

MOTOROLA SEMICONDUCTOR TECHNICAL DATA

Designer's Data Sheet
5-Watt Surmetic 40 Silicon Zener Diodes

... a complete series of 5 Watt Zener Diodes with tight limits and better operating characteristics that reflect the superior capabilities of silicon-oxide-passivated junctions. All this in an axial-lead, transfer-molded plastic package offering protection in all common environmental conditions.

- Up to 180 Watt Surge Rating @ 8.3 ms
- Maximum Limits Guaranteed on Seven Electrical Parameters
- Offered in 10%, 5%, 2% and 1% Vz Tolerance

Mechanical Characteristics:

CASE: Void-free, transfer-molded, thermosetting plastic
 FINISH: All external surfaces are corrosion resistant and leads are readily solderable
 POLARITY: Cathode indicated by color band. When operated in zener mode, cathode will be positive with respect to anode
 MOUNTING POSITION: Any
 WEIGHT: 0.7 gram (approx)

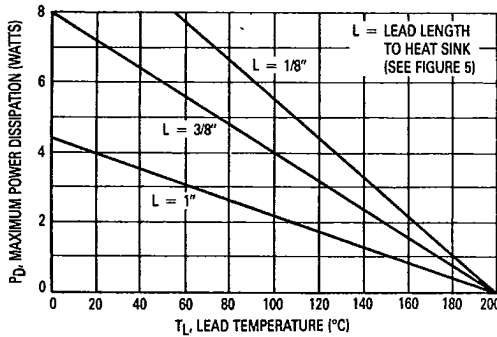


Figure 1. Power-Temperature Derating Curve

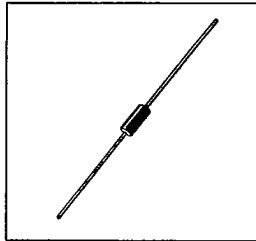
MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|--|----------------|-------------|-------|
| DC Power Dissipation @ $T_L = 75^\circ\text{C}$ Lead Length = 3/8" Derate above 75°C | P_D | 5 | Watts |
| Operating and Storage Junction Temperature Range | T_J, T_{stg} | -65 to +200 | °C |

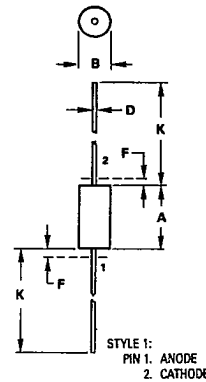
Designer's Data for "Worst Case" Conditions — The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

**1N5333A, B, C, D
 thru
 1N5388A, B, C, D**

**5-WATT
 ZENER REGULATOR
 DIODES
 3.3-200 VOLTS**



OUTLINE DIMENSIONS



NOTE:
 1. LEAD DIAMETER & FINISH NOT CONTROLLED WITHIN DIM "F"

| DIM | MILLIMETERS | | INCHES | |
|-----|-------------|-------|--------|-------|
| | MIN | MAX | MIN | MAX |
| A | 8.38 | 8.89 | 0.330 | 0.350 |
| B | 3.30 | 3.68 | 0.130 | 0.145 |
| D | 0.94 | 1.09 | 0.037 | 0.043 |
| F | — | 1.27 | — | 0.050 |
| K | 25.40 | 31.75 | 1.000 | 1.250 |

**CASE 17-02
 GLASS**

1N5333A, B, C, D thru 1N5388A, B, C, D

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted, V_F = 1.2 Max @ I_F = 1 A for all types)

