BAŞKENT UNIVERSITY
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ELECTIC-ELECTRICAL ENGINEERING

EEM214 ELECTRONICS I
LAB TASK REPORT

LAB I:
1N2846 DIODE

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CONTENTS

1. OVERVIEW OF DIODES

A diode is an electronic component that allows current to flow in only one direction. It consists of a p-n junction where the p-type and n-type semiconductor materials are sandwiched together. When a voltage is applied in the forward direction, the diode conducts current, but when the voltage is applied in the reverse direction, the diode blocks current flow. This property of diodes makes them useful for rectifying AC signals into DC, protecting circuits from reverse voltage damage, and many other applications in electronics.

On the other hand, a zener diode is a special type of diode that is designed to operate in the reverse breakdown region. In this region, the voltage across the zener diode remains constant over a wide range of currents. This unique property of zener diodes makes them useful for voltage regulation, voltage reference, and voltage clamping applications.

According to a textbook by Sedra and Smith (2018), "Zener diodes are widely used as voltage references in electronic circuits because they can maintain a nearly constant voltage across their terminals over a wide range of current values." Similarly, Boylestad and Nashelsky (2018) explain in their textbook that "The primary function of a diode is to rectify an ac voltage by blocking current flow in one direction and allowing current flow in the other direction. The zener diode, on the other hand, is designed to operate in the breakdown region and has a sharp breakdown voltage that can be used as a voltage reference or regulator."

In summary, diodes are electronic components that allow current to flow in only one direction, while zener diodes are a special type of diode that can maintain a constant voltage over a wide range of currents and are useful for voltage regulation and reference applications.

Zener diodes are commonly used in voltage reference circuits, voltage regulators, and as protection devices to prevent other components in a circuit from being damaged by voltage spikes or surges. They are also used in power supplies, audio amplifiers, and other electronic applications where a constant voltage is required. [1-2]

* There are many datasheet documentation for 1N2846 diode, but mostly release dates are outdated and lack of some important data. In my report, I've dealt with many different datasheets and gather this report around with help of different datasheet documentations [3-5] which were relatively the most informative documents.

2. 1N2846 DIODE

a. OVERVIEW

The 1N2846 is a high-power 50W silicon rectifier diode and has a "glass body construction (glass-encapsulated)" and a "stud anode" design with a maximum average forward max current rating of 5 amperes and a peak reverse voltage range of 3.9-200 volts. The diode has a standard axial lead package, which makes it easy to mount on a printed circuit board or in other electronic circuits.

The 1N2846 diode is designed to be used in power supply circuits as a rectifier for converting AC voltage to DC voltage. It can also be used in other applications such as battery charging circuits, voltage regulators, and motor control circuits. The diode's maximum forward voltage drop at a forward current of 20 amperes is around 1 volt, which means that it has a relatively low forward voltage drop compared to other high-power diodes. This low forward voltage drop reduces power dissipation and improves the efficiency of the circuit.

The 1N2846 diode has a maximum junction temperature rating of 200°C and a thermal resistance of 1.2°C/W, which means that it can handle high power dissipation without overheating. However, it is important to ensure that the diode is adequately cooled to prevent thermal runaway.

The 1N2846 diode is widely available from various manufacturers and distributors. It is commonly used in power electronics applications where high voltage and high current rectification is required. The 1N2846 diode is a reliable and high-performing diode that is suitable for a range of high-power applications. It offers low forward voltage drop, high surge current capability, and high temperature tolerance, making it a popular choice among engineers and hobbyists alike. The 1N2846 diode has a low forward voltage drop and a fast recovery time, which makes it suitable for high frequency rectification applications. It also has a high surge current capability, which enables it to handle short-duration current spikes without being damaged.

b. VARIATIONS
There are 4 kinds of 1N2846 diode. The differences between 1N2846A, 1N2846B, 1N2846C, and 1N2846D are in their maximum reverse voltage and maximum forward current ratings, as well as their tolerances and packaging options.
Specific differences:

1N2846A:
- Maximum reverse voltage (Vr): 100V
- Maximum forward current (If): 4A
- Tolerance: Standard
- Package: DO-4 (DO-203AA)

