

# 1N4678 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 – 1.8 V to 27 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.)

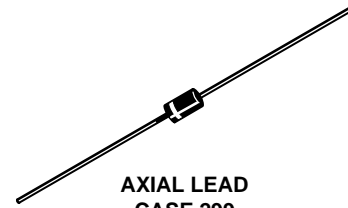
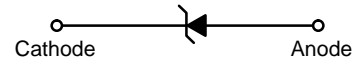
Rating	Symbol	Value	Unit
Max. Steady State Power Dissipation @ $T_L \leq 75^\circ\text{C}$ , Lead Length = 3/8" Derate above 75°C	$P_D$	500	mW
		4.0	mW/°C
Operating and Storage Temperature Range	$T_J, T_{stg}$	-65 to +200	°C

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



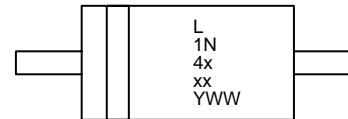
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AXIAL LEAD  
CASE 299  
GLASS

### MARKING DIAGRAM



L = Assembly Location  
 1N4xxx = Device Code  
 (See Table Next Page)  
 Y = Year  
 WW = Work Week

### ORDERING INFORMATION

Device	Package	Shipping
1N4xxx	Axial Lead	3000 Units/Box
1N4xxxRL	Axial Lead	5000/Tape & Reel
1N4xxxRL2 *	Axial Lead	5000/Tape & Reel
1N4xxxTA	Axial Lead	5000/Ammo Pack
1N4xxxTA2 *	Axial Lead	5000/Tape & Reel
1N4xxxRR1 †	Axial Lead	3000/Tape & Reel
1N4xxxRR2 ‡	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

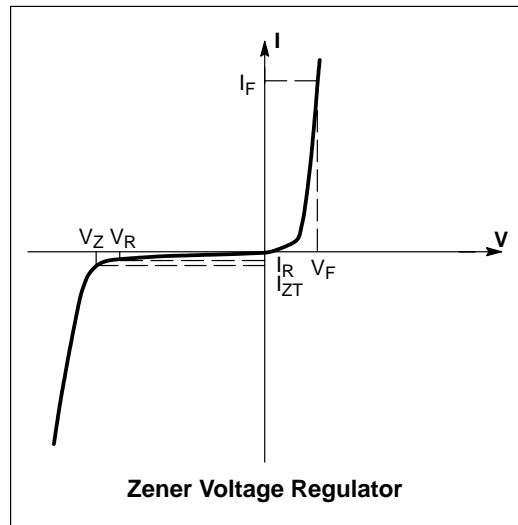
Devices listed in **bold, italic** are ON Semiconductor **Preferred** devices. **Preferred** devices are recommended choices for future use and best overall value.

# 1N4678 Series

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

**ELECTRICAL CHARACTERISTICS** ( $T_A = 25^\circ\text{C}$  unless otherwise noted,  $V_F = 1.5\text{ V Max @ } I_F = 100\text{ mA}$  for all types)

Symbol	Parameter
$V_Z$	Reverse Zener Voltage @ $I_{ZT}$
$I_{ZT}$	Reverse Current
$\Delta V_Z$	Reverse Zener Voltage Change
$I_{ZM}$	Maximum Zener Current
$I_R$	Reverse Leakage Current @ $V_R$
$V_R$	Breakdown Voltage
$I_F$	Forward Current
$V_F$	Forward Voltage @ $I_F$



# 1N4678 Series

**ELECTRICAL CHARACTERISTICS** ( $T_L = 30^\circ\text{C}$  unless otherwise noted,  $V_F = 1.5\text{ V Max}$  @  $I_F = 100\text{ mA}$  for all types)

