f ≤ 1kHz   |         | 0.2   | 0.5      |          | 0.2   | 0.5      | Ω      |

Notes : 1. ΔV<sub>ref</sub> is defined as the difference between the maximum and minimum values obtained over the full temperature range.

$$\Delta V_{ref} = V_{ref\ max.} - V_{ref\ min.}$$



2. The temperature coefficient is defined as the slopes (positive and negative) of the voltage vs temperature limits within which the reference voltage is guaranteed.



3. The dynamic Impedance is defined as  $|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_K}$

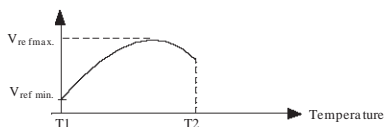
**ELECTRICAL CHARACTERISTICS**

T<sub>amb</sub> = 25°C (unless otherwise specified)

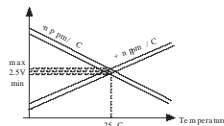
| Symbol                                 | Parameter   | TL1431I |       |          | TL1431AI |       |          | Unit   |
|--|---|---------|-------|----------|----------|-------|----------|--------|
|  |   | Min.    | Typ.  | Max.     | Min.     | Typ.  | Max.     |        |
| V <sub>ref</sub>                       | Reference Input Voltage - (figure 1)<br>V <sub>KA</sub> = V <sub>ref</sub> , I <sub>K</sub> = 10mA<br>T <sub>amb</sub> = 25°C   | 2.490   | 2.500 | 2.510    | 2.493    | 2.500 | 2.507    | V      |
| ΔV <sub>ref</sub>                      | Reference Input Voltage Deviation Over Temperature Range - (figure 1, note 1)<br>V <sub>KA</sub> = V <sub>ref</sub> , I <sub>K</sub> = 10mA, T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub> |         | 7     | 30       |          | 7     | 30       | mV     |
| $\frac{\Delta V_{ref}}{\Delta T}$      | Temperature Coefficient of Reference Input Voltage - (note 2)<br>V <sub>KA</sub> = V <sub>ref</sub> , I <sub>K</sub> = 10mA, T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>                 |         | ±22   | ±100     |          | ±22   | ±100     | ppm/°C |
| $\frac{\Delta V_{ref}}{\Delta V_{KA}}$ | Ratio of Change in Reference Input Voltage to Change in Cathode to Anode Voltage - (figure 2)<br>I <sub>K</sub> = 10mA, ΔV <sub>KA</sub> = 36 to 3V   |         | -1.1  | -2       |          | -1.1  | -2       | mV/V   |
| I <sub>ref</sub>                       | Reference Input Current - (figure 2)<br>I <sub>K</sub> = 10mA, R <sub>1</sub> = 10kΩ, R <sub>2</sub> = ∞<br>T <sub>amb</sub> = 25°C<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>       |         | 1.5   | 2.5<br>3 |          | 1.5   | 2.5<br>3 | μA     |
| ΔI <sub>ref</sub>                      | Reference Input Current Deviation Over Temperature Range - (figure 2)<br>I <sub>K</sub> = 10mA, R <sub>1</sub> = 10kΩ, R <sub>2</sub> = ∞<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub> |         | 0.5   | 1        |          | 0.8   | 1.2      | μA     |
| I <sub>min</sub>                       | Minimum Cathode Current for Regulation (figure 1)<br>V <sub>KA</sub> = V <sub>ref</sub>   |         | 0.5   | 1        |          | 0.5   | 0.7      | mA     |
| I <sub>off</sub>                       | Off-State Cathode Current - (figure 3)  |         | 180   | 500      |          | 180   | 500      | nA     |
| Z <sub>KA</sub>                        | Dynamic Impedance - (figure 1, note 3)<br>V <sub>KA</sub> = V <sub>ref</sub> , ΔI <sub>K</sub> = 1 to 100mA, f ≤ 1kHz   |         | 0.2   | 0.5      |          | 0.2   | 0.5      | Ω      |

**Notes :** 1. ΔV<sub>ref</sub> is defined as the difference between the maximum and minimum values obtained over the full temperature range.

