

**1.5KE6.8,A thru 1.5KE200,A**  
See Page 4-74



**MOTOROLA**

## Designers Data Sheet

**1N746 thru 1N759**  
**1N957A thru 1N986A**  
**1N4370 thru 1N4372**

**GLASS ZENER DIODES**  
**500 MILLIWATTS**  
**2.4-110 VOLTS**

### 500-MILLIWATT HERMETICALLY SEALED GLASS SILICON ZENER DIODES

- Complete Voltage Range — 2.4 to 110 Volts
- DO-35 Package — Smaller than Conventional DO-7 Package
- Double Slug Type Construction
- Metallurgically Bonded Construction
- Nitride Passivated Die

#### Designer's Data for "Worst Case" Conditions

The Designer's Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

#### MAXIMUM RATINGS

| Rating                                                                     | Symbol         | Value       | Unit                 |
|----------------------------------------------------------------------------|----------------|-------------|----------------------|
| DC Power Dissipation @ $T_L \leq 50^\circ\text{C}$ ,<br>Lead Length = 3/8" | $P_D$          |             |                      |
| *JEDEC Registration                                                        |                | 400         | mW                   |
| *Derate above $T_L = 50^\circ\text{C}$                                     |                | 3.2         | mW/ $^\circ\text{C}$ |
| Motorola Device Ratings                                                    |                | 500         | mW                   |
| Derate above $T_L = 50^\circ\text{C}$                                      |                | 3.33        | mW/ $^\circ\text{C}$ |
| Operating and Storage Junction<br>Temperature Range                        | $T_J, T_{stg}$ |             | $^\circ\text{C}$     |
| *JEDEC Registration                                                        |                | -65 to +175 |                      |
| Motorola Device Ratings                                                    |                | -65 to +200 |                      |

\*Indicates JEDEC Registered Data.

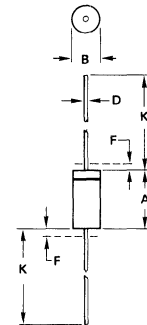
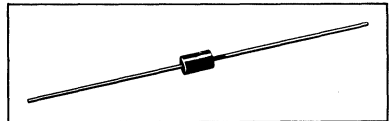
#### MECHANICAL CHARACTERISTICS

**MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES:**  $230^\circ\text{C}$ , 1/16"  
from case for 10 seconds

**FINISH:** All external surfaces are corrosion resistant with readily solderable leads.

**POLARITY:** Cathode indicated by color band. When operated in zener mode, cathode will be positive with respect to anode.

**MOUNTING POSITION:** Any



#### NOTES:

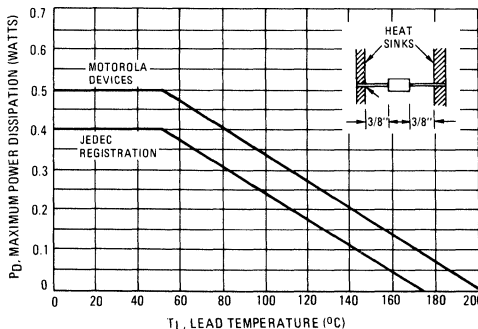
1. PACKAGE CONTOUR OPTIONAL WITHIN A AND B. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT NOT SUBJECT TO THE MINIMUM LIMIT OF B.
2. LEAD DIAMETER NOT CONTROLLED IN ZONE F TO ALLOW FOR FLASH, LEAD FINISH BUILDUP AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.
3. POLARITY DENOTED BY CATHODE BAND.
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

| DIM | MILLIMETERS |       | INCHES |       |
|-----|-------------|-------|--------|-------|
|     | MIN         | MAX   | MIN    | MAX   |
| A   | 3.05        | 5.08  | 0.120  | 0.200 |
| B   | 1.52        | 2.29  | 0.060  | 0.090 |
| D   | 0.46        | 0.56  | 0.018  | 0.022 |
| F   | —           | 1.27  | —      | 0.050 |
| K   | 25.40       | 38.10 | 1.000  | 1.500 |

All JEDEC dimensions and notes apply.