| JEDEC Type No. (Note 1) | Nominal Zener Voltage V _Z @ I _{ZT} Volts (Note 2) | Test Current I _{ZT} mA | Max Zener Impedance A & B Suffix Only | | Max Reverse Leakage Current | | | Applies to all Suffix | A & B Suffix Only | Maximum Regulator Current I _{ZM} mA (Note 5) |
|-------------------------|---|---------------------------------|---|--|---------------------------------------|----------------------|----------|-----------------------|-------------------|---|
| | | | Z _{ZT} @ I _{ZT} Ohms (Note 2) | Z _{ZK} @ I _{ZK} = 1 mA Ohms (Note 2) | I _R @ V _R Volts | V _R Volts | | | | |
| | | | | | | Non & A Suffix | B-Suffix | | | |
| 1N5333A | 3.3 | 380 | 3 | 400 | 300 | 1 | 1 | 20 | 0.85 | 1440 |
| 1N5334A | 3.6 | 350 | 2.5 | 500 | 150 | 1 | 1 | 18.7 | 0.8 | 1320 |
| 1N5335A | 3.9 | 320 | 2 | 500 | 50 | 1 | 1 | 17.6 | 0.54 | 1220 |
| 1N5336A | 4.3 | 290 | 2 | 500 | 10 | 1 | 1 | 16.4 | 0.49 | 1100 |
| 1N5337A | 4.7 | 260 | 2 | 450 | 5 | 1 | 1 | 15.3 | 0.44 | 1010 |
| 1N5338A | 5.1 | 240 | 1.5 | 400 | 1 | 1 | 1 | 14.4 | 0.39 | 930 |
| 1N5339A | 5.6 | 220 | 1 | 400 | 1 | 2 | 2 | 13.4 | 0.25 | 865 |
| 1N5340A | 6 | 200 | 1 | 300 | 1 | 3 | 3 | 12.7 | 0.19 | 790 |
| 1N5341A | 6.2 | 200 | 1 | 200 | 1 | 4 | 3 | 12.4 | 0.1 | 765 |
| 1N5342A | 6.8 | 175 | 1 | 200 | 10 | 4.9 | 5.2 | 11.5 | 0.15 | 700 |
| 1N5343A | 7.5 | 175 | 1.5 | 200 | 10 | 5.4 | 5.7 | 10.7 | 0.15 | 630 |
| 1N5344A | 8.2 | 150 | 1.5 | 200 | 10 | 5.9 | 6.2 | 10 | 0.2 | 580 |
| 1N5345A | 8.7 | 150 | 2 | 200 | 10 | 6.3 | 6.6 | 9.5 | 0.2 | 545 |
| 1N5346A | 9.1 | 150 | 2 | 150 | 7.5 | 6.6 | 6.9 | 9.2 | 0.22 | 520 |
| 1N5347A | 10 | 125 | 2 | 125 | 5 | 7.2 | 7.6 | 8.6 | 0.22 | 475 |
| 1N5348A | 11 | 125 | 2.5 | 125 | 5 | 8 | 8.4 | 8 | 0.25 | 430 |
| 1N5349A | 12 | 100 | 2.5 | 125 | 2 | 8.6 | 9.1 | 7.5 | 0.25 | 395 |
| 1N5350A | 13 | 100 | 2.5 | 100 | 1 | 9.4 | 9.9 | 7 | 0.25 | 365 |
| 1N5351A | 14 | 100 | 2.5 | 75 | 1 | 10.1 | 10.6 | 6.7 | 0.25 | 340 |
| 1N5352A | 15 | 75 | 2.5 | 75 | 1 | 10.8 | 11.5 | 6.3 | 0.25 | 315 |
| 1N5353A | 16 | 75 | 2.5 | 75 | 1 | 11.5 | 12.2 | 6 | 0.3 | 295 |
| 1N5354A | 17 | 70 | 2.5 | 75 | 0.5 | 12.2 | 12.9 | 5.8 | 0.35 | 280 |
| 1N5355A | 18 | 65 | 2.5 | 75 | 0.5 | 13 | 13.7 | 5.5 | 0.4 | 265 |
| 1N5356A | 19 | 65 | 3 | 75 | 0.5 | 13.7 | 14.4 | 5.3 | 0.4 | 250 |
