



MOTOROLA

# Micropower Voltage Reference Diodes

The LM285/LM385 series are micropower two-terminal bandgap voltage regulator diodes. Designed to operate over a wide current range of 10  $\mu$ A to 20 mA, these devices feature exceptionally low dynamic impedance, low noise and stable operation over time and temperature. Tight voltage tolerances are achieved by on-chip trimming. The large dynamic operating range enables these devices to be used in applications with widely varying supplies with excellent regulation. Extremely low operating current make these devices ideal for micropower circuitry like portable instrumentation, regulators and other analog circuitry where extended battery life is required.

The LM285/LM385 series are packaged in a low cost TO-226AA plastic case and are available in two voltage versions of 1.235 and 2.500 V as denoted by the device suffix (see Ordering Information table). The LM285 is specified over a  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  temperature range while the LM385 is rated from  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ .

The LM385 is also available in a surface mount plastic package in voltages of 1.235 and 2.500 V.

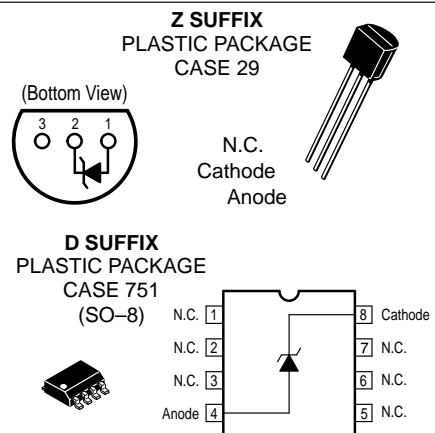
- Operating Current from 10  $\mu$ A to 20 mA
- 1.0%, 1.5%, 2.0% and 3.0% Initial Tolerance Grades
- Low Temperature Coefficient
- 1.0  $\Omega$  Dynamic Impedance
- Surface Mount Package Available

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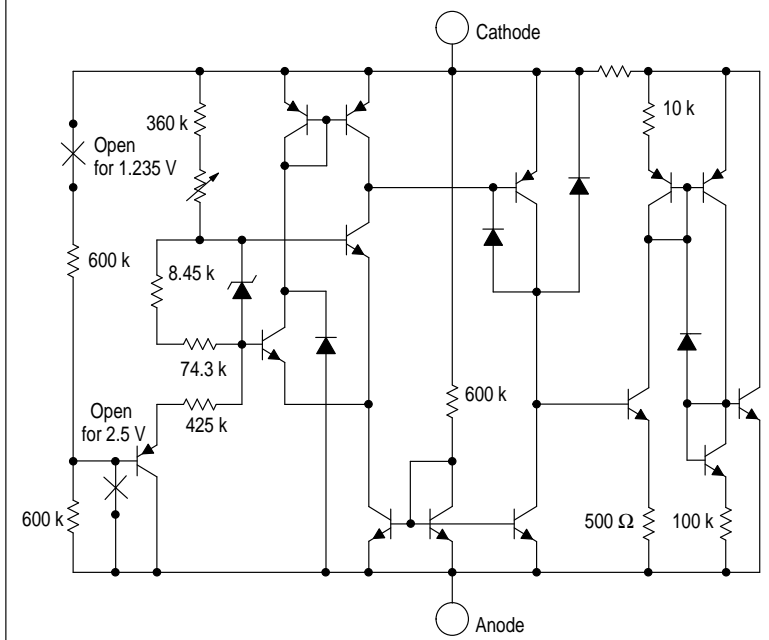
## LM285 LM385, B

