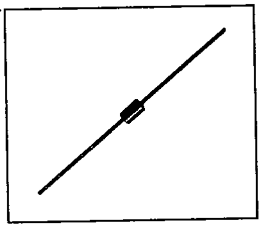
MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

1N5221A, B thru 1N5281A, B

GLASS ZENER DIODES
500 MILLIWATTS
2.4–200 VOLTS



Designer's Data Sheet

500 Milliwatt Hermetically Sealed Glass Silicon Zener Diodes

- Complete Voltage Range — 2.4 to 200 Volts
- DO-204AH Package — Smaller than Conventional DO-204AA Package
- Double Slug Type Construction
- Metallurgically Bonded Construction

Mechanical Characteristics:
CASE: Double slug type, hermetically sealed glass
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 230°C, 1/16″ from case for 10 seconds
FINISH: All external surfaces are corrosion resistant with readily solderable leads
POLARITY: Cathode indicated by color band. When operated in zener mode, cathode will be positive with respect to anode
MOUNTING POSITION: Any

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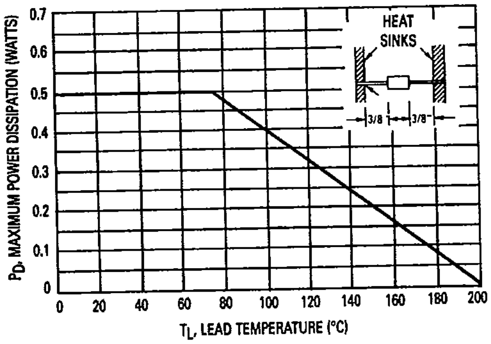


Figure 1. Steady State Power Derating

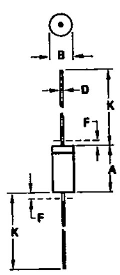
***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_L \leq 75°C$ Lead Length = 3/8″ Derate above T_L = 75°C	P_D	500 4	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

*Indicates JEDEC Registered Data

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 give to facilitate "worst case" design.

OUTLINE DIMENSIONS



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 Y14.5, 1973.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES 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

