

# 1N5221B Series

## 500 mW DO-35 Hermetically Sealed Glass Zener Voltage Regulators

This is a complete series of 500 mW Zener diodes with limits and excellent operating characteristics that reflect the superior capabilities of silicon-oxide passivated junctions. All this in an axial-lead hermetically sealed glass package that offers protection in all common environmental conditions.

### Specification Features:

- Zener Voltage Range – 2.4 V to 91 V
- ESD Rating of Class 3 (>16 KV) per Human Body Model
- DO-204AH (DO-35) Package – Smaller than Conventional DO-204AA Package
- Double Slug Type Construction
- Metallurgical Bonded Construction

### Mechanical Characteristics:

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

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

**MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES:** 230°C, 1/16" from the case for 10 seconds

**POLARITY:** Cathode indicated by polarity band

**MOUNTING POSITION:** Any

### MAXIMUM RATINGS (Note 1.)

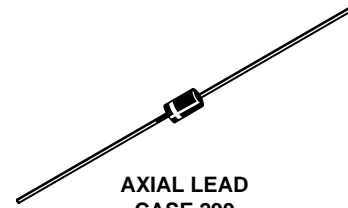
Rating	Symbol	Value	Unit
Max. Steady State Power Dissipation @ $T_L \leq 75^\circ\text{C}$ , Lead Length = 3/8" Derate above 75°C	$P_D$	500	mW
		4.0	mW/°C
Operating and Storage Temperature Range	$T_J, T_{stg}$	-65 to +200	°C

1. Some part number series have lower JEDEC registered ratings.



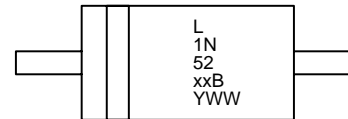
ON Semiconductor™

<http://onsemi.com>



AXIAL LEAD  
CASE 299  
GLASS

### MARKING DIAGRAM



L = Assembly Location  
1N52xxB = Device Code  
(See Table Next Page)  
Y = Year  
WW = Work Week

### ORDERING INFORMATION

Device	Package	Shipping
1N52xxB	Axial Lead	3000 Units/Box
1N52xxBRL	Axial Lead	5000/Tape & Reel
1N52xxBRL2 *	Axial Lead	5000/Tape & Reel
1N52xxBRA1	Axial Lead	3000/Ammo Pack
1N52xxBTA	Axial Lead	5000/Ammo Pack
1N52xxBTA2 *	Axial Lead	5000/Ammo Pack
1N52xxBRR1 †	Axial Lead	3000/Tape & Reel
1N52xxBRR2 ‡	Axial Lead	3000/Tape & Reel

\* The "2" suffix refers to 26 mm tape spacing.

† Polarity band **up** with cathode lead off first

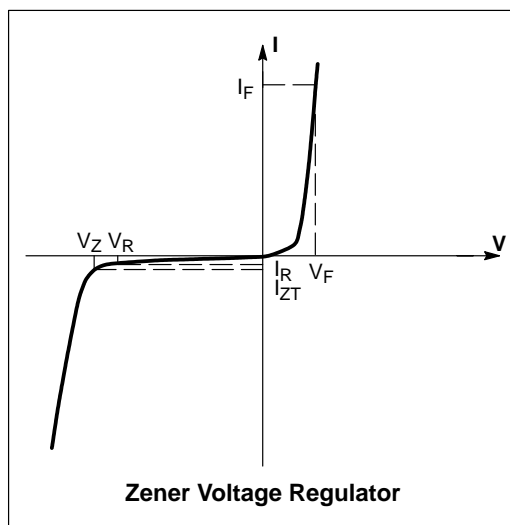
‡ Polarity band **down** with cathode lead off first

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

# 1N5221B Series

**ELECTRICAL CHARACTERISTICS** ( $T_A = 25^\circ\text{C}$  unless otherwise noted, Based on dc measurements at thermal equilibrium; lead length = 3/8"; thermal resistance of heat sink =  $30^\circ\text{C}/\text{W}$ ,  $V_F = 1.1\text{ V Max @ } I_F = 200\text{ mA}$  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 @ $I_F$
$\theta_{VZ}$	Maximum Zener Voltage Temperature Coefficient



**ELECTRICAL CHARACTERISTICS** ( $T_A = 25^\circ\text{C}$  unless otherwise noted, Based on dc measurements at thermal equilibrium; lead length = 3/8"; thermal resistance of heat sink =  $30^\circ\text{C}/\text{W}$ ,  $V_F = 1.1\text{ V Max @ } I_F = 200\text{ mA}$  for all types)

