

# 5 Watt Surmetic 40 Zener Voltage Regulators

## 1N53 Series

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
Junction-to-Lead Thermal Resistance	$\theta_{JL}$	40	mW/°C
		25	°C/W
Operating and Storage Temperature Range	$T_J, T_{stg}$	-65 to +200 (Note 1)	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

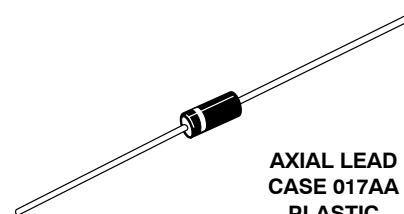
1. Max operating temperature for DC conditions is 150°C, but not to exceed 200°C for pulsed conditions with low duty cycle or non-repetitive.

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

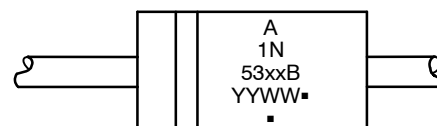


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### MARKING DIAGRAM



- 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

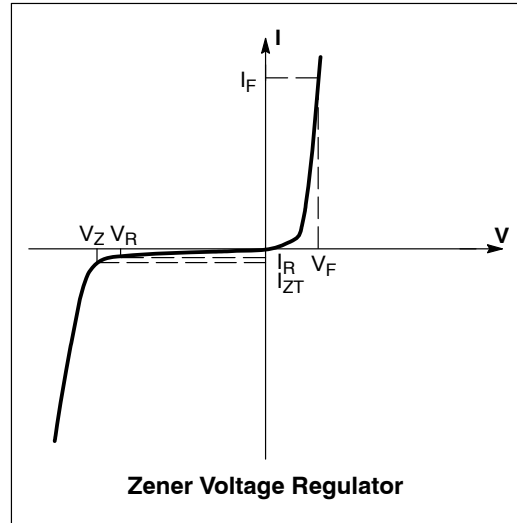
Device	Package	Shipping†
1N53xxB, G	Axial Lead (Pb-Free)	1000 Units/Box
1N53xxBRL, G	Axial Lead (Pb-Free)	4000/Tape & Reel

†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.

# 1N53 Series

**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 @ $T_A = 25^\circ\text{C}$
$\Delta V_Z$	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 <sup>†</sup> (Note 2)	Device Marking	Zener Voltage (Note 3)				Zener Impedance (Note 3)			Leakage Current		I <sub>R</sub> (Note 4)	ΔV <sub>Z</sub> (Note 5)	I <sub>ZM</sub> (Note 6)
		V <sub>Z</sub> (Volts)			@ I <sub>ZT</sub>	Z <sub>ZT</sub> @ I <sub>ZT</sub>	Z <sub>ZK</sub> @ I <sub>ZK</sub>	I <sub>ZK</sub>	I <sub>R</sub> @ V <sub>R</sub>				
		Min	Nom	Max	mA	Ω	Ω	mA	μA Max	Volts			
<b>1N5333B</b>	<b>1N5333B</b>	<b>3.14</b>	<b>3.3</b>	<b>3.47</b>	<b>380</b>	<b>3</b>	<b>400</b>	<b>1</b>	<b>300</b>	<b>1</b>	<b>20</b>	<b>0.85</b>	<b>1440</b>
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
<b>1N5337B</b>	<b>1N5337B</b>	<b>4.47</b>	<b>4.7</b>	<b>4.94</b>	<b>260</b>	<b>2</b>	<b>450</b>	<b>1</b>	<b>5</b>	<b>1</b>	<b>15.3</b>	<b>0.44</b>	<b>1010</b>
<b>1N5338B</b>	<b>1N5338B</b>	<b>4.85</b>	<b>5.1</b>	<b>5.36</b>	<b>240</b>	<b>1.5</b>	<b>400</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>14.4</b>	<b>0.39</b>	<b>930</b>
<b>1N5339B</b>	<b>1N5339B</b>	<b>5.32</b>	<b>5.6</b>	<b>5.88</b>	<b>220</b>	<b>1</b>	<b>400</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>13.4</b>	<b>0.25</b>	<b>865</b>
1N5340B	1N5340B	5.70	6.0	6.30	200	1	300	1	1	3	12.7	0.19	790
<b>1N5341B</b>	<b>1N5341B</b>	<b>5.89</b>	<b>6.2</b>	<b>6.51</b>	<b>200</b>	<b>1</b>	<b>200</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>12.4</b>	<b>0.1</b>	<b>765</b>
<b>1N5342B</b>	<b>1N5342B</b>	<b>6.46</b>	<b>6.8</b>	<b>7.14</b>	<b>175</b>	<b>1</b>	<b>200</b>	<b>1</b>	<b>10</b>	<b>5.2</b>	<b>11.5</b>	<b>0.15</b>	<b>700</b>
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
<b>1N5347B</b>	<b>1N5347B</b>	<b>9.50</b>	<b>10</b>	<b>10.5</b>	<b>125</b>	<b>2</b>	<b>125</b>	<b>1</b>	<b>5</b>	<b>7.6</b>	<b>8.6</b>	<b>0.22</b>	<b>475</b>