CASE 299-02
DO-204AH

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted. Based on dc measurements at thermal equilibrium; lead length = 3/8"; thermal resistance of heat sink = 30°C/W) V_F = 1.1 max @ I_F = 200 mA 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 and B Suffix only: Z_{ZT} @ I_{ZT} Ohms	Max Zener Impedance A and B Suffix only: Z_{ZK} @ I_{ZK} = 0.25 mA Ohms	Max Reverse Leakage Current A and B Suffix only: I_R µA	V_R Volts A	V_R Volts B	Non-Suffix: I_R @ V_R Used for Suffix A µA	Max Zener Voltage Temperature Coeff. (A and B Suffix only) θ_{VZ} (%/°C) (Note 3)
1N5221	2.4	20	30	1200	100	0.95	1	200	−0.085
1N5222	2.5	20	30	1250	100	0.95	1	200	−0.085
1N5223	2.7	20	30	1300	75	0.95	1	150	−0.080
1N5224	2.8	20	30	1400	75	0.95	1	150	−0.080
1N5225	3	20	29	1600	50	0.95	1	100	−0.075
1N5226	3.3	20	28	1600	25	0.95	1	100	−0.070
1N5227	3.6	20	24	1700	15	0.95	1	100	−0.065
1N5228	3.9	20	23	1900	10	0.95	1	75	−0.060
1N5229	4.3	20	22	2000	5	0.95	1	50	±0.055
1N5230	4.7	20	19	1900	5	1.9	2	50	±0.030
1N5231	5.1	20	17	1600	5	1.9	2	50	±0.030
1N5232	5.6	20	11	1600	5	2.9	3	50	+0.038
1N5233	6	20	7	1600	5	3.3	3.5	50	+0.038
1N5234	6.2	20	7	1000	5	3.8	4	50	+0.045
1N5235	6.8	20	5	750	3	4.8	5	30	+0.050
1N5236	7.5	20	6	500	3	5.7	6	30	+0.058
1N5237	8.2	20	8	500	3	6.2	6.5	30	+0.062
1N5238	8.7	20	8	600	3	6.2	6.5	30	+0.065
1N5239	9.1	20	10	600	3	6.7	7	30	+0.068
1N5240	10	20	17	600	3	7.6	8	30	+0.075
1N5241	11	20	22	600	2	8	8.4	30	+0.076
1N5242	12	20	30	600	1	8.7	9.1	10	+0.077
1N5243	13	9.5	13	600	0.5	9.4	9.9	10	+0.079
1N5244	14	9	15	600	0.1	9.5	10	10	+0.082
1N5245	15	8.5	16	600	0.1	10.5	11	10	+0.082
1N5246	16	7.8	17	600	0.1	11.4	12	10	+0.083
1N5247	17	7.4	19	600	0.1	12.4	13	10	+0.084
1N5248	18	7	21	600	0.1	13.3	14	10	+0.085
1N5249	19	6.6	23	600	0.1	13.3	14	10	+0.086
1N5250	20	6.2	25	600	0.1	14.3	15	10	+0.086
1N5251	22	5.6	29	600	0.1	16.2	17	10	+0.087
1N5252	24	5.2	33	600	0.1	17.1	18	10	+0.088
1N5253	25	5	35	600	0.1	18.1	19	10	+0.089
1N5254	27	4.6	41	600	0.1	20	21	10	+0.090
1N5255	28	4.5	44	600	0.1	20	21	10	+0.091
1N5256	30	4.2	49	600	0.1	22	23	10	+0.091
1N5257	33	3.8	58	700	0.1	24	25	10	+0.092
1N5258	36	3.4	70	700	0.1	26	27	10	+0.093
1N5259	39	3.2	80	800	0.1	29	30	10	+0.094
1N5260	43	3	93	900	0.1	31	33	10	+0.095
1N5261	47	2.7	105	1000	0.1	34	36	10	+0.095
1N5262	51	2.5	125	1100	0.1	37	39	10	+0.096
1N5263	56	2.2	150	1300	0.1	41	43	10	+0.096
1N5264	60	2.1	170	1400	0.1	44	46	10	+0.097
1N5265	62	2	185	1400	0.1	45	47	10	+0.097
1N5266	68	1.8	230	1600	0.1	49	52	10	+0.097
1N5267	75	1.7	270	1700	0.1	53	56	10	+0.098
1N5268	82	1.5	330	2000	0.1	59	62	10	+0.098
1N5269	87	1.4	370	2200	0.1	65	68	10	+0.099
1N5270	91	1.4	400	2300	0.1	66	69	10	+0.099
1N5271	100	1.3	500	2600	0.1	72	76	10	+0.110
1N5272	110	1.1	750	3000	0.1	80	84	10	+0.110
1N5273	120	1	900	4000	0.1	86	91	10	+0.110
1N5274	130	0.95	1100	4500	0.1	94	99	10	+0.110
1N5275	140	0.9	1300	4500	0.1	101	106	10	+0.110
1N5276	150	0.85	1500	5000	0.1	108	114	10	+0.110
1N5277	160	0.8	1700	5500	0.1	116	122	10	+0.110
1N5278	170	0.74	1900	5500	0.1	116	129	10	+0.110
1N5279	180	0.68	2200	6000	0.1	130	137	10	+0.110
1N5280	190	0.66	2400	6500	0.1	137	144	10	+0.110
1N5281	200	0.65	2500	7000	0.1	144	152	10	+0.110

NOTE 1. Tolerance — The JEDEC type numbers shown indicate a tolerance of ±10% with guaranteed limits on only V_Z, I_R and V_F as shown in the electrical characteristics table. Units with guaranteed limits on all six parameters are indicated by suffix "A" for ±10% tolerance, suffix "B" for ±5%, "C" for ±2% and "D" for ±1%.

NOTE 2. Special Selections† Available Include:
1. Nominal zener voltages between those shown.
2. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make zener voltages in excess of 200 volts possible as well as providing lower temperature coefficients, lower dynamic impedance and greater power handling ability.
3. Nominal voltages at non-standard test currents.

