

**500 mW DO-35 Glass  
Zener Voltage Regulator Diodes  
GENERAL DATA APPLICABLE TO ALL SERIES IN  
THIS GROUP  
500 Milliwatt  
Hermetically Sealed  
Glass Silicon Zener Diodes**

**1N4678  
SERIES  
500 mW  
DO-35 GLASS**

**GLASS ZENER DIODES  
500 MILLIWATTS  
1.8-200 VOLTS**



**Specification Features:**

- Complete Voltage Range — 1.8 to 200 Volts
- DO-204AH Package — Smaller than Conventional DO-204AA Package
- Double Slug Type Construction
- Metallurgically Bonded Construction

**Mechanical Characteristics:**

**CASE:** Double slug type, hermetically sealed glass

**MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES:** 230°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

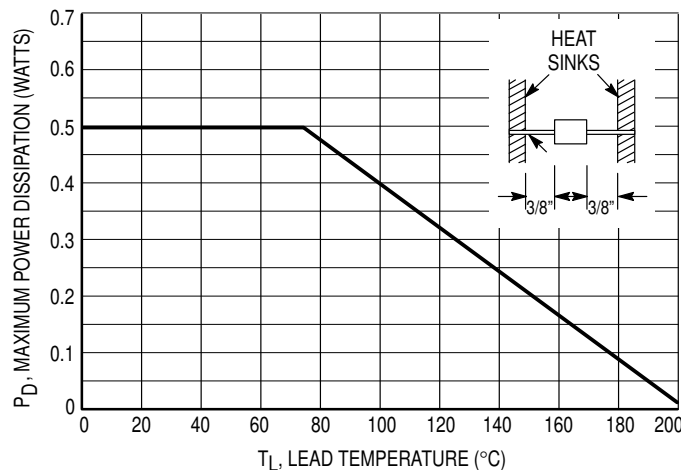
**WAFER FAB LOCATION:** Phoenix, Arizona

**ASSEMBLY/TEST LOCATION:** Seoul, Korea

**MAXIMUM RATINGS (Motorola Devices)\***

| Rating  | Symbol         | Value        | Unit        |
|---|----------------|--------------|-------------|
| DC Power Dissipation and $T_L \leq 75^\circ\text{C}$<br>Lead Length = 3/8"<br>Derate above $T_L = 75^\circ\text{C}$ | $P_D$          | 500<br>4     | mW<br>mW/°C |
| Operating and Storage Temperature Range   | $T_J, T_{stg}$ | - 65 to +200 | °C          |

\* Some part number series have lower JEDEC registered ratings.



**Figure 1. Steady State Power Derating**

# GENERAL DATA — 500 mW DO-35 GLASS

Low level oxide passivated zener diodes for applications requiring extremely low operating currents, low leakage, and sharp breakdown voltage.

- Zener Voltage Specified @  $I_{ZT} = 50 \mu\text{A}$
- Maximum Delta  $V_Z$  Given from 10 to 100  $\mu\text{A}$

## ELECTRICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ , $V_F = 1.5 \text{ V}$ Max at $I_F = 100 \text{ mA}$ for all types)