Device (Note 2.)	Device Marking	Zener Voltage (Note 3.)			Leakage Current (Note 4.)			$I_{ZM}$ (Note 5.)	$\Delta V_Z$ (Note 6.)
		$V_Z$ (Volts)			@ $I_{ZT}$	$I_R$ @ $V_R$			
		Min	Nom	Max	$\mu\text{A}$	$\mu\text{A Max}$	Volts	mA	Volts
1N4678	1N4678	1.71	1.8	1.89	50	7.5	1	120	0.7
1N4679	1N4679	1.9	2.0	2.1	50	5	1	110	0.7
1N4680	1N4680	2.09	2.2	2.31	50	5	1	100	0.75
1N4681	1N4681	2.28	2.4	2.52	50	2	1	95	0.8
1N4682	1N4682	2.565	2.7	2.835	50	1	1	90	0.85
1N4683	1N4683	2.85	3.0	3.15	50	0.8	1	85	0.9
1N4684	1N4684	3.135	3.3	3.465	50	7.5	1.5	80	0.95
1N4685	1N4685	3.42	3.6	3.78	50	7.5	2	75	0.95
1N4686	1N4686	3.705	3.9	4.095	50	5.0	2	70	0.97
1N4687	1N4687	4.085	4.3	4.515	50	4.0	2	65	0.99
<b>1N4688</b>	<b>1N4688</b>	<b>4.465</b>	<b>4.7</b>	<b>4.935</b>	<b>50</b>	<b>10</b>	<b>3</b>	<b>60</b>	<b>0.99</b>
1N4689	1N4689	4.845	5.1	5.355	50	10	3	55	0.97
1N4690	1N4690	5.32	5.6	5.88	50	10	4	50	0.96
1N4691	1N4691	5.89	6.2	6.51	50	10	5	45	0.95
1N4692	1N4692	6.46	6.8	7.14	50	10	5.1	35	0.9
1N4693	1N4693	7.125	7.5	7.875	50	10	5.7	31.8	0.75
1N4694	1N4694	7.79	8.2	8.61	50	1	6.2	29	0.5
1N4695	1N4695	8.265	8.7	9.135	50	1	6.6	27.4	0.1
1N4696	1N4696	8.645	9.1	9.555	50	1	6.9	26.2	0.08
1N4697	1N4697	9.5	10	10.5	50	1	7.6	24.8	0.1
1N4698	1N4698	10.45	11	11.55	50	0.05	8.4	21.6	0.11
1N4699	1N4699	11.4	12	12.6	50	0.05	9.1	20.4	0.12
1N4700	1N4700	12.35	13	13.65	50	0.05	9.8	19	0.13
1N4701	1N4701	13.3	14	14.7	50	0.05	10.6	17.5	0.14
1N4702	1N4702	14.25	15	15.75	50	0.05	11.4	16.3	0.15
1N4703	1N4703	15.2	16	16.8	50	0.05	12.1	15.4	0.16
1N4704	1N4704	16.15	17	17.85	50	0.05	12.9	14.5	0.17
1N4705	1N4705	17.1	18	18.9	50	0.05	13.6	13.2	0.18
1N4707	1N4707	19	20	21	50	0.01	15.2	11.9	0.2
1N4711	1N4711	25.65	27	28.35	50	0.01	20.4	8.8	0.27

**2. TOLERANCE AND TYPE NUMBER DESIGNATION ( $V_Z$ )**

The type numbers listed have a standard tolerance of  $\pm 5\%$  on the nominal zener voltage.

**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. REVERSE LEAKAGE CURRENT ( $I_R$ )**

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

**5. 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.

**6. MAXIMUM VOLTAGE CHANGE ( $\Delta V_Z$ )**

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

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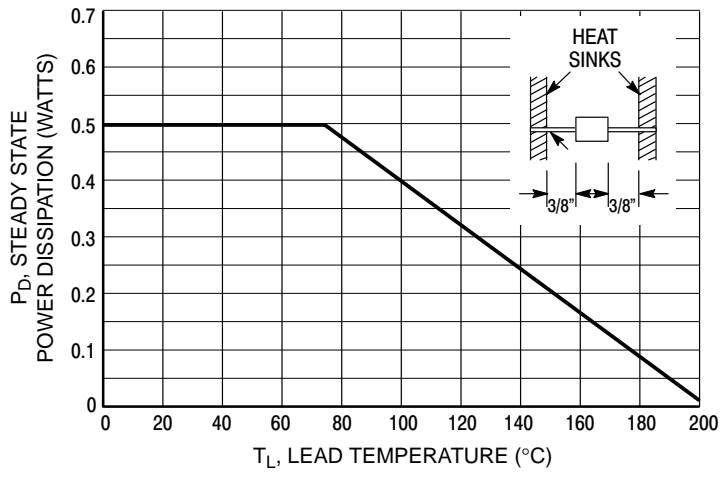