### MICROPOWER VOLTAGE REFERENCE DIODES

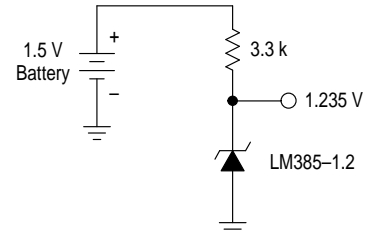
#### SEMICONDUCTOR TECHNICAL DATA



### Representative Schematic Diagram



### Standard Application



### ORDERING INFORMATION

| Device                     | Operating Temperature Range                  | Reverse Break-down Voltage | Tolerance   |
|----------------------------|--|----------------------------|-------------|
| LM285D-1.2<br>LM285Z-1.2   | $T_A = -40^{\circ}$ to $+85^{\circ}\text{C}$ | 1.235 V                    | $\pm 1.0\%$ |
| LM285D-2.5<br>LM285Z-2.5   |  | 2.500 V                    | $\pm 1.5\%$ |
| LM385BD-1.2<br>LM385BZ-1.2 | $T_A = 0^{\circ}$ to $+70^{\circ}\text{C}$   | 1.235 V                    | $\pm 1.0\%$ |
| LM385D-1.2<br>LM385Z-1.2   |  | 1.235 V                    | $\pm 2.0\%$ |
| LM385BD-2.5<br>LM385BZ-2.5 |  | 2.500 V                    | $\pm 1.5\%$ |
| LM385D-2.5<br>LM385Z-2.5   |  | 2.500 V                    | $\pm 3.0\%$ |

## LM285 LM385, B

### MAXIMUM RATINGS ( $T_A = 25^\circ\text{C}$ , unless otherwise noted)

| Rating  | Symbol           | Value                    | Unit             |
|---|------------------|--------------------------|------------------|
| Reverse Current                                       | $I_R$            | 30                       | mA               |
| Forward Current                                       | $I_F$            | 10                       | mA               |
| Operating Ambient Temperature Range<br>LM285<br>LM385 | $T_A$            | - 40 to + 85<br>0 to +70 | $^\circ\text{C}$ |
| Operating Junction Temperature                        | $T_J$            | + 150                    | $^\circ\text{C}$ |
| Storage Temperature Range                             | $T_{\text{stg}}$ | - 65 to + 150            | $^\circ\text{C}$ |

### ELECTRICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ , unless otherwise noted)

| Characteristic  | Symbol                            | LM285-1.2                |                      |                          | LM385-1.2/LM385B-1.2             |                          |                                  | Unit                  |
|---|-----------------------------------|--------------------------|----------------------|--------------------------|----------------------------------|--------------------------|----------------------------------|-----------------------|
|   |                                   | Min                      | Typ                  | Max                      | Min                              | Typ                      | Max                              |                       |
| Reverse Breakdown Voltage ( $I_{R\text{min}} \leq I_R \leq 20 \text{ mA}$ )<br>LM285-1.2/LM385B-1.2<br>$T_A = T_{\text{low}} \text{ to } T_{\text{high}}$ (Note 1)<br>LM385-1.2<br>$T_A = T_{\text{low}} \text{ to } T_{\text{high}}$ (Note 1)  | $V_{(\text{BR})R}$                | 1.223<br>1.200<br>–<br>– | 1.235<br>–<br>–<br>– | 1.247<br>1.270<br>–<br>– | 1.223<br>1.210<br>1.205<br>1.192 | 1.235<br>–<br>1.235<br>– | 1.247<br>1.260<br>1.260<br>1.273 | V                     |
| Minimum Operating Current<br>$T_A = 25^\circ\text{C}$<br>$T_A = T_{\text{low}} \text{ to } T_{\text{high}}$ (Note 1)  | $I_{R\text{min}}$                 | –<br>–                   | 8.0<br>–             | 10<br>20                 | –<br>–                           | 8.0<br>–                 | 15<br>20                         | $\mu\text{A}$         |
| Reverse Breakdown Voltage Change with Current<br>$I_{R\text{min}} \leq I_R \leq 1.0 \text{ mA}$ , $T_A = +25^\circ\text{C}$<br>$T_A = T_{\text{low}} \text{ to } T_{\text{high}}$ (Note 1)<br>$1.0 \text{ mA} \leq I_R \leq 20 \text{ mA}$ , $T_A = +25^\circ\text{C}$<br>$T_A = T_{\text{low}} \text{ to } T_{\text{high}}$ (Note 1) | $\Delta V_{(\text{BR})R}$         | –<br>–<br>–<br>–         | –<br>–<br>–<br>–     | 1.0<br>1.5<br>10<br>20   | –<br>–<br>–<br>–                 | –<br>–<br>–<br>–         | 1.0<br>1.5<br>20<br>25           | mV                    |
| Reverse Dynamic Impedance<br>$I_R = 100 \mu\text{A}$ , $T_A = +25^\circ\text{C}$  | Z                                 |                          | 0.6                  | –                        | –                                | 0.6                      | –                                | W                     |
| Average Temperature Coefficient<br>$10 \mu\text{A} \leq I_R \leq 20 \text{ mA}$ , $T_A = T_{\text{low}} \text{ to } T_{\text{high}}$ (Note 1)   | $\Delta V_{(\text{BR})}/\Delta T$ | –                        | 80                   | –                        | –                                | 80                       | –                                | ppm/ $^\circ\text{C}$ |
| Wideband Noise (RMS)<br>$I_R = 100 \mu\text{A}$ , $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$  | n                                 | –                        | 60                   | –                        | –                                | 60                       | –                                | $\mu\text{V}$         |
| Long Term Stability<br>$I_R = 100 \mu\text{A}$ , $T_A = +25^\circ\text{C} \pm 0.1^\circ\text{C}$  | S                                 | –                        | 20                   | –                        | –                                | 20                       | –                                | ppm/<br>kHR           |