| Type Number<br>(Note 1) | Zener Voltage<br>$V_Z$ @ $I_{ZT} = 50 \mu\text{A}$<br>Volts |              |              | Maximum<br>Reverse Current<br>$I_R \mu\text{A}$<br><br>(Note 3) | Test<br>Voltage<br>$V_R$ Volts | Maximum<br>Zener Current<br>$I_{ZM} \text{ mA}$<br>(Note 2) | Maximum<br>Voltage Change<br>$\Delta V_Z$ Volts<br>(Note 4) |
|-------------------------|---|--------------|--------------|---|--------------------------------|---|---|
|                         | Nom (Note 1)  | Min          | Max          |   |                                |   |   |
| 1N4678                  | 1.8   | 1.71         | 1.89         | 7.5   | 1                              | 120   | 0.7   |
| 1N4679                  | 2   | 1.9          | 2.1          | 5   | 1                              | 110   | 0.7   |
| 1N4680                  | 2.2   | 2.09         | 2.31         | 4   | 1                              | 100   | 0.75  |
| 1N4681                  | 2.4   | 2.28         | 2.52         | 2   | 1                              | 95  | 0.8   |
| 1N4682                  | 2.7   | 2.565        | 2.835        | 1   | 1                              | 90  | 0.85  |
| 1N4683                  | 3   | 2.85         | 3.15         | 0.8   | 1                              | 85  | 0.9   |
| 1N4684                  | 3.3   | 3.135        | 3.465        | 7.5   | 1.5                            | 80  | 0.95  |
| 1N4685                  | 3.6   | 3.42         | 3.78         | 7.5   | 2                              | 75  | 0.95  |
| 1N4686                  | 3.9   | 3.705        | 4.095        | 5   | 2                              | 70  | 0.97  |
| 1N4687                  | 4.3   | 4.085        | 4.515        | 4   | 2                              | 65  | 0.99  |
| <b>1N4688</b>           | <b>4.7</b>  | <b>4.465</b> | <b>4.935</b> | <b>10</b>   | <b>3</b>                       | <b>60</b>   | <b>0.99</b>   |
| 1N4689                  | 5.1   | 4.845        | 5.355        | 10  | 3                              | 55  | 0.97  |
| 1N4690                  | 5.6   | 5.32         | 5.88         | 10  | 4                              | 50  | 0.96  |
| 1N4691                  | 6.2   | 5.89         | 6.51         | 10  | 5                              | 45  | 0.95  |
| 1N4692                  | 6.8   | 6.46         | 7.14         | 10  | 5.1                            | 35  | 0.9   |
| 1N4693                  | 7.5   | 7.125        | 7.875        | 10  | 5.7                            | 31.8  | 0.75  |
| 1N4694                  | 8.2   | 7.79         | 8.61         | 1   | 6.2                            | 29  | 0.5   |
| 1N4695                  | 8.7   | 8.265        | 9.135        | 1   | 6.6                            | 27.4  | 0.1   |
| 1N4696                  | 9.1   | 8.645        | 9.555        | 1   | 6.9                            | 26.2  | 0.08  |
| 1N4697                  | 10  | 9.5          | 10.5         | 1   | 7.6                            | 24.8  | 0.1   |
| 1N4698                  | 11  | 10.45        | 11.55        | 0.05  | 8.4                            | 21.6  | 0.11  |
| 1N4699                  | 12  | 11.4         | 12.6         | 0.05  | 9.1                            | 20.4  | 0.12  |
| 1N4700                  | 13  | 12.35        | 13.65        | 0.05  | 9.8                            | 19  | 0.13  |
| 1N4701                  | 14  | 13.3         | 14.7         | 0.05  | 10.6                           | 17.5  | 0.14  |
| 1N4702                  | 15  | 14.25        | 15.75        | 0.05  | 11.4                           | 16.3  | 0.15  |
| 1N4705                  | 18  | 17.1         | 18.9         | 0.05  | 13.6                           | 13.2  | 0.18  |
| 1N4713                  | 30  | 28.5         | 31.5         | 0.01  | 22.8                           | 7.9   | 0.3   |

### NOTE 1. TOLERANCE AND VOLTAGE DESIGNATION ( $V_Z$ )

The type numbers shown have a standard tolerance of  $\pm 5\%$  on the nominal Zener voltage, C for  $\pm 2\%$ , D for  $\pm 1\%$ .

### NOTE 2. MAXIMUM ZENER CURRENT RATINGS ( $I_{ZM}$ )

Maximum Zener current ratings are based on maximum Zener voltage of the individual units and JEDEC 250 mW rating.

### NOTE 3. REVERSE LEAKAGE CURRENT ( $I_R$ )

Reverse leakage currents are guaranteed and measured at  $V_R$  as shown on the table.

### NOTE 4. MAXIMUM VOLTAGE CHANGE ( $\Delta V_Z$ )

Voltage change is equal to the difference between  $V_Z$  at 100  $\mu\text{A}$  and  $V_Z$  at 10  $\mu\text{A}$ .

### NOTE 5. ZENER VOLTAGE ( $V_Z$ ) MEASUREMENT

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

# GENERAL DATA — 500 mW DO-35 GLASS

## APPLICATION NOTE — ZENER VOLTAGE

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 to 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 2 for dc power:

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

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:

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

$\theta_{VZ}$ , the zener voltage temperature coefficient, is found from Figures 4 and 5.

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 7. 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 7 be exceeded.