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  $40 \pm 10$  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 ( $\Delta V_Z$ ):** 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  $40 \pm 10$  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.

<sup>†</sup>The "G" suffix indicates Pb-Free package or Pb-Free packages are available.

# 1N53 Series

## 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 <sup>†</sup> (Note 7)	Device Marking	Zener Voltage (Note 8)				Zener Impedance (Note 8)			Leakage Current		I <sub>R</sub> (Note 9)	ΔV <sub>Z</sub> (Note 10)	I <sub>ZM</sub> (Note 11)
		V <sub>Z</sub> (Volts)			@ I <sub>ZT</sub>	Z <sub>ZT</sub> @ I <sub>ZT</sub>	Z <sub>ZK</sub> @ I <sub>ZK</sub>	I <sub>ZK</sub>	I <sub>R</sub> @ V <sub>R</sub>				
		Min	Nom	Max	mA	Ω	Ω	mA	μA Max	Volts	A	Volts	mA
1N5348B	1N5348B	10.45	11	11.55	125	2.5	125	1	5	8.4	8.0	0.25	430
<b>1N5349B</b>	<b>1N5349B</b>	<b>11.4</b>	<b>12</b>	<b>12.6</b>	<b>100</b>	<b>2.5</b>	<b>125</b>	<b>1</b>	<b>2</b>	<b>9.1</b>	<b>7.5</b>	<b>0.25</b>	<b>395</b>
<b>1N5350B</b>	<b>1N5350B</b>	<b>12.35</b>	<b>13</b>	<b>13.65</b>	<b>100</b>	<b>2.5</b>	<b>100</b>	<b>1</b>	<b>1</b>	<b>9.9</b>	<b>7.0</b>	<b>0.25</b>	<b>365</b>
1N5351B	1N5351B	13.3	14	14.7	100	2.5	75	1	1	10.6	6.7	0.25	340
<b>1N5352B</b>	<b>1N5352B</b>	<b>14.25</b>	<b>15</b>	<b>15.75</b>	<b>75</b>	<b>2.5</b>	<b>75</b>	<b>1</b>	<b>1</b>	<b>11.5</b>	<b>6.3</b>	<b>0.25</b>	<b>315</b>
<b>1N5353B</b>	<b>1N5353B</b>	<b>15.2</b>	<b>16</b>	<b>16.8</b>	<b>75</b>	<b>2.5</b>	<b>75</b>	<b>1</b>	<b>1</b>	<b>12.2</b>	<b>6.0</b>	<b>0.3</b>	<b>295</b>
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
<b>1N5358B</b>	<b>1N5358B</b>	<b>20.9</b>	<b>22</b>	<b>23.1</b>	<b>50</b>	<b>3.5</b>	<b>75</b>	<b>1</b>	<b>0.5</b>	<b>16.7</b>	<b>4.7</b>	<b>0.45</b>	<b>216</b>
<b>1N5359B</b>	<b>1N5359B</b>	<b>22.8</b>	<b>24</b>	<b>25.2</b>	<b>50</b>	<b>3.5</b>	<b>100</b>	<b>1</b>	<b>0.5</b>	<b>18.2</b>	<b>4.4</b>	<b>0.55</b>	<b>198</b>
1N5360B	1N5360B	23.75	25	26.25	50	4	110	1	0.5	19	4.3	0.55	190
<b>1N5361B</b>	<b>1N5361B</b>	<b>25.65</b>	<b>27</b>	<b>28.35</b>	<b>50</b>	<b>5</b>	<b>120</b>	<b>1</b>	<b>0.5</b>	<b>20.6</b>	<b>4.1</b>	<b>0.6</b>	<b>176</b>
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
<b>1N5365B</b>	<b>1N5365B</b>	<b>34.2</b>	<b>36</b>	<b>37.8</b>	<b>30</b>	<b>11</b>	<b>160</b>	<b>1</b>	<b>0.5</b>	<b>27.4</b>	<b>3.5</b>	<b>0.65</b>	<b>132</b>
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
<b>1N5368B</b>	<b>1N5368B</b>	<b>44.65</b>	<b>47</b>	<b>49.35</b>	<b>25</b>	<b>25</b>	<b>210</b>	<b>1</b>	<b>0.5</b>	<b>35.8</b>	<b>2.7</b>	<b>0.8</b>	<b>100</b>
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
<b>1N5383B</b>	<b>1N5383B</b>	<b>142.5</b>	<b>150</b>	<b>157.5</b>	<b>8</b>	<b>330</b>	<b>1500</b>	<b>1</b>	<b>0.5</b>	<b>114</b>	<b>1.1</b>	<b>3.0</b>	<b>31.6</b>
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