| 1N5357A | 20 | 65 | 3 | 75 | 0.5 | 14.4 | 15.2 | 5.1 | 0.4 | 237 |
| 1N5358A | 22 | 50 | 3.5 | 75 | 0.5 | 15.8 | 16.7 | 4.7 | 0.45 | 216 |
| 1N5359A | 24 | 50 | 3.5 | 100 | 0.5 | 17.3 | 18.2 | 4.4 | 0.55 | 198 |
| 1N5360A | 25 | 50 | 4 | 110 | 0.5 | 18 | 19 | 4.3 | 0.55 | 190 |
| 1N5361A | 27 | 50 | 5 | 120 | 0.5 | 19.4 | 20.6 | 4.1 | 0.6 | 176 |
| 1N5362A | 28 | 50 | 6 | 130 | 0.5 | 20.1 | 21.2 | 3.9 | 0.6 | 170 |
| 1N5363A | 30 | 40 | 8 | 140 | 0.5 | 21.6 | 22.8 | 3.7 | 0.6 | 158 |
| 1N5364A | 33 | 40 | 10 | 150 | 0.5 | 23.8 | 25.1 | 3.5 | 0.6 | 144 |
| 1N5365A | 36 | 30 | 11 | 160 | 0.5 | 25.9 | 27.4 | 3.3 | 0.65 | 132 |
| 1N5366A | 39 | 30 | 14 | 170 | 0.5 | 28.1 | 29.7 | 3.1 | 0.65 | 122 |
| 1N5367A | 43 | 30 | 20 | 190 | 0.5 | 31 | 32.7 | 2.8 | 0.7 | 110 |
| 1N5368A | 47 | 25 | 25 | 210 | 0.5 | 33.8 | 35.8 | 2.7 | 0.8 | 100 |
| 1N5369A | 51 | 25 | 27 | 230 | 0.5 | 36.7 | 38.8 | 2.5 | 0.9 | 93 |
| 1N5370A | 56 | 20 | 35 | 280 | 0.5 | 40.3 | 42.6 | 2.3 | 1 | 86 |
| 1N5371A | 60 | 20 | 40 | 350 | 0.5 | 43 | 42.5 | 2.2 | 1.2 | 79 |
| 1N5372A | 62 | 20 | 42 | 400 | 0.5 | 44.6 | 47.1 | 2.1 | 1.35 | 76 |
| 1N5373A | 68 | 20 | 44 | 500 | 0.5 | 49 | 51.7 | 2 | 1.5 | 70 |
| 1N5374A | 75 | 20 | 45 | 620 | 0.5 | 54 | 56 | 1.9 | 1.6 | 63 |
| 1N5375A | 82 | 15 | 65 | 720 | 0.5 | 59 | 62.2 | 1.8 | 1.8 | 58 |
| 1N5376A | 87 | 15 | 75 | 760 | 0.5 | 63 | 66 | 1.7 | 2 | 54.5 |
| 1N5377A | 91 | 15 | 75 | 760 | 0.5 | 65.5 | 69.2 | 1.6 | 2.2 | 52.5 |
| 1N5378A | 100 | 12 | 90 | 800 | 0.5 | 72 | 76 | 1.5 | 2.5 | 47.5 |
| 1N5379A | 110 | 12 | 125 | 1000 | 0.5 | 79.2 | 83.6 | 1.4 | 2.5 | 43 |
| 1N5380A | 120 | 10 | 170 | 1150 | 0.5 | 86.4 | 91.2 | 1.3 | 2.5 | 39.5 |
| 1N5381A | 130 | 10 | 190 | 1250 | 0.5 | 93.6 | 98.8 | 1.2 | 2.5 | 36.6 |
| 1N5382A | 140 | 8 | 230 | 1500 | 0.5 | 101 | 106 | 1.2 | 2.5 | 34 |
| 1N5383A | 150 | 8 | 330 | 1500 | 0.5 | 108 | 114 | 1.1 | 3 | 31.6 |
| 1N5384A | 160 | 8 | 350 | 1650 | 0.5 | 115 | 122 | 1.1 | 3 | 29.4 |
| 1N5385A | 170 | 8 | 380 | 1750 | 0.5 | 122 | 129 | 1 | 3 | 28 |
| 1N5386A | 180 | 5 | 430 | 1750 | 0.5 | 130 | 137 | 1 | 4 | 26.4 |
| 1N5387A | 190 | 5 | 450 | 1850 | 0.5 | 137 | 144 | 0.9 | 5 | 25 |
| 1N5388A | 200 | 5 | 480 | 1850 | 0.5 | 144 | 152 | 0.9 | 5 | 23.6 |