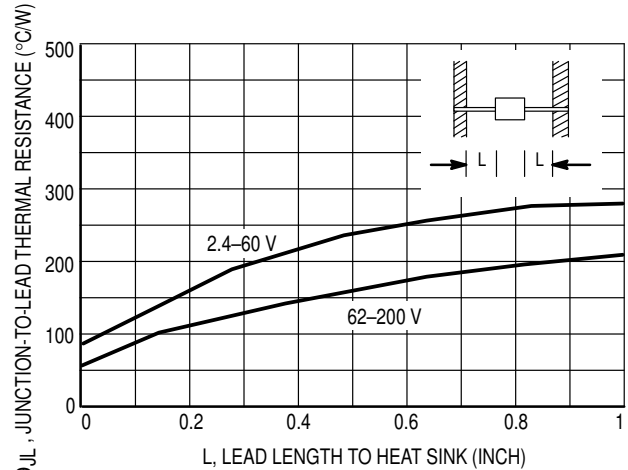


Figure 2. Typical Thermal Resistance

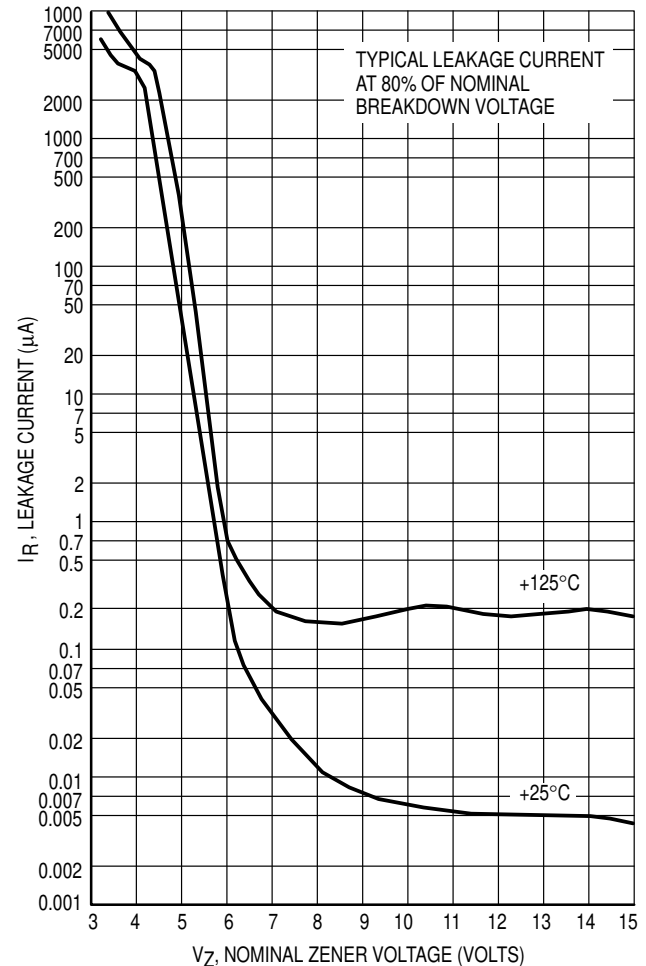


Figure 3. Typical Leakage Current

# GENERAL DATA — 500 mW DO-35 GLASS

## TEMPERATURE COEFFICIENTS

(-55°C to +150°C temperature range; 90% of the units are in the ranges indicated.)