Figure 1. Steady State Power Derating

**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:

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

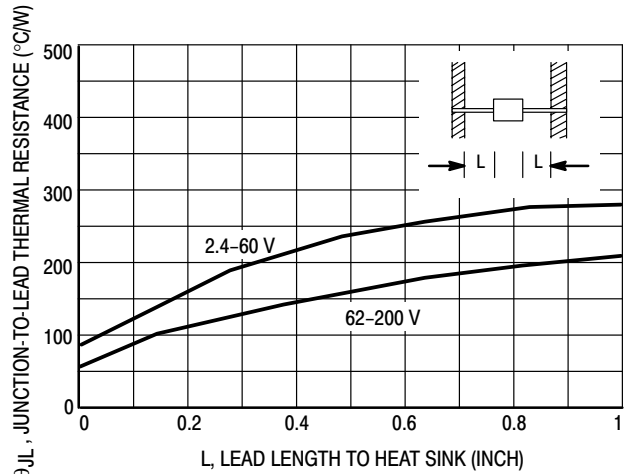
For worst-case design, using expected limits of  $I_Z$ , limits of  $P_D$  and the extremes of  $T_J(\Delta T_J)$  may be estimated. Changes in voltage,  $V_Z$ , can then be found from:

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

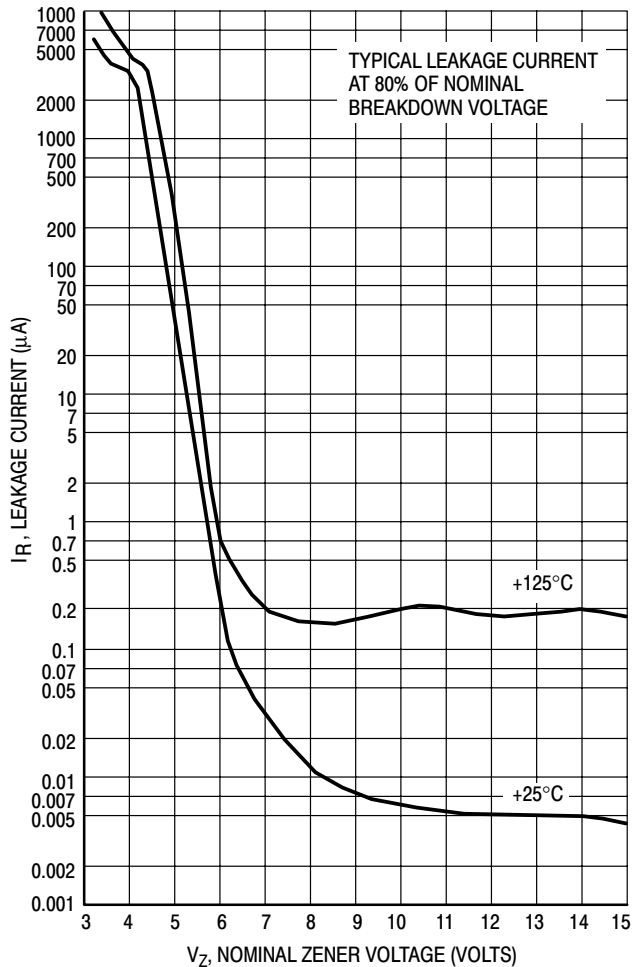
$\theta_{VZ}$ , the zener voltage temperature coefficient, is found from Figures 4 and 5.