**CASE 299-02**  
**DO-204AH**  
**(DO-35)**

#### STEADY STATE POWER DERATING



# 1N746 thru 1N759, 1N957A thru 1N986A, 1N4370 thru 1N4372

ELECTRICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ ,  $V_F = 1.5\text{ V}$  max at 200 mA for all types)

| Type Number (Note 1) | Nominal Zener Voltage $V_Z @ I_{ZT}$ (Note 2)<br>Volts | Test Current $I_{ZT}$ mA | Maximum Zener Impedance $Z_{ZT} @ I_{ZT}$ (Note 3)<br>Ohms | *Maximum DC Zener Current $I_{ZM}$ (Note 4)<br>mA |     | Maximum Reverse Leakage Current                                       |                                                                        |
|----------------------|--------------------------------------------------------|--------------------------|------------------------------------------------------------|---------------------------------------------------|-----|-----------------------------------------------------------------------|------------------------------------------------------------------------|
|                      |                                                        |                          |                                                            |                                                   |     | $T_A = 25^\circ\text{C}$<br>$I_R @ V_R = 1\text{ V}$<br>$\mu\text{A}$ | $T_A = 150^\circ\text{C}$<br>$I_R @ V_R = 1\text{ V}$<br>$\mu\text{A}$ |
| 1N4370               | 2.4                                                    | 20                       | 30                                                         | 150                                               | 190 | 100                                                                   | 200                                                                    |
| 1N4371               | 2.7                                                    | 20                       | 30                                                         | 135                                               | 165 | 75                                                                    | 150                                                                    |
| 1N4372               | 3.0                                                    | 20                       | 29                                                         | 120                                               | 150 | 50                                                                    | 100                                                                    |
| 1N746                | 3.3                                                    | 20                       | 28                                                         | 110                                               | 135 | 10                                                                    | 30                                                                     |
| 1N747                | 3.6                                                    | 20                       | 24                                                         | 100                                               | 125 | 10                                                                    | 30                                                                     |
| 1N748                | 3.9                                                    | 20                       | 23                                                         | 95                                                | 115 | 10                                                                    | 30                                                                     |
| 1N749                | 4.3                                                    | 20                       | 22                                                         | 85                                                | 105 | 2                                                                     | 30                                                                     |
| 1N750                | 4.7                                                    | 20                       | 19                                                         | 75                                                | 95  | 2                                                                     | 30                                                                     |
| 1N751                | 5.1                                                    | 20                       | 17                                                         | 70                                                | 85  | 1                                                                     | 20                                                                     |
| 1N752                | 5.6                                                    | 20                       | 11                                                         | 65                                                | 80  | 1                                                                     | 20                                                                     |
| 1N753                | 6.2                                                    | 20                       | 7                                                          | 60                                                | 70  | 0.1                                                                   | 20                                                                     |
| 1N754                | 6.8                                                    | 20                       | 5                                                          | 55                                                | 65  | 0.1                                                                   | 20                                                                     |
| 1N755                | 7.5                                                    | 20                       | 6                                                          | 50                                                | 60  | 0.1                                                                   | 20                                                                     |
| 1N756                | 8.2                                                    | 20                       | 8                                                          | 45                                                | 55  | 0.1                                                                   | 20                                                                     |
| 1N757                | 9.1                                                    | 20                       | 10                                                         | 40                                                | 50  | 0.1                                                                   | 20                                                                     |
| 1N758                | 10                                                     | 20                       | 17                                                         | 35                                                | 45  | 0.1                                                                   | 20                                                                     |
| 1N759                | 12                                                     | 20                       | 30                                                         | 30                                                | 35  | 0.1                                                                   | 20                                                                     |