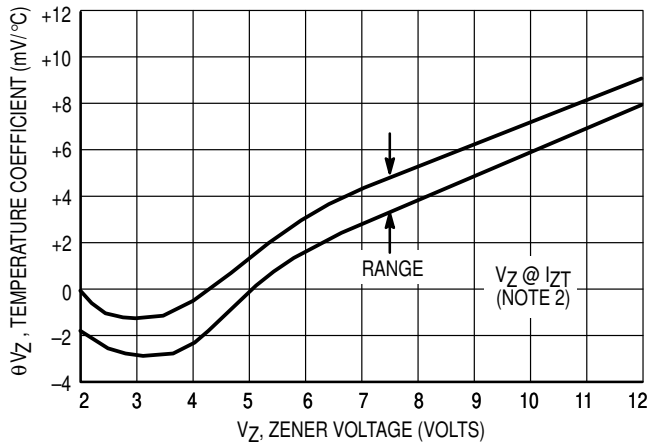


Figure 4a. Range for Units to 12 Volts

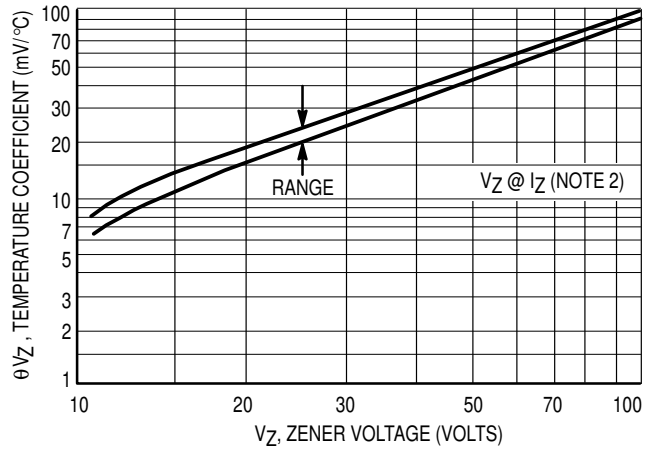


Figure 4b. Range for Units 12 to 100 Volts

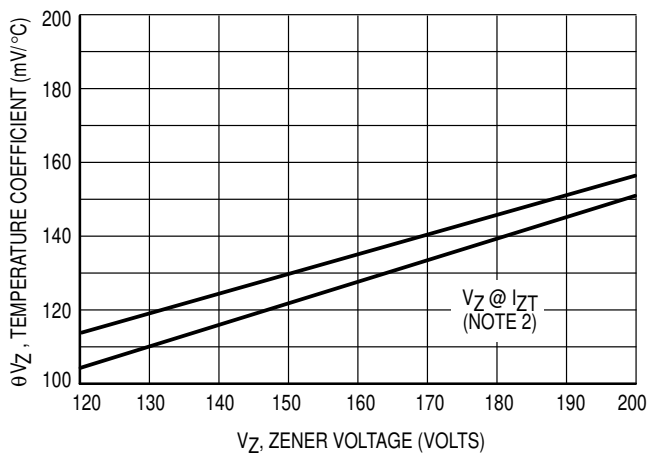


Figure 4c. Range for Units 120 to 200 Volts

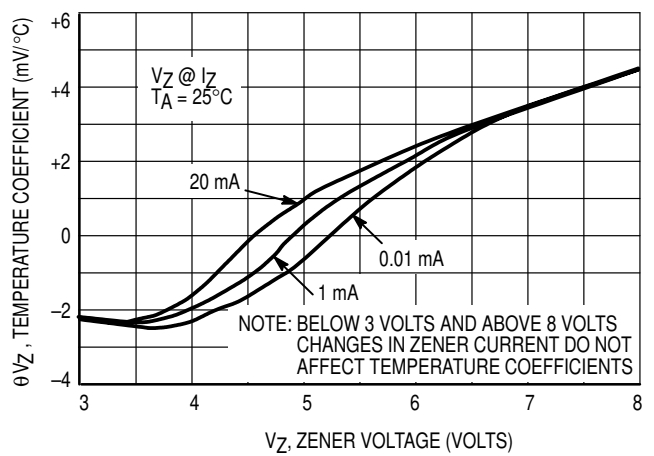


Figure 5. Effect of Zener Current

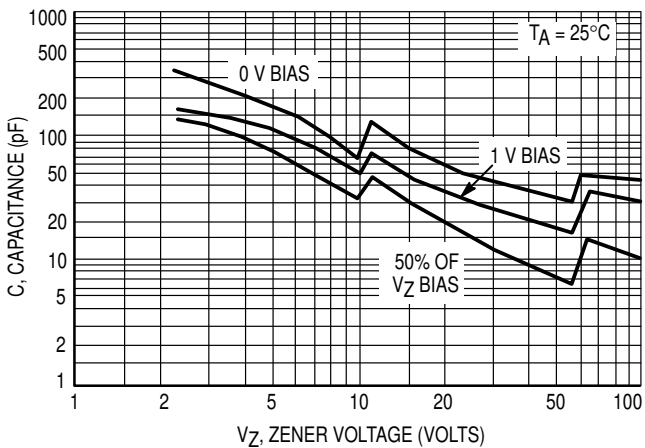


