Department of Electrical Engineering

Project Final Report

Subject : Power Electronics

Submitted to : Sir Engr Shayan Tariq Jan

Title of Project

WPT (Wireless Power Transfer Technology)

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Power Diodes Characteristics

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

Power Diode:

Power diodes are made of silicon p-n junction with two terminals, anode and cathode. Diode is forward biased when anode is made positive with respect to the cathode. 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.

Diode is reverse biased when cathode is made positive with respect to anode. When reverse biased, a small reverse current known as leakage current flows. This leakage current increases with increase in magnitude of reverse voltage until avalanche voltage is reached (breakdown voltage).

Forward Voltage Drop:

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

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.

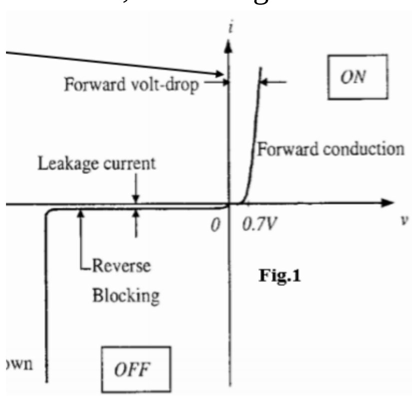
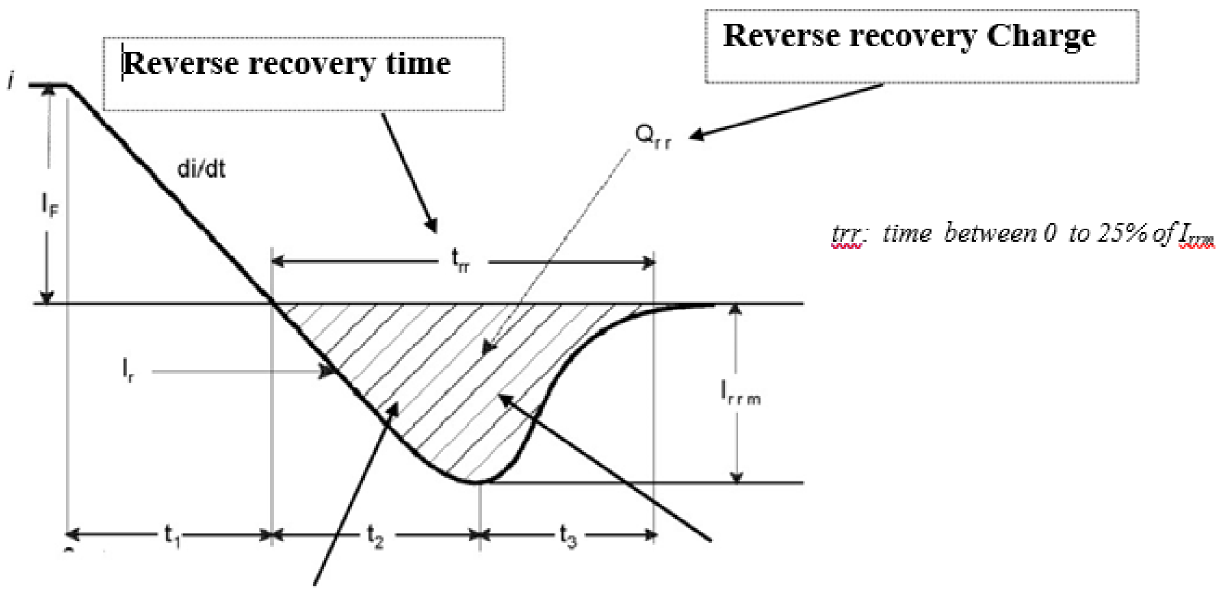


Fig.1

Reverse Recovery Characteristics

When a diode is in forward 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 pn-junction and the bulk semiconductor material.



Due to the minority carriers, which remain stored in the pn-junction (depletion region), and represents the time between zero crossing and the peak reverse current, Irrm.

Due to the charge stored in the body of the diode (bulk regions) and represents the time between Irrm and 25% of Irrm

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 high reverse recovery time of about 25 microseconds (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 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 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 is from less than 1 A to hundreds of amperes with voltage ratings from 50 V to about 3 KV. Use of fast recovery diodes are 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 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.

Schottky Diodes

A Schottky diode has metal (aluminium) and semi-conductor junction. A layer of metal is deposited on a thin epitaxial layer of the n-type silicon. In Schottky diode there is a larger barrier for electron flow from metal to semi-conductor. Figure shows the Schottky diode. When Schottky diode is forward biased free electrons on n-side gain enough energy to flow into the metal causing forward current. Since the metal does not have any holes there is no charge storage, decreasing the recovery time. Therefore, a Schottky diode can switch-off faster than an ordinary p-n junction diode. A Schottky diode has a relatively low forward voltage drop and reverse recovery losses. The leakage current is higher than a p-n junction diode. The maximum allowable voltage is about 100 V. Current ratings vary from about 1 to 300 A. They are mostly used in low voltage and high current dc power supplies. The operating frequency may be as high 100-300 kHz as the device is suitable for high frequency application.