| Type Number (Note 1) | Nominal Zener Voltage $V_Z$ (Note 2)<br>Volts | Test Current $I_{ZT}$ mA | Maximum Zener Impedance (Note 3) |                           |             | *Maximum DC Zener Current $I_{ZM}$ (Note 4)<br>mA |     | Maximum Reverse Current        |                    |           |
|----------------------|-----------------------------------------------|--------------------------|----------------------------------|---------------------------|-------------|---------------------------------------------------|-----|--------------------------------|--------------------|-----------|
|                      |                                               |                          | $Z_{ZT} @ I_{ZT}$<br>Ohms        | $Z_{ZK} @ I_{ZK}$<br>Ohms | $I_{ZK}$ mA |                                                   |     | $I_R$ Maximum<br>$\mu\text{A}$ | Test Voltage $V_R$ | $V_R$ 10% |
| 1N957A               | 6.8                                           | 18.5                     | 4.5                              | 700                       | 1.0         | 47                                                | 61  | 150                            | 5.2                | 4.9       |
| 1N958A               | 7.5                                           | 16.5                     | 5.5                              | 700                       | 0.5         | 42                                                | 55  | 75                             | 5.7                | 5.4       |
| 1N959A               | 8.2                                           | 15                       | 6.5                              | 700                       | 0.5         | 38                                                | 50  | 50                             | 6.2                | 5.9       |
| 1N960A               | 9.1                                           | 14                       | 7.5                              | 700                       | 0.5         | 35                                                | 45  | 25                             | 6.9                | 6.6       |
| 1N961A               | 10                                            | 12.5                     | 8.5                              | 700                       | 0.25        | 32                                                | 41  | 10                             | 7.6                | 7.2       |
| 1N962A               | 11                                            | 11.5                     | 9.5                              | 700                       | 0.25        | 28                                                | 37  | 5                              | 8.4                | 8.0       |
| 1N963A               | 12                                            | 10.5                     | 11.5                             | 700                       | 0.25        | 26                                                | 34  | 5                              | 9.1                | 8.6       |
| 1N964A               | 13                                            | 9.5                      | 13                               | 700                       | 0.25        | 24                                                | 32  | 5                              | 9.9                | 9.4       |
| 1N965A               | 15                                            | 8.5                      | 16                               | 700                       | 0.25        | 21                                                | 27  | 5                              | 11.4               | 10.8      |
| 1N966A               | 16                                            | 7.8                      | 17                               | 700                       | 0.25        | 19                                                | 37  | 5                              | 12.2               | 11.5      |
| 1N967A               | 18                                            | 7.0                      | 21                               | 750                       | 0.25        | 17                                                | 23  | 5                              | 13.7               | 13.0      |
| 1N968A               | 20                                            | 6.2                      | 25                               | 750                       | 0.25        | 15                                                | 20  | 5                              | 15.2               | 14.4      |
| 1N969A               | 22                                            | 5.6                      | 29                               | 750                       | 0.25        | 14                                                | 18  | 5                              | 16.7               | 15.8      |
| 1N970A               | 24                                            | 5.2                      | 33                               | 750                       | 0.25        | 13                                                | 17  | 5                              | 18.2               | 17.3      |
| 1N971A               | 27                                            | 4.6                      | 41                               | 750                       | 0.25        | 11                                                | 15  | 5                              | 20.6               | 19.4      |
| 1N972A               | 30                                            | 4.2                      | 49                               | 1000                      | 0.25        | 10                                                | 13  | 5                              | 22.8               | 21.6      |
| 1N973A               | 33                                            | 3.8                      | 58                               | 1000                      | 0.25        | 9.2                                               | 12  | 5                              | 25.1               | 23.8      |
| 1N974A               | 36                                            | 3.4                      | 70                               | 1000                      | 0.25        | 8.5                                               | 11  | 5                              | 27.4               | 25.9      |
| 1N975A               | 39                                            | 3.2                      | 80                               | 1000                      | 0.25        | 7.8                                               | 10  | 5                              | 29.7               | 28.1      |
| 1N976A               | 43                                            | 3.0                      | 93                               | 1500                      | 0.25        | 7.0                                               | 9.6 | 5                              | 32.7               | 31.0      |
| 1N977A               | 47                                            | 2.7                      | 105                              | 1500                      | 0.25        | 6.4                                               | 8.8 | 5                              | 35.8               | 33.8      |
| 1N978A               | 51                                            | 2.5                      | 125                              | 1500                      | 0.25        | 5.9                                               | 8.1 | 5                              | 38.8               | 36.7      |
| 1N979A               | 56                                            | 2.2                      | 150                              | 2000                      | 0.25        | 5.4                                               | 7.4 | 5                              | 42.6               | 40.3      |
| 1N980A               | 62                                            | 2.0                      | 185                              | 2000                      | 0.25        | 4.9                                               | 6.7 | 5                              | 47.1               | 44.6      |
| 1N981A               | 68                                            | 1.8                      | 230                              | 2000                      | 0.25        | 4.5                                               | 6.1 | 5                              | 51.7               | 49.0      |
| 1N982A               | 75                                            | 1.7                      | 270                              | 2000                      | 0.25        | 1.0                                               | 5.5 | 5                              | 56.0               | 54.0      |
| 1N983A               | 82                                            | 1.5                      | 330                              | 3000                      | 0.25        | 3.7                                               | 5.0 | 5                              | 62.2               | 59.0      |
| 1N984A               | 91                                            | 1.4                      | 400                              | 3000                      | 0.25        | 3.3                                               | 4.5 | 5                              | 69.2               | 65.5      |
| 1N985A               | 100                                           | 1.3                      | 500                              | 3000                      | 0.25        | 3.0                                               | 4.5 | 5                              | 76                 | 72        |
| 1N986A               | 110                                           | 1.1                      | 750                              | 4000                      | 0.25        | 2.7                                               | 4.1 | 5                              | 83.6               | 79.2      |

