

1N53 Series

5 Watt Surmetic™ 40 Zener Voltage Regulators

This is 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 that offers protection in all common environmental conditions.

Features

- Zener Voltage Range – 3.3 V to 200 V
- ESD Rating of Class 3 (>16 kV) per Human Body Model
- Surge Rating of up to 180 W @ 8.3 ms
- Maximum Limits Guaranteed on up to Six Electrical Parameters
- Pb-Free Packages are Available*

Mechanical Characteristics

CASE: Void free, transfer-molded, thermosetting plastic

FINISH: All external surfaces are corrosion resistant and leads are readily solderable

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 260°C, 1/16 in. from the case for 10 seconds

POLARITY: Cathode indicated by polarity band

MOUNTING POSITION: Any

MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|---|----------------|-------------------------|-------|
| Max. Steady State Power Dissipation @ $T_L = 25^\circ\text{C}$, Lead Length = 3/8 in Derate above 25°C | P_D | 5 | W |
| | | 40 | mW/°C |
| Junction-to-Lead Thermal Resistance | θ_{JL} | 25 | °C/W |
| Operating and Storage Temperature Range | T_J, T_{stg} | -65 to +200 (Note 1) | °C |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. Max operating temperature for DC conditions is 150°C, but not to exceed 200°C for pulsed conditions with low duty cycle or non-repetitive.



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MARKING DIAGRAM



- A = Assembly Location
 - 1N53xxB = Device Number
(Refer to Tables on Pages 3 & 4)
 - YY = Year
 - WW = Work Week
 - = Pb-Free Package
- (Note: Microdot may be in either location)

ORDERING INFORMATION

| Device | Package | Shipping† |
|--------------|-------------------------|------------------|
| 1N53xxB, G | Axial Lead (Pb-Free) | 1000 Units/Box |
| 1N53xxBRL, G | Axial Lead (Pb-Free) | 4000/Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted, $V_F = 1.2\text{ V Max @ } I_F = 1.0\text{ A}$ for all types)

| Symbol | Parameter |
|--------------|--|
| V_Z | Reverse Zener Voltage @ I_{ZT} |
| I_{ZT} | Reverse Current |
| Z_{ZT} | Maximum Zener Impedance @ I_{ZT} |
| I_{ZK} | Reverse Current |
| Z_{ZK} | Maximum Zener Impedance @ I_{ZK} |
| I_R | Reverse Leakage Current @ V_R |
| V_R | Breakdown Voltage |
| I_F | Forward Current |
| V_F | Forward Voltage @ I_F |
| I_R | Maximum Surge Current @ $T_A = 25^\circ\text{C}$ |
| ΔV_Z | Reverse Zener Voltage Change |
| I_{ZM} | Maximum DC Zener Current |



ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted, $V_F = 1.2\text{ V Max @ } I_F = 1.0\text{ A}$ for all types)