$$\Delta V_{ref} = V_{ref \max} - V_{ref \min}$$

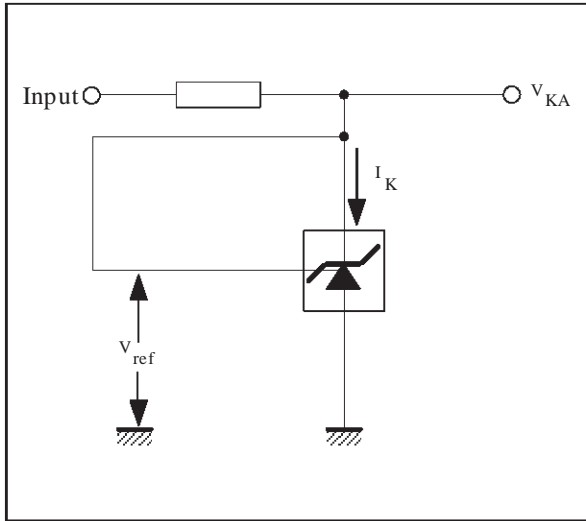


2. The temperature coefficient is defined as the slopes (positive and negative) of the voltage vs temperature limits within which the reference voltage is guaranteed.

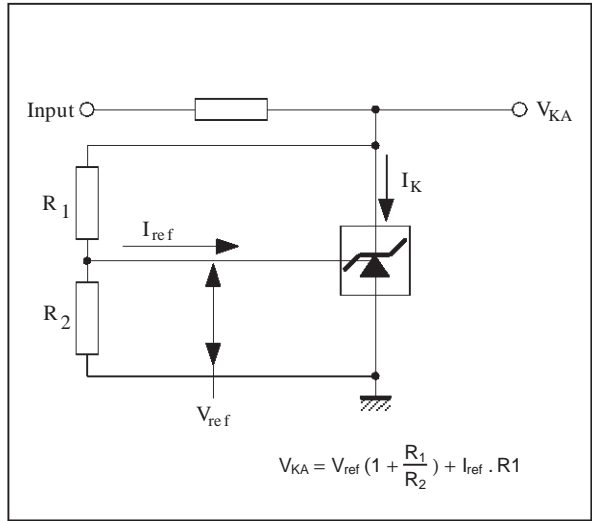


3. The dynamic Impedance is defined as  $|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_K}$

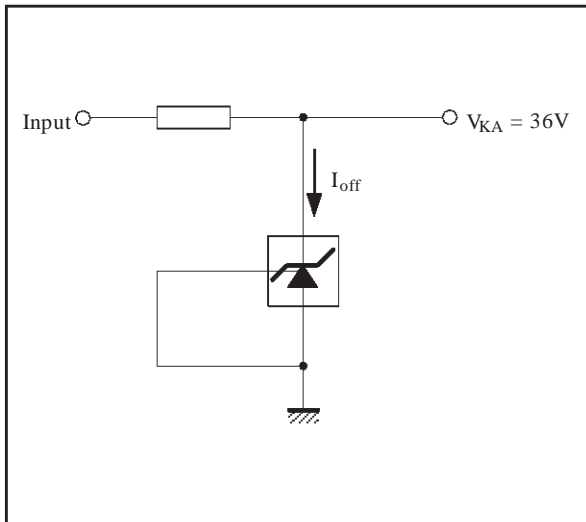
**Figure 1 :** Test Circuit for  $V_{KA} = V_{ref}$



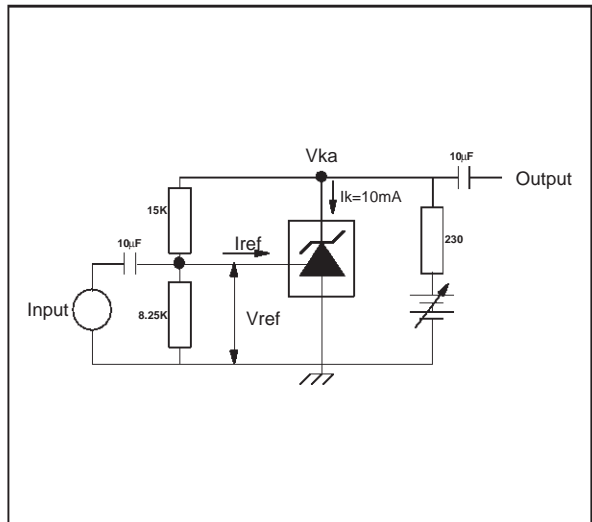
**Figure 2 :** Test Circuit for  $V_{KA} > V_{ref}$