1N2846B:
- Maximum reverse voltage (Vr): 200V
- Maximum forward current (If): 4A
- Tolerance: Standard
- Package: DO-4 (DO-203AA)

1N2846C:
- Maximum reverse voltage (Vr): 300V
- Maximum forward current (If): 4A
- Tolerance: Standard
- Package: DO-4 (DO-203AA)

1N2846D:
- Maximum reverse voltage (Vr): 400V
- Maximum forward current (If): 4A
- Tolerance: Standard
- Package: DO-4 (DO-203AA)

As we see the only difference betwwen these variations is Vr. The suffix letters (A, B, C, D) indicate the increasing maximum reverse voltage ratings of the diodes. It is important to choose a diode with a maximum reverse voltage rating that is higher than the maximum voltage that will be applied across it in the circuit to avoid damaging the diode. The maximum forward current rating indicates the highest current that the diode can safely conduct in the forward direction.

The tolerance indicates how closely the actual characteristics of the diode match the nominal values specified in the datasheet. Standard tolerance diodes typically have a tolerance of +/- 5%. Other available tolerance levels may include +/- 2%, +/- 1%, or even tighter tolerances.
The package type (DO-4) refers to a specific cylindrical package format that can handle higher power dissipation than smaller packages.

* From now on, we are going to elaborate the research for 1N2846B.

c. MAX. RATINGS

MAXIMUM RATINGS

Parameter	Value
DC Power Dissipation	50 W
Voltage Range	6.8 – 200 V
Junction Temperature	-65°C to +175°C
Storage Temperature	-65°C to +175°C
Power Derating	0.5W/°C above 75°C
Forward Voltage	@ 2.0 A: 1.5 Volts

The max ratings provide important information on the limits of operation for the device.

The DC power dissipation specifies the maximum power that can be safely handled by the device, which is 50 watts. The voltage range is specified as 6.8 – 200 V, which indicates the range of voltages that the device is designed to operate at.

The junction temperature and storage temperature indicate the range of temperatures that the device can safely withstand during operation and storage respectively. The junction temperature range is -65°C to +175°C, while the storage temperature range is -65°C to +175°C.

The power derating specification indicates that the device needs to be derated by 0.5 W/°C above 75°C. This means that as the temperature of the device increases beyond 75°C, the maximum power that can be safely handled by the device decreases. Therefore, if the device is being operated in high-temperature environments, the power dissipation needs to be reduced accordingly.

The forward voltage at 2.0 A is specified as 1.5 volts, which indicates the voltage drop across the device when a current of 2.0 A is passed through it. This information is useful in determining the voltage levels that the device can be used with.

d. MECHANICAL / PACKAGING INFORMATION

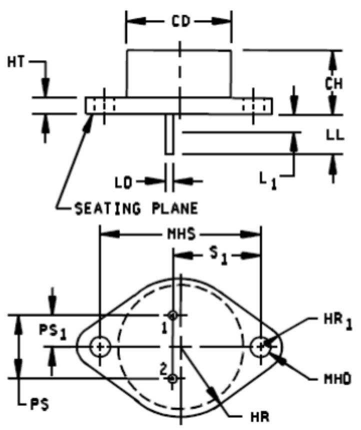
- CASE: Industry Standard TO-3 (TO-204AD), hermetically sealed, 0.052 inch diameter pins. This indicates that the diode is packaged in an industry-standard TO-3 case with hermetically sealed construction, and has pins with a diameter of 0.052 inches.
- FINISH: All external surfaces are corrosion resistant and terminal solderable. This indicates that the diode has a corrosion-resistant finish on all external surfaces, and the terminals are designed for easy soldering.
- POLARITY: Standard Polarity units are connected anode to case. Reverse polarity (cathode to case) is indicated by suffix R. In either example, both pins are common with one another as anode or cathode. This specifies that the standard polarity of the diode is anode-to-case connection, while reverse polarity (cathode-to-case) units are indicated by the suffix "R". It also clarifies that both pins are common with each other as either anode or cathode.
- WEIGHT: 15 grams. This specifies the weight of the diode.
- MOUNTING HARDWARE: Consult factory for optional insulator and sheet metal screws which can be seen on figure at very below. This indicates that optional insulators and sheet metal screws are available from the manufacturer, and provides the package dimensions for reference.

