"THE AVALANCHE OR REGULATOR DIODE"

By: Wolfgang Prenosil July 1958

Synopsis:

The results of an engineering survey of the Avalanche or Regulator Diode (also called Zener-Diode) requested by F. M. Breene are contained in this report and certain specific characteristics are highlighted.

Introduction:

The term "zener diode" embraces a group of diodes which show the ability to hold a reverse voltage substantially constant over an appreciable range of current values.

The mechanism of the avalanche diode exhibits the following characteristics: by increasing the reverse voltage applied to a diode we reach a point where the dynamic resistance suddenly becomes very low. In this region, even at considerable change in current, the applied voltage remains fairly constant.

The voltage associated with that portion of the reverse volt ampere characteristic of a semiconductor is called "zener or breakdown voltage."

However, this effect is not due to a mechanism that is commonly associated with the term "zener;" that is, the flow of current through an insulator in a very intense electric field, sufficient to excite an electron directly from the valence band to the conduction band. It is rather a result of electron avalanche analogous to the Townsend discharge in a gas. Therefore, the term "avalanche or regulator diode" seems to be more appropriate.

It has been observed that the diode in this breakdown region has a positive temperature coefficient depending on the slope and the breakdown voltage. This coefficient is in the order of +0.1% per °C of the breakdown voltage.

Being a junction device, the diode may have a rather high shunt capacity. From a manufacturer's data sheet we discern very low regulator voltage diodes have capacitances in the order of 50 uufd; the capacitance decreases with increasing regulator voltage and drops to 2 or 3 uufd for diodes with high voltage.

The breakdown voltage, in general, depends upon the resistivity of the P and N regions and the rate of change of resistivity through the junction transition region.

The alloy type junction can be made with a breakdown voltage that depends only on the resistivity of the starting material. For diffused junctions, however, the breakdown voltage depends upon the concentration of the starting material, the time and the temperature of diffusion.

The need for both AC and DC reference devices is very common and it is obvious that a diode exhibiting the mentioned characteristics will serve this purpose satisfactorily.

1. Applications

The avalanche or regulator diode is, as the name implies, an ideal means for regulation and has several advantages over gas tubes on standard cells.

The avalanche or regulator diode may be used in nonlinear compensation techniques to obtain: (a) very accurate operating points of transistors as required for frequency standards; (b) stabilization over extreme ranges of temperature without the attendant extremes of power dissipation and AC losses, as found in some high power output stages; (c) stabilization of operating point of transistors in spite of power supply variations, and, (d) elimination of external resistance for other circuit considerations, for example, to improve supply voltage economy.

The diode can also be used as a part of a transistor amplifier. The diode is connected from the collector of the transistor to ground through an inductance. Owing to the regulating action of a resistor diode combination, the transistor collector voltage will remain practically constant regardless of changes in temperature or supply voltage.

The use of avalanche diodes as temperature sensitive elements is also very attractive, since their temperature dependent properties are similar to those of the P-N junctions that comprise the junction transistor.

If the avalanche diode is selected so that its reverse current is equal to I_{CBO} for the corresponding transistor, this equality will hold over a wide range of temperatures.

Battery charging rectifiers must be voltage and current regulated to obtain maximum life from the batteries. The output voltage must be held constant within ± 1/2% for any load current within ratings of the rectifier. This is an ideal job for the avalanche diode.

The avalanche diode also facilitates the design of a simple and accurate method of converting a binary number stored in a shift register into an analog direct voltage.

As it is shown with these few examples, the number of applications is only limited by the ingenuity of the circuit designer and the avalanche or regulator diode can be considered a very versatile member of the semiconductor family.

2. Systems and Equipment

Reference devices are very common in any electronic equipment, particularly in instruments, amplifiers, computer and radar systems.

Wherever a DC voltage is used as reference, the incorporation of gaseuos reference tubes was quite satisfactory as long as an extreme precision was not necessary and reasonably large voltages were available. For those cases where low voltages were employed, standard cells served the purpose. The variation of the AC parameters of a transistor with operating point and temperature are, in most of the cases, of utmost importance. It is therefore desirable to develop techniques for maintaining the collector voltage and emitter current of transistors within close limits in the range of operation conditions.

The operational voltages used in transistor circuits are too low for gaseous tubes and too high for standard cells. Considerable loading of the reference device is expected in many applications which cannot be imposed on a standard cell, even if the voltage range would be adequate. Since the avalanche diode can meet all these requirements, the diode seems to be a natural for transistor circuitry.

The extremely small size of an avalanche diode, an inherent property of all semi-conductor devices, in comparison with other reference devices is, of course, another reason to employ the diode wherever the electrical specifications fit.

3. Industrial, Military or Entertainment Uses

As indicated in paragraph 1 of page 1, the regulator diode is not so much a primary component, essential for the function of a circuit, as it is a component to step up the quality and performance of a piece of equipment.

This may already indicate to a certain extent the field of activities in electronics in which this device will be employed. For the time being, it is mainly industrial - and military electronics, where the highest degree of quality, performance and reliability is required.

However, the increasing incorporation of transistors in equipment which serves mainly entertainment purposes also opens here a potential market.-- First, because certain performances can be expected only from a transistor when specific requirements are met and, second, because the equipment serving entertainment is expected to operate at a fairly high quality level which means, for example, independent of supply voltage variations, changes in temperature, etc.

Therefore, it is safe to say that the avalanche diode will become equally prominent in the industrial, entertainment and military field of electronics.

4. Composite Electrical Specifications

The listing of avalanche diodes attached shows that a voltage range from 2.0 to 550 volts and a power range up to 10 watt is covered by presently available diode types.

The tolerance of the regulated voltages are 10 to 40% ± and partially an inherent property of the avalanche diode. Nevertheless, improvements in this respect are not out of the realm of possibility.

The temperature dependency and capacity of the avalanche diode may be a critical parameter. All companies engaged in the manufacture of avalanche diodes try to do their best to compensate for these particular characteristics, which can be done by:

1. rigid selection
2. combinations (special assemblies of avalanche and regulator diodes)
3. improving the material and the construction of the diode

Another important factor is the dynamic resistance which determines the dissipation also the degree of regulation and consequently the applicability. Striving in this direction for improvement would be an important part of the efforts connected with the fabrication of avalanche diodes.

A company engaged in the manufacture of regulator diodes, exhibiting superior qualities than the presently available ones, would experience a uniquely profitable position.

The resulting fact from this analysis is that only the quality of the product could be considered a competitive or selective factor, whereas the price is a secondary factor, at least for the time being.

Meeting or advancing the present level of quality in the avalanche diode business almost insures good commercial results.

5. Ratings

The following denominations are used for commercially available diodes.

Regulator Voltage	......volts	Eb
Minimum Reg. Volt	......volts	Eb1
Maximum Reg. Volt	......volts	Eb2
Maximum Current at Breakdown	......mA	Iz
Dynamic Impedance at Iz	......ohms	Z
Maximum Dissipation	......mV	
Temperature Coefficient	......%/°C	
Maximum Temperature	......°C	
Capacitance	......uufd	

Note: The maximum temperature is specified differently by various manufacturers. Reference is made either to ambient, or base, or junction, or storage.

Several other parameters may be of interest to the designer. However, industry feels that a regulator diode is sufficiently described by using the above terms. Following are some typical parameters of regulator diodes, which are presently marketed.

Avalanche Voltage Range		Dynamic Impedance		Max. Dissip.	Temp. Coeff.	Max. Temp.
Min.	Max.	Z	Iz	mW	%/°C	°C
2.00	3.20	45	10	250	0.045	200 A
5.70	6.30	70	1000	10 W	0.03	150
11.00	13.00	40	7.5	350	0.06	150 A
24.00	30.00	90	3.5	500	0.095	150
58.90	65.10	12	50	10 W	0.10	155 A
130.00	160.00	370	7.0	5000	0.095	150 A

6. Package

The heat dissipation of a diode is directly proportional to its current-carrying capability. Therefore, the packages will be necessarily different in size, shape and material, according to these requirements.

Another factor may determine greatly the package design. The combination of different, mostly opposed, electrical characteristics of avalanche diodes and other semiconductors also may be done physically; that is, in a common encapsulation.

These combinations up grade the quality and performance of an avalanche diode considerably.

Package design will have to take this characteristic, which opens a potential market, into consideration.

For the sake of uniformity existent package design, perhaps with small alterations, should be the preferred style.

Our presently used glass package construction may take care of 2 to 300 mW dissipation. This is a relatively low value for an avalanche diode. Nevertheless, it should not be too difficult to introduce obviously possible improvements for our package.

In this case, dissipations up to 1 watt should be allowable. For higher dissipations, the metal - stud - mount will be the most preferable encapsulation.

The different sizes of this package will allow a consistency in shape up to kw dissipation.

7. Features of Combinations

As mentioned before it has been observed that avalanche diodes have a positive temperature coefficient depending on the slope and the breakdown voltage. This coefficient may be on the order of +0.1%/°C.

In order to compensate for this temperature effect it is useful to operate the avalanche diode in series with a temperature sensitive element having a negative temperature coefficient. It is known that a forward biased diode has such a negative temperature coefficient.

Under constant current conditions the variation in the voltage drop across the diode is about 2.0 mv/°C for germanium and 1.8 mv/°C for silicon. By connecting one or more diodes biased in the forward direction in series with the reversed biased avalanche diode, we can obtain near zero temperature coefficient for the combination. The addition of a few forward biased diodes in series with the avalanche diode does not cause any appreciable change in the regulated voltage, since the forward voltage drop across the diodes is usually very small. A silicon diode adds about 0.5 volts and is some times used to trim a combination to the correct voltage.