## LM285 LM385, B

### ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C, unless otherwise noted)

| Characteristic  | Symbol                  | LM285–2.5                |                    |                          | LM385–2.5/LM385B–2.5             |                      |                                  | Unit        |
|---|-------------------------|--------------------------|--------------------|--------------------------|----------------------------------|----------------------|----------------------------------|-------------|
|   |                         | Min                      | Typ                | Max                      | Min                              | Typ                  | Max                              |             |
| Reverse Breakdown Voltage (I <sub>Rmin</sub> ≤ I <sub>R</sub> ≤ 20 mA)<br>LM285–2.5/LM385B–2.5<br>T <sub>A</sub> = T <sub>low</sub> to T <sub>high</sub> (Note 1)<br>LM385–2.5<br>T <sub>A</sub> = T <sub>low</sub> to T <sub>high</sub> (Note 1)   | V <sub>(BR)R</sub>      | 2.462<br>2.415<br>–<br>– | 2.5<br>–<br>–<br>– | 2.538<br>2.585<br>–<br>– | 2.462<br>2.436<br>2.425<br>2.400 | 2.5<br>–<br>2.5<br>– | 2.538<br>2.564<br>2.575<br>2.600 | V           |
| Minimum Operating Current<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>low</sub> to T <sub>high</sub> (Note 1)   | I <sub>Rmin</sub>       | –<br>–                   | 13<br>–            | 20<br>30                 | –<br>–                           | 13<br>–              | 20<br>30                         | μA          |
| Reverse Breakdown Voltage Change with Current<br>I <sub>Rmin</sub> ≤ I <sub>R</sub> ≤ 1.0 mA, T <sub>A</sub> = +25°C<br>T <sub>A</sub> = T <sub>low</sub> to T <sub>high</sub> (Note 1)<br>1.0 mA ≤ I <sub>R</sub> ≤ 20 mA, T <sub>A</sub> = +25°C<br>T <sub>A</sub> = T <sub>low</sub> to T <sub>high</sub> (Note 1) | ΔV <sub>(BR)R</sub>     | –<br>–<br>–<br>–         | –<br>–<br>–<br>–   | 1.0<br>1.5<br>10<br>20   | –<br>–<br>–<br>–                 | –<br>–<br>–<br>–     | 2.0<br>2.5<br>20<br>25           | mV          |
| Reverse Dynamic Impedance<br>I <sub>R</sub> = 100 μA, T <sub>A</sub> = +25°C  | Z                       |                          | 0.6                | –                        | –                                | 0.6                  | –                                | W           |
| Average Temperature Coefficient<br>20 μA ≤ I <sub>R</sub> ≤ 20 mA, T <sub>A</sub> = T <sub>low</sub> to T <sub>high</sub> (Note 1)  | ΔV <sub>(BR)R</sub> /ΔT | –                        | 80                 | –                        | –                                | 80                   | –                                | ppm/°C      |
| Wideband Noise (RMS)<br>I <sub>R</sub> = 100 μA, 10 Hz ≤ f ≤ 10 kHz   | n                       | –                        | 120                | –                        | –                                | 120                  | –                                | μV          |
| Long Term Stability<br>I <sub>R</sub> = 100 μA, T <sub>A</sub> = +25°C ± 0.1°C  | S                       | –                        | 20                 | –                        | –                                | 20                   | –                                | ppm/<br>kHR |