Device (Note 2.)	Device Marking	Zener Voltage (Note 3.)				Zener Impedance (Note 4.)			Leakage Current		$\theta_{VZ}$ (Note 5.)
		$V_Z$ (Volts)			@ $I_{ZT}$	$Z_{ZT}$ @ $I_{ZT}$	$Z_{ZK}$ @ $I_{ZK}$		$I_R$ @ $V_R$		
		Min	Nom	Max	mA	$\Omega$	$\Omega$	mA	$\mu\text{A}$	Volts	%/°C
1N5221B	1N5221B	2.28	2.4	2.52	20	30	1200	0.25	100	1	-0.085
1N5222B	1N5222B	2.375	2.5	2.625	20	30	1250	0.25	100	1	-0.085
1N5223B	1N5223B	2.565	2.7	2.835	20	30	1300	0.25	75	1	-0.08
1N5224B	1N5224B	2.66	2.8	2.94	20	30	1400	0.25	75	1	-0.08
1N5225B	1N5225B	2.85	3.0	3.15	20	29	1600	0.25	50	1	-0.075
<b>1N5226B</b>	<b>1N5226B</b>	<b>3.14</b>	<b>3.3</b>	<b>3.46</b>	<b>20</b>	<b>28</b>	<b>1600</b>	<b>0.25</b>	<b>25</b>	<b>1</b>	<b>-0.07</b>
1N5227B	1N5227B	3.42	3.6	3.78	20	24	1700	0.25	15	1	-0.065
<b>1N5228B</b>	<b>1N5228B</b>	<b>3.71</b>	<b>3.9</b>	<b>4.09</b>	<b>20</b>	<b>23</b>	<b>1900</b>	<b>0.25</b>	<b>10</b>	<b>1</b>	<b>-0.06</b>
1N5229B	1N5229B	4.09	4.3	4.51	20	22	2000	0.25	5	1	$\pm 0.055$
1N5230B	1N5230B	4.47	4.7	4.93	20	19	1900	0.25	5	2	$\pm 0.03$
<b>1N5231B</b>	<b>1N5231B</b>	<b>4.85</b>	<b>5.1</b>	<b>5.35</b>	<b>20</b>	<b>17</b>	<b>1600</b>	<b>0.25</b>	<b>5</b>	<b>2</b>	<b><math>\pm 0.03</math></b>
<b>1N5232B</b>	<b>1N5232B</b>	<b>5.32</b>	<b>5.6</b>	<b>5.88</b>	<b>20</b>	<b>11</b>	<b>1600</b>	<b>0.25</b>	<b>5</b>	<b>3</b>	<b>0.038</b>
1N5233B	1N5233B	5.7	6.0	6.3	20	7	1600	0.25	5	3.5	0.038
<b>1N5234B</b>	<b>1N5234B</b>	<b>5.89</b>	<b>6.2</b>	<b>6.51</b>	<b>20</b>	<b>7</b>	<b>1000</b>	<b>0.25</b>	<b>5</b>	<b>4</b>	<b>0.045</b>
<b>1N5235B</b>	<b>1N5235B</b>	<b>6.46</b>	<b>6.8</b>	<b>7.14</b>	<b>20</b>	<b>5</b>	<b>750</b>	<b>0.25</b>	<b>3</b>	<b>5</b>	<b>0.05</b>

## 2. TOLERANCE

The JEDEC type numbers shown indicate a tolerance of  $\pm 5\%$ .

## 3. ZENER VOLTAGE ( $V_Z$ ) MEASUREMENT

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

## 4. 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  $I_{Z(ac)} = 0.1 I_{Z(dc)}$  with the ac frequency = 60 Hz.

## 5. TEMPERATURE COEFFICIENT ( $\theta_{VZ}$ ) \*

Test conditions for temperature coefficient are as follows:

- $I_{ZT} = 7.5\text{ mA}$ ,  $T_1 = 25^\circ\text{C}$ ,  $T_2 = 125^\circ\text{C}$  (1N5221B through 1N5242B)
- $I_{ZT} = \text{Rated } I_{ZT}$ ,  $T_1 = 25^\circ\text{C}$ ,  $T_2 = 125^\circ\text{C}$  (1N5243B through 1N5281B)

Device to be temperature stabilized with current applied prior to reading breakdown voltage at the specified ambient temperature.

\* For more information on special selections contact your nearest ON Semiconductor representative.

# 1N5221B Series

**ELECTRICAL CHARACTERISTICS** ( $T_A = 25^\circ\text{C}$  unless otherwise noted, Based on dc measurements at thermal equilibrium; lead length = 3/8"; thermal resistance of heat sink =  $30^\circ\text{C/W}$ ,  $V_F = 1.1\text{ V Max}$  @  $I_F = 200\text{ mA}$  for all types) (continued)