Figure 6a. Typical Capacitance 2.4–100 Volts

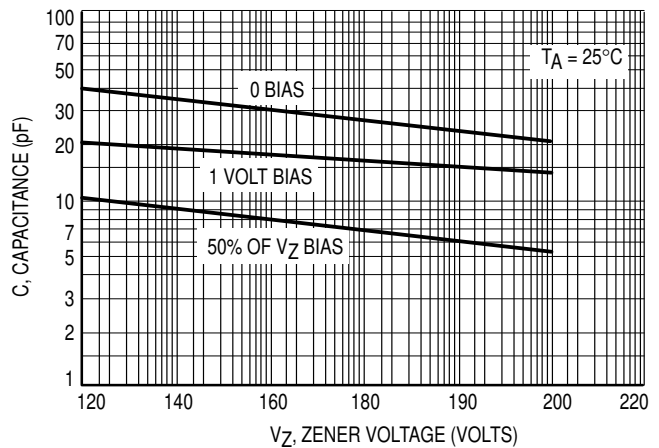
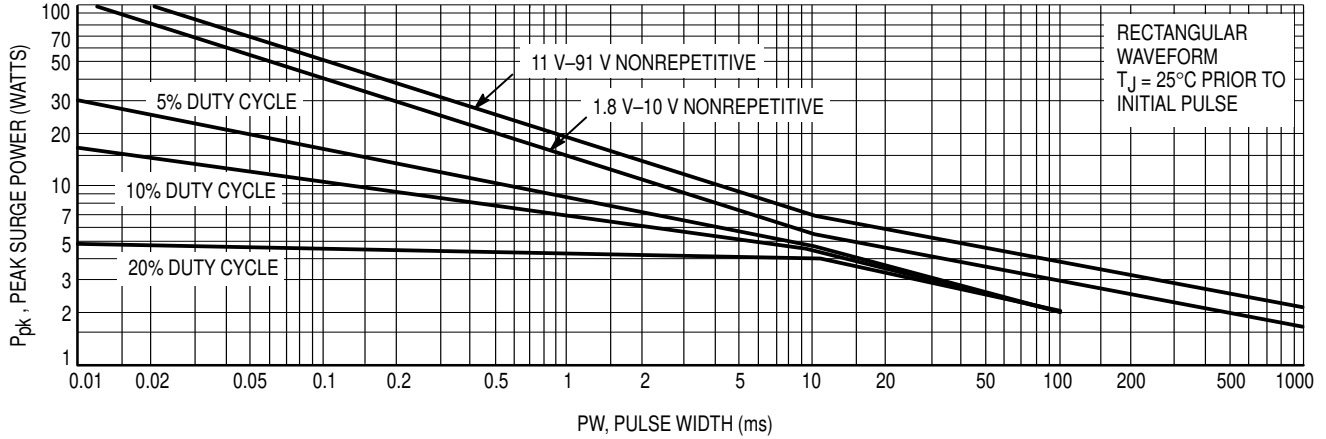
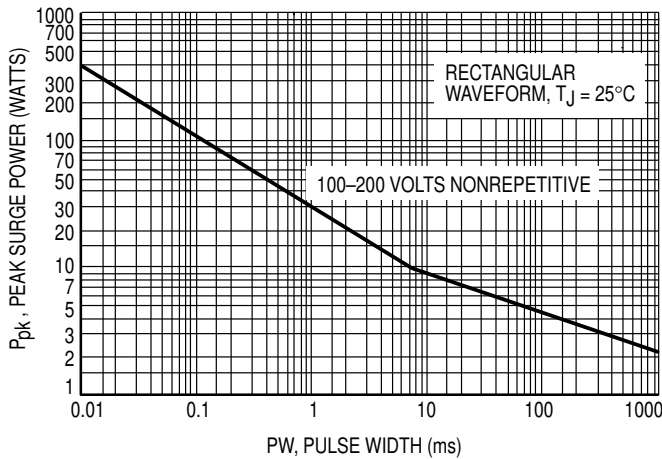


Figure 6b. Typical Capacitance 120–200 Volts

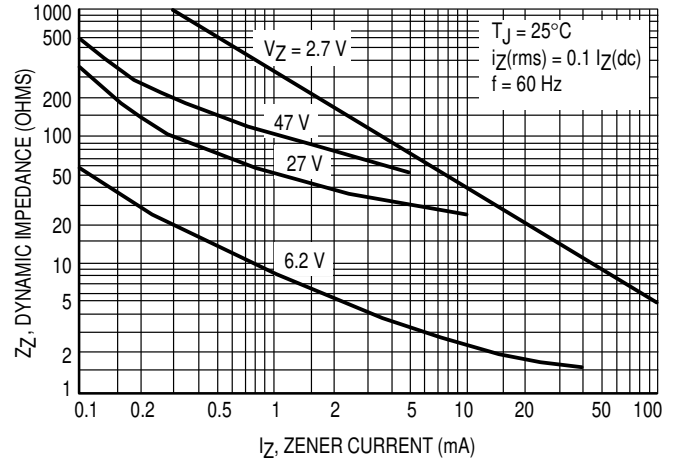
# GENERAL DATA — 500 mW DO-35 GLASS



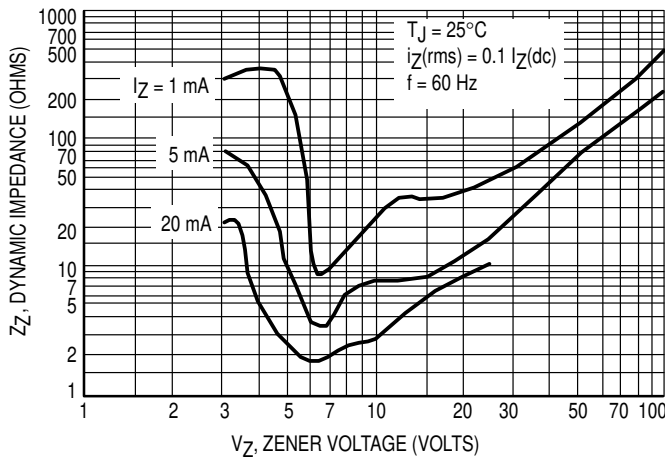
**Figure 7a. Maximum Surge Power 1.8-91 Volts**