Overall, the 1N2846 diode is designed for easy soldering and is housed in a hermetically sealed TO-3 case, making it suitable for use in harsh environments where protection from the elements is important. Its standard and reverse polarity options allow for flexibility in circuit design, and its weight and package dimensions are provided for ease of installation.

MECHANICAL AND PACKAGING

- CASE: Industry Standard TO-3 (TO-204AD), hermetically sealed, 0.052 inch diameter pins.
- FINISH: All external surfaces are corrosion resistant and terminal solderable.
- POLARITY: Standard Polarity units are connected anode to case. Reverse polarity (cathode to case) is indicated by suffix R. In either example, both pins are common with one another as anode or cathode (see circuit on last page).
- WEIGHT: 15 grams.
- MOUNTING HARDWARE: Consult factory for optional insulator and sheet metal screws
- See package dimensions on last page

PACKAGE DIMENSIONS



Ltr	Dimensions				Notes
	Inches		Millimeters		
	Min	Max	Min	Max	
CH	.270	.380	6.86	9.65	
LD	.048	.053	0.97	1.35	
CD		.875		22.23	
PS	.420	.440	10.67	11.18	3
PS_1	.205	.225	5.21	5.72	3
HT	.060	.135	1.52	3.42	
LL	.312	.500	7.92	12.70	
L_1		.050		1.27	
MHD	.151	.165	3.84	4.09	
MHS	1.177	1.197	29.90	30.40	
HR	.495	.525	12.57	13.34	
HR_1	.131	.188	3.33	4.78	
S_1	.655	.675	16.64	17.15	

NOTES:

1. Dimensions are in inches.
2. Milimeter equivalents are given for general information only.
3. These dimensions should be measured at points .050 inch (1.27mm) + .005 inch (0.13mm) -.000 inch (0.00mm) below seating plane.
4. The seating plane of the header shall be flat within .001 (0.03mm) concave to .004 inch (0.10mm) convex .001 inch (0.003mm) cocave to .006 inch (0.15mm) convex overall.
5. Pins 1 and 2 are internally connected with an internal jumper.
6. Devices wih B suffix have the anode internally connected to the case and devices with RB suffix (reverse polarity) have the cathode internally connected to the case.
7. In accordance with ASME Y14.5M, diameters are equivalent to ϕx symbology.

FIGURE 1. Physical dimensions (similar to TO-3)

e. THE ELECTRICAL CHARACTERISTICS

The electrical characteristics of a component refer to its behavior and performance when subjected to various electrical conditions. Here are the details of the electrical characteristics for the 1N2846 diode:

Nominal zener voltage: This value indicates the nominal zener voltage that the diode is designed to provide when it is operated at its rated current and temperature. In this case, the 1N2846 diode has a nominal zener voltage of 200 volts.

Zener test current: This value indicates the test current that is used to measure the zener voltage of the diode. In this case, the 1N2846 diode is tested at a zener current of 65 mA.

Maximum dynamic impedance (Z_{zt}): This value indicates the maximum dynamic impedance of the diode at a certain operating point. Dynamic impedance refers to the change in voltage that occurs in response to a change in current. In this case, the maximum dynamic impedance Z_{zt} of the 1N2846 diode is 100 ohms.

Zener knee current Z_{zk} @1mA: This value indicates the current at which the diode reaches its zener knee point. The zener knee point is the point at which the voltage across the diode begins to decrease rapidly with increasing current. In this case, the zener knee current Zzk of the 1N2846 diode is 600 mA at a test current of 1 mA.

Maximum DC Zener current (I_{zm}): This value indicates the maximum DC current that the diode can handle without exceeding its rated power dissipation. In this case, the maximum DC zener current (I_{zm}) of the 1N2846 diode is 200 mA at a stud temperature of 75°C.

Typical temperature coefficient: This value indicates the typical change in zener voltage that occurs in response to a change in temperature. In this case, the typical temperature coefficient of the 1N2846 diode is 0.100%/°C.