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**

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## TEMPERATURE COEFFICIENTS

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

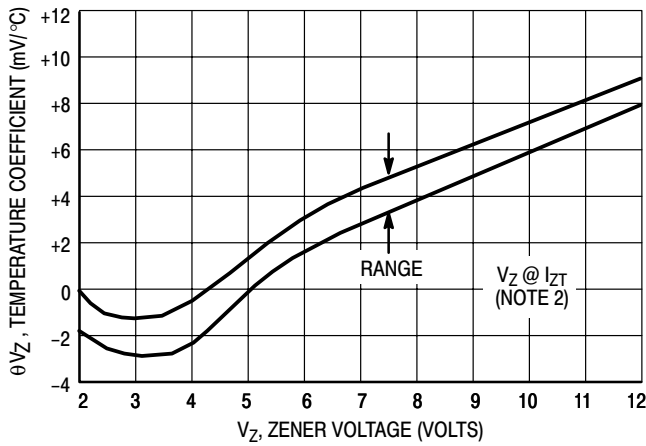


Figure 4a. Range for Units to 12 Volts

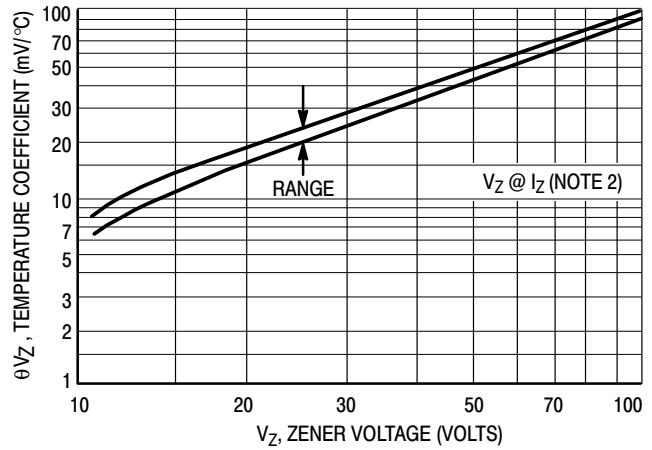


Figure 4b. Range for Units 12 to 100 Volts

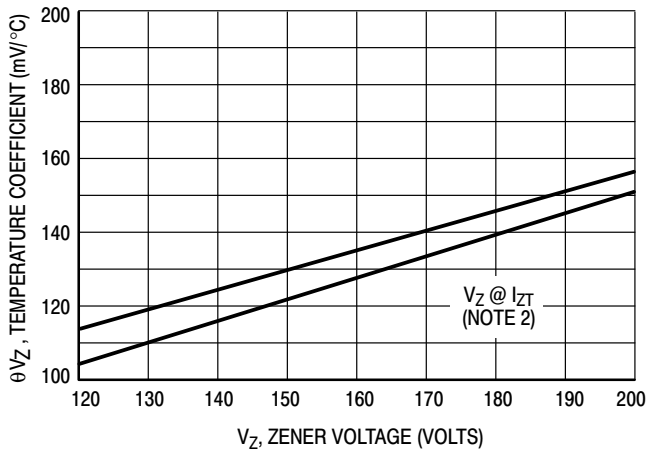