NOTE 3. Temperature Coefficient (θ_{VZ}) — Test conditions for temperature coefficient are as follows:
a. I_{ZT} = 7.5 mA, T_1 = 25°C,
T_2 = 125°C (1N5221A,B through 1N5242A,B).
b. I_{ZT} = Rated I_{ZT}, T_1 = 25°C,
T_2 = 125°C (1N5243A,B through 1N5272A,B).
Device to be temperature stabilized with current applied prior to reading breakdown voltage at the specified ambient temperature.

NOTE 4. Zener Voltage (V_Z) Measurement — Nominal zener voltage is measured with the device junction in thermal equilibrium at the lead temperature of 30°C ±1°C and 3/8" lead length.

NOTE 5. 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 $I_Z(ac) = I_Z(dc)$ with the ac frequency = 60 Hz.

†For more information on special selections contact your nearest Motorola representative.

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 (°C/W) and P_D is the power dissipation. The value for θ_{LA} will vary and depends on the device mounting method. θ_{LA} is generally 30 to 40°C/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:

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

ΔT_{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:

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

θ_{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.

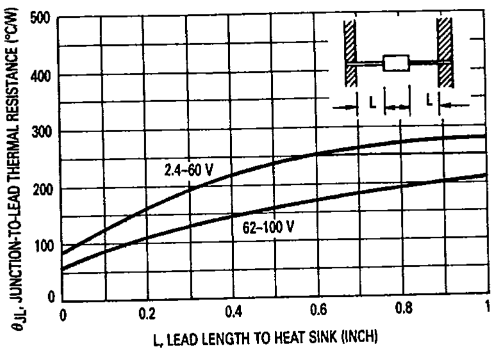


Figure 2. Typical Thermal Resistance

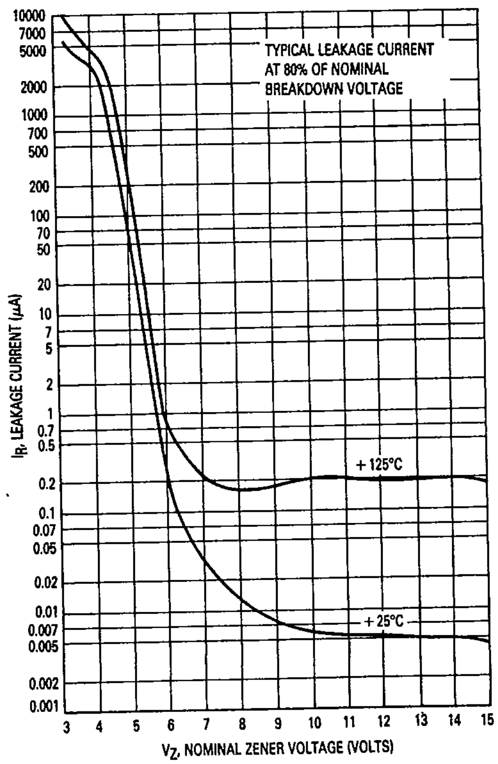


Figure 3. Typical Leakage Current

TEMPERATURE COEFFICIENTS

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

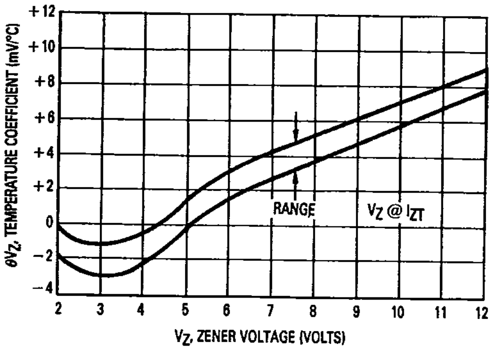


Figure 4a. Range for Units to 12 Volts

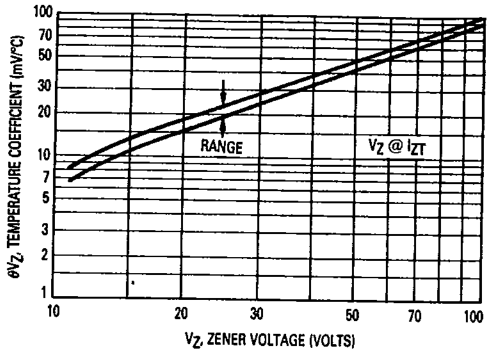


Figure 4b. Range for Units 12 to 100 Volts

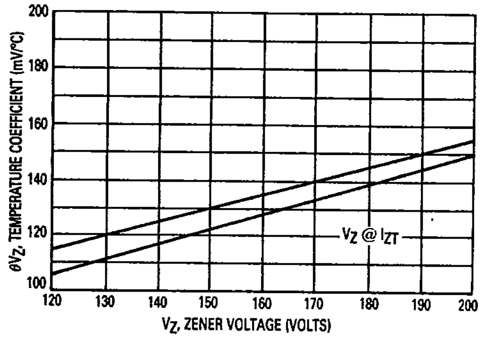


Figure 4c. Range for Units 120 to 200 Volts

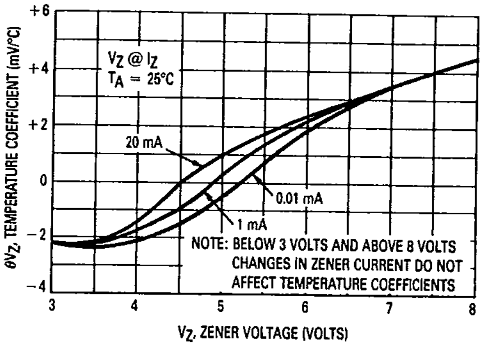


Figure 5. Effect of Zener Current

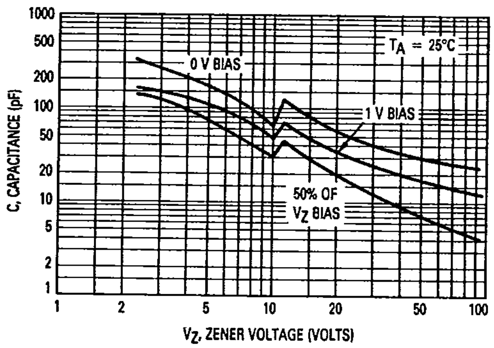


Figure 6a. Typical Capacitance 1–100 Volts

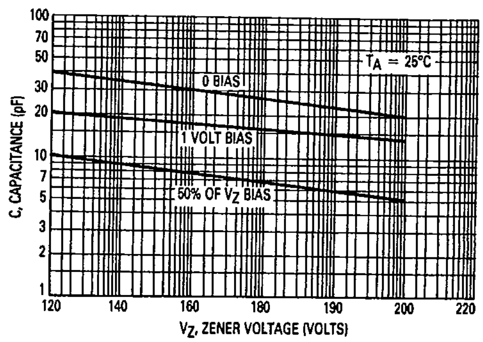