Temperature compensation, furthermore, can be achieved by using temperature sensitive resistors as composite elements. Such elements are special types of ceramic resistors and thermistors, also the new T.I. sensistor and our SA2 temperature compensation diodes. A characteristic property of all these elements is that they have relatively large negative temperature coefficients (on the order of 2 to 8%/°C).

Direct Current Voltage Regulator:

The regulator voltage for a particular diode is constant over wide variations in reverse current. The diode is suited for use in d-c voltage regulating or reference circuits, such as that shown in Figure 1. Resistor R should be so chosen that the reverse current in the diode does not exceed a value given by the ratio of the maximum power dissipation of the diode to the regulator voltage.

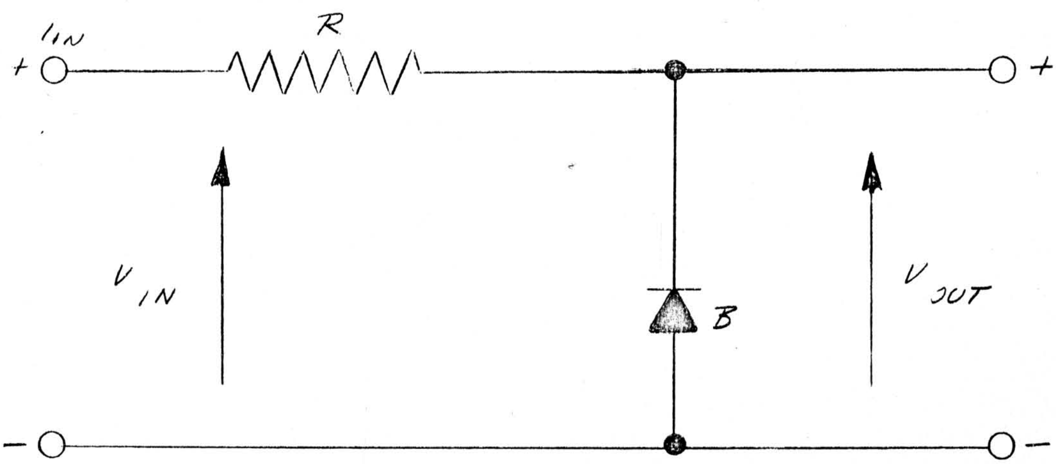

FIG. 1

The configuration shown in the Figure is incorporated in almost any linear amplifier to provide stable voltages on tubes or transistors. These kinds of amplifiers are used to amplify low signals from sensing devices like thermocouples or pressure cells, used particularly in the chemical and petroleum industry. A minimum of five to ten avalanche diode is employed in such amplifiers. The author developed a linear amplifier for pressure cell sensing and telemetering systems for the oil industry which used seventeen regulator diodes. From available information, it can be discerned that about 50,000 of these amplifiers are produced every year.

At a rough estimate, a market for approximately 2-300,000 regulator diodes per year is given only by linear amplifiers. If a price of approximately $3.00 each is considered the total value per year would be $6 - 900,000.00.

units/year 2 - 300,000.
Dollars/year 6 - 900,000.00

Alternating Current Peak Voltage Regulator:

A simple a-c peak voltage regulator may be constructed by connecting two silicon diodes back to back as shown in Figure 2. The peak output voltage is limited to the regulator voltage of the diodes, which my lie anywhere in the range from three to several hundred volts. This circuit could also be used as an effective speech clipper.

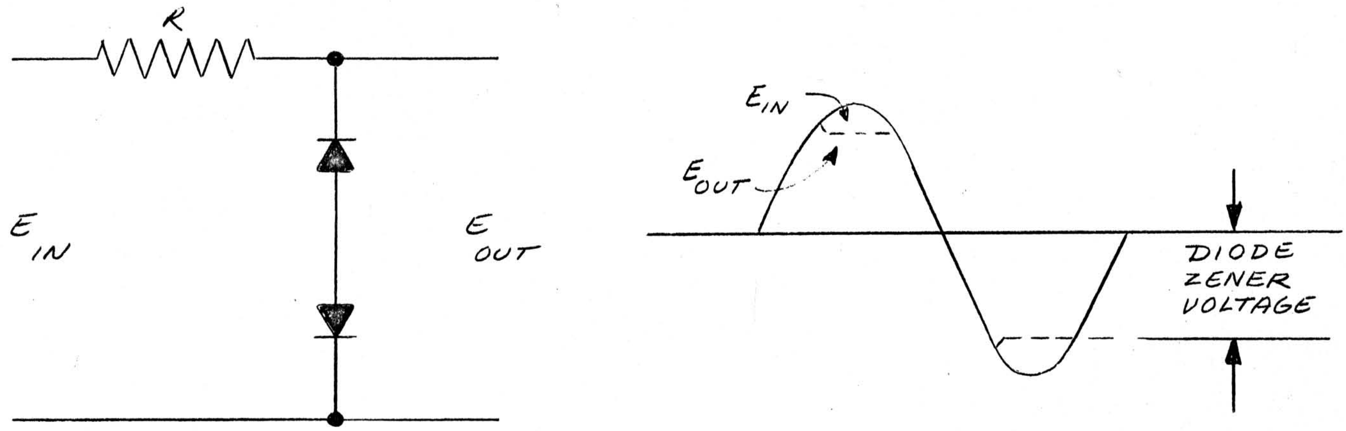

FIG. 2

The application of avalanche diodes in the above fashion takes place in all better quality F.M. receivers (commercial and military) in order to limit the amplitude of the F.M.

If only two regulator diodes find use in each F.M. receiver, the yearly supply has to be in the order of millions considering the enormous amount of F.M. receivers built.

units/year 1,000,000
Dollars/year 3,000,000.00

D.C. Coupling Device:

Figure 3 shows a diode used as a coupling device between the plate of a stage of an amplifier and the grid of the following stage. While a resistor may be used in place of the diode to achieve the necessary change in level, there is a signal loss owing to the voltage divider action of the resistor. By using a diode, the full signal amplitude is retained, the d-c level being reduced by a factor equal to the avalanche voltage of the diode.

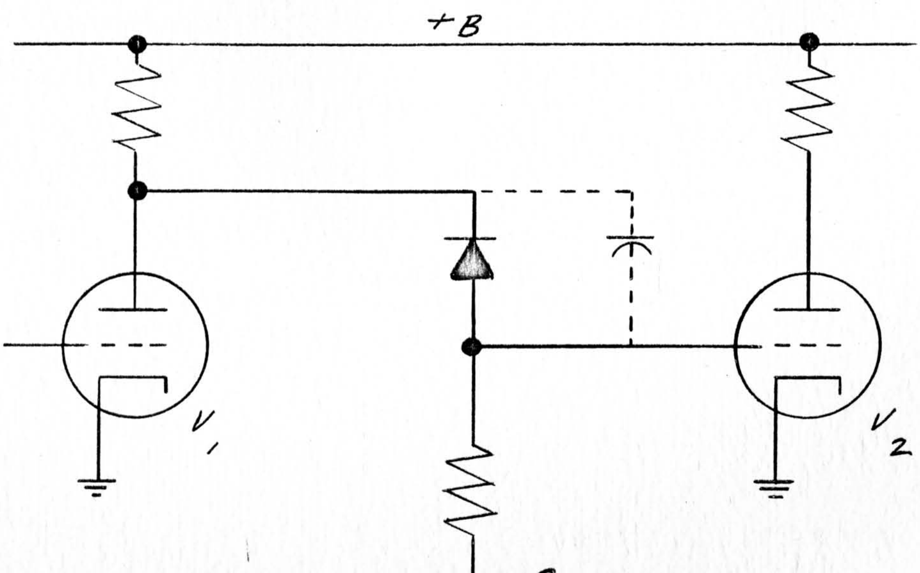

FIG. 3

This method of coupling can be applied at most any amplifier. For the time being, the price of the avalanche diode is perhaps responsible for the relatively limited use of this configuration, because resistors and capacitors are still cheaper by orders of magnitude. However, when the price of lower-grade avalanche diode ($ 0.50 per diode) will permit the use also in simple circuits, the number of units demanded per year for this particular application will be in the order of millions.

units/year 3,000,000
Dollar/year 1,500.000.00

Slicing Circuit:

Figure 4 shows a fast slicing circuit; V_1 conducts until its grid potential falls below the slicing level when the current is suddenly transferred to V_2, as indicated by the waveforms. Normally, the grid of V_2 is returned to a fixed direct voltage, which makes the slicing level dependent on the d-c level of the incoming signal. By including a silicon diode as shown, with a suitable R-C smooting network, the difference in the d-c levels of the two grids is fixed by the regulator voltage of the diode. With output amplitude dependent on the d-c level of the input signal, there is virtually no change in the slicing operation of the circuit with input levels ranging from 75 to 200 volts.