Figure 4c. Range for Units 120 to 200 Volts

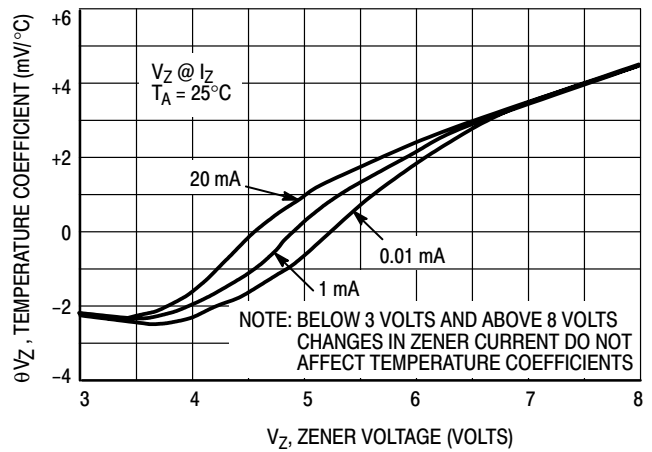


Figure 5. Effect of Zener Current

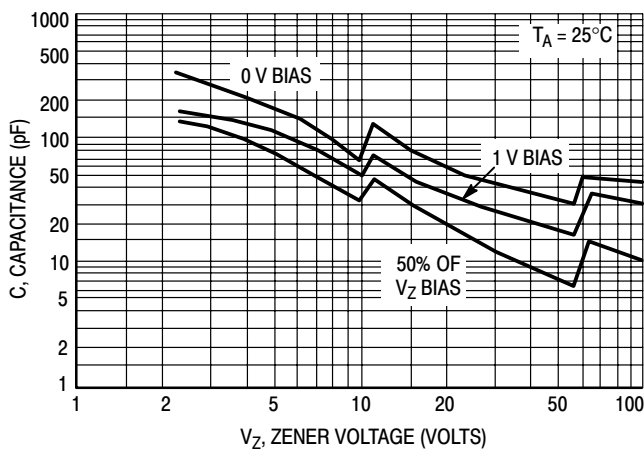


Figure 6a. Typical Capacitance 2.4–100 Volts

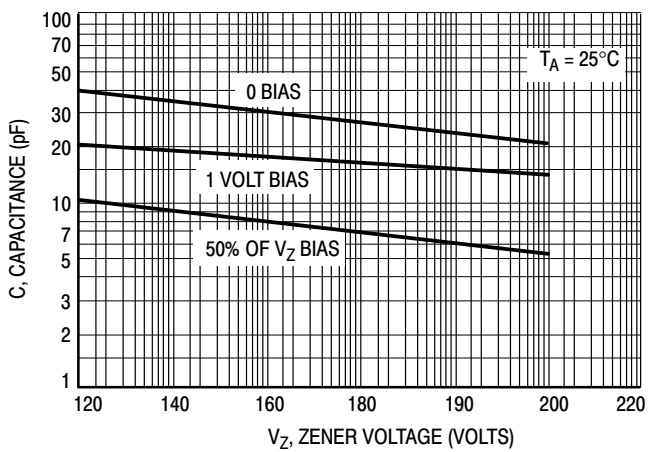


Figure 6b. Typical Capacitance 120–200 Volts

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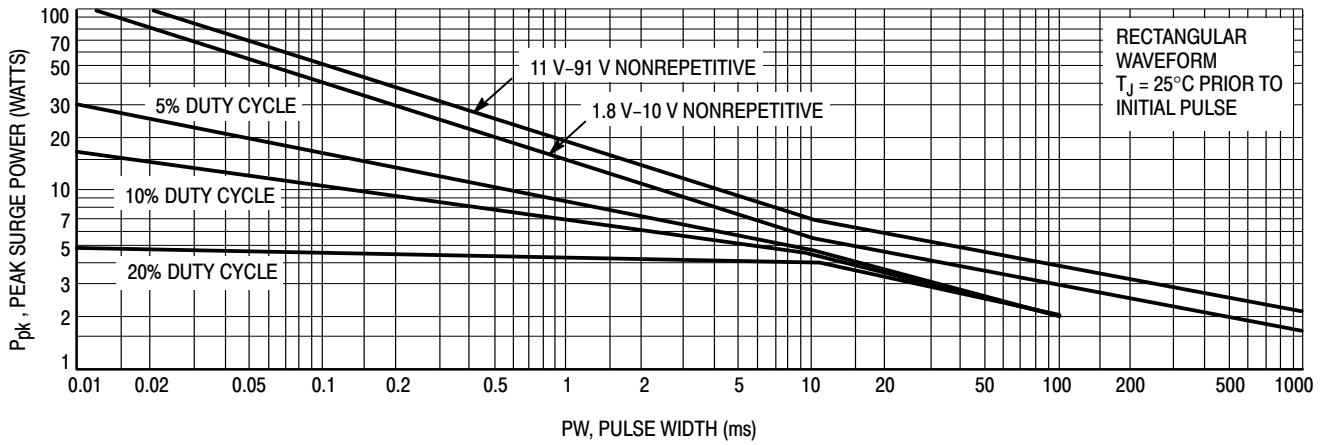