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  $40 \pm 10$  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 7 ( $T_A = 25^\circ\text{C} + 8^\circ\text{C}, -2^\circ\text{C}$ ).
- VOLTAGE REGULATION ( $\Delta V_Z$ ):** 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  $40 \pm 10$  ms. Mounting contact located as specified in Note 7 ( $T_A = 25^\circ\text{C} + 8^\circ\text{C}, -2^\circ\text{C}$ ).
- 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.

<sup>†</sup>The "G" suffix indicates Pb-Free package or Pb-Free packages are available.

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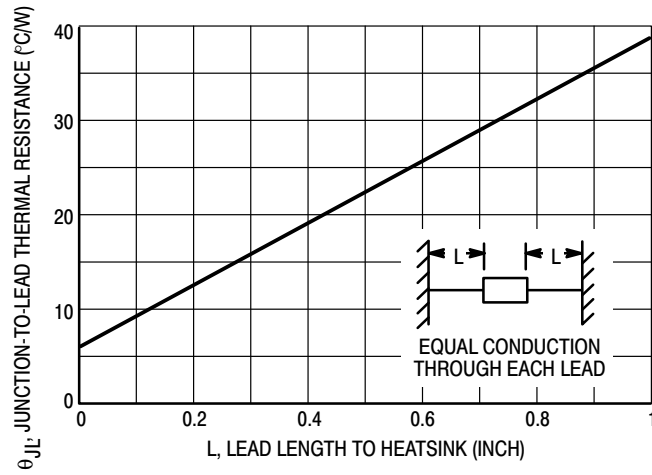