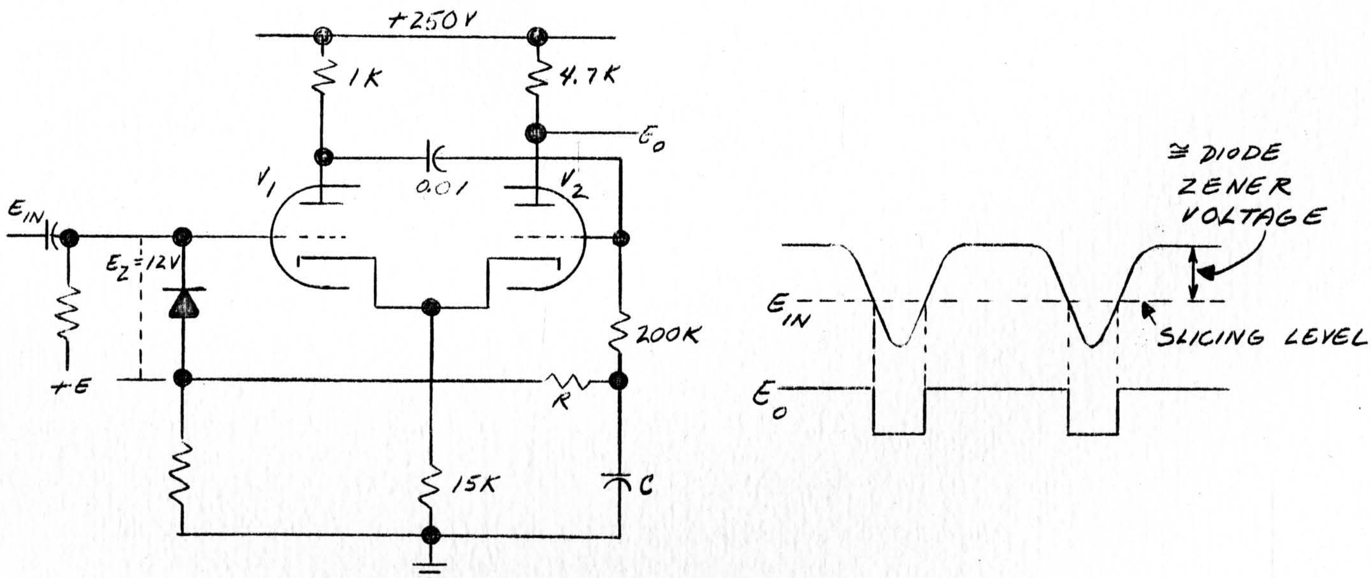

FIG. 4

This circuit, shown in Figure 4, can be useful incorporated in computer design. Considering the many uses and purposes of computors, it is difficult to estimate any figures of avalanche diodes employed on this kind of equipment. Nevertheless, the demand ought to be tremendous.

Avalanche or regulator diodes facilitate design of a simple and accurate method of converting binary number stored in a shift register into a analog direct voltage. The accuracy required of such a device is 1 part of 2^n where n is the number of binary digits. If n is greater than 4 or 5, it is usually necessary to provide the flip-flops in the register with puffer stages, which may work into a ladder-adding network or drive relays that control suitably weighted resistors. The method shown in Figure 5 requires no additional stages and is relatively independent of tube characteristics and supply voltages.

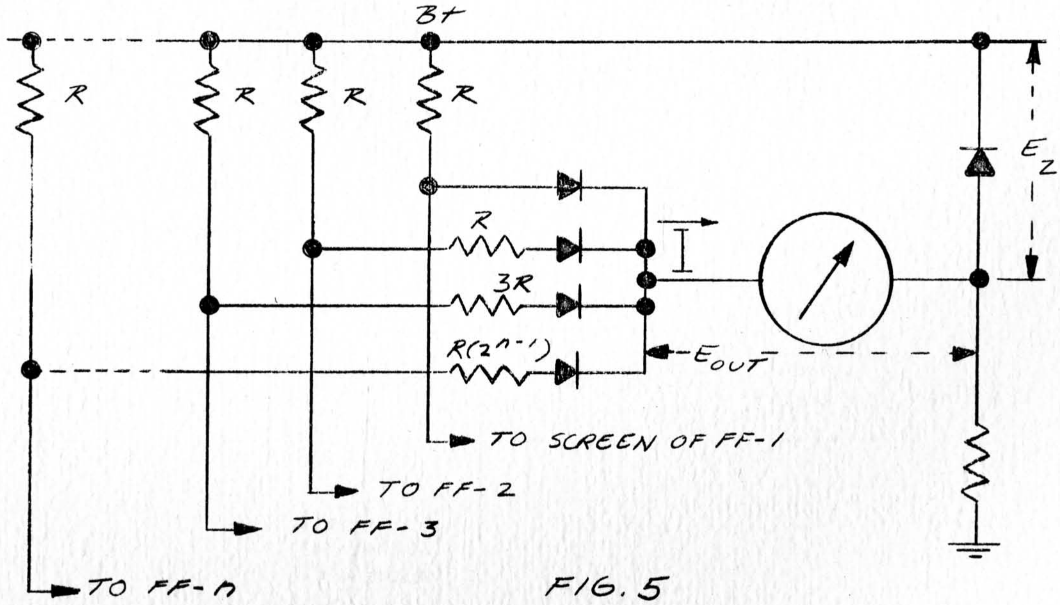

FIG. 5

As mentioned in respect to the circuit demonstrated in Figure 4, it is difficult to estimate the size of sales possible in avalanche diodes for this particular computer - application.

Battery Charging Rectifier:

A battery charging rectifier must be both voltage and current regulated. To obtain maximum life from the batteries, the output voltage must be held constant within ± 1/2 percent for any load current within the rating of the rectifier. The block diagram of a regulating system which accomplishes this is given in Figure 6. Semiconductor devices can be profitably applied in six of the boxes in the block diagram: the rectifier, the current sensing element, the voltage standard, the gate circuit, the error detector and the current amplifier.

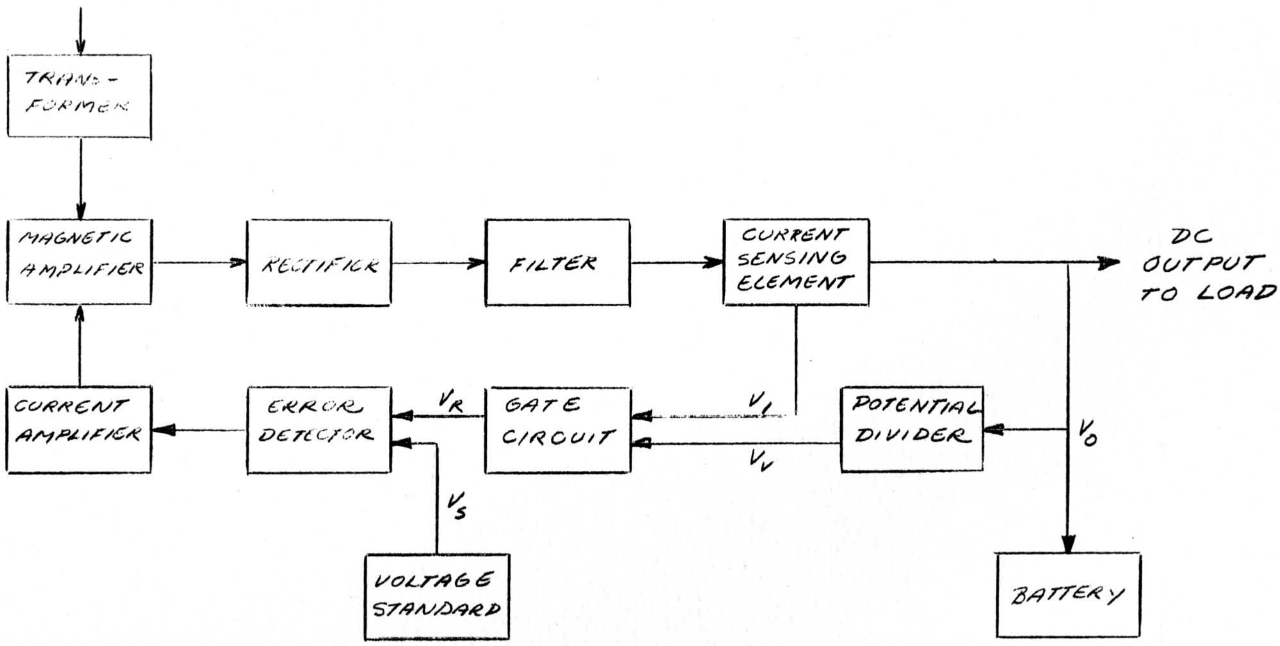

FIG. 6

The precision obtained in regulating the rectifier voltage or current is limited by the stability of the voltage standard. The silicon diode operated in the breakdown region exhibits here again the most desirable characteristics. If we consider that at least two avalanche diodes can be used in the circuit shown in Figure 6, and if we furthermore assume that yearly about a million of battery chargers are produced, it is seen that here again two million avalanche diodes participate on the market.

units/year 2,000,000
Dollars/year 6,000,000.00

Temperature Compensated Voltage Regulator:

A principal factor in stabilization of the transistor operating point is a stable collector voltage supply. Figure 7 shows a circuit employing a regulator (reverse biased) and several regular (forward biased) diodes. The addition of some forward biased diodes in series with the avalanche diode does not cause any appreciable change of the regulated voltage but compensate for the positive temperature coefficient.