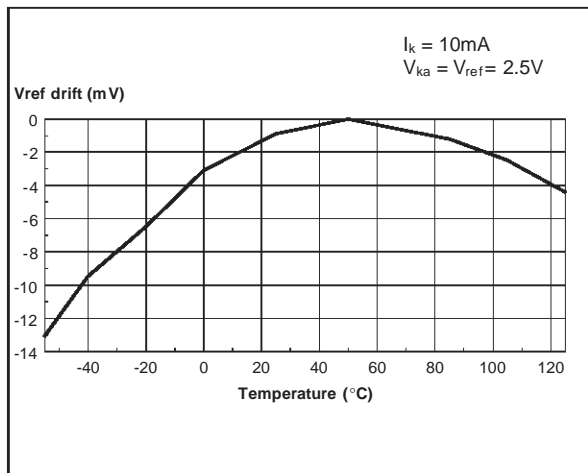
**Figure 3 :** Test Circuit for  $I_{off}$



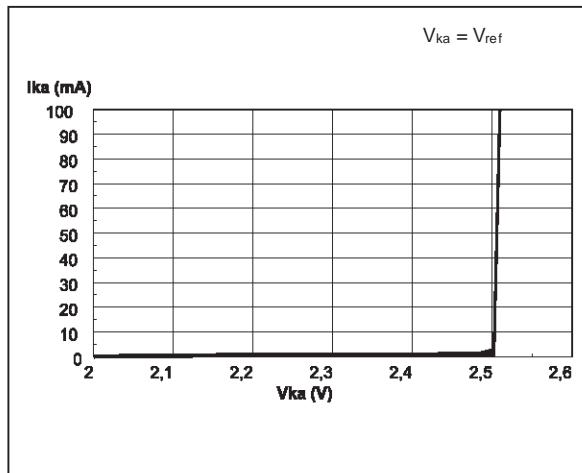
**Figure 4 :** Test Circuit for Phase Margin and Voltage Gain



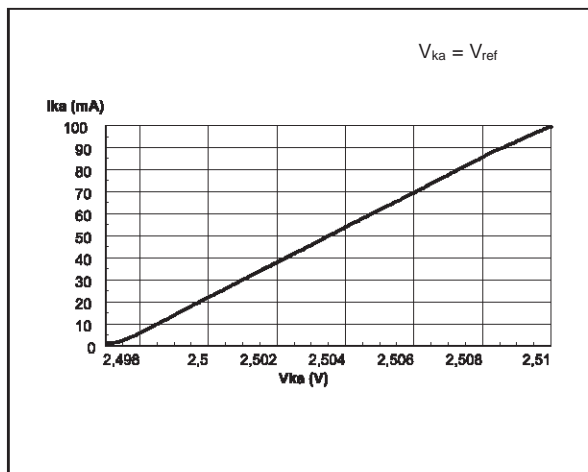
DRIFT (mV) vs TEMPERATURE (°C)



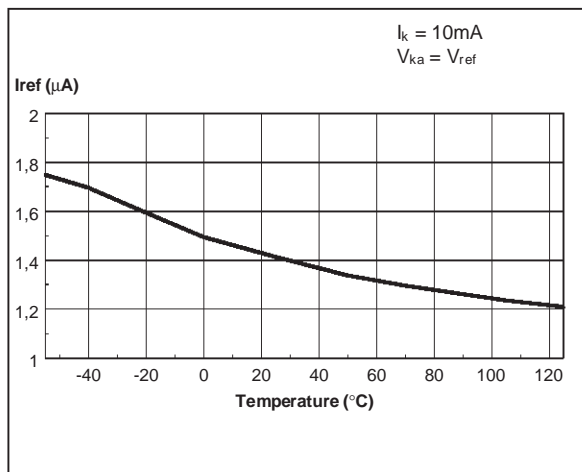
CATHODE CURRENT vs CATHODE VOLTAGE



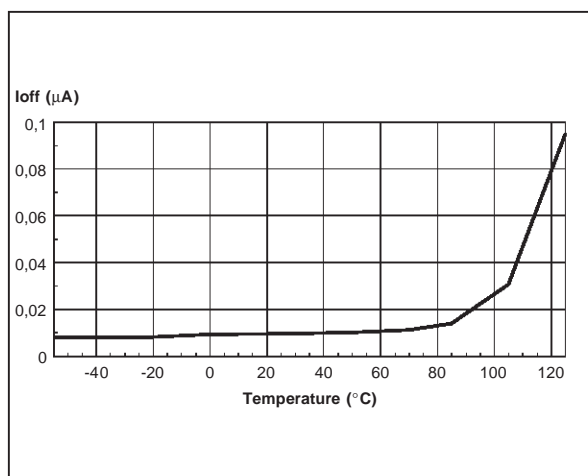
CATHODE CURRENT vs CATHODE VOLTAGE (detailed version)