Figure 7a. Maximum Surge Power 1.8-91 Volts

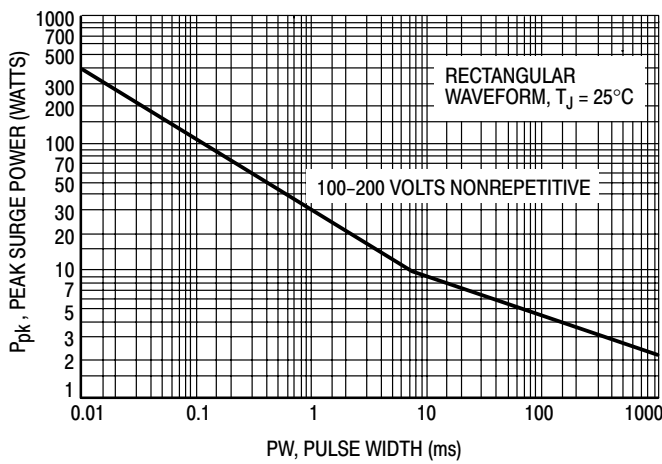


Figure 7b. Maximum Surge Power DO-204AH 100-200 Volts

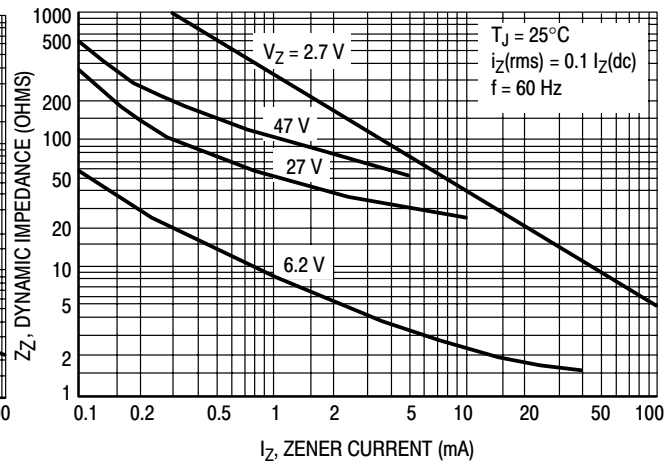


Figure 8. Effect of Zener Current on Zener Impedance

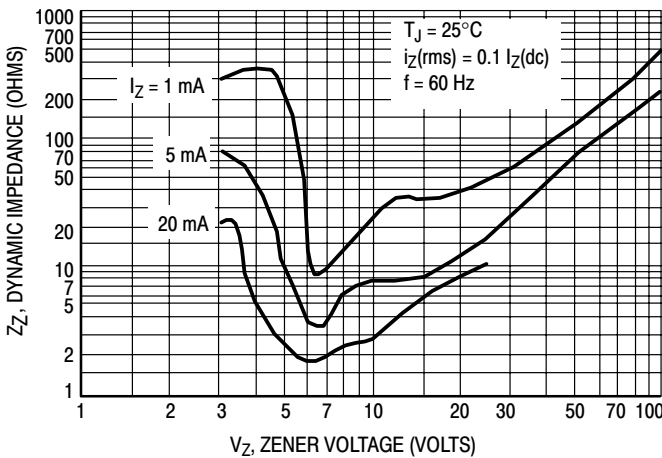


Figure 9. Effect of Zener Voltage on Zener Impedance

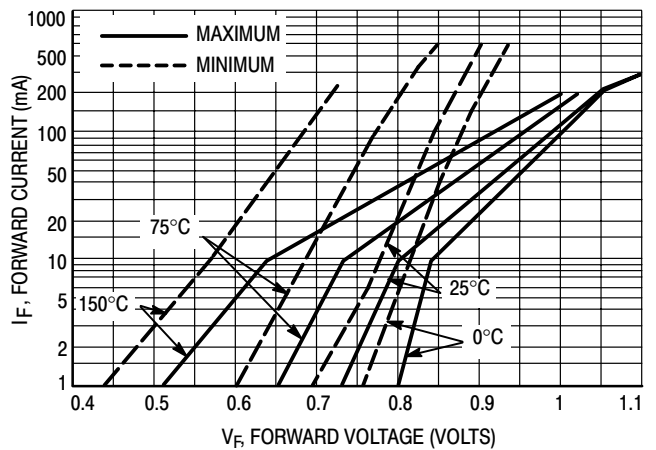


Figure 10. Typical Forward Characteristics

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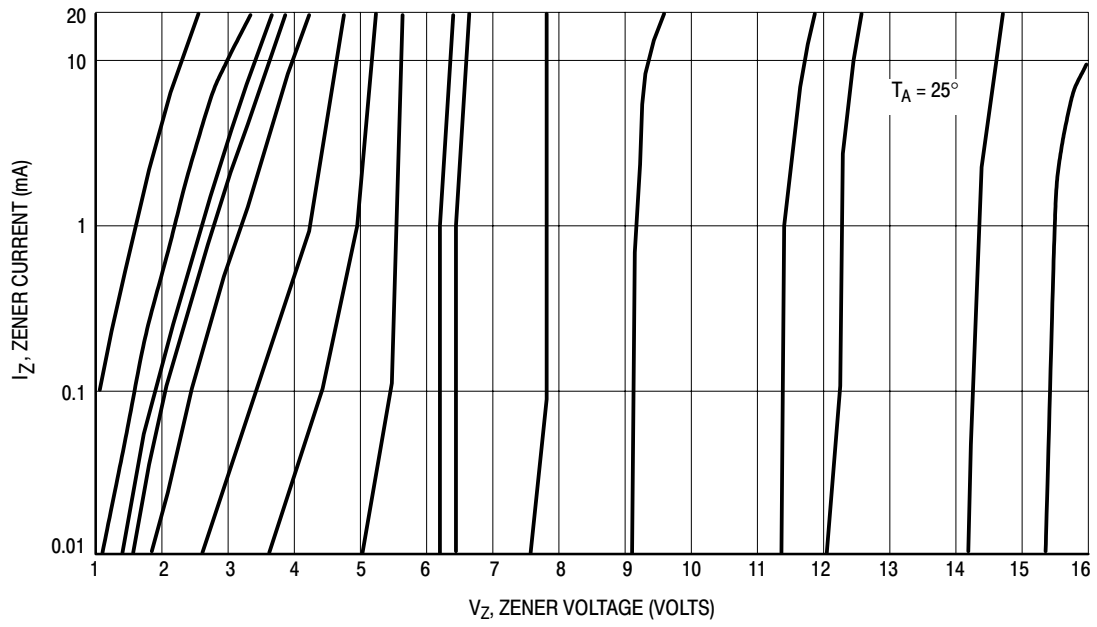