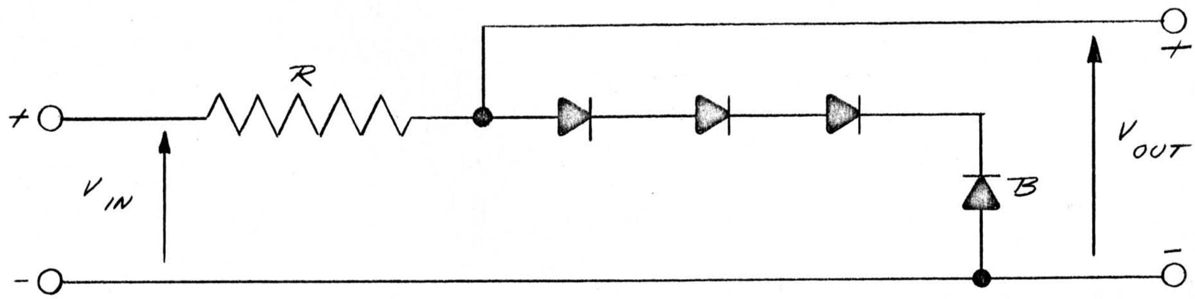

FIG. 7

Temperature Compensated Stage in Transistor Amplifier:

The regulator diode can be used as part of the transistor amplifier as shown in Figure 8. In this circuit R_L is the regulating resistance for the breakdown diode B. B is connected from the collector of the transistor to ground through an inductance L, which limits the shunting effect of the regulator diode on the output of the amplifier.

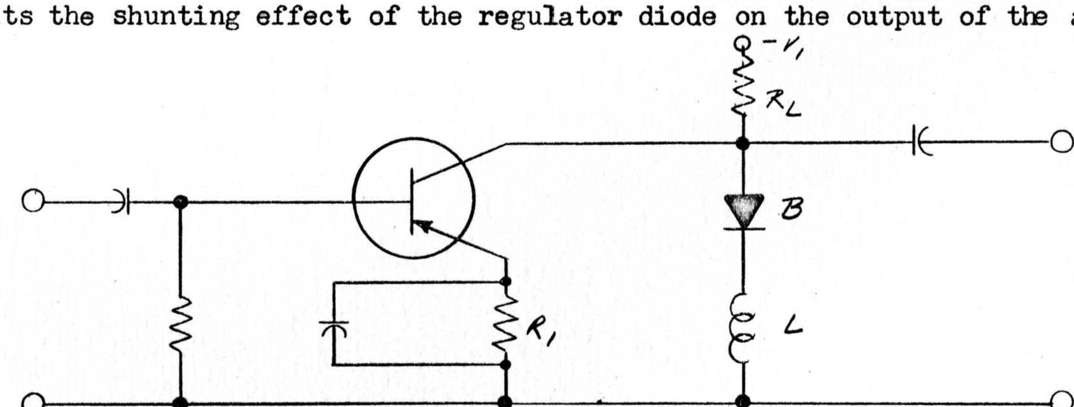

FIG. 8

Figures 7 and 8 show another variante of application of regulator diodes in transistor circuits. Since transistors enter more and more the entertainment market no one can even predict what amount of avalanche diodes can be sold in connection with transistors circuits.

The broadest field of application for regulator diodes is of course the computer field. Here, the diode is used as a gate, signal limiter, voltage stabilizer, etc. Hughes Aircraft, for example, used avalanche diodes to an extent that brought Transitron and Hoffman a $700,000.00 business in 1957 and will bring them probably twice as much in 1958, as estimated by the application section and procurement personnel in Culver City and El Segundo, respectively.

As the attached letter shows, our western market is estimated to have a potential of $1,500,000.00. It is safe to assume that our midwest and eastern regions have at least the same capacity.

HUGHES AIRCRAFT COMPANY

INTERDEPARTMENTAL CORRESPONDENCE

TO: W. H. Gray

CC: A. J. Bayley
R. A. Darrow
D. B. Rogers
R. A. Styles

DATE: 6/13/58

SUBJECT: Regulator Diodes
Western Region

FROM: E. Mitchell

This report is presented in answer to your IDC request of June 11, 1958, concerning requirements for a zener diode.

1. Applications

Widely used as reference elements in a broad range of circuitry. The Transitron brochure covers about 12 such applications.

Equipments or systems utilizing these elements are predominantly military although there is also some industrial usage. I know of no entertainment applications of consequence.

2. Generalized or Composite Specifications (for a reference diode)

The needs of the present known market in the west totalling conservatively about 1.5 million dollars are not inconsistent with the idealized or optimum specification.

Idealized Specification:

a) A single unit.
b) Coaxial glass package.
c) No power limitation.
d) Zero temperature coefficient.
e) Zero dynamic coefficient.

3. In practical terms we could define the product in two power categories.

a) 1/4 watt coaxial glass package.
b) 1 watt or more, coaxial glass package.

The circuit designer would like to be freed from the restrictions of power in the typical control circuit.

(T.I. is planning to release a larger glass package soon with over a watt dissipation. This is in the hardware stage).

c) Voltage steps from 3 to 30 volts. Some representative types will illustrate the presently available units. (Later in memo).

d) Recognizing the practical limitations of achieving the idealized "0-0" reference element the following generalized spec defines the requirements for an overpackage type configuration composed of sub-min reference elements and sub-min stabistors:

1. Coaxial lead configuration.
2. 3-30 volts.
3. 1% tolerance.
4. Δ.01%/°C
5. -55°C to +125° C.
6. 200 mw (1/2 watt preferred).

4. The present known volume of reference diode sales in the Western Region are approximately 1.5 million dollars.

Some representative types taken from the Standards lists of N.A.A. and H.A.C. are listed with prices where known.

N.A.A.	TYPE	VOLTS AND TOLERANCE @ 25°C	MAX. DYNAMIC RES.
	SV 126	7V ± 5%/10 mA	8 ohms
	SV 136	13 V ± 5%/5 mA	70 Ω
	SV 169	24 V ± 5%/5 mA	300 Ω
	IN 429	6.2 V ± .3 V/7.5 mA	20 Ω ΔV ± .05V/-55°C to 100°C
	IN 430 A	8.4 V ± .4 V/10 mA	15 Ω ΔV ± .001%/°C/-55°C to 100°C
	IN 437		

H.A.C.	TYPE	VOLTS	PRICE	QUANTITY	
	925008-12	24-26	$ 7.00	5000	Trans.
	925008-16	8.8-15	28.00	5000	Hoff.
	925008-18	74-80	14.00	3000	Trans.
	925008-19	17-18	3.50	20000	Trans.
	925008-21	11-12	4.50	4000	Trans.
	925008-23	18-19	7.00	2000	Trans.
	925008-28	7-8	4.50	6000	Hoff.
	925008-30	9.9-10.1	12.00	5000	Trans.
	925008-32	49-50	13.00	3000	Trans.

E. Mitchell

EM:ew

(2)

BENDIX AVIATION CORPORATION • RED BANK DIVISION • EATONTOWN, NEW JERSEY

May 29, 1958

Hughes Products
80 Mulberry Street
Newark, New Jersey

Dave -
This type of thing looks to be increasing rather heavily -
Jack

Gentlemen:

Subject: Silicon Zener Diodes

We at this division are working on a product system which uses a rather large number of silicon zener diodes.

We are at the present time making every effort to determine the sources for zener diodes and are, therefore, screening potential vendors to determine if they are making units of the type described below.

Voltage Ranges - 4.3 to 27 volts (higher voltages could be used)

Dissipation Ratings - 250 milliwatts) 750 milliwatts) at 25° C derated to 0 at 10 watts) 150° C

Maximum Temperature Range - -65° C to 150° C

Temperature Coefficient - From 0.01%/C° for 4.3 volt units to 0.09%/C° for 27 volt units. Special temperature compensated 8 volt zener diodes are supplied with a 0.003%/C° temperature coefficient.

We should appreciate a reply to this letter, enclosing with your reply all test and specification information available, so that the same can be presented to our Engineering Department for a review prior to discussing this with your representatives.

Please direct all replies to the attention of the writer. Your cooperation in assisting us to develop alternate sources will be greatly appreciated.

Very truly yours,

RED BANK DIVISION
BENDIX AVIATION CORPORATION

L. D. Fyfe

L. D. Fyfe

JUN 4 - 1958

SILICON ZENER OR AVALANCHE DIODES

In order of Min. E_{b1}, Max. E_{b2}, and type no.