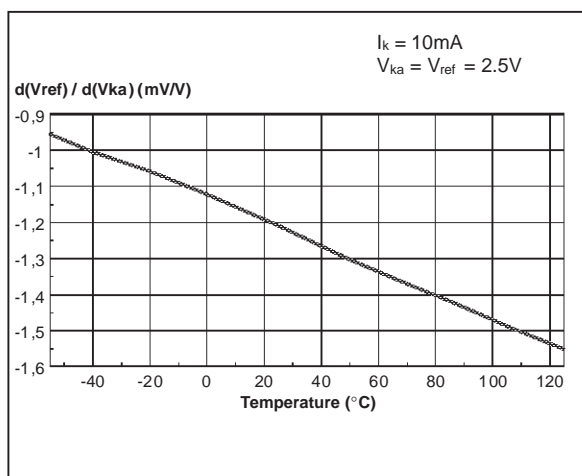
REFERENCE CURRENT vs TEMPERATURE



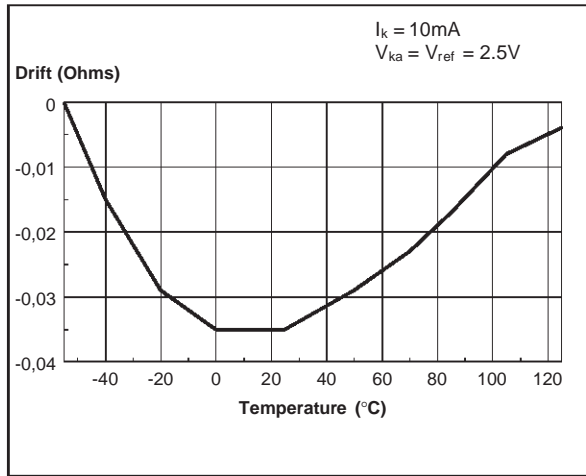
OFF-STATE CATHODE CURRENT vs TEMPERATURE



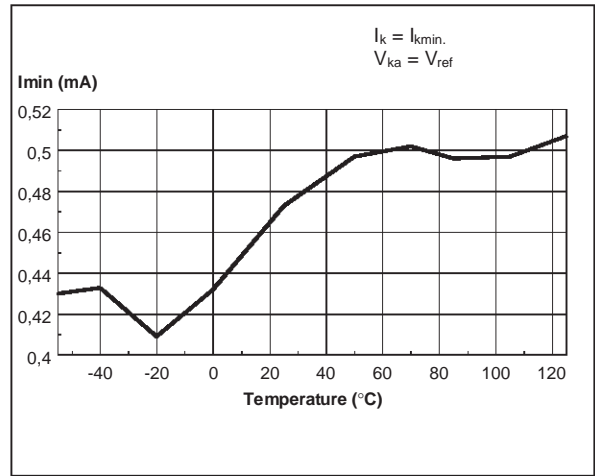
RATIO OF CHANGE IN  $V_{ref}$  TO CHANGE IN  $V_{KA}$  vs TEMPERATURE



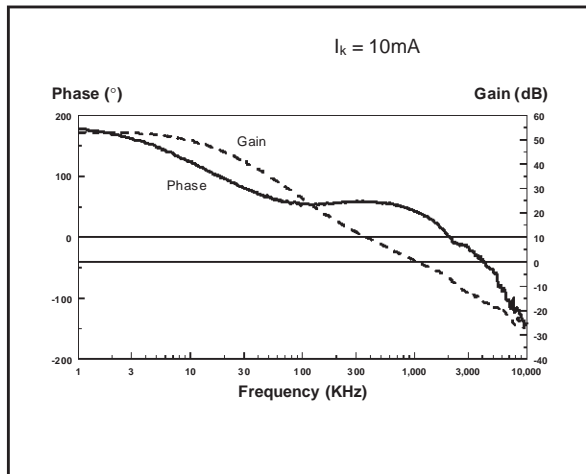
**DRIFT OF R<sub>KA</sub> vs TEMPERATURE**