Maximum reverse current: This value indicates the maximum reverse current that the diode can handle without exceeding its maximum allowable power dissipation. In this case, the maximum reverse current of the 1N2846 diode is 5 µA at a reverse voltage of 152 volts.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Part Number (1)	Nominal Zener Voltage V_Z @ I_{ZT}	Zener Test Current (I_{ZT})	Maximum Dynamic Impedance (2)		Max DC Zener Current (I_{ZM}) @ 75°C Stud Temperature (3)	Typical Temperature Coefficient α_{VZ}	Maximum Reverse Current I_R @ V_R	
	Volts	mA	Z_{ZT} @ I_{ZT} ohms	Z_{ZK} @ 1mA (I_{ZK}) ohms	mA	%/°C	µA	Volts
1N2824B	33.0	380	3.20	90	1300	0.085	5.0	25.1
1N2825B	36.0	350	3.50	90	1150	0.085	5.0	27.4
1N2826B	39.0	320	4.00	90	1050	0.090	5.0	29.7
1N2827B	43.0	290	4.50	90	975	0.090	5.0	32.7
1N2828B	45.0	280	4.50	100	930	0.090	5.0	34.2
1N2829B	47.0	270	5.00	100	880	0.090	5.0	35.8
1N2830B	50.0	250	5.00	100	830	0.090	5.0	38.0
1N2831B	51.0	245	5.20	100	810	0.090	5.0	38.8
1N2832B	56.0	220	6.00	110	740	0.090	5.0	42.6
1N2833B	62.0	200	7.00	120	660	0.090	5.0	47.1
1N2834B	68.0	180	8.00	140	600	0.090	5.0	51.7
1N2835B	75.0	170	9.00	150	540	0.090	5.0	56.0
1N2836B	82.0	150	11.00	160	490	0.090	5.0	62.2
1N2837B	91.0	140	15.00	180	420	0.090	5.0	69.2
1N2838B	100.0	120	20.00	200	400	0.090	5.0	76.0
1N2839B	105.0	120	25.00	210	380	0.095	5.0	79.8
1N2840B	110.0	110	30.00	220	365	0.095	5.0	83.6
1N2841B	120.0	100	40.00	240	335	0.095	5.0	91.2
1N2842B	130.0	95	50.00	275	310	0.095	5.0	98.8
1N2843B	150.0	85	75.00	400	270	0.095	5.0	114.0
1N2844B	160.0	80	80.00	450	250	0.095	5.0	121.6
1N2845B	180.0	68	90.00	525	220	0.095	5.0	136.8
1N2846B	200.0	65	100.00	600	200	0.100	5.0	152.0

f. GRAPHS

In the max ratings section provided, it is stated that the maximum DC power dissipation for the device is 50 watts. This means that the device can safely dissipate up to 50 watts of power without being damaged. However, the power derating curve shows that the maximum power dissipation decreases as the operating temperature increases. The curve shows that the device can operate at 50 watts of power dissipation up to an operating temperature of 75°C. At this point, the device's power dissipation capability begins to decrease, and the maximum power dissipation decreases at a rate of 0.5W/°C. As the operating temperature continues to increase, the maximum power dissipation that the device can safely handle decreases, until it reaches zero watts at an operating temperature of 175°C. This means that at an operating temperature of 175°C or higher, the device cannot safely dissipate any power without being damaged. Therefore, if the device is used in an application where the operating temperature will exceed 75°C, it is important to ensure that the power dissipation does not exceed the maximum allowable limit for that operating temperature, as shown in the power derating curve. Failure to observe the maximum allowable power dissipation can result in device failure and potentially cause damage to the system in which it is used.