Device (Note 6.)	Device Marking	Zener Voltage (Note 7.)				Zener Impedance (Note 8.)			Leakage Current		$\theta_{VZ}$ (Note 9.)
		$V_Z$ (Volts)			@ $I_{ZT}$	$Z_{ZT}$ @ $I_{ZT}$	$Z_{ZK}$ @ $I_{ZK}$		$I_R$ @ $V_R$		
		Min	Nom	Max	mA	$\Omega$	$\Omega$	mA	$\mu\text{A}$	Volts	$\%^\circ\text{C}$
1N5236B <b>1N5237B</b>	1N5236B <b>1N5237B</b>	7.13 <b>7.79</b>	7.5 <b>8.2</b>	7.87 <b>8.61</b>	20 <b>20</b>	6 <b>8</b>	500 <b>500</b>	0.25 <b>0.25</b>	3 <b>3</b>	6 <b>6.5</b>	0.058 <b>0.062</b>
1N5238B 1N5239B <b>1N5240B</b>	1N5238B 1N5239B <b>1N5240B</b>	8.265 8.65 <b>9.5</b>	8.7 9.1 <b>10</b>	9.135 9.55 <b>10.5</b>	20 20 <b>20</b>	8 10 <b>17</b>	600 600 <b>600</b>	0.25 0.25 <b>0.25</b>	3 3 <b>3</b>	6.5 7 <b>8</b>	0.065 0.068 <b>0.075</b>
1N5241B <b>1N5242B</b>	1N5241B <b>1N5242B</b>	10.45 <b>11.4</b>	11 <b>12</b>	11.55 <b>12.6</b>	20 <b>20</b>	22 <b>30</b>	600 <b>600</b>	0.25 <b>0.25</b>	2 <b>1</b>	8.4 <b>9.1</b>	0.076 <b>0.077</b>
1N5243B 1N5244B <b>1N5245B</b>	1N5243B 1N5244B <b>1N5245B</b>	12.35 13.3 <b>14.25</b>	13 14 <b>15</b>	13.65 14.7 <b>15.75</b>	9.5 9 <b>8.5</b>	13 15 <b>16</b>	600 600 <b>600</b>	0.25 0.25 <b>0.25</b>	0.5 0.1 <b>0.1</b>	9.9 10 <b>11</b>	0.079 0.082 <b>0.082</b>
<b>1N5246B</b>	<b>1N5246B</b>	<b>15.2</b>	<b>16</b>	<b>16.8</b>	<b>7.8</b>	<b>17</b>	<b>600</b>	<b>0.25</b>	<b>0.1</b>	<b>12</b>	<b>0.083</b>
1N5247B 1N5248B 1N5249B <b>1N5250B</b>	1N5247B 1N5248B 1N5249B <b>1N5250B</b>	16.15 17.1 18.05 <b>19</b>	17 18 19 <b>20</b>	17.85 18.9 19.95 <b>21</b>	7.4 7 <b>6.2</b>	19 21 23 <b>25</b>	600 600 600 <b>600</b>	0.25 0.25 0.25 <b>0.25</b>	0.1 0.1 0.1 <b>0.1</b>	13 14 14 <b>15</b>	0.084 0.085 0.086 <b>0.086</b>
1N5251B 1N5252B 1N5253B 1N5254B 1N5255B	1N5251B 1N5252B 1N5253B 1N5254B 1N5255B	20.9 22.8 23.75 25.65 26.6	22 24 25 27 28	23.1 25.2 26.25 28.35 29.4	5.6 5.2 5.0 4.6 4.5	29 33 35 41 44	600 600 600 600 600	0.25 0.25 0.25 0.25 0.25	0.1 0.1 0.1 0.1 0.1	17 18 19 21 21	0.087 0.088 0.089 0.090 0.091
1N5256B 1N5257B 1N5258B 1N5259B 1N5260B	1N5256B 1N5257B 1N5258B 1N5259B 1N5260B	28.5 31.35 34.2 37.05 40.85	30 33 36 39 43	31.5 34.65 37.8 40.95 45.15	4.2 3.8 3.4 3.2 3.0	49 58 70 80 93	600 700 700 800 900	0.25 0.25 0.25 0.25 0.25	0.1 0.1 0.1 0.1 0.1	23 25 27 30 33	0.091 0.092 0.093 0.094 0.095
1N5261B 1N5262B 1N5263B 1N5264B 1N5265B	1N5261B 1N5262B 1N5263B 1N5264B 1N5265B	44.65 48.45 53.2 57 58.9	47 51 56 60 62	49.35 53.55 58.8 63 65.1	2.7 2.5 2.2 2.1 2.0	105 125 150 170 185	1000 1100 1300 1400 1400	0.25 0.25 0.25 0.25 0.25	0.1 0.1 0.1 0.1 0.1	36 39 43 46 47	0.095 0.096 0.096 0.097 0.097
1N5266B 1N5267B 1N5268B 1N5269B 1N5270B	1N5266B 1N5267B 1N5268B 1N5269B 1N5270B	64.6 71.25 77.9 82.65 86.45	68 75 82 87 91	71.4 78.75 86.1 91.35 95.55	1.8 1.7 1.5 1.4 1.4	230 270 330 370 400	1600 1700 2000 2200 2300	0.25 0.25 0.25 0.25 0.25	0.1 0.1 0.1 0.1 0.1	52 56 62 68 69	0.097 0.098 0.098 0.099 0.099

## 6. TOLERANCE

The JEDEC type numbers shown indicate a tolerance of  $\pm 5\%$ .

## 7. ZENER VOLTAGE ( $V_Z$ ) MEASUREMENT

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

## 8. 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  $I_{Z(ac)} = 0.1 I_{Z(dc)}$  with the ac frequency = 60 Hz.

## 9. TEMPERATURE COEFFICIENT ( $\theta_{VZ}$ ) \*

Test conditions for temperature coefficient are as follows:

- $I_{ZT} = 7.5\text{ mA}$ ,  $T_1 = 25^\circ\text{C}$ ,  $T_2 = 125^\circ\text{C}$  (1N5221B through 1N5242B)
- $I_{ZT} = \text{Rated } I_{ZT}$ ,  $T_1 = 25^\circ\text{C}$ ,  $T_2 = 125^\circ\text{C}$  (1N5243B through 1N5281B)

Device to be temperature stabilized with current applied prior to reading breakdown voltage at the specified ambient temperature.