**NOTES:** 1. T<sub>low</sub> = –40°C for LM285–1.2, LM285–2.5  
= 0°C for LM385–1.2, LM385B–1.2, LM385–2.5, LM385B–2.5

T<sub>high</sub> = +85°C for LM285–1.2, LM285–2.5  
= +70°C for LM385–1.2, LM385B–1.2, LM385–2.5, LM385B–2.5

# LM285 LM385, B

## TYPICAL PERFORMANCE CURVES FOR LM285-1.2/385-1.2/385B-1.2

Figure 1. Reverse Characteristics

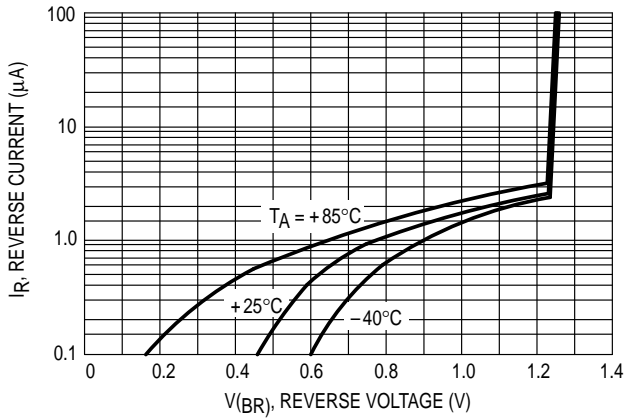


Figure 2. Reverse Characteristics

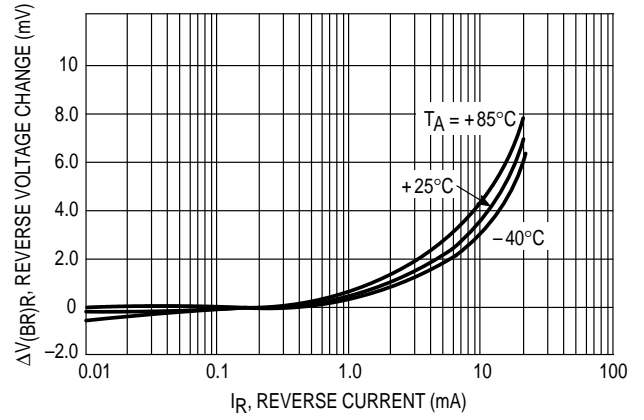


Figure 3. Forward Characteristics

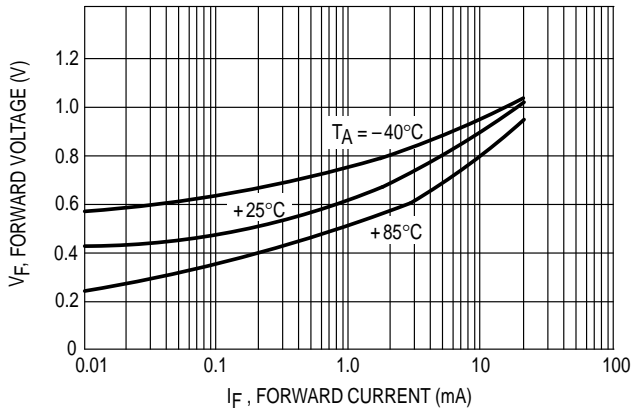


Figure 4. Temperature Drift

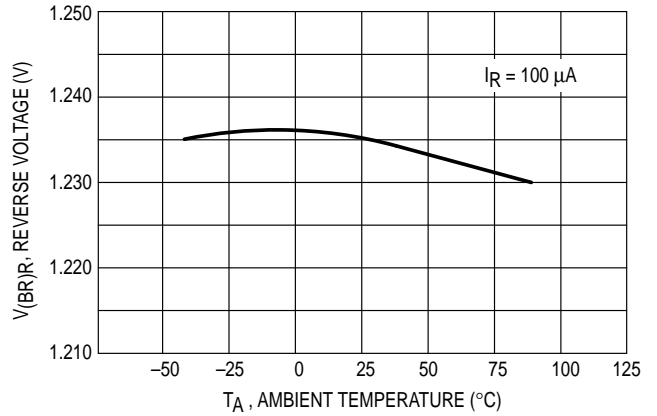


Figure 5. Noise Voltage

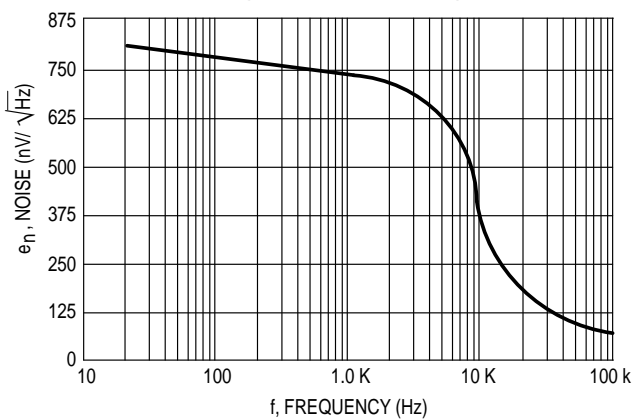
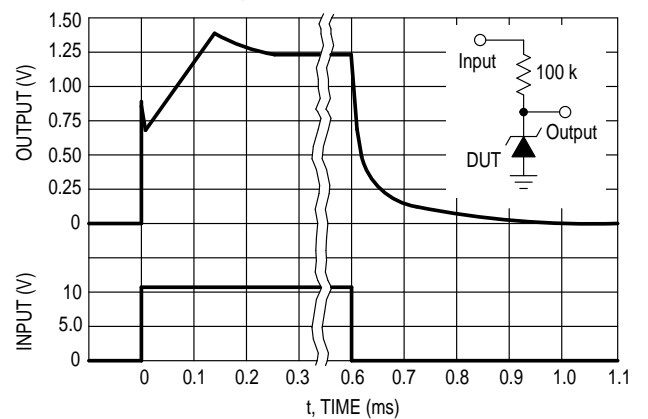