## NOTE 1. TOLERANCE AND VOLTAGE DESIGNATION

### Tolerance Designation

The type numbers shown have tolerance designations as follows:

1N4370 series:  $\pm 10\%$ , suffix A for  $\pm 5\%$  units.

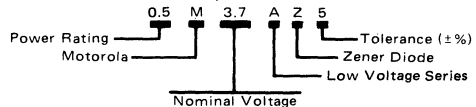
1N746 series:  $\pm 10\%$ , suffix A for  $\pm 5\%$  units.

1N957 series: suffix A for  $\pm 10\%$  units,  
suffix B for  $\pm 5\%$  units.

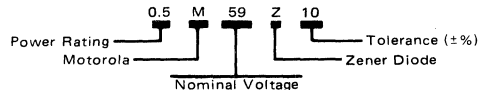
### Voltage Designation

To designate units with zener voltages other than those listed, the Motorola type number should be modified as shown below. Unless otherwise specified, the electrical characteristics other than the nominal voltage ( $V_Z$ ) and test voltage for leakage current will conform to the characteristics of the next higher voltage type shown in the table.

EXAMPLE: 1N746 series, 1N4370 series variations



EXAMPLE: 1N957 series variations



### Matched Sets for Closer Tolerances or Higher Voltages

Series matched sets make zener voltages in excess of 100 volts or tolerances of less than 5% possible as well as providing lower temperature coefficients, lower dynamic impedance and greater power handling ability.

For Matched Sets or other special circuit requirements, contact your Motorola Sales Representative.

# 1N746 thru 1N759, 1N957A thru 1N986A, 1N4370 thru 1N4372

## NOTE 2. ZENER VOLTAGE ( $V_Z$ ) MEASUREMENT

Nominal zener voltage is measured with the device junction in thermal equilibrium at the lead temperature of  $30^\circ\text{C} \pm 1^\circ\text{C}$  and 3/8" lead length.