MANUFAC-TURER	TYPE No.	ZENER OR AVALANCHE VOLTAGE RANGE MIN. E_{b1} (volts)	TO MAX. E_{b2}	@I_Z (ma)	DYNAMIC IMPEDANCE Z (ohms)	@I_Z (ma)	MAX. DISS. (mw)	TEMP. COEFF. (%/°C)	MAX. TEMP. (°C)	PRICE 1-100
HSD	GZ1	2.00-	3.20	5.0	45	10	250		200A	
BTHB	SJDX7A/3	2.50-	3.50	10					250J	
LTCB	Z2A33	2.50-	4.00	20	30	20	750		100	
HSD	1N471	3.00-	3.90	5.0	50	10	200		200A	5.50
HSD	GZ2	3.00-	3.90	5.0	40	10	250		200A	
TII	650C0	3.52-	3.89	5.0			150	.045	150A	
BTHB	SJDX7A/4	3.50-	4.50	10					250J	
IREC	3Z3.9	3.60-	4.30	850	.50	150	3500	.04		
IREC	10Z3.9	3.60-	4.30	2500	.25	500	10W	.04		
IREC	IZ3.9	3.60-	4.30	250	1.0	50	1000	.04		
USS	LZ3.9	3.60-	4.30	5.0	25	20	400	.07		
IREC	MZ3.9	3.60-	4.30	125	1.5	25	500	.04		
USS	Z3.9	3.60-	4.30	5.0	30	10	150	.07	150	
USS	ZT3.9	3.60-	4.30	5.0	30	10	200	.06		
IREC	ZZ3.9	3.60-	4.30	110	3.0	22	350	.045		
USS	Z2A47	3.60-	5.80	20	25	20	750		100	
TII	650C1	3.61-	3.99	5.0			150	.042	150A	
HSD	1N472	3.70-	4.50	5.0	45	10	200		200A	5.50
TII	650C	3.70-	4.50	5.0			150		150	
HSD	GZ3	3.70-	4.50	5.0	30	10	250		200A	
TII	650C2	3.71-	4.10	5.0			150	.040	150A	
TII	650C3	3.80-	4.20	5.0			150	.040	150A	
TII	650C4	3.90-	4.31	5.0			150	.039	150A	
TII	650C6	4.09-	4.52	5.0			150	.035	150A	
TII	650C7	4.18-	4.62	5.0			150	.032	150A	
TII	651C0	4.28-	4.73	5.0			150	.030	150A	
TRA	SV121	4.28-	4.73	10	55	10	250	.02		
TRA	SV1004	4.28-	4.73	10	55	10	750	.02	150	
TRA	SV2004	4.28-	4.73	1000	.50	1000	10W	.02	150	
IREC	3Z4.7	4.30-	5.10	700	.50	125	3500	.00		
IREC	10Z4.7	4.30-	5.10	2000	.25	400	10W	.00		
IREC	IZ4.7	4.30-	5.10	200	1.0	40	1000	.00		
USS	LZ4.7	4.30-	5.10	5.0	20	20	400	.05		
IREC	MZ4.7	4.30-	5.10	100	1.5	20	500	.00		
USS	Z4.7	4.30-	5.10	5.0	25	10	150	.04	150	
USS	ZT4.7	4.30-	5.10	5.0	25	10	200	.04		
IREC	ZZ4.7	4.30-	5.10	90	4.0	18	350	.01		
HSD	1N473	4.30-	5.40	5.0	35	10	200		200A	5.50
TII	651C	4.30-	5.40	5.0			150		150	
HSD	GZ4	4.30-	5.40	5.0	25	10	250		200A	
TRA	SV5	4.30-	5.40	50	55				150	
TRA	SV804	4.30-	5.40	150	55				150	
TRA	SV904	4.30-	5.40	2000	.50				150	
TII	651C1	4.37-	4.83	5.0			150	.028	150A	

SYMBOLS AND LETTER CODES

FOLLOWING LINE NO.

- □ - New
- * - Revised
- # - Foreign Mfr.

FOLLOWING TYPE NO.

- T - Tentative
- R - Military use only
- M - Mil. Specs.
- D - Under Development
- A - Army Specs.
- N - Navy Specs.
- F - AF Specs.

FOLLOWING TEMP.

- A - Ambient
- B - Base (stud)
- J - Junction
- S - Storage

SILICON ZENER OR AVALANCHE DIODES *(cont.)*

In order of Min. E_{b1}, Max. E_{b2}, and type no.

MANUFAC-TURER	TYPE No.	ZENER OR AVALANCHE VOLTAGE RANGE MIN. TO MAX. E_{b1} (volts) E_{b2}		@I_Z (ma)	DYNAMIC IMPEDANCE Z (ohms)	@I_Z (ma)	MAX. DISS. (mw)	TEMP. COEFF. (%/°C)	MAX. TEMP. (°C)	PRICE 1-100
TII	651C2	4.47-	4.94	5.0			150	.026	150A	
BTHB	SJDX7A/5	4.50-	5.50	10					250J	
TII	651C3	4.56-	5.04	5.0			150	.024	150A	
TII	651C4	4.66-	5.15	5.0			150	.022	150A	
TII	650C5	4.75-	5.25	5.0			150	.018	150A	
TII	651C5	4.75-	5.25	5.0			150	.018	150A	
TRA	SV122	4.75-	5.25	10	55	10	250	.00		
TRA	SV1005	4.75-	5.25	10	55	10	750	.00	150	
TRA	SV2005	4.75-	5.25	1000	.50	1000	10W	.00	150	
TII	651C6	4.85-	5.36	5.0			150	.014	150A	
TII	651C7	4.94-	5.46	5.0			150	.010	150A	
TII	651C8	5.04-	5.57	5.0			150	.007	150A	
IREC	3Z5.6	5.10-	6.20	625	.75	110	3500	.03		
IREC	10Z5.6	5.10-	6.20	1750	.40	350	10W	.03		
IREC	1Z5.6	5.10-	6.20	175	1.5	35	1000	.03		
USS	LZ5.6	5.10-	6.20	5.0	7.5	20	400	.04		
IREC	MZ5.6	5.10-	6.20	90	2.3	17.5	500	.03		
USS	Z5.6	5.10-	6.20	5.0	10	10	150	.01	150	
USS	ZT5.6	5.10-	6.20	5.0	10	10	200	.01		
IREC	ZZ5.6	5.10-	6.20	70	5.0	14	350	.00		
TII	651C9	5.13-	5.67	5.0			150	.002	150A	
HSD	1N474	5.20-	6.40	5.0	20	10	200		200A	5.50
TII	652C	5.20-	6.40	5.0			150		150	
HSD	GZ5	5.20-	6.40	5.0	10	10	250		200A	
TRA	SV6	5.20-	6.40	10	20	10	250	.02		
TRA	SV805	5.20-	6.40	10	20	10	750	.02	150	
TRA	SV905	5.20-	6.40	1000	.70	1000	10W	.02	150	
TII	652C0	5.23-	5.78	5.0			150	.000	150A	
TII	652C1	5.32-	5.88	5.0			150	.002	150A	
TRA	SV123	5.23-	5.78	10	20	10	250	.015		
TRA	SV1006	5.23-	5.78	10	20	10	750	.015	150	
TRA	SV2006	5.23-	5.78	1000	.70	1000	10W	.015	150	
LTCB	Z2A68	5.40-	8.50	20	15	20	750		100	
TII	652C2	5.42-	5.99	5.0			150	.006	150A	
LTCB	SJDX7A/6	5.50-	6.50	10					250J	
TII	652C3	5.51-	6.09	5.0			150	.010	150A	
WEC	GA53342-2	5.58-	6.82	10			100			
TII	652C4	5.61-	6.20	5.0			150	.015	150A	
TII	652C5	5.70-	6.30	5.0			150	.019	150A	
TRA	SV124	5.70-	6.30	10	20	10	250	.03		
TRA	SV1007	5.70-	6.30	10	20	10	750	.03	150	
TRA	SV2007	5.70-	6.30	1000	.70	1000	10W	.03	150	
TII	652C6	5.80-	6.41	5.0			150	.021	150A	
TII	652C7	5.89-	6.51	5.0			150	.024	150A	

SYMBOLS AND LETTER CODES

FOLLOWING LINE NO.

- □ - New
- • - Revised
- # - Foreign Mfr.

FOLLOWING TYPE NO.

- T - Tentative
- R - Military use only
- M - Mil. Specs.
- D - Under Development
- A - Army Specs.
- N - Navy Specs.
- F - AF Specs.

FOLLOWING TEMP.

- A - Ambient
- B - Base (stud)
- J - Junction
- S - Storage

SILICON ZENER OR AVALANCHE DIODES *(cont.)*

In order of Min. E_{b1}, Max. E_{b2}, and type no.

MANUFAC-TURER	TYPE No.	ZENER OR AVALANCHE VOLTAGE RANGE MIN. E_{b1} (volts)	TO MAX. E_{b2}	@I_z (ma)	DYNAMIC IMPEDANCE Z (ohms)	@I_z (ma)	MAX. DISS. (mw)	TEMP. COEFF. (%/°C)	MAX. TEMP. (°C)	PRICE 1-100
HSD	1N429	5.90-	6.50	7.5	20	7.5	200		200A	9.00
TII	652C8	5.99-	6.62	5.0			150	.027	150A	
TII	652C9	6.08-	6.72	5.0			150	.030	150A	
TII	653C0	6.18-	6.83	5.0			150	.032	150A	
TRA	SV125	6.18-	6.83	10	8.0	10	250	.038		
TRA	SV1008	6.18-	6.83	10	8.0	10	750	.038		
TRA	SV2008	6.18-	6.83	1000	.80	1000	10W	.038	150	
HSD	1N475	6.20-	8.	5.0	10	10	200		200A	5.50
IREC	3Z6.8	6.20-	7.50	525	1.0	100	3500	.05		
IREC	10Z6.8	6.20-	7.50	1500	.50	300	10W	.05		
IREC	IZ6.8	6.20-	7.50	150	2.0	30	1000	.05		
USS	LZ6.8	6.20-	7.50	5.0	7.5	20	400	.01		
IREC	MZ6.8	6.20-	7.50	75	3.0	15	500	.05		
USS	Z6.8	6.20-	7.50	5.0	10	10	150	.01	150	
USS	ZT6.8	6.20-	7.50	5.0	10	10	200	.01		
IREC	ZZ6.8	6.20-	7.50	60	10	12	350	.025		
TII	653C	6.20-	8.	5.0			150		150	
HSD	GZ6	6.20-	8.	5.0	5.0	10	250		200A	
TRA	SV7	6.20-	8.	30	8.0				150	
TRA	SV806	6.20-	8.	90	8.0				150	
TRA	SV906	6.20-	8.	1200	.80				150	
TII	653C1	6.27-	6.93	5.0			150	.034	150A	
TII	653C2	6.37-	7.04	5.0			150	.036	150A	
TII	653C3	6.46-	7.14	5.0			150	.038	150A	
TII	SJDX7A/7	6.50-	7.50	10					250J	
TRA	653C4	6.65-	7.35	5.0			150	.041	150A	
TRA	SV126	6.65-	7.35	10	8.0	10	250	.043		
TRA	SV1009	6.65-	7.35	10	8.0	10	750	.043	150	
TRA	SV2009	6.65-	7.35	1000	.80	1000	10W	.043	150	
TII	653C5	6.84-	7.56	5.0			150	.043	150A	
TII	653C6	7.03-	7.71	5.0			150	.046	150A	
TRA	SV127	7.13-	7.88	10	8.0	10	250	.047	150	
TRA	SV1010	7.13-	7.88	10	8.0	10	750	.047	150	
TRA	SV2010	7.13-	7.88	1000	.80	1000	10W	.047	150	
TII	653C7	7.22-	7.98	5.0			150	.049	150A	
WEC	GA53339-3	7.38-	9.02	10			3000			
WEC	GA53341-3	7.38-	9.02	10	15	10	500			
WEC	GA53342-3	7.38-	9.02	10			100			
TII	653C8	7.41-	8.19	5.0			150	.050	150A	
BTHB	SJDX7A/8	7.50-	8.50	10					250J	
IREC	3Z8.2	7.50-	9.10	425	1.5	80	3500	.06		
IREC	10Z8.2	7.50-	9.10	1200	.75	250	10W	.06		
IREC	IZ8.2	7.50-	9.10	120	3.0	25	1000	.06		
IREC	LZ8.2	7.50-	9.10	5.0	20	20	400	.02		