| Device [†] (Note 2) | Device Marking | Zener Voltage (Note 3) | | | | Zener Impedance (Note 3) | | | Leakage Current | | I_R (Note 4) | ΔV_Z (Note 5) | I_{ZM} (Note 6) |
|---------------------------------|-------------------|------------------------|------------|-------------|------------|--------------------------|---------------------|----------|--------------------|------------|-------------------|--------------------------|----------------------|
| | | V_Z (Volts) | | | @ I_{ZT} | Z_{ZT} @ I_{ZT} | Z_{ZK} @ I_{ZK} | I_{ZK} | I_R @ V_R | | | | |
| | | Min | Nom | Max | mA | Ω | Ω | mA | $\mu\text{A Max}$ | Volts | A | Volts | mA |
| 1N5333B | 1N5333B | 3.14 | 3.3 | 3.47 | 380 | 3 | 400 | 1 | 300 | 1 | 20 | 0.85 | 1440 |
| 1N5334B | 1N5334B | 3.42 | 3.6 | 3.78 | 350 | 2.5 | 500 | 1 | 150 | 1 | 18.7 | 0.8 | 1320 |
| 1N5335B | 1N5335B | 3.71 | 3.9 | 4.10 | 320 | 2 | 500 | 1 | 50 | 1 | 17.6 | 0.54 | 1220 |
| 1N5336B | 1N5336B | 4.09 | 4.3 | 4.52 | 290 | 2 | 500 | 1 | 10 | 1 | 16.4 | 0.49 | 1100 |
| 1N5337B | 1N5337B | 4.47 | 4.7 | 4.94 | 260 | 2 | 450 | 1 | 5 | 1 | 15.3 | 0.44 | 1010 |
| 1N5338B | 1N5338B | 4.85 | 5.1 | 5.36 | 240 | 1.5 | 400 | 1 | 1 | 1 | 14.4 | 0.39 | 930 |
| 1N5339B | 1N5339B | 5.32 | 5.6 | 5.88 | 220 | 1 | 400 | 1 | 1 | 2 | 13.4 | 0.25 | 865 |
| 1N5340B | 1N5340B | 5.70 | 6.0 | 6.30 | 200 | 1 | 300 | 1 | 1 | 3 | 12.7 | 0.19 | 790 |
| 1N5341B | 1N5341B | 5.89 | 6.2 | 6.51 | 200 | 1 | 200 | 1 | 1 | 3 | 12.4 | 0.1 | 765 |
| 1N5342B | 1N5342B | 6.46 | 6.8 | 7.14 | 175 | 1 | 200 | 1 | 10 | 5.2 | 11.5 | 0.15 | 700 |
| 1N5343B | 1N5343B | 7.13 | 7.5 | 7.88 | 175 | 1.5 | 200 | 1 | 10 | 5.7 | 10.7 | 0.15 | 630 |
| 1N5344B | 1N5344B | 7.79 | 8.2 | 8.61 | 150 | 1.5 | 200 | 1 | 10 | 6.2 | 10 | 0.2 | 580 |
| 1N5345B | 1N5345B | 8.27 | 8.7 | 9.14 | 150 | 2 | 200 | 1 | 10 | 6.6 | 9.5 | 0.2 | 545 |
| 1N5346B | 1N5346B | 8.65 | 9.1 | 9.56 | 150 | 2 | 150 | 1 | 7.5 | 6.9 | 9.2 | 0.22 | 520 |
| 1N5347B | 1N5347B | 9.50 | 10 | 10.5 | 125 | 2 | 125 | 1 | 5 | 7.6 | 8.6 | 0.22 | 475 |

Devices listed in **bold, italic** are ON Semiconductor **Preferred** devices. **Preferred** devices are recommended choices for future use and best overall value.

- TOLERANCE AND TYPE NUMBER DESIGNATION:** The JEDEC type numbers shown indicate a tolerance of $\pm 5\%$.
- ZENER VOLTAGE (V_Z) and IMPEDANCE (I_{ZT} and I_{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 ($T_A = 25^\circ\text{C} + 8^\circ\text{C}, -2^\circ\text{C}$).
- SURGE CURRENT (I_R):** 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 5 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 zener are shown in Figure 6. Mounting contact located as specified in Note 2 ($T_A = 25^\circ\text{C} + 8^\circ\text{C}, -2^\circ\text{C}$).
- VOLTAGE REGULATION (ΔV_Z):** The 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 current time duration for each V_Z measurement is 40 ± 10 ms. Mounting contact located as specified in Note 2 ($T_A = 25^\circ\text{C} + 8^\circ\text{C}, -2^\circ\text{C}$).
- 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. $T_L = 25^\circ\text{C}$ at $3/8''$ maximum from the device body.

[†]The "G" suffix indicates Pb-Free package or Pb-Free packages are available.

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ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted, $V_F = 1.2\text{ V Max @ } I_F = 1.0\text{ A}$ for all types)