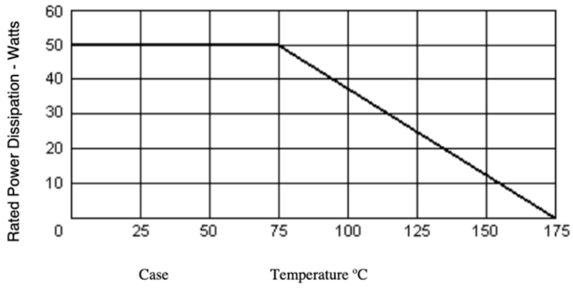
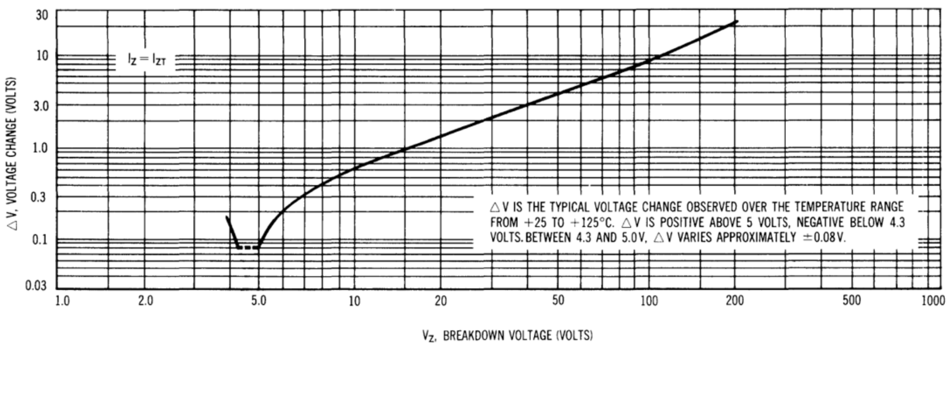


FIGURE 2
POWER DERATING CURVE

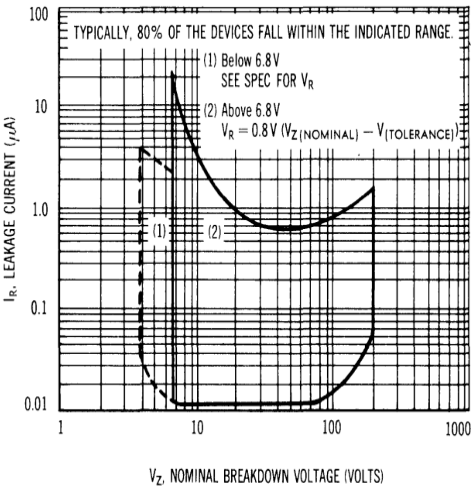
The temperature characteristic curve for a zener diode shows how the zener voltage changes as the temperature changes. The curve typically shows that at lower temperatures, the zener voltage is higher than the nominal zener voltage, and as the temperature increases, the zener voltage decreases. In the case of the 1N2846 diode, the typical temperature coefficient is given as 0.100, which means that for every degree Celsius increase in temperature above 25°C, the zener voltage will decrease by 0.100 volts. However, the curve also shows a sudden increase in voltage change at around 5 volts, which corresponds to the breakdown voltage of the diode. This is because the breakdown voltage is determined by the doping concentration of the diode, which can be affected by temperature changes. As the temperature increases, the doping concentration decreases, which causes the breakdown voltage to increase at a faster rate. It's important to note that the temperature characteristic curve for a zener diode is typically provided as a reference only, and the actual performance of the diode in a specific application may differ due to various factors such as the quality of the diode and the operating conditions.

FIGURE 1 — TEMPERATURE CHARACTERISTICS



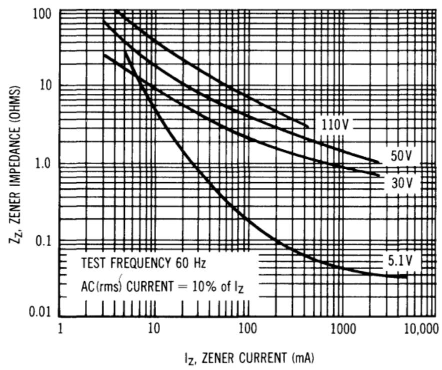
The leakage current and nominal breakdown voltage graph provides information on the relationship between the two parameters. It shows the typical behavior of a zener diode under different operating conditions. The nominal breakdown voltage is the voltage at which the zener diode starts conducting in the reverse direction. The graph shows that at low reverse bias voltages, the leakage current is very small. However, as the reverse bias voltage increases, the leakage current also increases, reaching a maximum value at the nominal breakdown voltage. At this point, the zener diode starts conducting in the reverse direction, and the voltage across the diode remains almost constant. The graph shows that the nominal breakdown voltage is maintained over a range of reverse current values.