Figure 6. Response Time



# LM285 LM385, B

## TYPICAL PERFORMANCE CURVES FOR LM285-2.5/385-2.5/385B-2.5

Figure 7. Reverse Characteristics

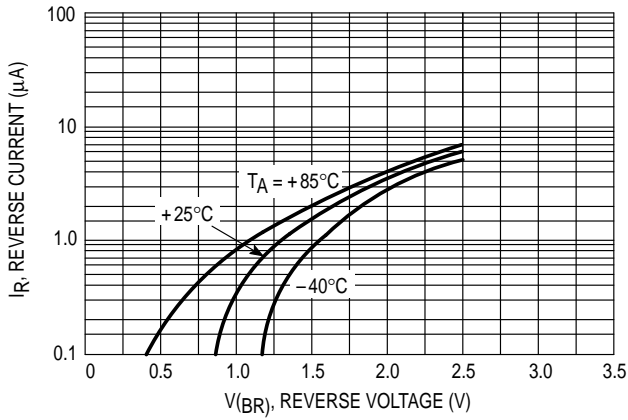


Figure 8. Reverse Characteristics

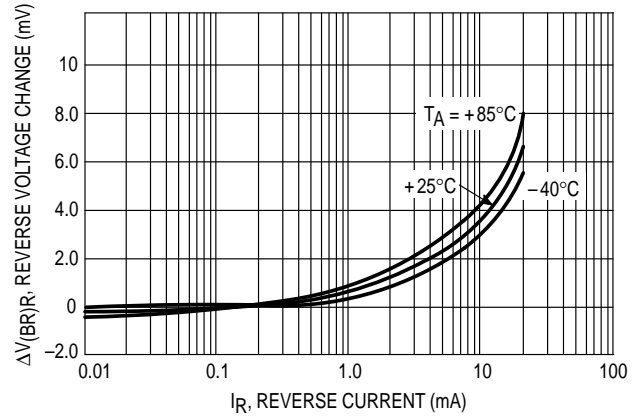


Figure 9. Forward Characteristics