Figure 1. Typical Thermal Resistance

## TEMPERATURE COEFFICIENTS

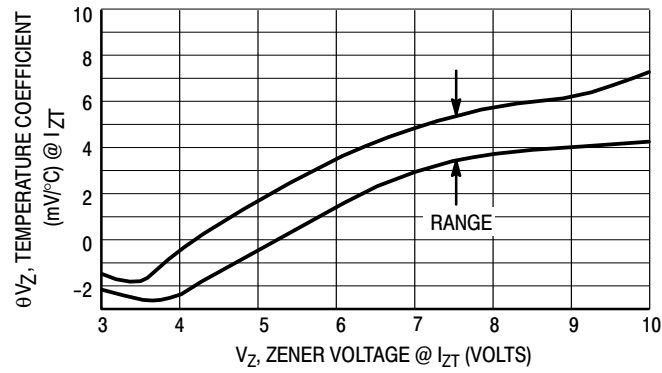


Figure 2. Temperature Coefficient-Range for Units 3 to 10 Volts

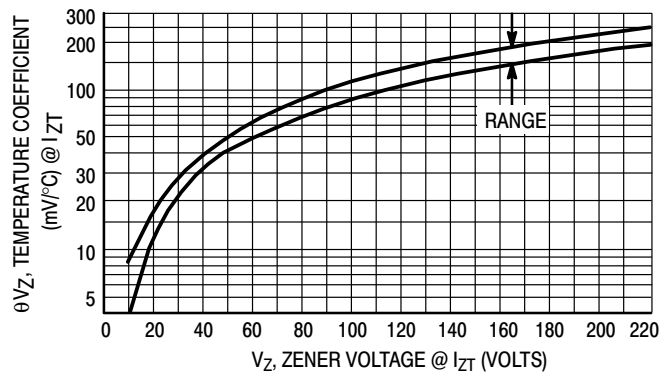
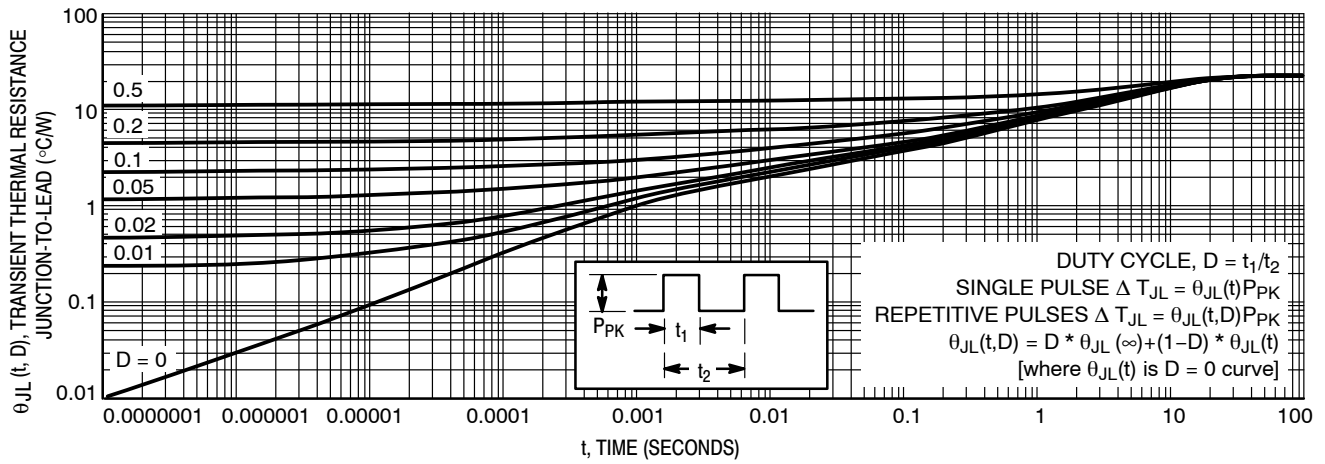
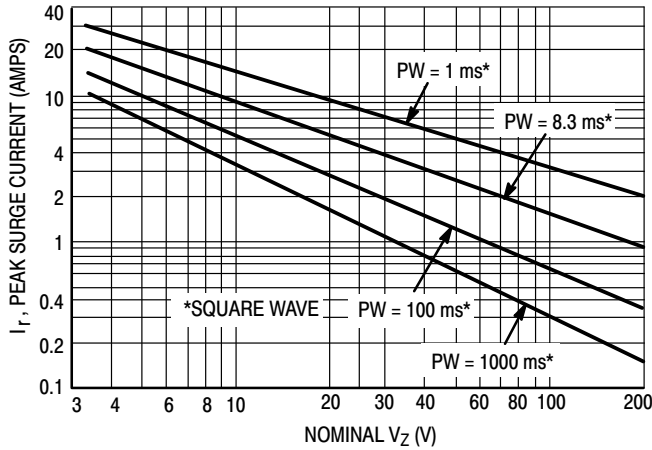