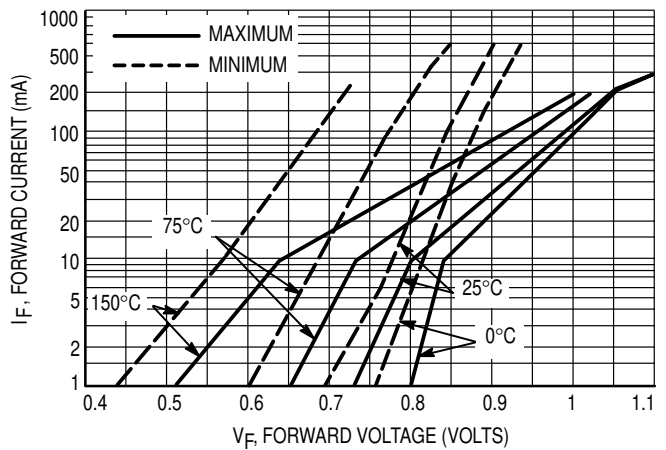
**Figure 7b. Maximum Surge Power DO-204AH 100-200 Volts**



**Figure 8. Effect of Zener Current on Zener Impedance**



**Figure 9. Effect of Zener Voltage on Zener Impedance**



**Figure 10. Typical Forward Characteristics**

# GENERAL DATA — 500 mW DO-35 GLASS

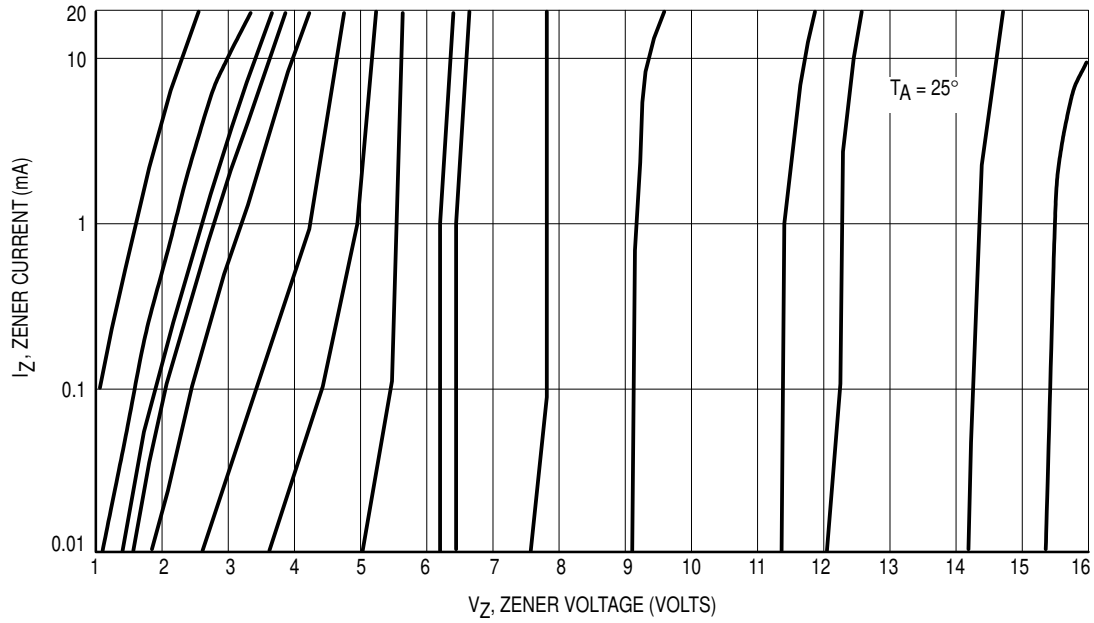


Figure 11. Zener Voltage versus Zener Current —  $V_Z = 1$  thru 16 Volts

