International Journal of Engineering & Scientific Research
Vol.6 Issue 12, December 2018,
ISSN: 2347-6532 Impact Factor: 6.660
Journal Homepage: http://esrjournal.com, Email: esrjeditor@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

STUDY OF REVERSE POWER DIODES CHARACTERISTICS

Mintu Yadav, Research Scholar, Department of Physics, Singhania University,

Mail id: gargiyadavphy@gmail.com

Dr. Sanjay Gaur, Assistant Professor of Physics, Department of Physics, Singhania University,

Abstract

A Power diode and thyristor devices are most important in different power electronic converter topologies. However, the main difference between them is that the latter is a controlled device when turned on. The power diode is controlled by the input source, while thyristors are required to conditions to be controlled, the input source and gate control signal.

1. INTRODUCTION

1.1 Power Diode

Power diodes are made of silicon p-n junction with two terminals, an anode, and a cathode. A diode is forward biased when the anode is made positive concerning the cathode. The diode conducts fully when the diode voltage is more than the cut-in voltage (0.7 V for Si). Conducting diode will have a small voltage drop across it.

A diode is reverse biased when the cathode is made positive concerningthe anode. When reverse biased, a small reverse current known as leakage current flows. This leakage current increases with the magnitude of reverse voltage increase until avalanche voltage is reached (breakdown voltage).

International Journal of Engineering & Scientific Research
Vol.6 Issue 12, December 2018,
ISSN: 2347-6532 Impact Factor: 6.660
Journal Homepage: http://esrjournal.com, Email: esrjeditor@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

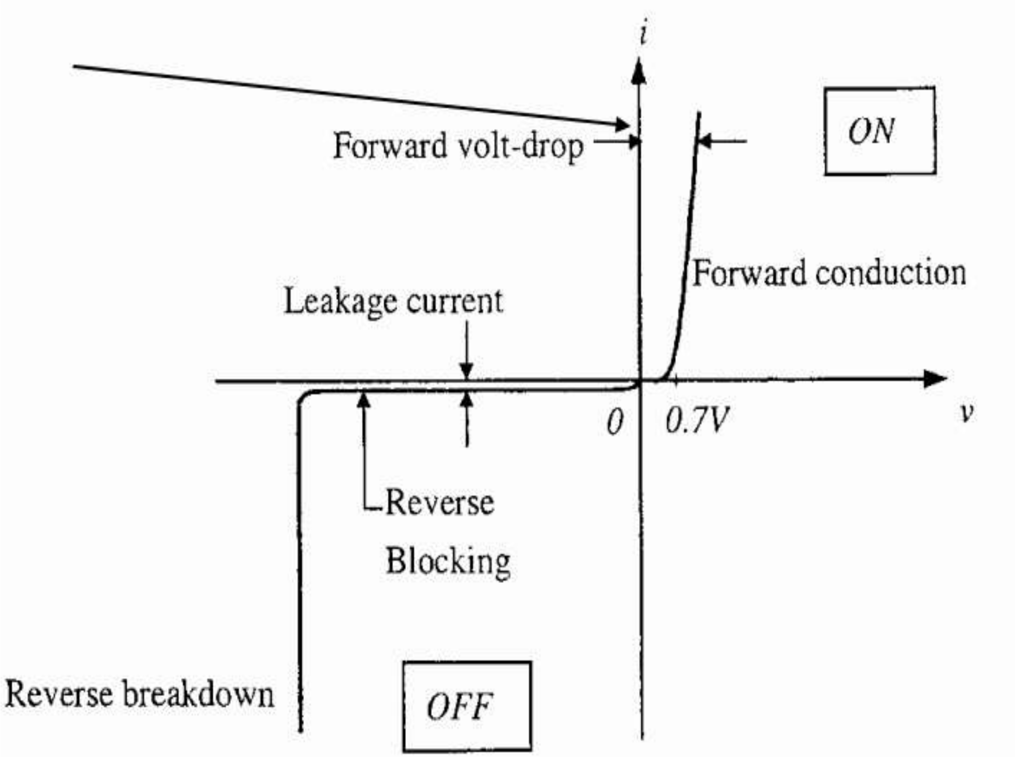


Fig.1 shows the V-I characteristics of the diode.