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# 1N5221B Series

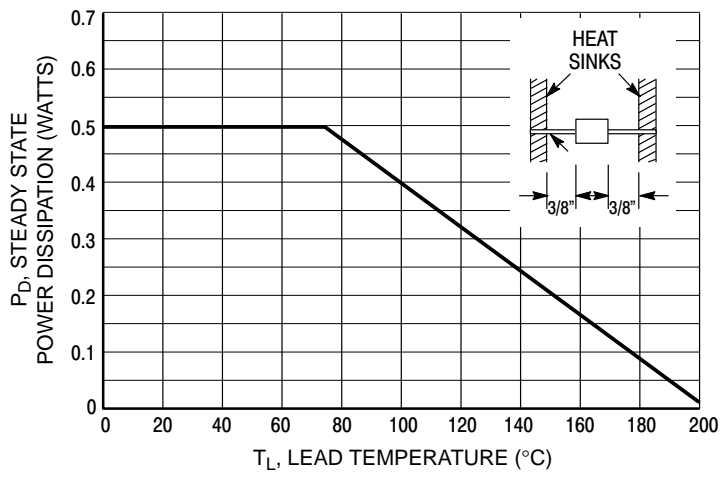


Figure 1. Steady State Power Derating

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.

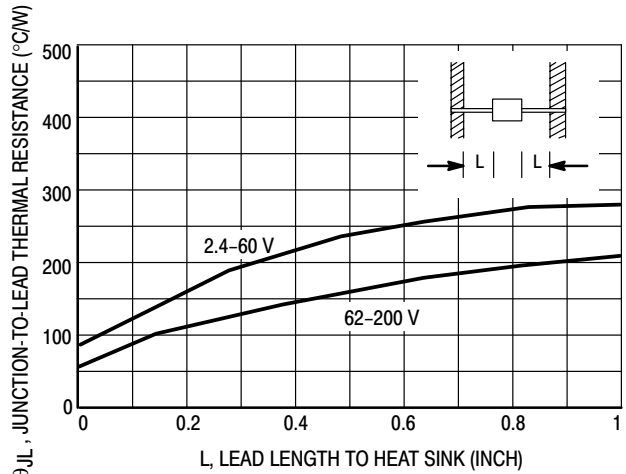


Figure 2. Typical Thermal Resistance

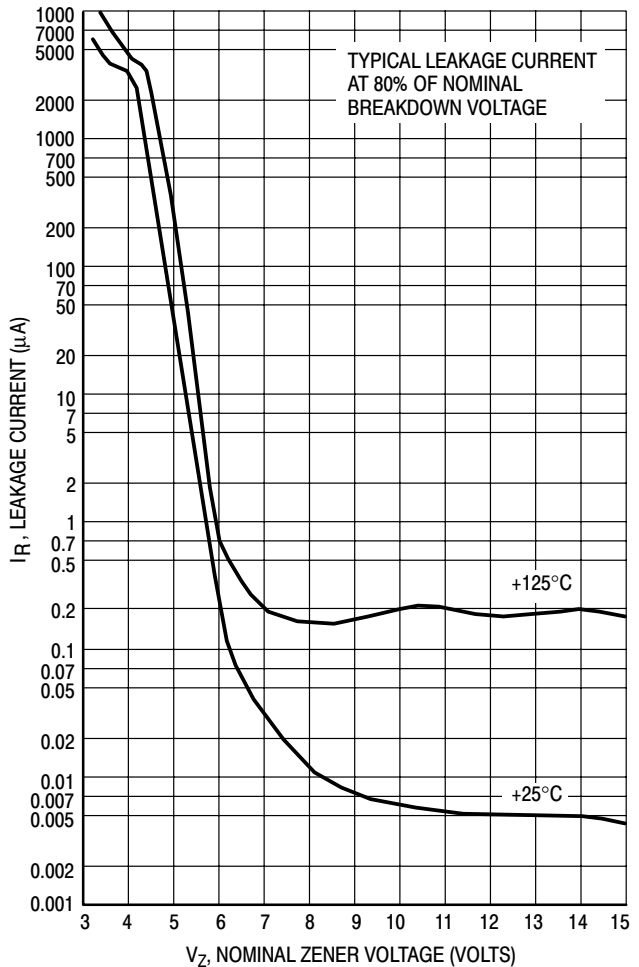


Figure 3. Typical Leakage Current

# 1N5221B Series

## TEMPERATURE COEFFICIENTS

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