SYMBOLS AND LETTER CODES

FOLLOWING LINE NO.

- □ - New
- * - Revised
- # - Foreign Mfr.

FOLLOWING TYPE NO.

- T - Tentative
- R - Military use only
- M - Mil. Specs.
- D - Under Development
- A - Army Specs.
- N - Navy Specs.
- F - AF Specs.

FOLLOWING TEMP.

- A - Ambient
- B - Base (stud)
- J - Junction
- S - Storage

SILICON ZENER OR AVALANCHE DIODES *(cont.)*

In order of Min. E_{b1}, Max. E_{b2}, and type no.

MANUFAC-TURER	TYPE No.	ZENER OR AVALANCHE VOLTAGE RANGE MIN. TO MAX. E_{b1} (volts) E_{b2}		@I_Z (ma)	DYNAMIC IMPEDANCE Z (ohms)	@I_Z (ma)	MAX. DISS. (mw)	TEMP. COEFF. (%/°C)	MAX. TEMP. (°C)	PRICE 1-100
IREC	MZ8.2	7.50-	9.10	60	4.5	12.5	500	.06		
USS	Z8.2	7.50-	9.10	5.0	25	10	150	.02	150	
USS	ZT8.2	7.50-	9.10	5.0	25	10	200	.02		
IREC	ZZ8.2	7.50-	9.10	50	15	10	350	.035		
HSD	1N225	7.50-	10.	.20			150		150A	6.00
HSD	1N1313	7.50-	10.				150		150A	3.50
TRA	SV9	7.50-	10.	10	15	10	250	.055		
TRA	SV808	7.50-	10.	10	15	10	750	.055	150	
TRA	SV908	7.50-	10.	1000	.80	1000	10W	.055	150	
TII	653C9	7.60-	8.40	5.0			150	.050	150A	
TRA	SV128	7.60-	8.40	10	15	10	250	.05	150	
TRA	SV1011	7.60-	8.40	10	15	10	750	.05	150	
TRA	SV2011	7.60-	8.40	1000	.80	1000	10W	.05	150	
LTCB	Z2A100	7.80-	12.20	20	20	20	750		100	
HSD	1N430	8. -	8.80	10	15	10	250		150A	20.00
HSD	1N430A	8. -	8.80	10						30.00
HSD	1N430B	8. -	8.80	10						40.00
TRA	SV129	8.08-	8.93	10	15	10	250	.054	150	
TRA	SV1012	8.08-	8.93	10	15	10	750	.054	150	
TRA	SV2012	8.08-	8.93	1000	.80	1000	10W	.054	150	
TII	654C9	8.50-	9.50	5.0			150		150	
BTHB	SJDX7A/9	8.50-	9.50	10					250J	
TRA	SV131	8.55-	9.45	10	15	10	250	.057	150	
TRA	SV1013	8.55-	9.45	10	15	10	750	.057	150	
TRA	SV2013	8.55-	9.45	1000	.80	1000	10W	.057	150	
HSD	1N1351	9. -	11.	500	2.0	10	10W		155A	10.00
HSD	1N226	9. -	12.	.20			150		150A	6.00
HSD	1N1314	9. -	12.				150		150A	3.50
TRA	SV11	9. -	12.	20	50				150	
TRA	SV810	9. -	12.	60	50				150	
TRA	SV910	9. -	12.	800	1.5				150	
TRA	SV132	9.04-	9.98	10	15	10	250	.058	150	
TRA	SV1014	9.04-	9.98	10	15	10	750	.058	150	
TRA	SV2014	9.04-	9.98	1000	.80	1000	10W	.58	150	
IREC	3Z10	9.10-	11.	350	2.5	70	3500	.07		
IREC	10Z10	9.10-	11.	1000	1.25	200	10W	.07		
IREC	1Z10	9.10-	11.	100	4.5	20	1000	.07		
USS	LZ10	9.10-	11.	5.0	45	20	400	.03		
IREC	MZ10	9.10-	11.	50	6.8	10	500	.07		
USS	Z10	9.10-	11.	5.0	50	10	150	.03	150	
USS	ZT10	9.10-	11.	5.0	50	10	200	.025		
IREC	ZZ10	9.10-	11.	40	25	8.0	350	.05		
HSD	1N1351A	9.50-	10.50	500	2.0	500	10W	.06		
TII	655C9	9.50-	10.50	5.0			150		150	

SYMBOLS AND LETTER CODES

FOLLOWING LINE NO.

- □ - New
- • - Revised
- # - Foreign Mfr.

FOLLOWING TYPE NO.

- T - Tentative
- R - Military use only
- M - Mil. Specs.
- D - Under Development
- A - Army Specs.
- N - Navy Specs.
- F - AF Specs.

FOLLOWING TEMP.

- A - Ambient
- B - Base (stud)
- J - Junction
- S - Storage

SILICON ZENER OR AVALANCHE DIODES *(cont.)*

In order of Min. E_{b1}, Max. E_{b2}, and type no.

MANUFAC-TURER	TYPE No.	ZENER OR AVALANCHE VOLTAGE RANGE: MIN. E_{b1} TO MAX. E_{b2} (volts)	ZENER OR AVALANCHE VOLTAGE RANGE: @I_z (ma)	DYNAMIC IMPEDANCE: Z (ohms)	DYNAMIC IMPEDANCE: @I_z (ma)	MAX. DISS. (mw)	TEMP. COEFF. (%/°C)	MAX. TEMP. (°C)	PRICE 1-100
TRA	SV133	9.50- 10.50	5.0	50	5.0	250	.06	150	
TRA	SV1015	9.50- 10.50	5.0	50	5.0	750	.06	150	
TRA	SV2015	9.50- 10.50	500	1.5	500	10W	.06	150	
HSD	1N1352	9.90- 12.10	500	.90	500	10W		155A	10.00
HSD	1N1352A	10.45- 11.55	500	2.0	500	10W	.06		10.00
TRA	SV134	10.45- 11.55	5.0	50	5.0	250	.063	150	
TRA	SV1016	10.45- 11.55	5.0	50	5.0	750	.063	150	
TRA	SV2016	10.45- 11.55	500	1.5	500	10W	.063	150	
HSD	1N1353	10.80- 13.20	500	2.0	10	10W		155A	10.00
WEC	GA53339-4	10.80- 13.20	10			3000			
WEC	GA53341-4	10.80- 13.20	2.0	15	2.0	500			
WEC	GA53342-4	10.80- 13.20	10			100			
IREC	3Z12	11. - 13.	275	4.0	50	3500	.075		
WEC	GA52931	11. - 13.	40	6.0	10	500		135	
IREC	10Z12	11. - 13.	850	2.0	170	10W	.075		
IREC	IZ12	11. - 13.	80	7.5	15	1000	.075		
USS	LZ12	11. - 13.	1.0	65	20	400	.045		
IREC	MZ12	11. - 13.	40	12	7.5	500	.075		
USS	Z12	11. - 13.	1.0	70	10	150	.045	150	
USS	ZT12	11. - 13.	1.0	70	10	200	.04		
IREC	ZZ12	11. - 13.	30	40	7.5	350	.06		
HSD	1N227	11. - 14.50	.20			150		150A	6.00
HSD	1N1315	11. - 14.50				150		150A	3.50
TRA	SV13	11. - 14.50	5.0	70	5.0	250	.07		
TRA	SV812	11. - 14.50	5.0	70	5.0	750	.07	150	
TRA	SV912	11. - 14.50	500	2.0	500	10W	.07	150	
HSD	1N1353A	11.40- 12.60	500	2.0	500	10W	.06		
TRA	SV135	11.40- 12.60	5.0	50	5.0	250	.066	150	
TRA	SV1017	11.40- 12.60	5.0	70	5.0	750	.066	150	
TRA	SV2017	11.40- 12.60	500	2.0	500	10W	.066	150	
HSD	1N1354	11.70- 14.30	500	1.1	500	10W		155A	10.00
LTCB	Z2A150	11.80- 18.20	20	45	20	750		100	
HSD	1N1354A	12.35- 13.65	500	2.0	500	10W	.07		
TRA	SV136	12.35- 13.65	5.0	50	5.0	250	.069	150	
TRA	SV1018	12.35- 13.65	5.0	70	5.0	750	.069	150	
TRA	SV2018	12.35- 13.65	500	2.0	500	10W	.069	150	
IREC	3Z15	13. - 16.	225	7.5	40	3500	.08		
IREC	10Z15	13. - 16.	650	4.0	140	10W	.08		
IREC	IZ15	13. - 16.	65	15	13	1000	.08		
USS	LZ15	13. - 16.	1.0	95	10	400	.065		
IREC	MZ15	13. - 16.	33	23	6.0	500	.08		
USS	Z15	13. - 16.	1.0	100	5.0	150	.065	150	
USS	ZT15	13. - 16.	1.0	100	5.0	200	.06		
IREC	ZZ15	13. - 16.	25	60	5.0	350	.07		

SYMBOLS AND LETTER CODES

FOLLOWING LINE NO.