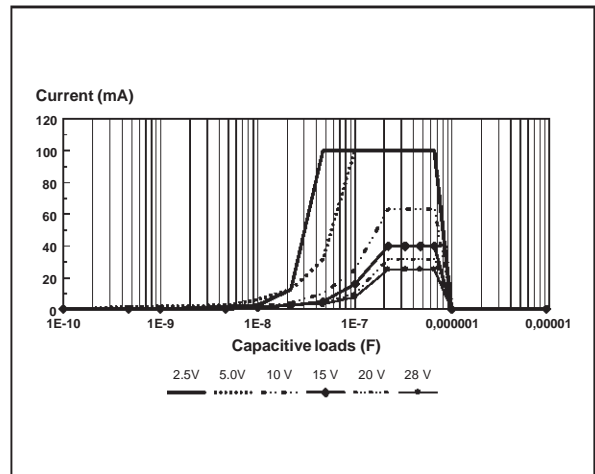
**MINIMUM OPERATING CURRENT vs TEMPERATURE**



**PHASE MARGIN vs FREQUENCY**

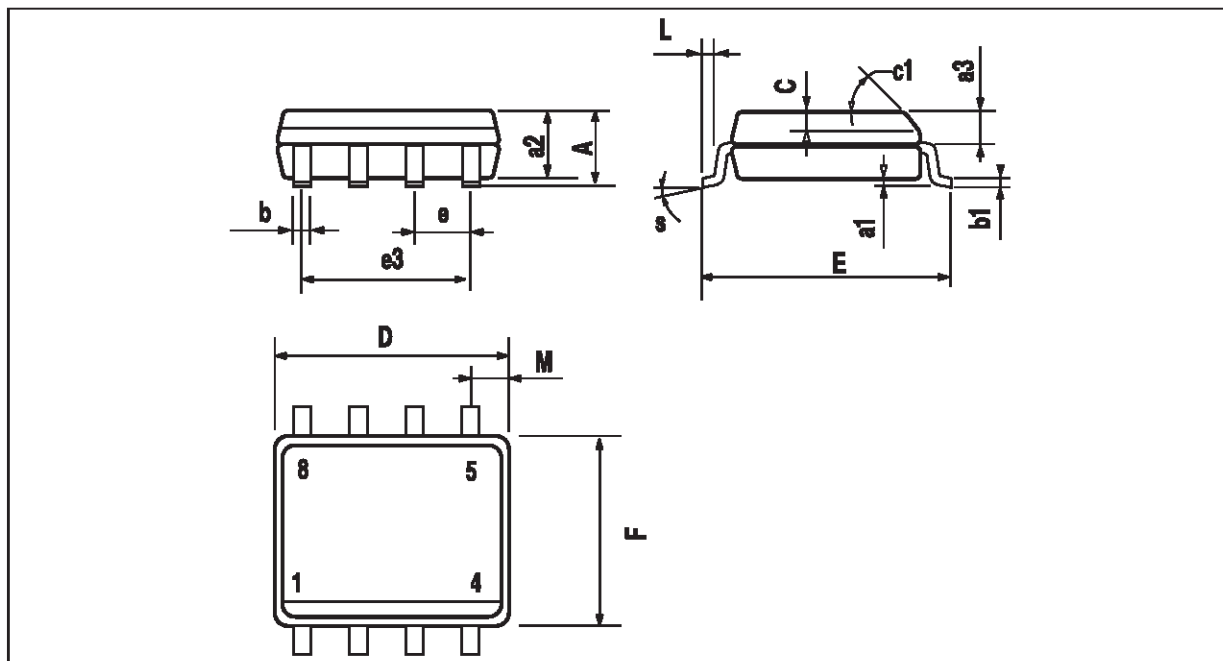


**STABILITY FOR CAPACITIVE LOADS**



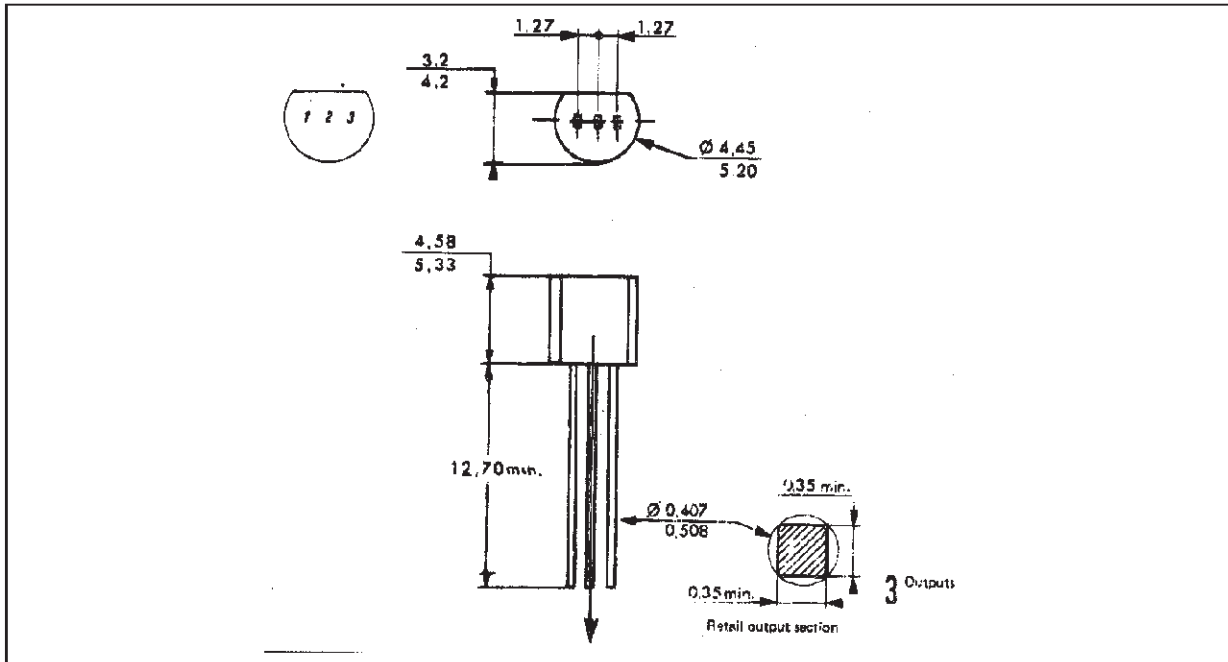
**PACKAGE MECHANICAL DATA**

**8 PINS - BATWING PLASTIC MICROPACKAGE (SO)**



| Dimensions | Millimeters |      |      | Inches |       |       |
|------------|-------------|------|------|--------|-------|-------|
|            | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A          |             |      | 1.75 |        |       | 0.069 |
| a1         | 0.1         |      | 0.25 | 0.004  |       | 0.010 |
| a2         |             |      | 1.65 |        |       | 0.065 |
| a3         | 0.65        |      | 0.85 | 0.026  |       | 0.033 |
| b          | 0.35        |      | 0.48 | 0.014  |       | 0.019 |
| b1         | 0.19        |      | 0.25 | 0.007  |       | 0.010 |
| C          | 0.25        |      | 0.5  | 0.010  |       | 0.020 |
| c1         | 45° (typ.)  |      |      |        |       |       |
| D          | 4.8         |      | 5.0  | 0.189  |       | 0.197 |
| E          | 5.8         |      | 6.2  | 0.228  |       | 0.244 |