FIGURE 3 — LEAKAGE CURRENT



The graph of zener impedance versus zener current is a characteristic curve that represents the relationship between the zener impedance (Zz) and the zener current (Iz). The zener impedance is the AC resistance of the zener diode when it is operated in the breakdown region. It is also known as the dynamic impedance. The zener impedance is an important parameter in the design of voltage regulator circuits using zener diodes. The lower the zener impedance, the better the voltage regulation. The graph shows that the zener impedance is high at low zener currents and decreases as the zener current increases. This means that the voltage regulation is better at higher currents. The slope of the curve is the incremental resistance, which is the change in zener impedance per unit change in zener current. At low zener currents, the incremental resistance is high, indicating poor voltage regulation. At higher zener currents, the incremental resistance is low, indicating better voltage regulation. The graph also shows that the zener impedance increases with increasing temperature. This is because the zener breakdown voltage decreases with increasing temperature, which results in a higher zener current for a given load voltage. The higher zener current leads to a higher zener impedance.

FIGURE 4 — ZENER IMPEDANCE versus ZENER CURRENT



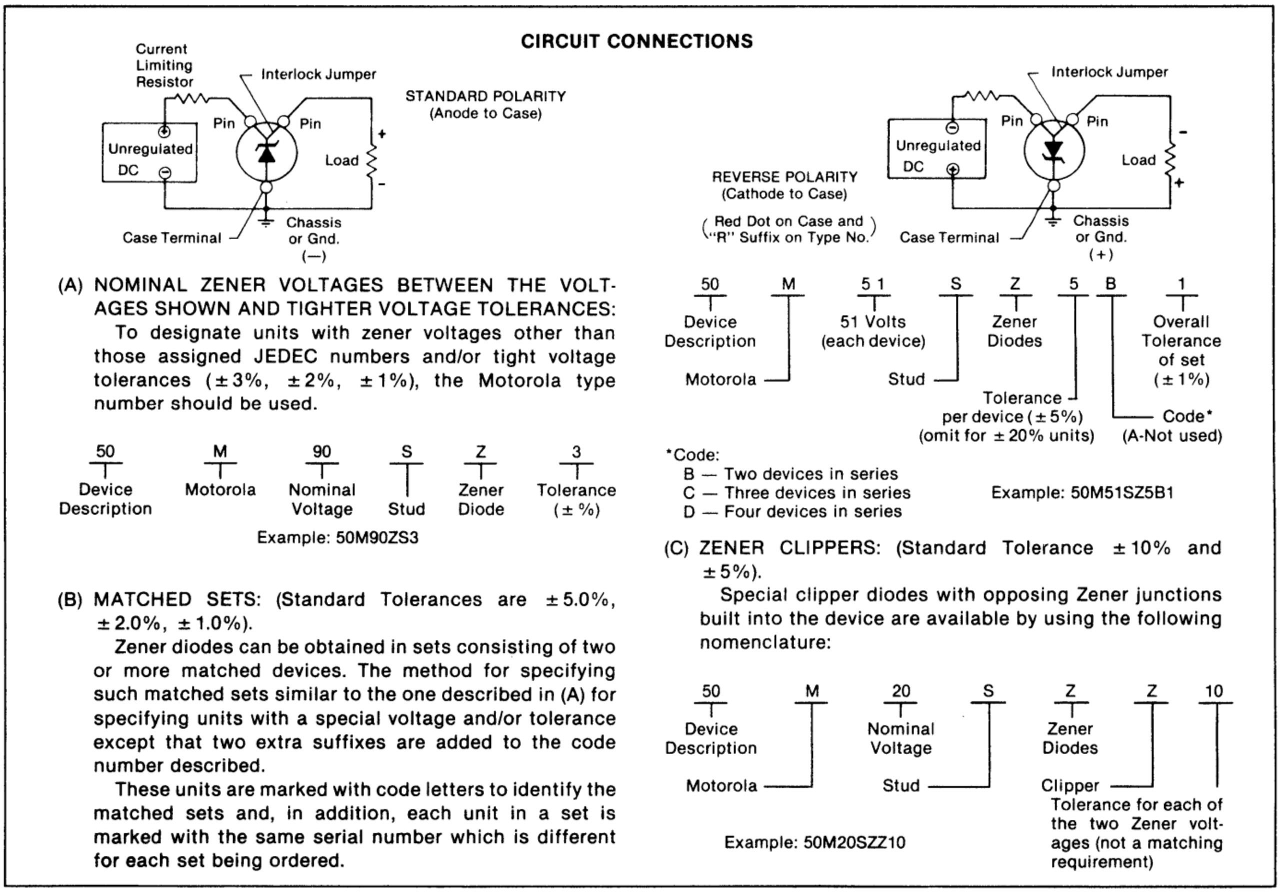
g. CIRCUIT CONNECTIONS

The information provided in this section is taken from the Motorola datasheet for 1N2846, but it is applicable to other companies that manufacture this diode as well.