Figure 6b. Typical Capacitance 120–220 Volts

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1N5221A, B thru 1N5281A, B

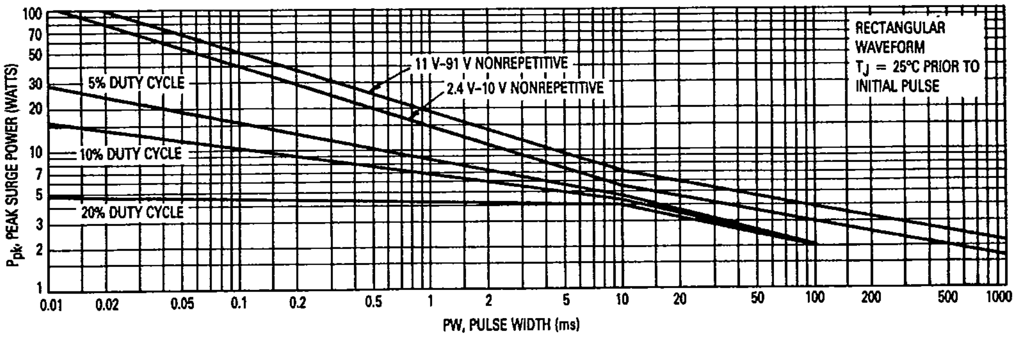

Figure 7a. Maximum Surge Power 2.4–9 Volts

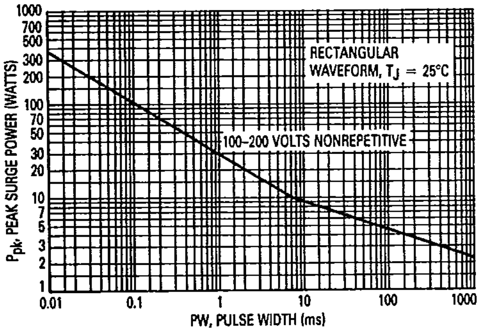

Figure 7b. Maximum Surge Power DO-204AH 100–200 Volts

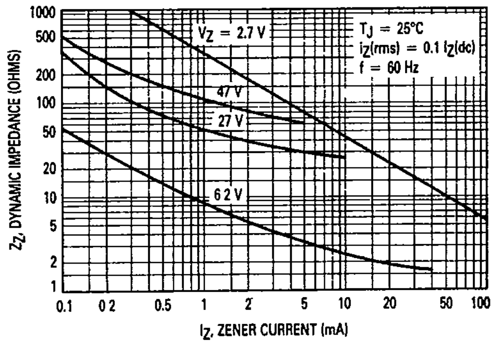

Figure 8. Effect of Zener Current on Zener Impedance

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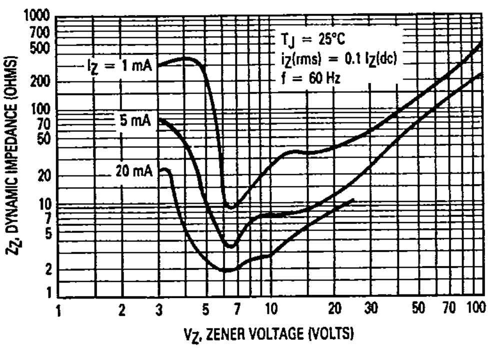


Figure 9. Effect of Zener Voltage on Zener Impedance

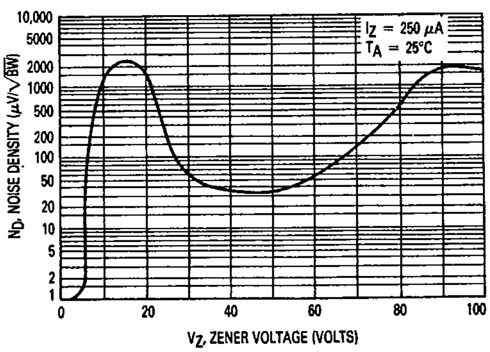
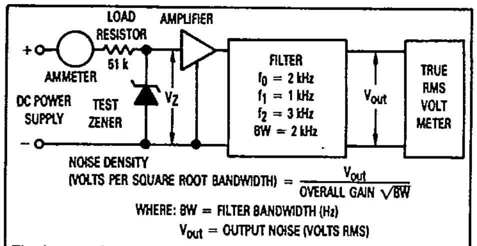


Figure 10. Typical Noise Density



The input voltage and load resistance are high so that the zener diode is driven from a constant current source. The amplifier is low noise so that the amplifier noise is negligible compared to that of the test zener. The filter bandpass is known so that the noise density can be calculated from the formula shown.