## NOTE 3. ZENER IMPEDANCE ( $Z_Z$ ) DERIVATION

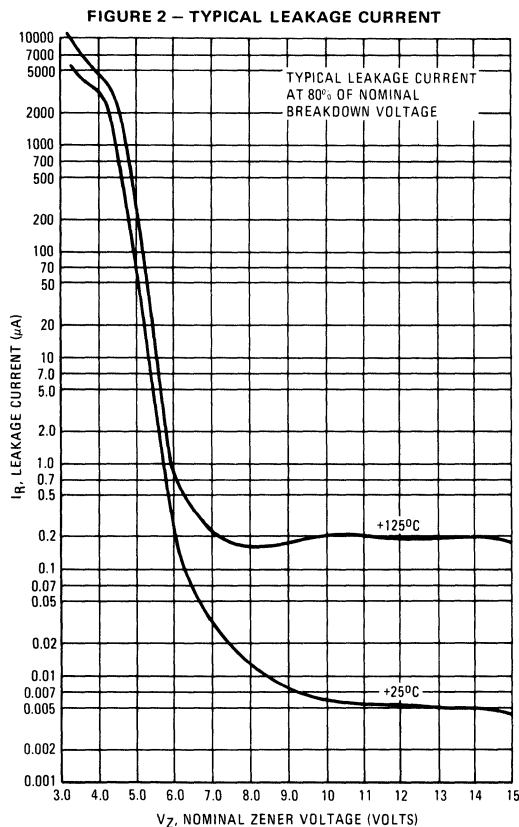
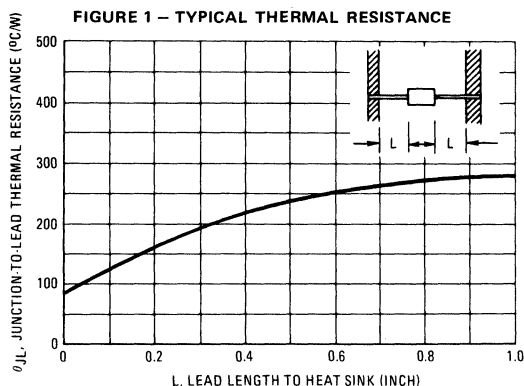
$Z_{ZT}$  and  $Z_{ZK}$  are measured by dividing the ac voltage drop across the device by the ac current applied. The specified limits are for  $I_Z(\text{ac}) = 0.1 I_Z(\text{dc})$  with the ac frequency = 60 Hz.

## NOTE 4. MAXIMUM ZENER CURRENT RATINGS ( $I_{ZM}$ )

Maximum zener current ratings are based on the maximum voltage of a 10% 1N746 type unit or a 20% 1N957 type unit. For closer tolerance units (10% or 5%) or units where the actual zener voltage ( $V_Z$ ) is known at the operating point, the maximum zener current may be increased and is limited by the derating curve.

Under high power-pulse operation, the zener voltage will vary with time and may also be affected significantly by the zener resistance. For best regulation, keep current excursions as low as possible.

Surge limitations are given in Figure 6. They are lower than would be expected by considering only junction temperature, as current crowding effects cause temperatures to be extremely high in small spots, resulting in device degradation should the limits of Figure 6 be exceeded.



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## APPLICATION NOTE

Since the actual voltage available from a given zener diode is temperature dependent, it is necessary to determine junction temperature under any set of operating conditions in order to calculate its value. The following procedure is recommended:

Lead Temperature,  $T_L$ , should be determined from:

$$T_L = \theta_{LA} P_D + T_A$$

$\theta_{LA}$  is the lead-to-ambient thermal resistance ( $^\circ\text{C}/\text{W}$ ) and  $P_D$  is the power dissipation. The value for  $\theta_{LA}$  will vary and depends on the device mounting method.  $\theta_{LA}$  is generally 30–40 $^\circ\text{C}/\text{W}$  for the various clips and tie points in common use and for printed circuit board wiring.

The temperature of the lead can also be measured using a thermocouple placed on the lead as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of  $T_L$ , the junction temperature may be determined by:

$$T_J = T_L + \Delta T_{JL}$$

$\Delta T_{JL}$  is the increase in junction temperature above the lead temperature and may be found from Figure 1 for dc power.