Figure 3. Temperature Coefficient-Range for Units 10 to 220 Volts

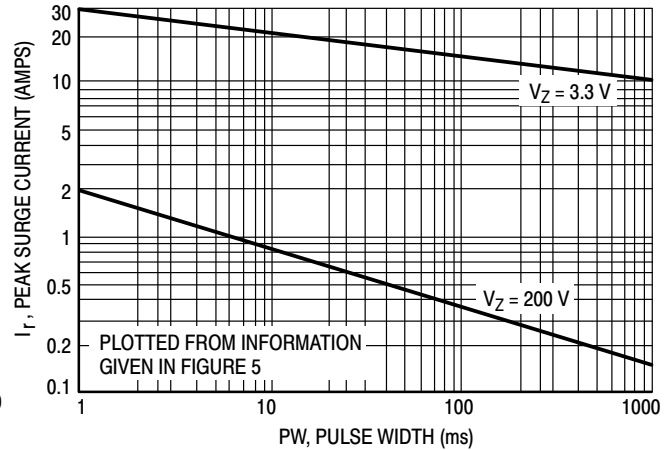
# 1N53 Series



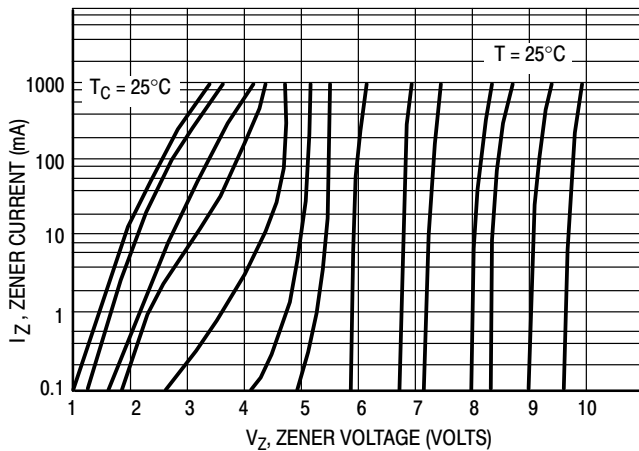
**Figure 4. Typical Thermal Response**  
L, Lead Length = 3/8 Inch



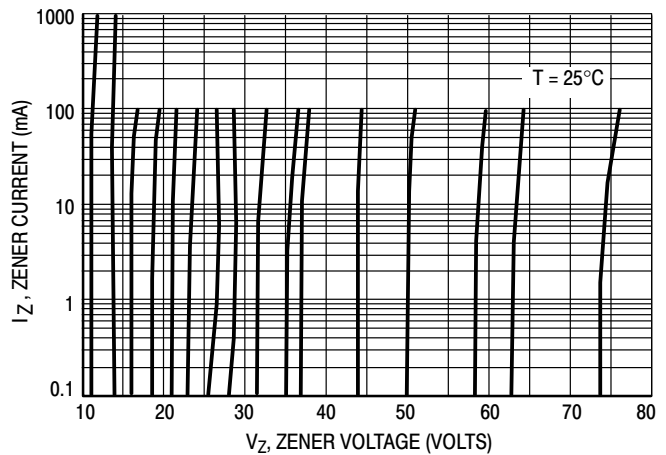
**Figure 5. Maximum Non-Repetitive Surge Current**  
versus Nominal Zener Voltage  
(See Note 4)



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

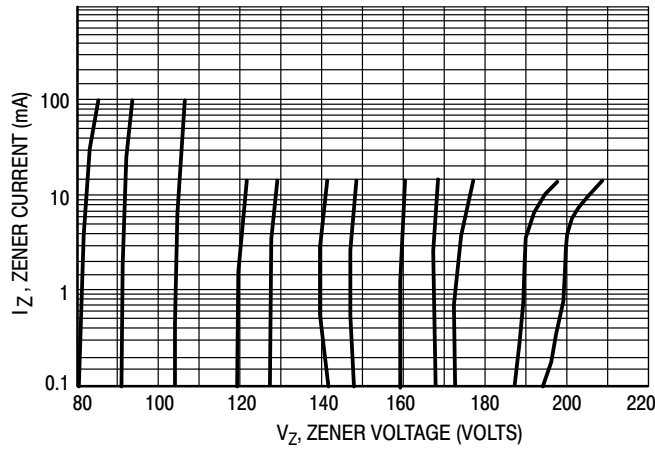


**Figure 7. Zener Voltage versus Zener Current**  
 $V_Z = 3.3$  thru 10 Volts



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

## 1N53 Series



**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:

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

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

Junction Temperature,  $T_J$ , may be found from:

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

$\Delta T_{JL}$  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  $T_J$  ( $\Delta T_J$ ) 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 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.

# MECHANICAL CASE OUTLINE

## PACKAGE DIMENSIONS

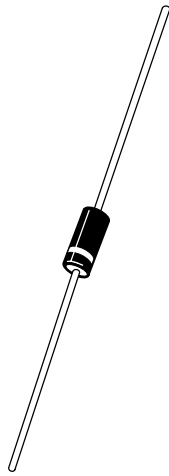
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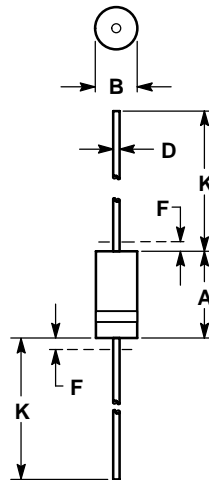
### SURMETIC 40, AXIAL LEAD

CASE 017AA-01  
ISSUE O

DATE 23 SEP 2005



SCALE 1:1




#### 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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