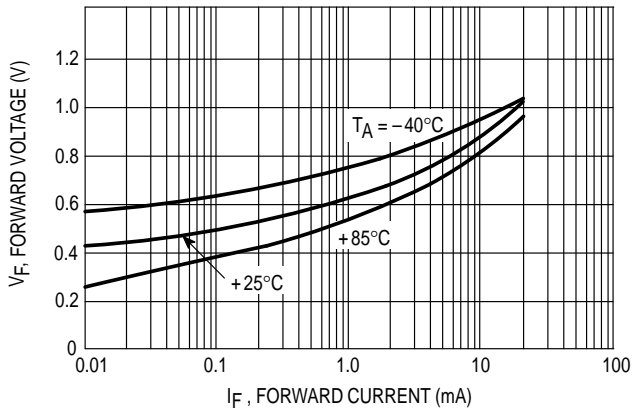


Figure 10. Temperature Drift

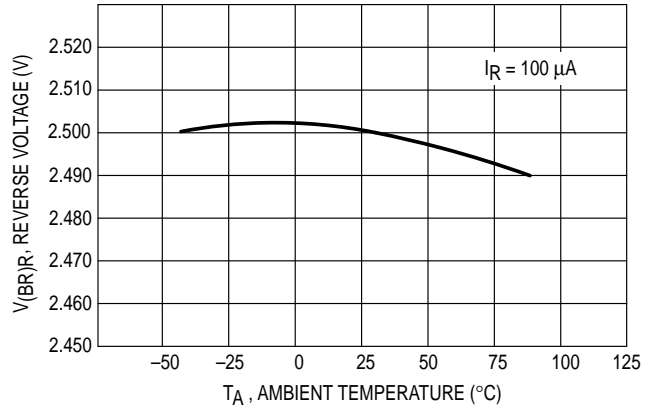


Figure 11. Noise Voltage

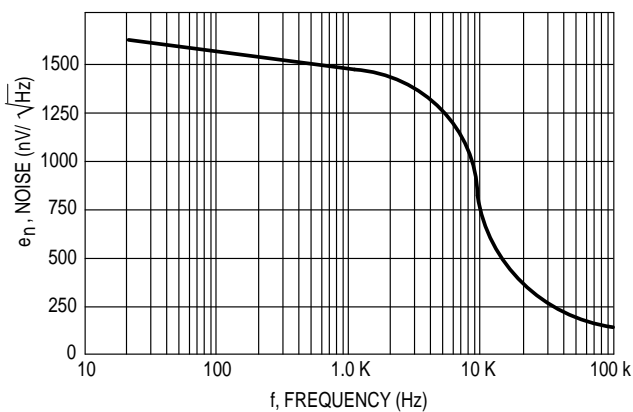
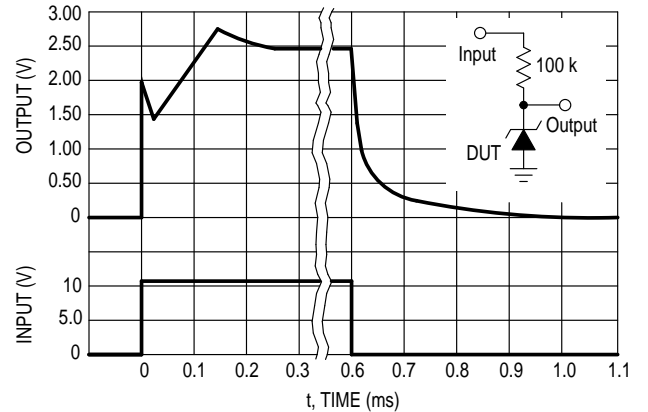


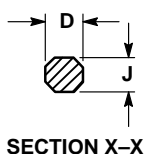
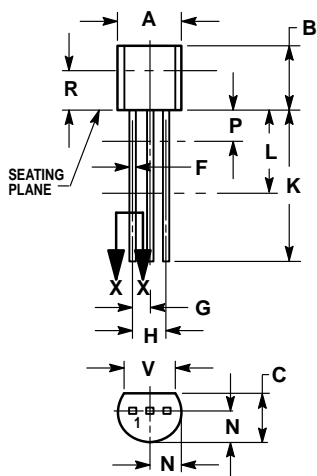
Figure 12. Response Time