Figure 11. Zener Voltage versus Zener Current —  $V_Z = 1$  thru 16 Volts

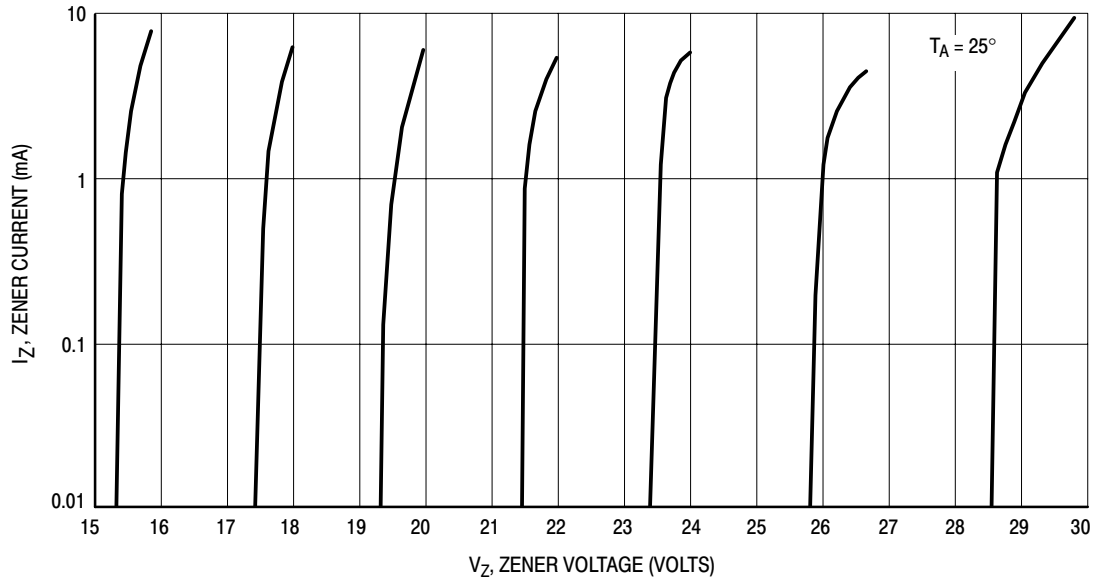


Figure 12. Zener Voltage versus Zener Current —  $V_Z = 15$  thru 30 Volts

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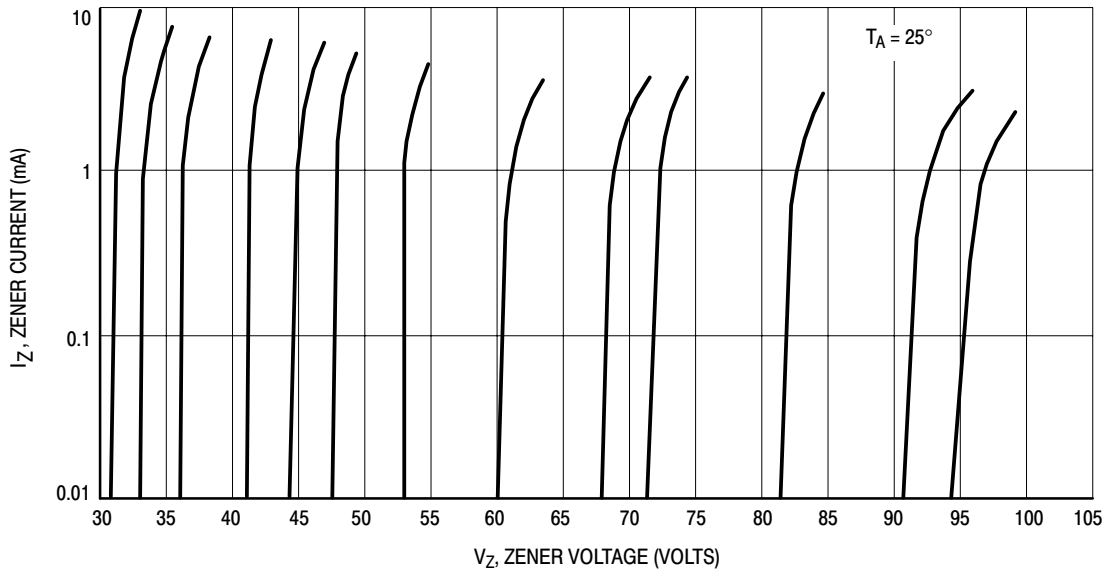


Figure 13. Zener Voltage versus Zener Current —  $V_Z = 30$  thru 105 Volts