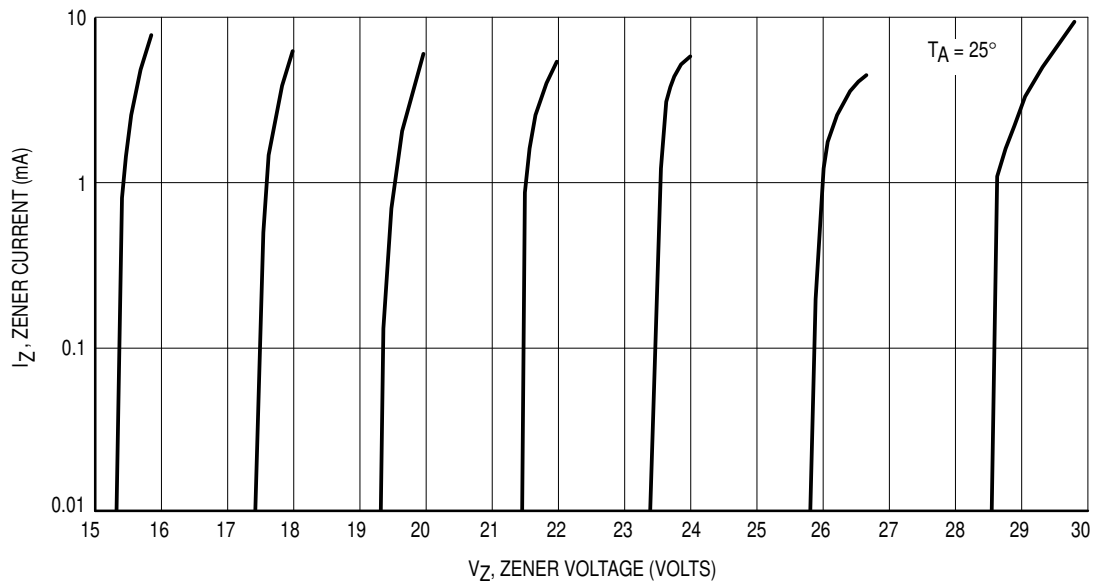


Figure 12. Zener Voltage versus Zener Current —  $V_Z = 15$  thru 30 Volts

# GENERAL DATA — 500 mW DO-35 GLASS

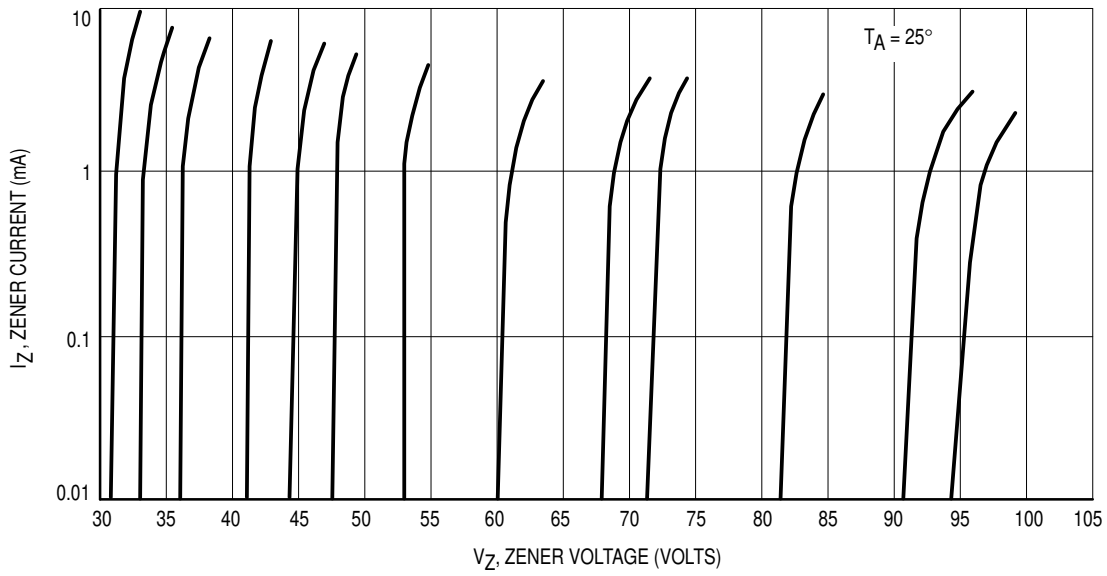


Figure 13. Zener Voltage versus Zener Current —  $V_Z = 30$  thru 105 Volts

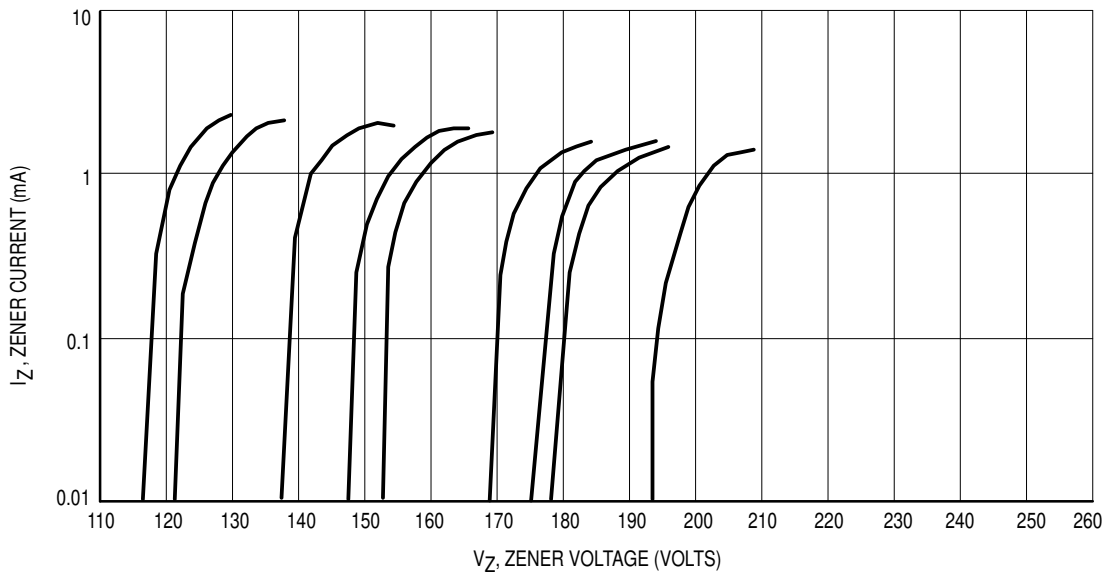
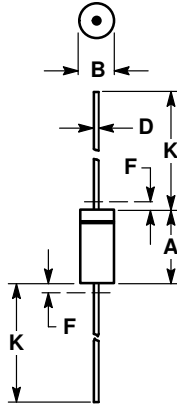