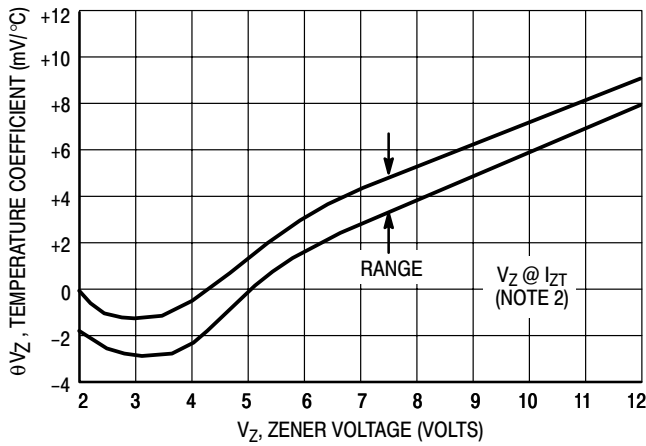


Figure 4a. Range for Units to 12 Volts

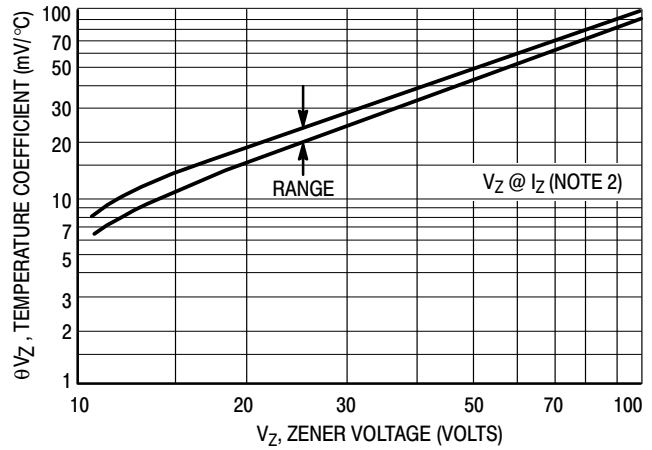


Figure 4b. Range for Units 12 to 100 Volts

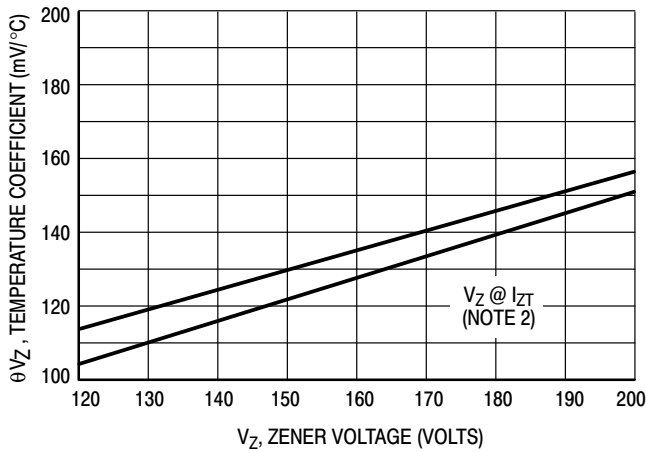


Figure 4c. Range for Units 120 to 200 Volts

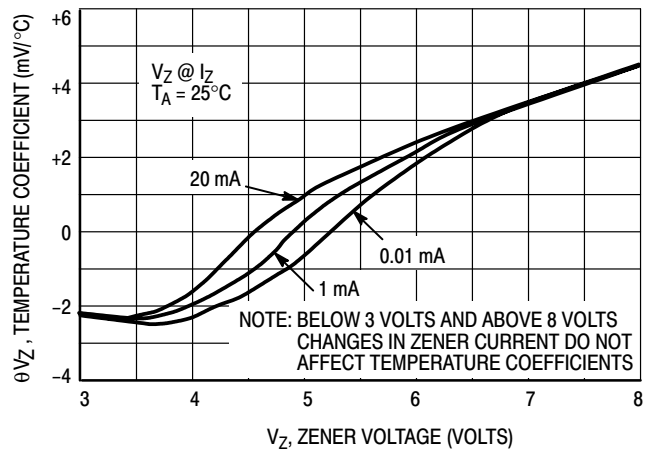


Figure 5. Effect of Zener Current

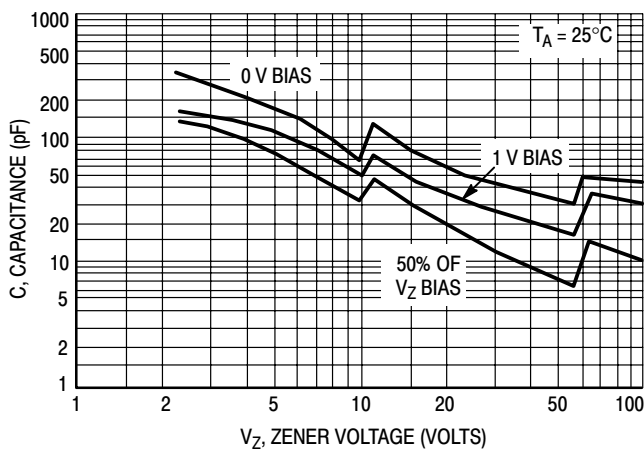


Figure 6a. Typical Capacitance 2.4–100 Volts

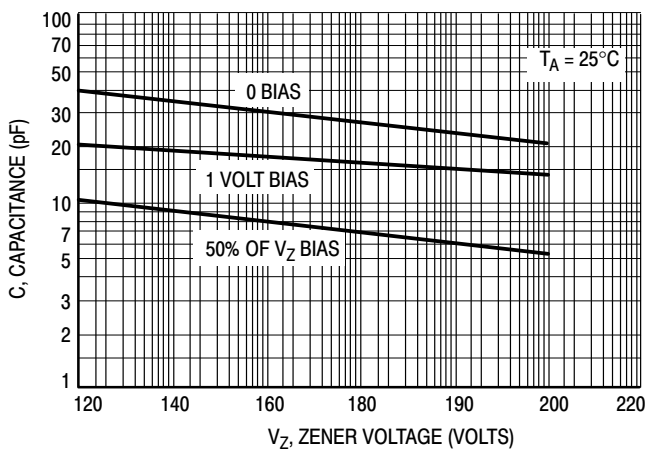