- □ - New
- • - Revised
- # - Foreign Mfr.

FOLLOWING TYPE NO.

- T - Tentative
- R - Military use only
- M - Mil. Specs.
- D - Under Development
- A - Army Specs.
- N - Navy Specs.
- F - AF Specs.

FOLLOWING TEMP.

- A - Ambient
- B - Base (stud)
- J - Junction
- S - Storage

SILICON ZENER OR AVALANCHE DIODES *(cont.)*

In order of Min. E_{b1}, Max. E_{b2}, and type no.

MANUFAC-TURER	TYPE No.	ZENER OR AVALANCHE VOLTAGE RANGE MIN. E_{b1} TO MAX. E_{b2} (volts)	@I_Z (ma)	DYNAMIC IMPEDANCE Z (ohms)	@I_Z (ma)	MAX. DISS. (mw)	TEMP. COEFF. (%/°C)	MAX. TEMP. (°C)	PRICE 1-100
TRA	SV137	13.30- 14.70	5.0	50	5.0	250	.072	150	
TRA	SV1019	13.30- 14.70	5.0	70	5.0	750	.072	150	
TRA	SV2019	13.30- 14.70	500	2.0	500	10W	.072	150	
HSD	1N1355	13.50- 16.50	500	2.0	10	10W		155A	10.00
WEC	GA53339-5	13.50- 16.50	10			3000			
WEC	GA53341-5	13.50- 16.50	2.0	20	2.0	500			
WEC	GA53342-5	13.50- 16.50	2.0			100			
HSD	1N228	13.50- 18.	.20			150		150A	6.00
HSD	1N1316	13.50- 18.				150		150A	3.50
TRA	SV15	13.50- 18.	14	120				150	
TRA	SV815	13.50- 18.	40	120				150	
TRA	SV915	13.50- 18.	600	3.0				150	
WEC	GA52932	14. - 16.	60	7.0	10	1000		135	
HSD	1N1355A	14.25- 15.75	500	2.0	500	10W	.07		
TRA	SV138	14.25- 15.75	5.0	120	5.0	250	.075	150	
TRA	SV1020	14.25- 15.75	5.0	120	5.0	750	.075	150	
TRA	SV2020	14.24- 15.75	500	3.0	500	10W	.075	150	
HSD	1N1356	14.40- 17.60	500	1.2	500	10W		155A	10.00
HSD	1N1356A	15.20- 16.80	500	3.0	500	10W	.07		
TRA	SV139	15.20- 16.80	5.0	120	5.0	250	.076	150	
TRA	SV1021	15.20- 16.80	5.0	120	5.0	750	.076	150	
TRA	SV2021	15.20- 16.80	500	3.0	500	10W	.076	150	
IREC	3Z18	16. - 20.	200	15	35	3500	.085		
IREC	10Z18	16. - 20.	550	7.5	110	10W	.085		
IREC	IZ18	16. - 20.	55	30	10	1000	.085		
USS	LZ18	16. - 20.	1.0	145	10	400	.08		
IREC	MZ18	16. - 20.	27	45	5.0	500	.085		
USS	Z18	16. - 20.	1.0	150	5.0	150	.08	150	
USS	ZT18	16. - 20.	1.0	150	5.0	200	.07		
IREC	ZZ18	16. - 20.	20	80	4.0	350	.08		
TRA	SV141	16.15- 17.85	5.0	120	5.0	250	.077	150	
TRA	SV1022	16.15- 17.85	5.0	120	5.0	750	.077	150	
TRA	SV2022	16.15- 17.85	500	3.0	500	10W	.077	150	
HSD	1N1357	16.20- 19.80	500	3.0	10	10W		155A	10.00
WEC	GA53339-6	16.20- 19.80	10			3000			
WEC	GA53341-6	16.20- 19.80	2.0	25	2.0	500			
WEC	GA53342-6	16.20- 19.80	2.0			100			
WEC	GA52933	17. - 19.	55	7.0	10	1000		135	
HSD	1N229	17. - 21.	.20			150		150A	6.00
HSD	1N1317	17. - 21.				150		150A	3.50
TRA	SV18	17. - 21.	5.0	200	5.0	250	.08		
TRA	SV818	17. - 21.	5.0	200	5.0	750	.08	150	
TRA	SV918	17. - 21.	500	3.0	500	10W	.08	150	
WEC	GA52999	17. - 23.	150	5.0	10	1000		135	

SYMBOLS AND LETTER CODES

FOLLOWING LINE NO.

- □ - New
- • - Revised
- # - Foreign Mfr.

FOLLOWING TYPE NO.

- T - Tentative
- R - Military use only
- M - Mil. Specs.
- D - Under Development
- A - Army Specs.
- N - Navy Specs.
- F - AF Specs.

FOLLOWING TEMP.

- A - Ambient
- B - Base (stud)
- J - Junction
- S - Storage

SILICON ZENER OR AVALANCHE DIODES *(cont.)*

In order of Min. E_{b1}, Max. E_{b2}, and type no.

MANUFAC-TURER	TYPE No.	ZENER OR AVALANCHE VOLTAGE RANGE MIN. TO MAX. E_{b1} (volts) E_{b2}	@I_z (ma)	DYNAMIC IMPEDANCE Z (ohms)	@I_z (ma)	MAX. DISS. (mw)	TEMP. COEFF. (%/°C)	MAX. TEMP. (°C)	PRICE 1-100
HSD	1N1357A	17.10- 18.90	500	3.0	500	10W	.07		
TRA	SV142	17.10- 18.90	5.0	200	5.0	250	.078	150	
TRA	SV1023	17.10- 18.90	5.0	200	5.0	750	.078	150	
TRA	SV2023	17.10- 18.90	500	3.0	500	10W	.078	150	
HSD	1N1358	18. - 22.	150	1.4	150	10W		155A	10.00
TRA	SV143	18.05- 19.95	5.0	200	5.0	250	.079	150	
TRA	SV1024	18.05- 19.95	5.0	200	5.0	750	.079	150	
TRA	SV2024	18.05- 19.95	500	3.0	500	10W	.079	150	
HSD	1N1358A	19. - 21.	150	3.0	150	10W	.08		
WEC	GA52934	19. - 21.	50	7.0	10	1000		135	
TRA	SV144	19. - 21.	5.0	200	5.0	250	.081	150	
TRA	SV1025	19. - 21.	5.0	200	5.0	750	.081	150	
TRA	SV2025	19. - 21.	500	3.0	500	10W	.081	150	
HSD	1N1359	19.80- 24.20	150	3.0	10	10W		155A	10.00
WEC	GA53339-7	19.80- 24.20	10	20	10	3000	.080		
WEC	GA53341-7	19.80- 24.20	2.0	30	2.0	500	.08		
WEC	GA53342-7	19.80- 24.20	2.0			100			
IREC	3Z22	20. - 24.	160	22.5	30	3500	.09		
IREC	10Z22	20. - 24.	450	12	90	10W	.09		
IREC	IZ22	20. - 24.	45	45	9.0	1000	.09		
USS	LZ22	20. - 24.	1.0	195	10	400	.085		
IREC	MZ22	20. - 24.	23	70	4.5	500	.09		
USS	Z22	20. - 24.	1.0	200	5.0	150	.085	150	
USS	ZT22	20. - 24.	1.0	200	5.0	200	.08		
IREC	ZZ22	20. - 24.	16	125	3.5	350	.09		
HSD	1N230	20. - 27.	.20			150		150A	6.50
HSD	1N1318	20. - 27.				150		150A	3.50
TRA	SV24	20. - 27.	10	300				150	
TRA	SV824	20. - 27.	27	300				150	
TRA	SV924	20. - 27.	400	8.0				150	
HSD	1N1359A	20.90- 23.10	150	3.0	150	10W	.08		
TRA	SV168	20.90- 23.10	5.0	300	5.0	250	.084	150	
TRA	SV1033	20.90- 23.10	5.0	300	5.0	750	.084	150	
TRA	SV2044	20.90- 23.10	150	8.0	150	10W	.084	150	
HSD	1N1360	21.60- 26.40	150	1.7	150	10W		155A	
HSD	1N1360A	22.80- 25.60	150	3.0	150	10W	.08		
TRA	SV169	22.80- 25.20	5.0	300	5.0	250	.086	150	
TRA	SV1034	22.80- 25.20	5.0	300	5.0	750	.086	150	
TRA	SV2045	22.80- 25.20	150	8.0	150	10W	.086	150	
IREC	3Z27	24. - 30.	125	30	25	3500	.095		
INRC	10Z27	24. - 30.	350	15	70	10W	.095		
IREC	HZ27	24. - 30.	200	7.0	40	5000	.00		
IREC	IZ27	24. - 30.	35	60	7.0	1000	.095		
IREC	LZ27	24. - 30.	1.0	290	10	400	.09		

SYMBOLS AND LETTER CODES

FOLLOWING LINE NO.