$$\Delta T_{JL} = \theta_{JLPD}$$

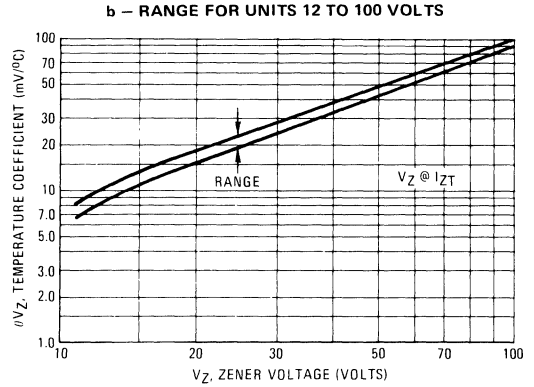
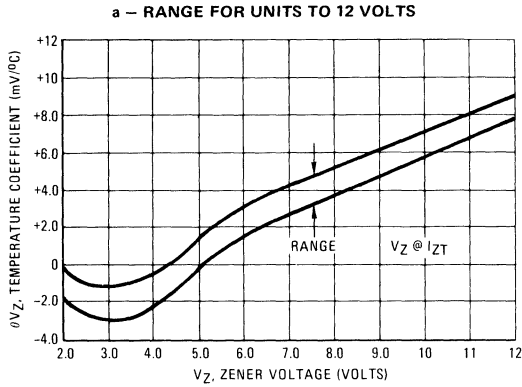
For worst-case design, using expected limits of  $I_Z$ , limits of  $P_D$  and the extremes of  $T_J(\Delta T_J)$  may be estimated. Changes in voltage,  $V_Z$ , can then be found from:

$$\Delta V = \theta_{VZ} \Delta T_J$$

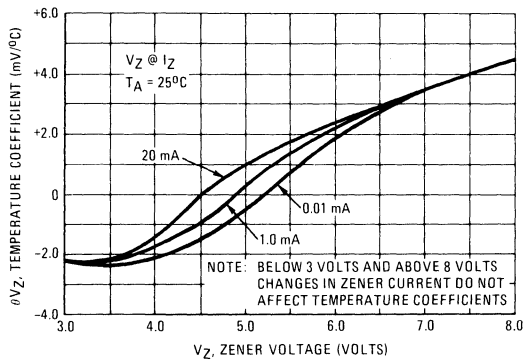
$\theta_{VZ}$ , the zener voltage temperature coefficient, is found from Figures 3 and 4.

# 1N746 thru 1N759, 1N957A thru 1N986A, 1N4370 thru 1N4372

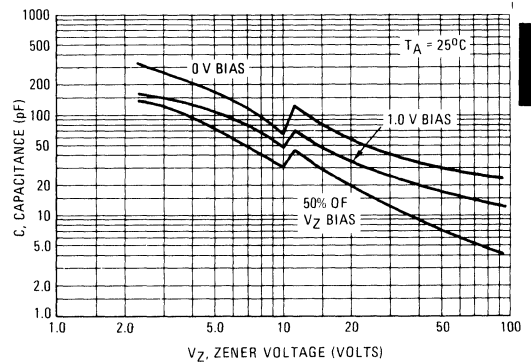
**FIGURE 3 – TEMPERATURE COEFFICIENTS**  
(-55°C to +150°C temperature range; 90% of the units are in the ranges indicated.)



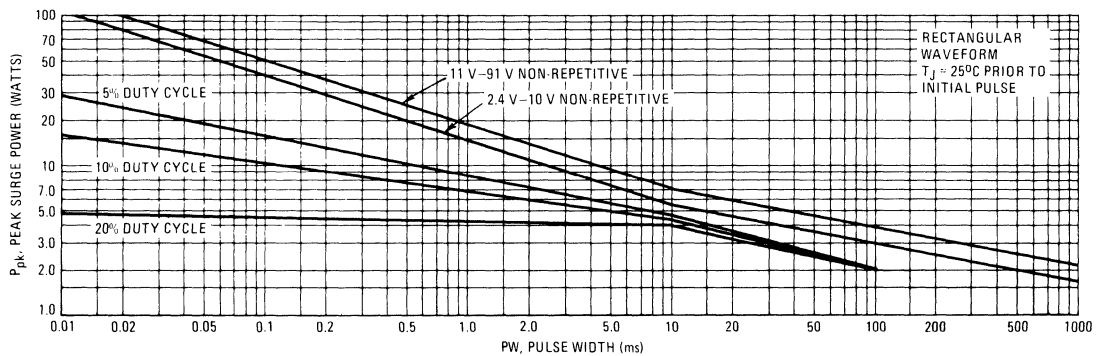
**FIGURE 4 – EFFECT OF ZENER CURRENT**



**FIGURE 5 – TYPICAL CAPACITANCE**



**FIGURE 6 – MAXIMUM SURGE POWER**



This graph represents 90 percentil data points.  
For worst-case design characteristics, multiply surge power by 2/3.