Figure 6b. Typical Capacitance 120–200 Volts

# 1N5221B Series

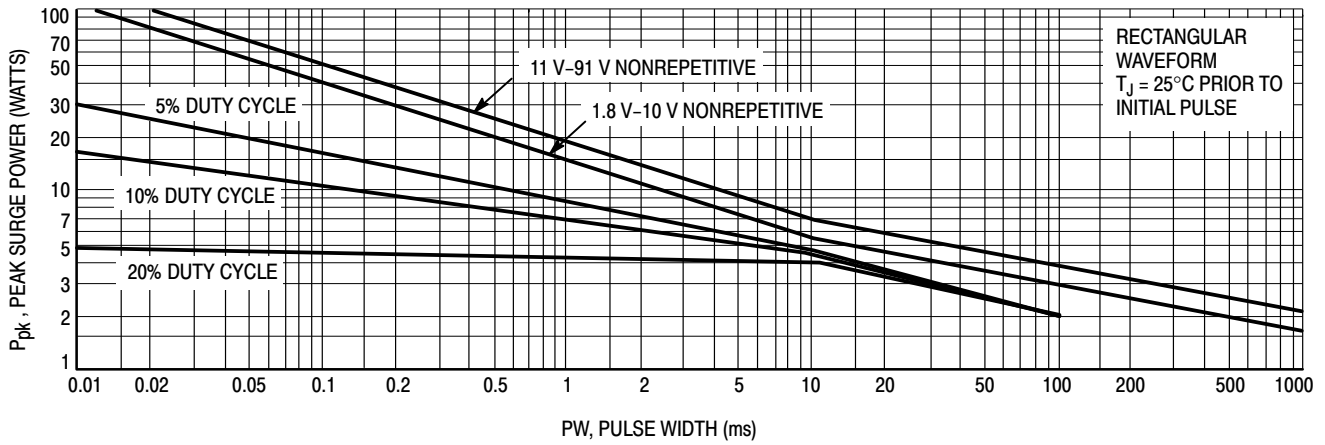


Figure 7a. Maximum Surge Power 1.8-91 Volts

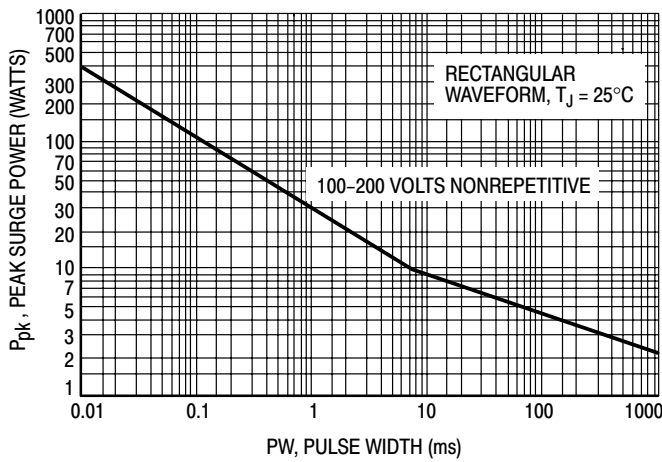


Figure 7b. Maximum Surge Power DO-204AH 100-200 Volts

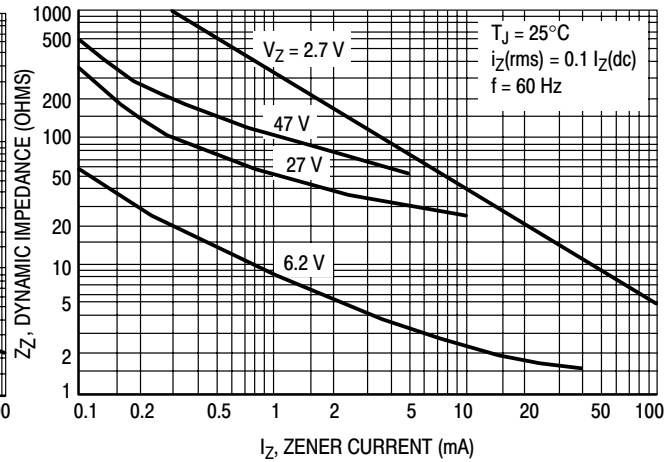


Figure 8. Effect of Zener Current on Zener Impedance

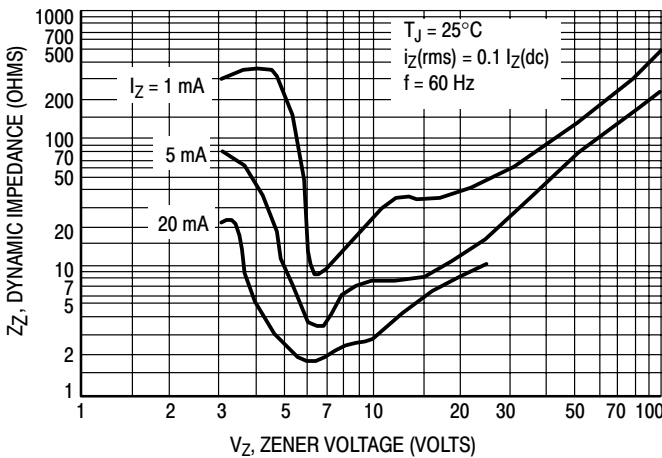


Figure 9. Effect of Zener Voltage on Zener Impedance