Forward Voltage Drop:

- Is the forward-conducting junction level
- The forward voltage drop is due to the forward resistance of the junction.
- forward volt drop is across the junction

2. REVERSE LEAKAGE CURRENT

Thermal agitation does break some of the bonds in the crystal, resulting in minority carriers, which permit a small reverse current flow, i.e. **leakage current**.

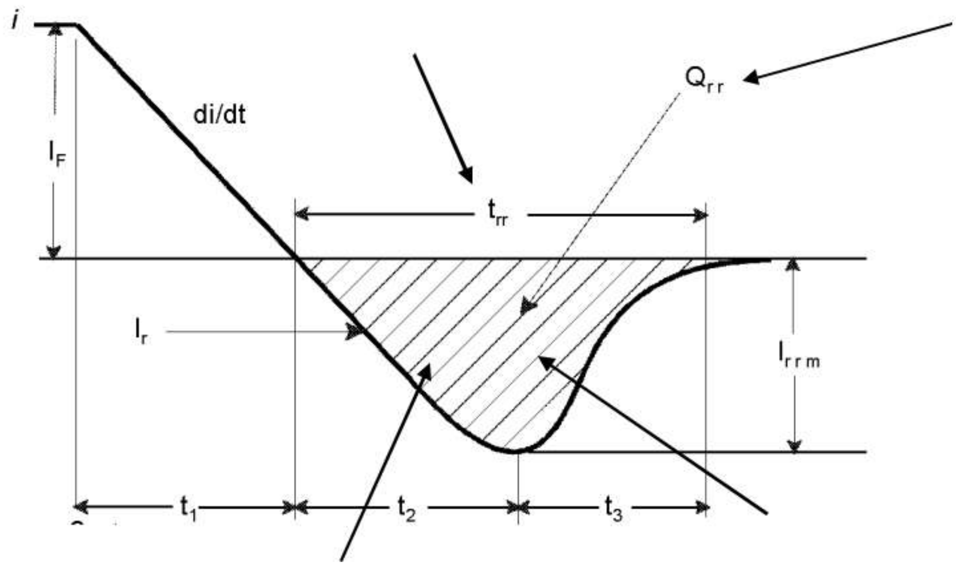
NOTE: The less abundant charge carriers are called **minority carriers**;

3. Reverse Recovery Characteristics

International Journal of Engineering & Scientific Research
Vol.6 Issue 12, December 2018,
ISSN: 2347-6532 Impact Factor: 6.660
Journal Homepage: http://esrjournal.com, Email: esrjeditor@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

When a diode is in forwarding conduction mode, a sudden reversal of the polarity of the applied voltage would not stop the diode current at once. But the diode continues to conduct in the opposite direction due to minority carriers that remain stored in a junction and the bulk semiconductor material. Fig.2 shows the effect of minority carriers on the turn-off characteristics of the power diode.

Reverse recovery time



The charge carriers (holes & electrons) require a certain time to recombine with opposite charges and to be neutralized; this time is called the **reverse recovery time trr o**f the diode.

From Fig.2, one can find the following relationships:

$$t_{rr} = t_2 + t_3 \quad I_{rr} = t_2 \frac{di}{dt} \quad \text{then} \quad Q_{rr} = \frac{1}{2} I_{rrm} t_2 + \frac{1}{2} I_{rrm} t_3 = \frac{1}{2} I_{rrm} t_{rr}$$

$$I_{rrm} \cong \frac{2Q_{rr}}{t_{rr}} = t_2 \frac{di}{dt}$$

Hence,

International Journal of Engineering & Scientific Research
Vol.6 Issue 12, December 2018,
ISSN: 2347-6532 Impact Factor: 6.660
Journal Homepage: http://esrjournal.com, Email: esrjeditor@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

$$I_{rrm} = \sqrt{2Q_{rr}\frac{di}{dt}}$$

The fast decay of negative current creates an inductive drop that adds to the reverse blocking voltage V_R as illustrated in Fig.3.