| Device [†] (Note 7) | Device Marking | Zener Voltage (Note 8) | | | | Zener Impedance (Note 8) | | | Leakage Current | | I_R (Note 9) | ΔV_Z (Note 10) | I_{ZM} (Note 11) |
|---------------------------------|-------------------|------------------------|------------|--------------|------------|--------------------------|---------------------|----------|--------------------|-------------|-------------------|------------------------------|-----------------------|
| | | V_Z (Volts) | | | @ I_{ZT} | Z_{ZT} @ I_{ZT} | Z_{ZK} @ I_{ZK} | I_{ZK} | I_R @ V_R | | | | |
| | | Min | Nom | Max | mA | Ω | Ω | mA | $\mu\text{A Max}$ | Volts | | | |
| 1N5348B | 1N5348B | 10.45 | 11 | 11.55 | 125 | 2.5 | 125 | 1 | 5 | 8.4 | 8.0 | 0.25 | 430 |
| 1N5349B | 1N5349B | 11.4 | 12 | 12.6 | 100 | 2.5 | 125 | 1 | 2 | 9.1 | 7.5 | 0.25 | 395 |
| 1N5350B | 1N5350B | 12.35 | 13 | 13.65 | 100 | 2.5 | 100 | 1 | 1 | 9.9 | 7.0 | 0.25 | 365 |
| 1N5351B | 1N5351B | 13.3 | 14 | 14.7 | 100 | 2.5 | 75 | 1 | 1 | 10.6 | 6.7 | 0.25 | 340 |
| 1N5352B | 1N5352B | 14.25 | 15 | 15.75 | 75 | 2.5 | 75 | 1 | 1 | 11.5 | 6.3 | 0.25 | 315 |
| 1N5353B | 1N5353B | 15.2 | 16 | 16.8 | 75 | 2.5 | 75 | 1 | 1 | 12.2 | 6.0 | 0.3 | 295 |
| 1N5354B | 1N5354B | 16.15 | 17 | 17.85 | 70 | 2.5 | 75 | 1 | 0.5 | 12.9 | 5.8 | 0.35 | 280 |
| 1N5355B | 1N5355B | 17.1 | 18 | 18.9 | 65 | 2.5 | 75 | 1 | 0.5 | 13.7 | 5.5 | 0.4 | 264 |
| 1N5356B | 1N5356B | 18.05 | 19 | 19.95 | 65 | 3 | 75 | 1 | 0.5 | 14.4 | 5.3 | 0.4 | 250 |
| 1N5357B | 1N5357B | 19 | 20 | 21 | 65 | 3 | 75 | 1 | 0.5 | 15.2 | 5.1 | 0.4 | 237 |
| 1N5358B | 1N5358B | 20.9 | 22 | 23.1 | 50 | 3.5 | 75 | 1 | 0.5 | 16.7 | 4.7 | 0.45 | 216 |
| 1N5359B | 1N5359B | 22.8 | 24 | 25.2 | 50 | 3.5 | 100 | 1 | 0.5 | 18.2 | 4.4 | 0.55 | 198 |
| 1N5360B | 1N5360B | 23.75 | 25 | 26.25 | 50 | 4 | 110 | 1 | 0.5 | 19 | 4.3 | 0.55 | 190 |
| 1N5361B | 1N5361B | 25.65 | 27 | 28.35 | 50 | 5 | 120 | 1 | 0.5 | 20.6 | 4.1 | 0.6 | 176 |
| 1N5362B | 1N5362B | 26.6 | 28 | 29.4 | 50 | 6 | 130 | 1 | 0.5 | 21.2 | 3.9 | 0.6 | 170 |
| 1N5363B | 1N5363B | 28.5 | 30 | 31.5 | 40 | 8 | 140 | 1 | 0.5 | 22.8 | 3.7 | 0.6 | 158 |
| 1N5364B | 1N5364B | 31.35 | 33 | 34.65 | 40 | 10 | 150 | 1 | 0.5 | 25.1 | 3.5 | 0.6 | 144 |
| 1N5365B | 1N5365B | 34.2 | 36 | 37.8 | 30 | 11 | 160 | 1 | 0.5 | 27.4 | 3.5 | 0.65 | 132 |
| 1N5366B | 1N5366B | 37.05 | 39 | 40.95 | 30 | 14 | 170 | 1 | 0.5 | 29.7 | 3.1 | 0.65 | 122 |
| 1N5367B | 1N5367B | 40.85 | 43 | 45.15 | 30 | 20 | 190 | 1 | 0.5 | 32.7 | 2.8 | 0.7 | 110 |
| 1N5368B | 1N5368B | 44.65 | 47 | 49.35 | 25 | 25 | 210 | 1 | 0.5 | 35.8 | 2.7 | 0.8 | 100 |
| 1N5369B | 1N5369B | 48.45 | 51 | 53.55 | 25 | 27 | 230 | 1 | 0.5 | 38.8 | 2.5 | 0.9 | 93 |
| 1N5370B | 1N5370B | 53.2 | 56 | 58.8 | 20 | 35 | 280 | 1 | 0.5 | 42.6 | 2.3 | 1.0 | 86 |