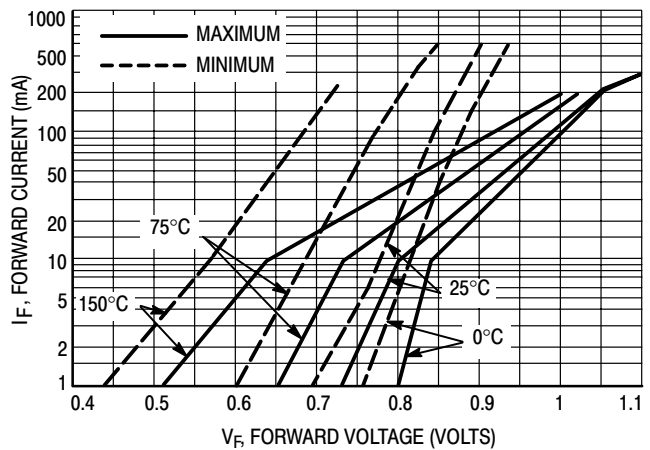


Figure 10. Typical Forward Characteristics

# 1N5221B Series

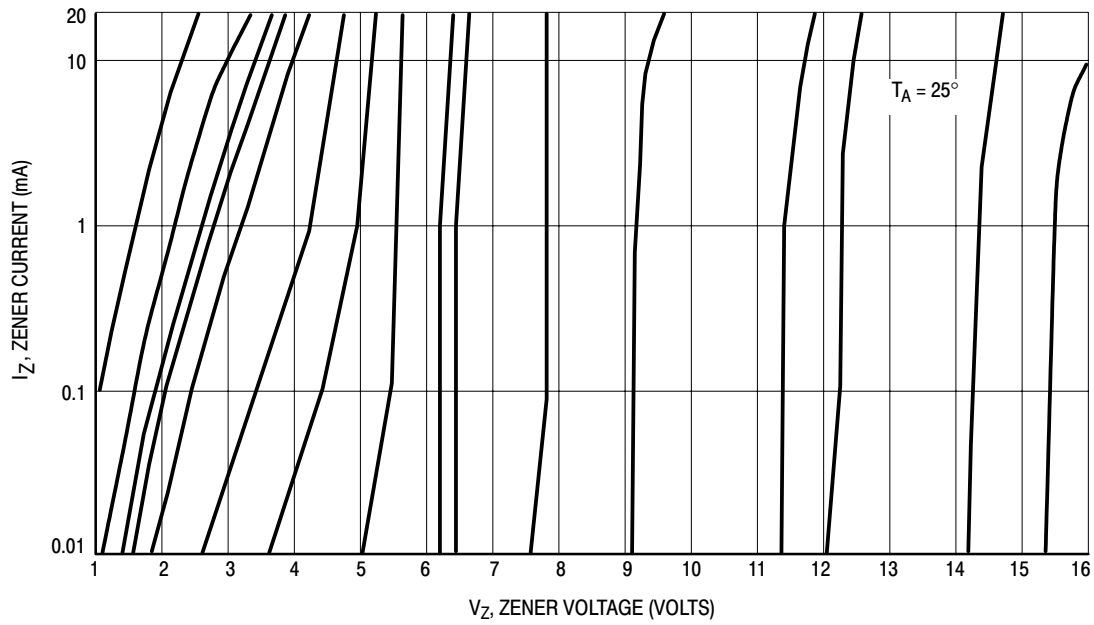


Figure 11. Zener Voltage versus Zener Current —  $V_Z = 1$  thru 16 Volts

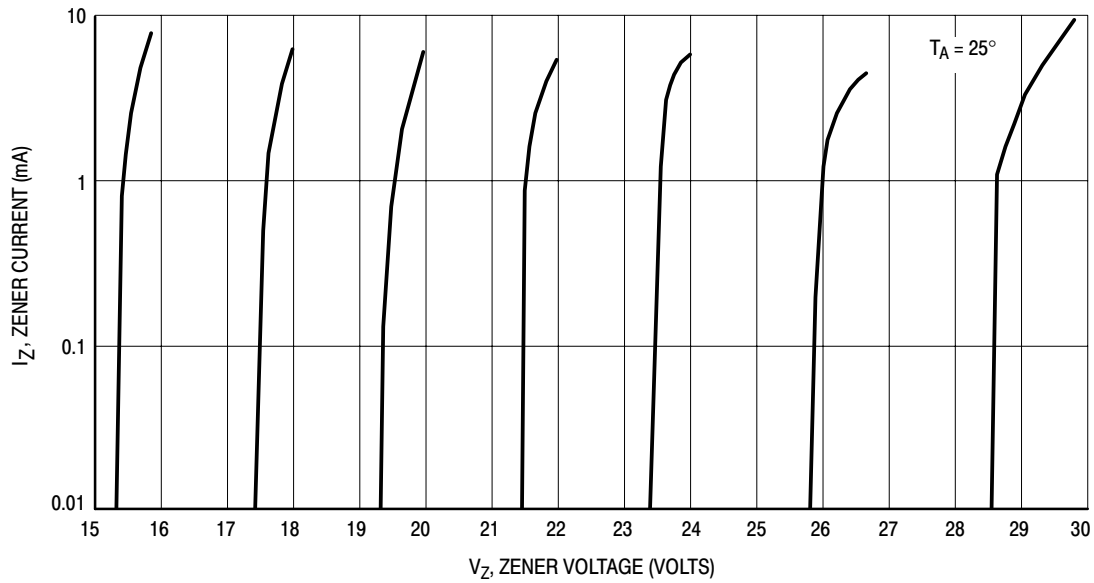


Figure 12. Zener Voltage versus Zener Current —  $V_Z = 15$  thru 30 Volts



# 1N5221B Series

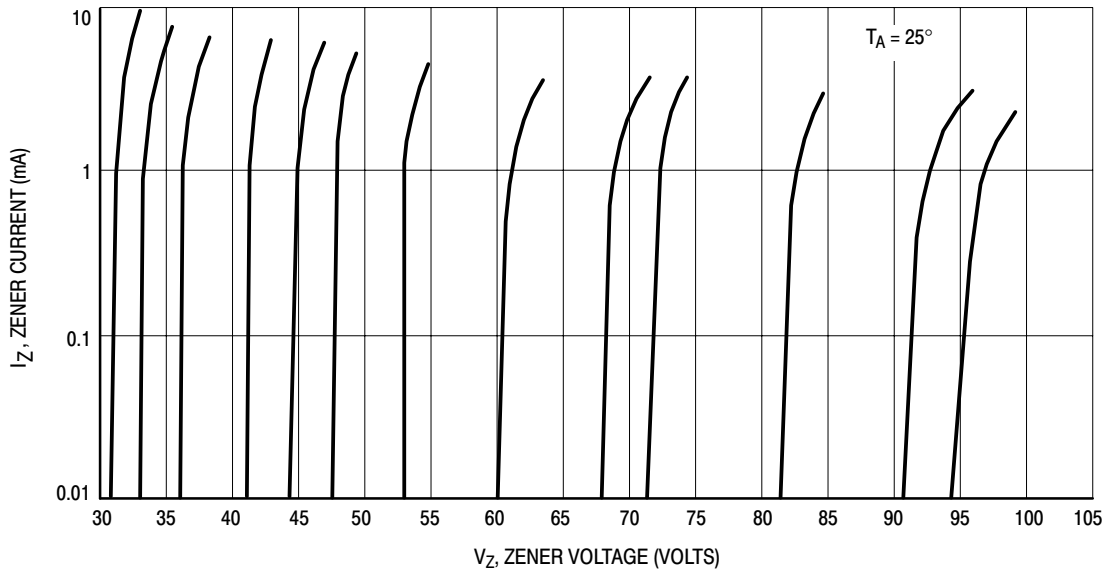


Figure 13. Zener Voltage versus Zener Current —  $V_Z = 30$  thru 105 Volts