There are two types of reverse recovery characteristics of junction diodes: **Soft recovery and Fast recovery** where, the **softness factor, SF** is the ratio of t_2/t_3.

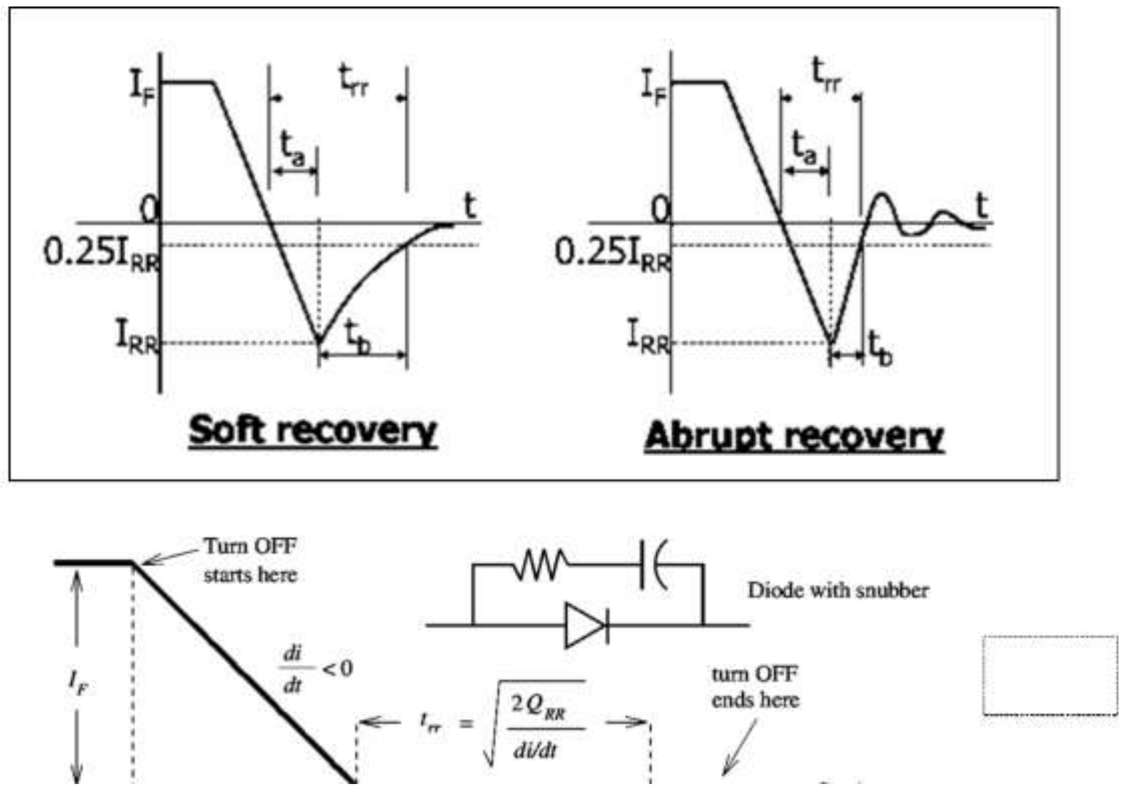
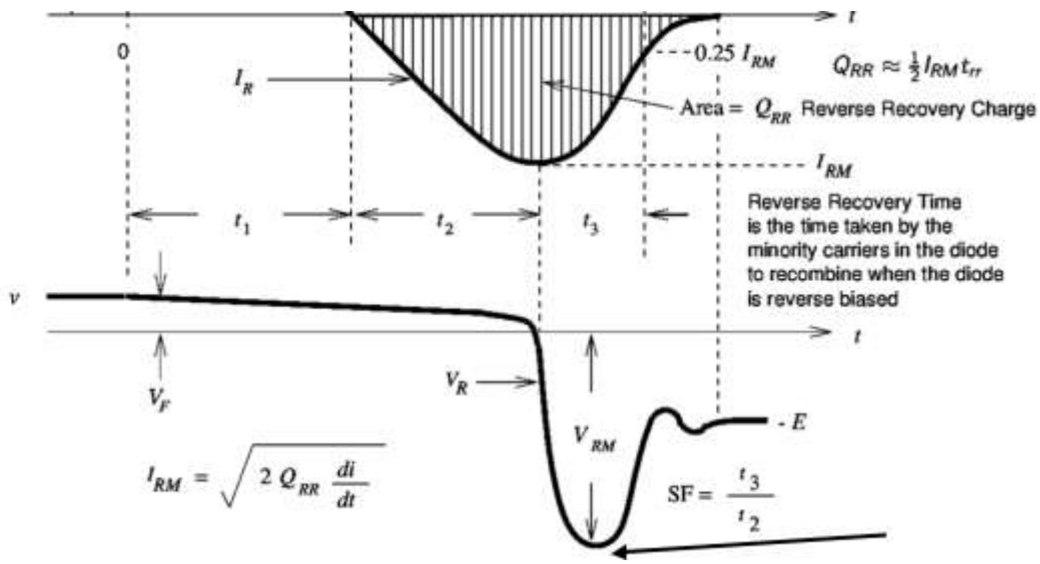