Figure 11. Noise Density Measurement Method

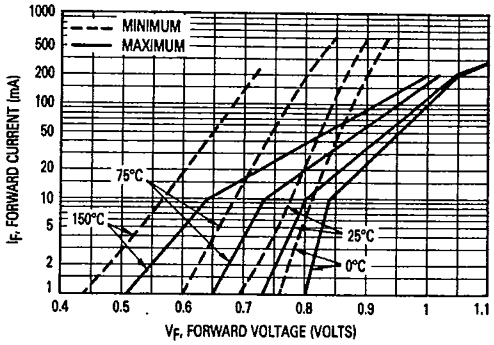


Figure 12. Typical Forward Characteristics

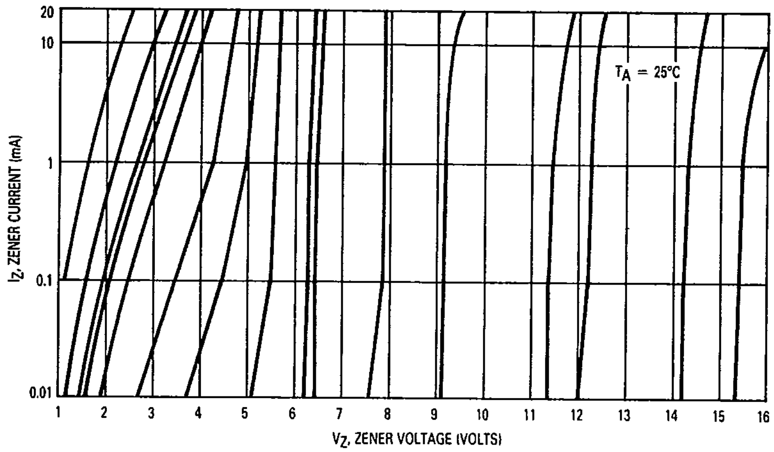


Figure 13. Zener Voltage versus Zener Current — V_Z = 1 thru 16 Volts

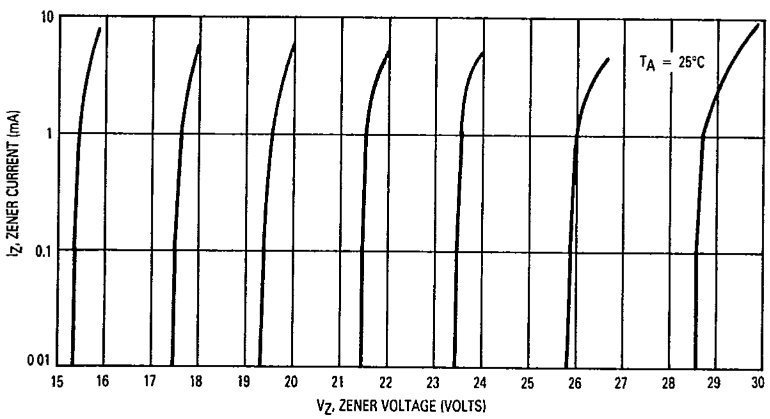


Figure 14. Zener Voltage versus Zener Current — V_Z = 15 thru 30 Volts

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1N5221A, B thru 1N5281A, B

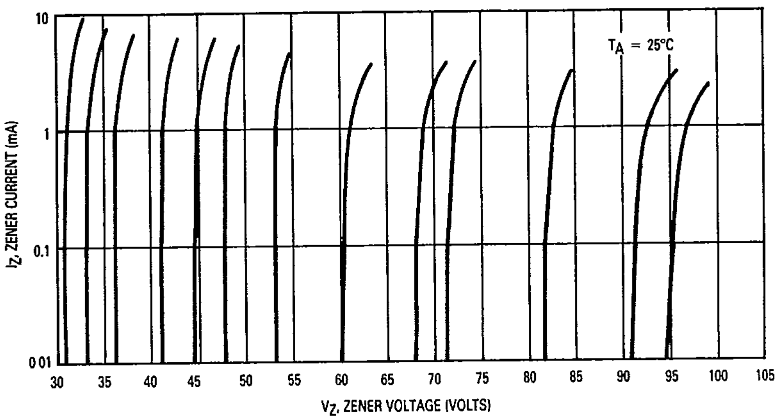

Figure 15. Zener Voltage versus Zener Current — V_Z = 30 thru 105 Volts

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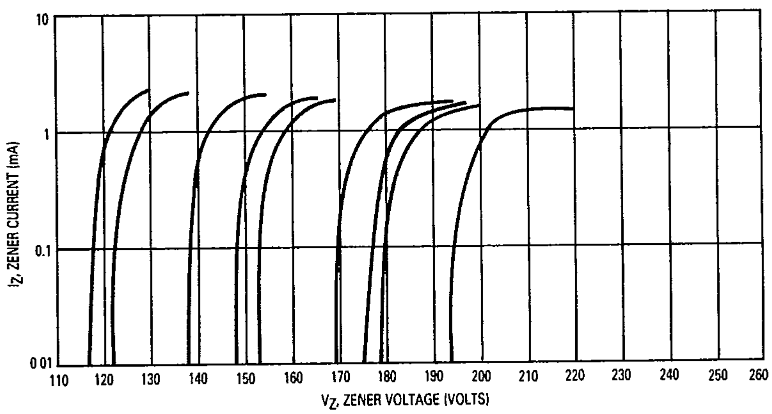

Figure 16. Zener Voltage versus Zener Current — V_Z = 110–220 Volts