# LM285 LM385, B

## OUTLINE DIMENSIONS

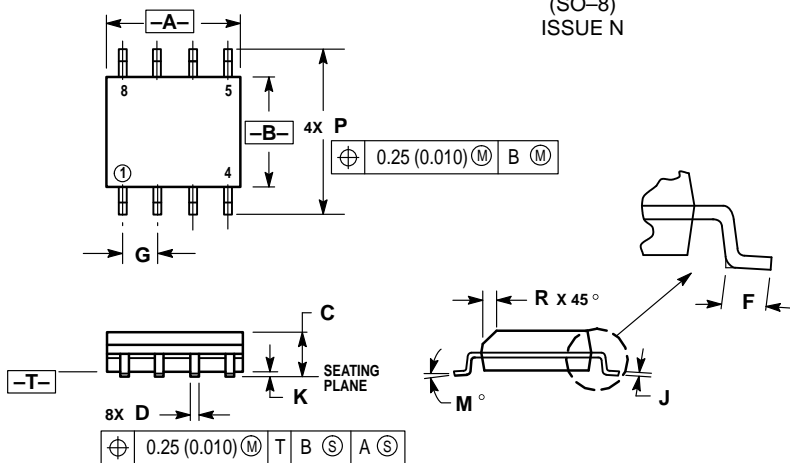
### Z SUFFIX PLASTIC PACKAGE CASE 29-04 ISSUE AD



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: INCH.
  3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
  4. DIMENSION F APPLIES BETWEEN P AND L. DIMENSION D AND J APPLY BETWEEN L AND K MINIMUM. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

| DIM | INCHES |       | MILLIMETERS |      |
|-----|--------|-------|-------------|------|
|     | MIN    | MAX   | MIN         | MAX  |
| A   | 0.175  | 0.205 | 4.45        | 5.20 |
| B   | 0.170  | 0.210 | 4.32        | 5.33 |
| C   | 0.125  | 0.165 | 3.18        | 4.19 |
| D   | 0.016  | 0.022 | 0.41        | 0.55 |
| F   | 0.016  | 0.019 | 0.41        | 0.48 |
| G   | 0.045  | 0.055 | 1.15        | 1.39 |
| H   | 0.095  | 0.105 | 2.42        | 2.66 |
| J   | 0.015  | 0.020 | 0.39        | 0.50 |
| K   | 0.500  | —     | 12.70       | —    |
| L   | 0.250  | —     | 6.35        | —    |
| N   | 0.080  | 0.105 | 2.04        | 2.66 |
| P   | —      | 0.100 | —           | 2.54 |
| R   | 0.115  | —     | 2.93        | —    |
| V   | 0.135  | —     | 3.43        | —    |


### D SUFFIX PLASTIC PACKAGE CASE 751-05 (SO-8) ISSUE N



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: MILLIMETER.
  3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
  4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
  5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

| DIM | MILLIMETERS |      | INCHES    |       |
|-----|-------------|------|-----------|-------|
|     | MIN         | MAX  | MIN       | MAX   |
| A   | 4.80        | 5.00 | 0.189     | 0.196 |
| B   | 3.80        | 4.00 | 0.150     | 0.157 |
| C   | 1.35        | 1.75 | 0.054     | 0.068 |
| D   | 0.35        | 0.49 | 0.014     | 0.019 |
| F   | 0.40        | 1.25 | 0.016     | 0.049 |
| G   | 1.27 BSC    | —    | 0.050 BSC | —     |
| J   | 0.18        | 0.25 | 0.007     | 0.009 |
| K   | 0.10        | 0.25 | 0.004     | 0.009 |
| M   | 0°          | 7°   | 0°        | 7°    |
| P   | 5.80        | 6.20 | 0.229     | 0.244 |
| R   | 0.25        | 0.50 | 0.010     | 0.019 |

## LM285 LM385, B

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**MOTOROLA**



LM285/D