Fig.3



Important Notes:

- For practical purposes, one needsto be concerned with the total recovery time, try, and the peak value of the peak reverse current, I_{RR}.

- The recovery current causes additional loss (switching loss) in the diode; this can be known by multiplying the diode current times the diode voltage shown in Fig.3.

- For high-frequency applications rectifier power diode cannot be used, this is due to the long reverse recovery time of these diodes. Increasing switching frequency (i.e., high sudden changing of polarity across the diode when working at high frequency) results in increasing the di/dt which will lead to high overshoot voltage across the diode. This will also lead that the charge carriers (holes & electrons) requiring a longer time to recombine with opposite charges and to be neutralized.

- As shown in example 1, longer for results in an increase in the recovery charge stored that results in exceeding the rated current and voltage of the diode.

- The larger the active junction area, the larger the charge difference. Therefore, devices in the same family with larger die sizes, *represented by higher current ratings*, will have a larger reverse recovery charge.

- The maximum current reverse recovery current increases greatly with temperature and di/dt.
- When compared in real-world applications, the diodes must have a fast recovery time along with having the least amount of ringing, measured by an SF value closest to 1. ***This means that it is not only important to have a fast recovery, but one that is also a soft recovery.***

Based on the diode reverse recovery characteristics power diode are classified into:

- Standard Recovery (General) Diodes
- Fast Recovery Diodes
- Schottky Diodes
- Silicon Carbide Diodes.

For high-frequency rectifier applications, Fast recovery and Schottky Diodes are generally used because of their short reverse recovery time and low voltage drop in their forward bias condition

General Purpose Diodes

The diodes have a high reverse recovery time of about 25 micro secs (µsec). They are used in low-speed (frequency) applications. e.g., line commutated converters, diode rectifiers, and converters for a low input frequency up to 1 kHz. Diode ratings cover a very wide range with current ratings less than 1 A to several thousand amps (2000 A) and with voltage ratings from 50 V to 5 KV. These diodes are generally manufactured by a diffusion process. Alloyed type rectifier diodes are used in welding power supplies. They are most cost-effective and rugged, and their ratings can go up to 300A and 1KV.