Figure 14. Zener Voltage versus Zener Current —  $V_Z = 110$  thru 220 Volts

# Zener Voltage Regulator Diodes — Axial Leaded

## 500 mW DO-35 Glass



- 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 Y14.5M, 1982.

| 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  
GLASS

(Refer to Section 10 for Surface Mount, Thermal Data and Footprint Information.)

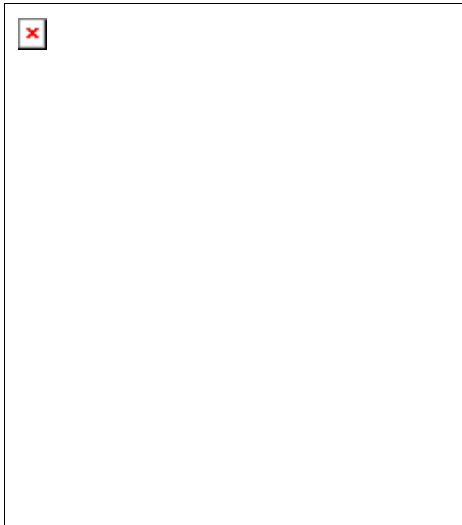
### MULTIPLE PACKAGE QUANTITY (MPQ) REQUIREMENTS

| Package Option | Type No. Suffix | MPQ (Units) |
|----------------|-----------------|-------------|
| Tape and Reel  | RL, RL2(1)      | 5K          |
| Tape and Ammo  | TA, TA2(1)      | 5K          |

- NOTES: 1. The "2" suffix refers to 26 mm tape spacing.  
2. Radial Tape and Reel may be available. Please contact your Motorola representative.

Refer to Section 10 for more information on Packaging Specifications.





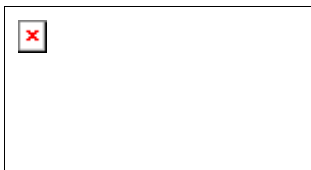
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**Associated Documents**

| Item                       | Short Desc   |
|----------------------------|--|
| <a href="#">Data Sheet</a> | 500 Milliwatt Hermetically Sealed Glass Silicon Zener Diodes |

**Device 1N4685**  
**Zener 3.6V .25W 5%**

**Mechanical Characteristics:**

CASE: Double slug type, hermetically sealed glass  
 MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 230°C, 1/16 1  
 FINISH: All external surfaces are corrosion resistant with readily solderable leads  
 POLARITY: Cathode indicated by color band. When operated in zener mode, cath  
 respect to anode  
 MOUNTING POSITION: Any  
 WAFER FAB LOCATION: Phoenix, Arizona  
 ASSEMBLY/TEST LOCATION: Seoul, Korea

**Features:**

- Complete Voltage Range - 1.8 to 200 Volts
- DO-204AH Package - Smaller than Conventional DO-204AA Package
- Double Slug Type Construction
- Metallurgically Bonded Construction

**Orderable Parts**

| Action | Orderable Part | Short Desc. | Package Desc. | Pin Count | Case Outline | <u>Status</u> |
|--------|----------------|-------------|---------------|-----------|--------------|---------------|
|--------|----------------|-------------|---------------|-----------|--------------|---------------|

|     |           |                            |        |   |                        |                |
|-----|-----------|----------------------------|--------|---|------------------------|----------------|
| N/A | 1N4685    | Zener<br>3.6V .25W<br>5%   | DO-204 | 2 | <a href="#">299-02</a> | Last Shipments |
| N/A | 1N4685RA1 | Radial<br>Tape and<br>Ammo | DO-204 | 2 | <a href="#">299-02</a> | Last Shipments |
| N/A | 1N4685RL  | Tape and<br>Reel           | DO-204 | 2 | <a href="#">299-02</a> | Active         |

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