Zener diodes are available in a variety of nominal voltages and tolerances. To specify units with zener voltages other than those assigned JEDEC numbers and/or tight voltage tolerances, the Motorola type number should be used. For example, the code "50 M 90 S Z 3" designates a zener diode with a nominal voltage of 50V and a tolerance of ±5%.

Matched sets of zener diodes can be obtained to ensure that each device in the set has the same nominal voltage and tolerance. These matched sets are marked with code letters to identify the set, and each unit in the set is marked with the same serial number. The method for specifying matched sets is similar to that described for specifying units with a special voltage and/or tolerance, except that two extra suffixes are added to the code number.

Zener clippers are special clipper diodes with opposing zener junctions built into the device. They are available with a standard tolerance of ±10% or ±5%. The nomenclature for specifying zener clippers is similar to that used for specifying zener diodes, with the addition of the letters "ZC" at the end of the code number. Overall, these options for zener diodes and zener clippers allow for greater flexibility and precision in circuit design, ensuring that the desired voltage levels and tolerances are achieved.


CIRCUIT CONNECTIONS

(A) NOMINAL ZENER VOLTAGES BETWEEN THE VOLTAGES SHOWN AND TIGHTER VOLTAGE TOLERANCES:
To designate units with zener voltages other than those assigned JEDEC numbers and/or tight voltage tolerances (±3%, ±2%, ±1%), the Motorola type number should be used.

50 — Device Description; M — Motorola; 90 — Nominal Voltage; S — Stud; Z — Zener Diode; 3 — Tolerance (± %)

Example: 50M90ZS3

(B) MATCHED SETS: (Standard Tolerances are ±5.0%, ±2.0%, ±1.0%).
Zener diodes can be obtained in sets consisting of two or more matched devices. The method for specifying such matched sets similar to the one described in (A) for specifying units with a special voltage and/or tolerance except that two extra suffixes are added to the code number described.
These units are marked with code letters to identify the matched sets and, in addition, each unit in a set is marked with the same serial number which is different for each set being ordered.

50 — Device Description; M — Motorola; 5 1 — 51 Volts (each device); S — Stud; Z — Zener Diodes; 5 — Tolerance per device (±5%) (omit for ±20% units); B — Code* (A-Not used); 1 — Overall Tolerance of set (±1%)

*Code:
B — Two devices in series
C — Three devices in series
D — Four devices in series

Example: 50M51SZ5B1

(C) ZENER CLIPPERS: (Standard Tolerance ±10% and ±5%).
Special clipper diodes with opposing Zener junctions built into the device are available by using the following nomenclature:

50 — Device Description; M — Motorola; 20 — Nominal Voltage; S — Stud; Z — Zener Diodes; Z — Clipper; 10 — Tolerance for each of the two Zener voltages (not a matching requirement)

Example: 50M20SZZ10

3.BIBLIOGRAPHY

[1] Boylestad, R. L., & Nashelsky, L. (2018). Electronic Devices and Circuit Theory. Pearson Education.

[2] Sedra, A. S., & Smith, K. C. (2018). Microelectronic Circuits. Oxford University Press.

[3] (Digitorn Corp., 2021) https://digitroncorp.com/getmedia/b12f2044-d173-4617-b9fa-d6632f25b756/1N2804B-1N2846B.pdf?ext=.pdf
Access: Mar 10,23.

[4] (Motorola, n.d.) https://datasheetspdf.com/pdf-file/787988/Motorola/1N2846/1
Access: Mar 17,23.

[5] (Microsemi,2003)
https://pdf1.alldatasheet.com/pdfjsview/web/viewer.html?file=//pdf1.alldatasheet.com/datasheet-pdf/view/419613/MICROSEMI/1N2846B/+318735VKhwSPuHRMfNUCH.Hx+/datasheet.pdf
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