NOTES:

- (1) TOLERANCE AND VOLTAGE DESIGNATION — The JEDEC type numbers shown indicate a tolerance of ±10% with guaranteed limits on only V_Z, I_R, I_F, and V_F as shown in the electrical characteristics table. Units with guaranteed limits on all seven parameters are indicated by suffix "A" for ±10% tolerance and suffix "B" for ±5%, C for ±2% and D for ±1%.
- (2) ZENER VOLTAGE (V_Z) AND IMPEDANCE (Z_{ZT} & Z_{ZK}) — Test conditions for Zener voltage and impedance are as follows: I_Z is applied 40 ± 10 ms prior to reading. Mounting contacts are located 3/8" to 1/2" from the inside edge of mounting clips to the body of the diode. (T_A = 25°C ± 2°C).
- (3) SURGE CURRENT (I_S) — Surge current is specified as the maximum allowable peak, non-recurrent square-wave current with a pulse width, PW, of 8.3 ms. The data given in Figure 6 may be used to find the maximum surge current for a square wave of any pulse width between 1 ms and 1000 ms by plotting the applicable points on logarithmic paper. Examples of this, using the 3.3 V and 200 V zeners, are shown in Figure 7. Mounting contact located as specified in Note 3. (T_A = 25°C ± 2°C).
- (4) VOLTAGE REGULATION (ΔV_Z) — Test conditions for voltage regulation are as follows: V_Z measurements are made at 10% and then at 50% of the I_Z max value listed in the electrical characteristics table. The test currents are the same for the 5% and 10% tolerance devices. The test current time duration for each V_Z measurement is 40 ± 10 ms. (T_A = 25°C ± 2°C). Mounting contact located as specified in Note 2.
- (5) MAXIMUM REGULATOR CURRENT (I_{ZM}) — The maximum current shown is based on the maximum voltage of a 5% type unit, therefore, it applies only to the B-suffix device. The actual I_{ZM} for any device may not exceed the value of 5 watts divided by the actual V_Z of the device. T_L = 75°C at 38° maximum from the device body.