Fast Recovery Diodes

The diodes have a low recovery time, generally less than 5µs. The major field of applications is in electrical power conversion i.e., in free-wheeling ac-dc and dc-ac converter circuits. Their current ratings are from less than 1 A to hundreds of amperes with voltage ratings from 50 V to about 3 KV. The use of fast recovery diodes is preferable for freewheeling in SCR circuits because of low recovery loss, lower junction temperature, and reduced di/dt. For high voltage ratings greater than 400V they are manufactured by the diffusion process and the recovery time is controlled by platinum or gold diffusion. For less than 400 V rating epitaxial diodes provide faster switching speeds than diffused diodes. Epitaxial diodes have a very narrow base width resulting in a fast recovery time of about 50 ns.

4. CONCLUSION

Recent years have seen a push toward ever-higher switching frequencies, to reduce the volume and mass of power converters. At high frequencies, unavoidable parasitic capacitances and inductances dominate the circuit action, leading to unacceptable switching loss and inefficiency. The question naturally arises: Do the inherent limitations of practical components and parasitic elements impose an upper limit on the usable switching frequency? In attempting an answer, much attention has been paid to resonant and quasi-resonant converter topologies; to the switching devices and their drive circuits; and to transformers and inductors. To date, however, little work has been done to establish the effect of nonideal rectifier diodes, which play an essential role in power converters, especially those with a dc output. One reason may be the inherent nonlinearity of diodes, which gives rise to intractable equations, precluding helpful analysis.

REFERENCES

[1]. B. K. Bose, Power Electronics and Variable Frequency Drives: Technology and Applications. New York: IEEE Press, 1996.
[2]. N. Mohan, T. M. Underland, and W. P. Robbins, Power Electronics: Converters, Applications, and Design, 2nd ed. New York: Wiley, 1995. [3] M. K. Kazimierczuk and D. Czarkowski, Resonant Power Converters. New York: Wiley, 1995.
[3]. J. G. Kassakian, M. F. Schlecht, and G. C. Verghese, Principles of Power Electronics. Reading, MA: Addison-Wesley, 1991.

[4]. L. V. Karadzinov, D. J. Jefferies, G. L. Arsov, and J. H. B. Deane, "Simple piecewise-linear diode model for transient behavior," Int. J. Electron., vol. 78, no. 1, pp. 143–160, 1995.

[5]. G. L. Arsov and L. V. Karadzinov, "Influence of the circuit parameters on the DH phenomenon," in Proc. 8th Symp. Power Electron.—Ee'95, Novi Sad, Yugoslavia, Sept. 27–29, 1995, pp. 253–258.

[6]. C. R. Winterhalter, S. Pendharkar, and K. Shenai, "Modeling and characterization of reverse recovery performance of high-power GaAs Schottky and silicon P-i-N rectifiers," in Proc. 26th Annu. IEEE Power Electron. Spec. Conf.—PESC'95, vol. 2, Atlanta, GA, June 18–22, 1995, pp. 847–850.

[7]. Luo, Fei & Wei, Wensheng& Shen, Qi & Zhang, Chunxi. (2015). Detection of reverse recovery characteristics of power diodes. IET Power Electronics. 9. 10.1049/it-pel.2015.0203.

[8]. Maswood, A.I. (2007). The Power Diode. 10.1016/B978-012088479-7/50020-1.

[9]. Mao, Saijun& Zhang, Pengcheng& Popovic, Jelena & Ferreira, Jan. (2017). Diode reverse recovery analysis of Cockcroft-Walton voltage multiplier for high voltage generation. 1765-1770. 10.1109/IFEEC.2017.7992315.

[10]. Sidharthan, P. & Narayanan, G. & Datta, S. (2017). Experimental investigation on reverse recovery characteristics of high-performance high-frequency diodes. 1-6. 10.1109/SPICES.2017.8091322.