| e          |             | 1.27 |      |        | 0.050 |       |
| e3         |             | 3.81 |      |        | 0.150 |       |
| F          | 3.8         |      | 4.0  | 0.150  |       | 0.157 |
| L          | 0.4         |      | 1.27 | 0.016  |       | 0.050 |
| M          |             |      | 0.6  |        |       | 0.024 |
| S          | 8° (max.)   |      |      |        |       |       |

**PACKAGE MECHANICAL DATA**  
**3 PINS - PLASTIC PACKAGE TO92**



| Dimensions | Millimeters |      |       | Inches |        |        |
|------------|-------------|------|-------|--------|--------|--------|
|            | Min.        | Typ. | Max.  | Min.   | Typ.   | Max.   |
| L          |             | 1.27 |       |        | 0.05   |        |
| B          | 3.2         | 3.7  | 4.2   | 0.126  | 0.1457 | 0.1654 |
| O1         | 4.45        | 5.00 | 5.2   | 0.1752 | 0.1969 | 0.2047 |
| C          | 4.58        | 5.03 | 5.33  | 0.1803 | 0.198  | 0.2098 |
| K          | 12.7        |      |       | 0.5    |        |        |
| O2         | 0.407       | 0.5  | 0.508 | 0.016  | 0.0197 | 0.02   |
| a          | 0.35        |      |       | 0.0138 |        |        |

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