FIGURE 7 – EFFECT OF ZENER CURRENT ON ZENER IMPEDANCE

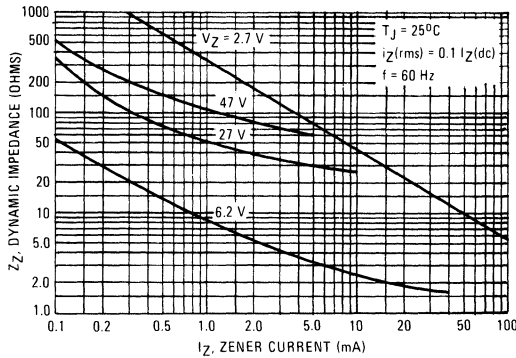
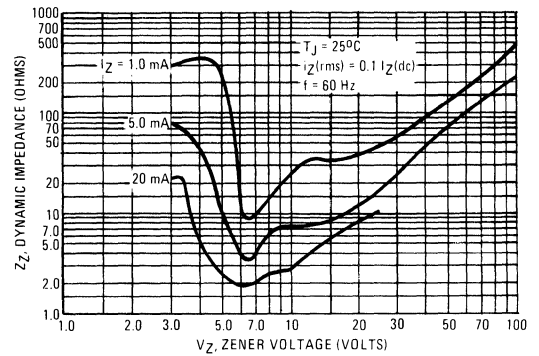


FIGURE 8 – EFFECT OF ZENER VOLTAGE ON ZENER IMPEDANCE



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FIGURE 9 – TYPICAL NOISE DENSITY

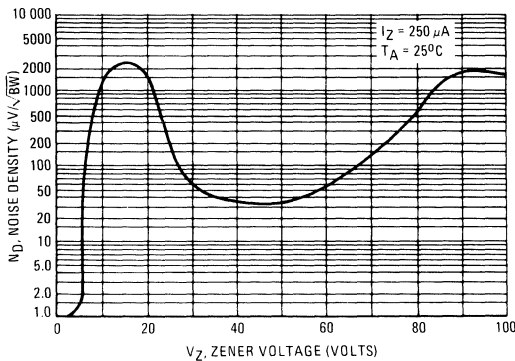


FIGURE 10 – NOISE DENSITY MEASUREMENT METHOD

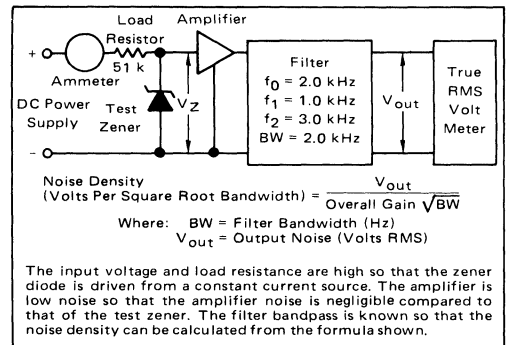
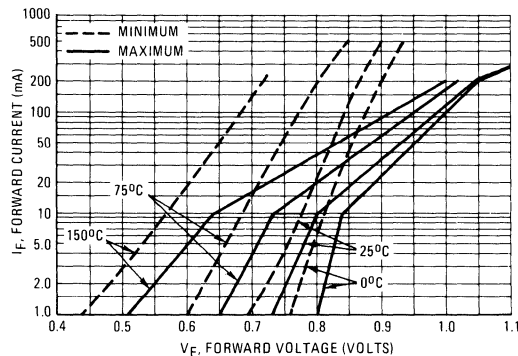


FIGURE 11 – TYPICAL FORWARD CHARACTERISTICS



1N746 thru 1N759, 1N957A thru 1N986A, 1N4370 thru 1N4372