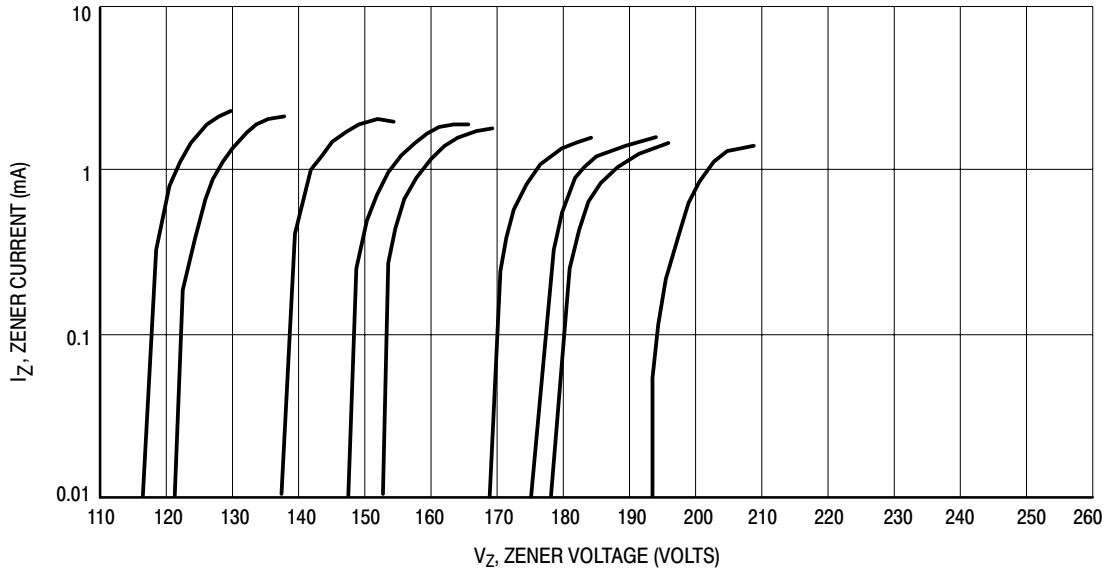


Figure 14. Zener Voltage versus Zener Current —  $V_Z = 110$  thru 220 Volts

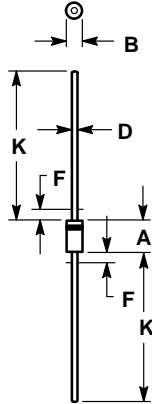
# 1N4678 Series

## 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**

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