| 1N5371B | 1N5371B | 57 | 60 | 63 | 20 | 40 | 350 | 1 | 0.5 | 45.5 | 2.2 | 1.2 | 79 |
| 1N5372B | 1N5372B | 58.9 | 62 | 65.1 | 20 | 42 | 400 | 1 | 0.5 | 47.1 | 2.1 | 1.35 | 76 |
| 1N5373B | 1N5373B | 64.6 | 68 | 71.4 | 20 | 44 | 500 | 1 | 0.5 | 51.7 | 2.0 | 1.52 | 70 |
| 1N5374B | 1N5374B | 71.25 | 75 | 78.75 | 20 | 45 | 620 | 1 | 0.5 | 56 | 1.9 | 1.6 | 63 |
| 1N5375B | 1N5375B | 77.9 | 82 | 86.1 | 15 | 65 | 720 | 1 | 0.5 | 62.2 | 1.8 | 1.8 | 58 |
| 1N5377B | 1N5377B | 86.45 | 91 | 95.55 | 15 | 75 | 760 | 1 | 0.5 | 69.2 | 1.6 | 2.2 | 52.5 |
| 1N5378B | 1N5378B | 95 | 100 | 105 | 12 | 90 | 800 | 1 | 0.5 | 76 | 1.5 | 2.5 | 47.5 |
| 1N5380B | 1N5380B | 114 | 120 | 126 | 10 | 170 | 1150 | 1 | 0.5 | 91.2 | 1.3 | 2.5 | 39.5 |
| 1N5381B | 1N5381B | 123.5 | 130 | 136.5 | 10 | 190 | 1250 | 1 | 0.5 | 98.8 | 1.2 | 2.5 | 36.6 |
| 1N5383B | 1N5383B | 142.5 | 150 | 157.5 | 8 | 330 | 1500 | 1 | 0.5 | 114 | 1.1 | 3.0 | 31.6 |
| 1N5384B | 1N5384B | 152 | 160 | 168 | 8 | 350 | 1650 | 1 | 0.5 | 122 | 1.1 | 3.0 | 29.4 |
| 1N5386B | 1N5386B | 171 | 180 | 189 | 5 | 430 | 1750 | 1 | 0.5 | 137 | 1.0 | 4.0 | 26.4 |
| 1N5387B | 1N5387B | 180.5 | 190 | 199.5 | 5 | 450 | 1850 | 1 | 0.5 | 144 | 0.9 | 5.0 | 25 |
| 1N5388B | 1N5388B | 190 | 200 | 210 | 5 | 480 | 1850 | 1 | 0.5 | 152 | 0.9 | 5.0 | 23.6 |

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Figure 1. Typical Thermal Resistance

TEMPERATURE COEFFICIENTS



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



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

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Figure 4. Typical Thermal Response
L, Lead Length = 3/8 Inch



Figure 5. Maximum Non-Repetitive Surge Current versus Nominal Zener Voltage
(See Note 4)



Figure 6. Peak Surge Current versus Pulse Width
(See Note 4)



Figure 7. Zener Voltage versus Zener Current
 $V_Z = 3.3$ thru 10 Volts



Figure 8. Zener Voltage versus Zener Current
 $V_Z = 11$ thru 75 Volts

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**Figure 9. Zener Voltage versus Zener Current
V_Z = 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 1 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.

Data of Figure 4 should not be used to compute surge capability. Surge limitations are given in Figure 5. 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 5 be exceeded.

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PACKAGE DIMENSIONS

SURMETIC 40, AXIAL LEAD CASE 017AA ISSUE O



NOTES:

1. CONTROLLING DIMENSION: INCH
2. LEAD DIAMETER AND FINISH NOT CONTROLLED WITHIN DIMENSION F.
3. CATHODE BAND INDICATES POLARITY

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

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