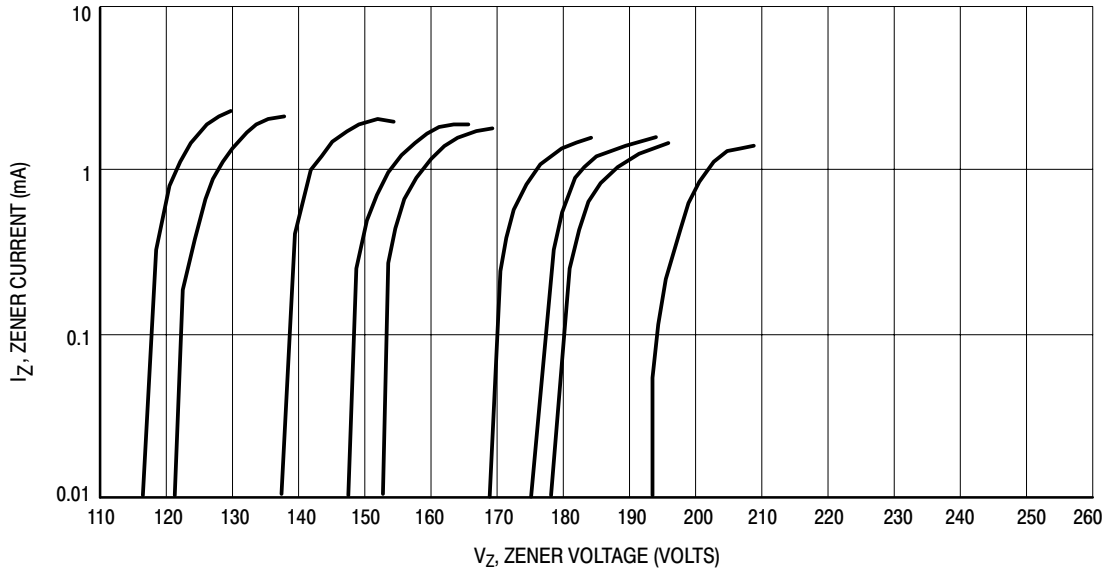


Figure 14. Zener Voltage versus Zener Current —  $V_Z = 110$  thru 220 Volts

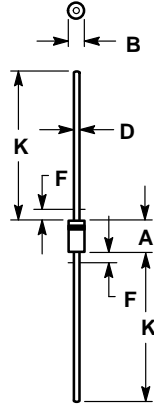
# 1N5221B Series

## OUTLINE DIMENSIONS

# Zener Voltage Regulators – Axial Leaded

## 500 mW DO–35 Glass

GLASS DO–35/D0–204AH  
CASE 299–02  
ISSUE A



- 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.

**Notes**

# 1N5221B Series

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