- □ - New
- • - Revised
- # - Foreign Mfr.

FOLLOWING TYPE NO.

- T - Tentative
- R - Military use only
- M - Mil. Specs.
- D - Under Development
- A - Army Specs.
- N - Navy Specs.
- F - AF Specs.

FOLLOWING TEMP.

- A - Ambient
- B - Base (stud)
- J - Junction
- S - Storage

SILICON ZENER OR AVALANCHE DIODES *(cont.)*

In order of Min. E_{b1}, Max. E_{b2}, and type no.

MANUFACTURER	TYPE No.	ZENER OR AVALANCHE VOLTAGE RANGE MIN. E_{b1} (volts)	TO MAX. E_{b2}	@I_Z (ma)	DYNAMIC IMPEDANCE Z (ohms)	@I_Z (ma)	MAX. DISS. (mw)	TEMP. COEFF. (%/°C)	MAX. TEMP. (°C)	PRICE 1-100
IREC	MZ27	24.	30.	18	90	3.5	500	.095		
USS	Z27	24.	30.	1.0	300	5.0	150	.09	150	
IREC	ZZ27	24.	30.	13	200	3.0	350	.095		
HSD	1N1361	24.30	29.70	150	3.0	10	10W		155A	11.00
TRA	SV171	24.70	27.30	5.0	300	5.0	250	.088	150	
TRA	SV1035	24.70	27.30	5.0	300	5.0	750	.088	150	
TRA	SV2046	24.70	27.30	150	8.0	150	10W	.088	150	
HSD	1N231	25.	32.	.20			150		150A	6.50
HSD	1N1319	25.	32.				150		150A	3.50
HSD	1N1361A	25.65	28.35	150	3.0	150	10W	.08		
WEC	GA53339-8	26.30	29.70	10	25	10	3000	.085		
WEC	GA53341-8	26.30	29.70	2.0	35	2.0	500	.085		
WEC	GA53342-8	26.30	29.70	2.0			100			
HSD	1N1362	27.	33.	150	2.1	150	10W		155A	11.00
HSD	1N1362A	28.50	31.50	150	4.0	150	10W	.08		11.00
HSD	1N1363	29.70	36.30	150	4.0	10	10W		155A	11.00
INRC	HZ33	30.	36.	150	10	30	5000	.03		
USS	LZ33	30.	36.	.20	350	5.0	400	.095		
USS	Z33	30.	36.	.20	400	1.0	150	.095	150	
HSD	1N232	30.	39.	.20			150		150A	6.25
HSD	1N1320	30.	39.				150		150A	3.50
HSD	1N1363A	31.35	34.65	150	4.0	150	10W	.08		11.00
HSD	1N1364	32.40	39.60	150	2.7	150	10W		155A	11.00
HSD	1N1364A	34.20	37.80	150	5.0	150	10W	.09		11.00
HSD	1N1365	35.10	42.90	150	5.0	10	10W		155A	11.00
USS	LZ39	36.	43.	.20	550	5.0	400			
USS	Z39	36.	43.	.20	600	1.0	150	.10	150	
HSD	1N233	37.	45.	.20			150		150A	6.50
HSD	1N1321	37.	45.				150		150A	3.50
HSD	1N1365A	37.05	40.95	150	5.0	150	10W	.09		11.00
HSD	1N1366	38.70	47.30	150	3.6	150	10W		155A	11.00
HSD	1N1366A	40.85	45.15	150	6.0	150	10W	.09		11.00
HSD	1N1367	42.30	51.70	150	7.0	10	10W		155A	11.00
IREC	HZ47	43.	51.	110	20	22	5000	.06		
USS	LZ47	43.	51.	.20	750	5.0	400			
USS	Z47	43.	51.	.20	800	1.0	150		150	
HSD	1N1322	43.	54.				150		150A	3.50
HSD	1N1367A	44.65	49.35	150	7.0	150	10W	.09		11.00
HSD	1N1368	45.90	56.10	150	5.2	150	10W		155A	11.00
HSD	1N1368A	48.45	53.55	150	8.0	150	10W	.10		11.00
HSD	1N1369	50.40	61.60	150	9.0	10	10W		155A	11.00
USS	LZ56	51.	62.	.20	1000	5.0	400			
USS	Z56	51.	62.	.20	1000	1.0	150		150	
HSD	1N1323	52.	64.				150		150A	3.50

SYMBOLS AND LETTER CODES

FOLLOWING LINE NO.

- □ - New
- • - Revised
- # - Foreign Mfr.

FOLLOWING TYPE NO.

- T - Tentative
- R - Military use only
- M - Mil. Specs.
- D - Under Development
- A - Army Specs.
- N - Navy Specs.
- F - AF Specs.

FOLLOWING TEMP.

- A - Ambient
- B - Base (stud)
- J - Junction
- S - Storage

SILICON ZENER OR AVALANCHE DIODES *(cont.)*

In order of Min. E_{b1}, Max. E_{b2}, and type no.

MANUFAC-TURER	TYPE No.	ZENER OR AVALANCHE VOLTAGE RANGE MIN. TO MAX. E_{b1} (volts) E_{b2}	@I_z (ma)	DYNAMIC IMPEDANCE Z (ohms)	@I_z (ma)	MAX. DISS. (mw)	TEMP. COEFF. (%/°C)	MAX. TEMP. (°C)	PRICE 1-100
HSD	1N1369A	53.20- 58.80	150	9.0	150	10W	.10		11.00
HSD	1N1370	55.80- 68.20	50	8.0	50	10W		155A	13.00
HSD	1N1370A	58.90- 65.10	50	12	50	10W	.10		13.00
HSD	1N1371	61.20- 74.80	50	14	10	10W		155A	13.00
WEC	GA53339-9	61.20- 74.80	10	50	10	3000	.095		
WEC	GA53341-9	61.20- 74.80	.50	100	.50	500	.095		
WEC	GA53342-9	61.20- 74.80	.50			100			
IREC	HZ68	62. - 75.	75	60	14	5000	.075		
USS	LZ68	62. - 75.	.20			400			
USS	Z68	62. - 75.	.20			150		150	
HSD	1N1324	62. - 80.				150		150A	3.50
HSD	1N1371A	64.60- 71.40	50	14	50	10W	.10		13.00
HSD	1N1372	67.50- 82.50	50	12	50	10W		155A	13.00
HSD	1N1372A	71.25- 78.75	50	20	50	10W	.11		13.00
HSD	1N1373	73.80- 90.20	50	22	10	10W		155A	13.00
USS	LZ82	75. - 91.	.20			400			
USS	Z82	75. - 91.	.20			150		150	
HSD	1N1325	75. -100.				150		150A	3.50
HSD	1N1373A	77.90- 86.10	50	22	50	10W	.11		13.00
HSD	1N1374	82. -100.	50	30	50	10W		155A	13.00
HSD	1N1374A	86.45- 95.55	50	35	50	10W	.12		13.00
HSD	1N1375	90. -110.	50	40	10	10W		155A	13.00
WEC	GA53339-10	90. -110.	10			3000			
WEC	GA53341-10	90. -110.	.50	200	.50	500			
WEC	GA53342-10	90. -110.	.50			100			
HSD	1N1326	90. -120.				150		150A	3.50
IREC	HZ100	91. -110.	50	180	10	5000	.085		
USS	LZ100	91. -110.	.20			400			
USS	Z100	91. -110.	.20			150		150	
HSD	1N1375A	95. -105.	50	40	50	10W	.12		13.00
USS	Z120	110. -130.	.20			150		150	
HSD	1N1327	110. -145.				150		150A	3.50
IREC	HZ150	130. -160.	35	370	7.0	5000	.095		
USS	Z150	130. -160.	.10			150		150	
WEC	GA52935	130. -170.	20	100	10	1000		135	
WEC	GA53339-11	135. -165.	10	300	10	3000	.10		
WEC	GA53341-11	135. -165.	.50	340	.50	500	.10		
WEC	GA53342-11	135. -165.	.50			100			
USS	Z180	160. -200.	.10			150		150	
USS	Z220	200. -240.	.10			150		150	
USS	Z270	240. -300.	.10			150		150	
USS	Z330	300. -360.	.10			150		150	
USS	Z390	360. -430.	.10			150		150	
USS	Z470	430. -510.	.10			150		150	
USS	Z560	510. -620.	.10			150		150	

SYMBOLS AND LETTER CODES

FOLLOWING LINE NO.

- □ - New
- • - Revised
- # - Foreign Mfr.

FOLLOWING TYPE NO.

- T - Tentative
- R - Military use only
- M - Mil. Specs.
- D - Under Development
- A - Army Specs.
- N - Navy Specs.
- F - AF Specs.

FOLLOWING TEMP.

- A - Ambient
- B - Base (stud)
- J - Junction
- S - Storage