1N5333A, B, C, D thru 1N5388A, B, C, D

TEMPERATURE COEFFICIENTS

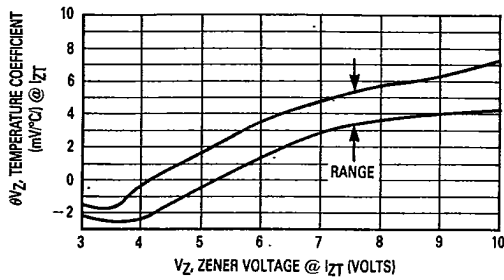


Figure 2. Temperature Coefficient-Range for Units 3 to 10 Volts

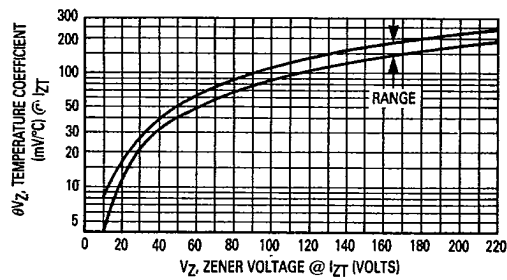


Figure 3. Temperature Coefficient-Range for Units 10 to 220 Volts

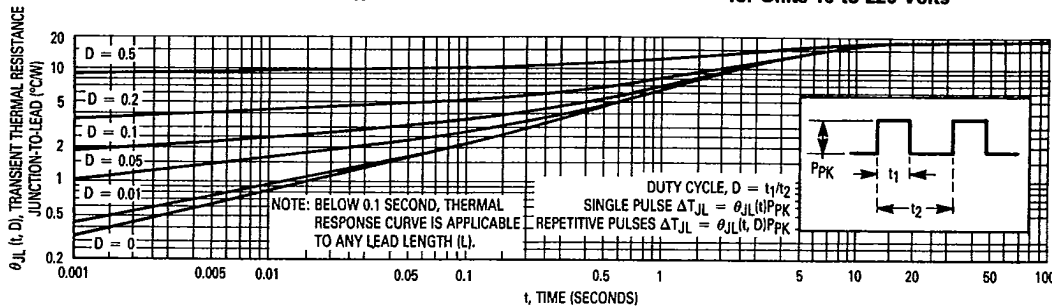


Figure 4. Typical Thermal Response L, Lead Length = 3.8 Inch

4

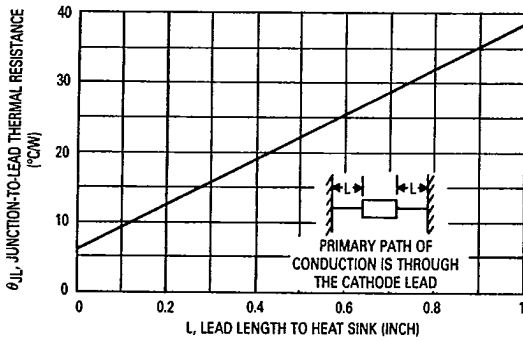


Figure 5. Typical Thermal Resistance

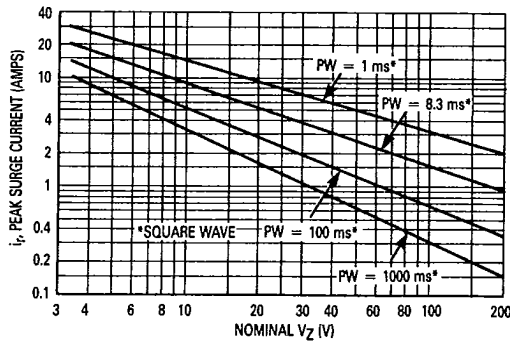


Figure 6. Maximum Non-Repetitive Surge Current versus Nominal Zener Voltage (See Note 3)

Data of Figure 4 should not be used to compute surge capability. 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.

1N5333A, B, C, D thru 1N5388A, B, C, D

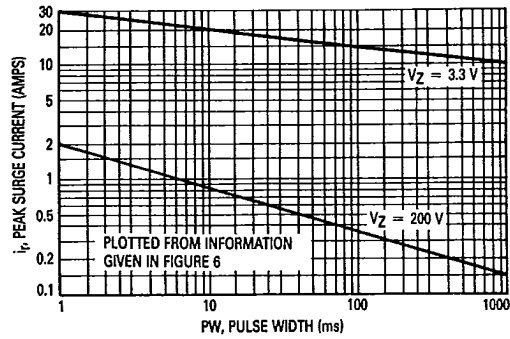


Figure 7. Peak Surge Current versus Pulse Width (See Note 3)

ZENER VOLTAGE versus ZENER CURRENT (Figures 8, 9 and 10)

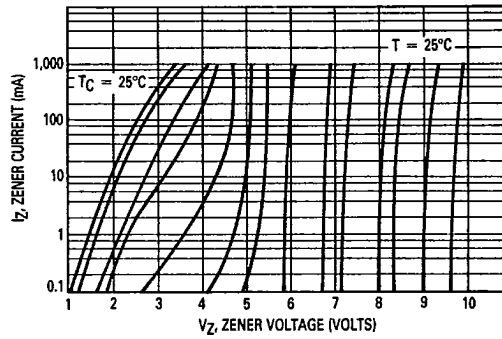


Figure 8. Zener Voltage versus Zener Current Vz = 3.3 thru 10 Volts

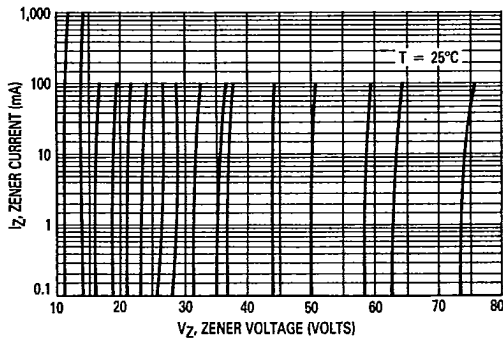


Figure 9. Zener Voltage versus Zener Current Vz = 11 thru 75 Volts

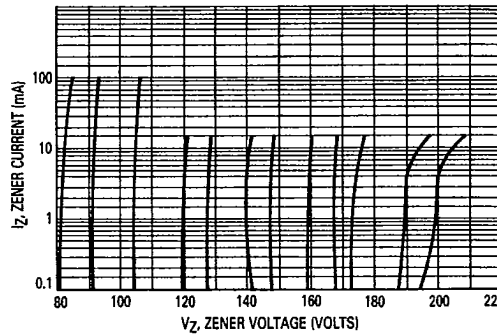


Figure 10. Zener Voltage versus Zener Current Vz = 82 thru 200 Volts

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:

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

θ_{LA} is the lead-to-ambient thermal resistance and P_D is the power dissipation.

Junction Temperature, T_J , may be found from:

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

ΔT_{JL} is the increase in junction temperature above the lead temperature and may be found from Figure

4 for a train of power pulses or from Figure 5 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 (ΔT_J) may be estimated. Changes in voltage, V_Z , can then be found from:

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

θ_{VZ} , the zener voltage temperature coefficient, is found from Figures 2 and 3.

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.

4