Silicon Carbide SiC Schottky Barrier Diode (SBD)

SiC (Silicon Carbide) is a compound semiconductor comprised of silicon (Si) and carbon (C). Compared to Si, SiC has

- Ten times the dielectric breakdown field strength.
- Three times the bandgap.
- Three times the thermal conductivity.

Both p-type and n-type regions, which are necessary to fashion device structures in a semiconductor materials, can be formed in SiC. These properties make SiC an attractive material from which to manufacture power devices that can far exceed the performance of their Si counterparts. SiC devices can withstand higher breakdown voltage, have lower resistivity, and can operate at higher temperature.

SiC SBDs (Schottky barrier diodes) with breakdown voltage from 600V (which far exceeds the upper limit for silicon SBDs) and up are readily available. Compared to silicon FRDs (fast recovery diodes),

SiC SBDs have much lower reverse recovery current and recovery time, hence dramatically lower recovery loss and noise emission.

https://odayahmeduot.files.wordpress.com/2015/11/

Advantages of Power Diodes

Diodes come in many forms, like rectifiers, LEDs, variCaps, zeners, photo-diodes, etc.... Following are some uses,

1. Rectifiers would convert AC to DC and protect your devices from being swapping positive and negative power supply.
2. LEDs are indicators, comes in various sizes and easy to use than conventional bulbs.
3. Varicaps are used in dynamic TV, radio tuning circuits, easy to use and compact.
4. Zeners are used as voltage regulators, would protect the circuits from over-currents.
5. Photo-diodes would conduct only under light.

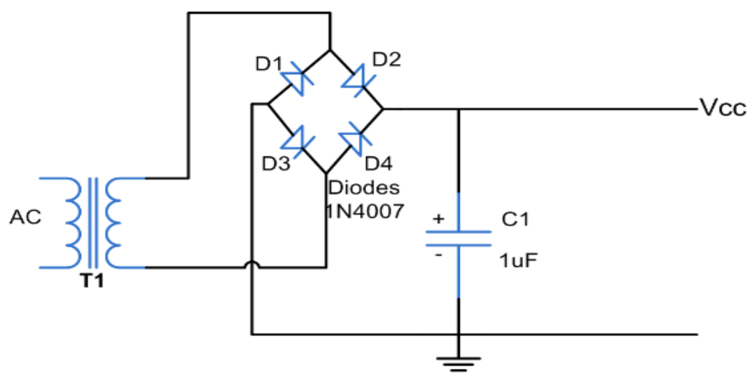
Disadvantages of Power Diodes

The main problem with a diode bridge is the fact that you always have two diodes in series with your circuit, and this creates a voltage drop of about 1.4 V between the power source and the load.

The power loss is simply this voltage drop multiplied by the load current.

It also means that you cannot connect the negative side of the load, which you might ordinarily consider to be "ground", to any external ground, which might be connected to either side of the power source.

AC to DC converter using Diodes (Bridge Rectifier) for wireless power transfer:



An AC power source is required for powering major appliances but almost all electronic circuits require a steady DC supply. A simple rectifier circuit described in this project converts the input from AC source to DC voltage. Firstly, the AC input from mains is stepped down to a lower value of voltage. This AC supply is then passed through a rectifier circuit to remove the negative cycle of AC waveform. The resulting signal is then filtered to get the DC output. The major part of the circuit is connected to the secondary coil of the transformer which is comprised by diodes and capacitor**. While the diodes act as actifiers, capacitor filters out the DC component from the circuit.**

Wireless Transmitter:

Take a PVC pipe and whirl a wire on it seven times after whirling a wire about three inches make a loop for center terminal and continue the process. Now take transistor 2N2222 and connect its base terminal to one end of the copper coil, the collector terminal to the other end of the copper coil and now connect the emitter terminal to the negative terminal of AA battery. The center terminal of the copper coil will be connected with the positive terminal of an AA battery. When then the receiver coil is placed 1 inch above of the transmitter coil, then the LED will blink.

In this project, the input mains supply is stepped down from 230 V AC to a desired level (depending upon the rating of the load connected). Peak voltage across the load is matched to the peak value of AC voltage from output of a transformer. This is achieved here by using a step down transformer 12-0-12V of 500mA rating. The reduced voltage level (12V) appears on the secondary winding of the transformer. This AC signal has alternating positive and negative waveform cycle while the desired output should always be positive. Therefore the signal is rectified using a bridge rectifier to block the negative portion of the waveform. Almost all rectifiers comprise a number of diodes in a certain arrangement for converting AC to DC than is possible with only one diode. Here, four 1N4007 diodes (D1-D4) have been used as shown in the circuit diagram. The bridge rectifier rectifies the stepped down AC to pulsating DC which contains ripples. So a filter capacitor C1(1uF) is connected across the output of the rectifier so as to bypass the AC component present in it. The output obtained can now be used to power electronic devices/circuits.

Working/Methdolgy

The wireless power transmission can be defined as, the energy can be transmitted from the transmitter to a receiver through an oscillating magnetic field.

To accomplish this, power source (DC current) is changed into high frequency AC (Alternating Current) by particularly designed electronics erected into the transmitter. The AC boosts a copper wire coil in the transmitter, which produces a magnetic field. When the receiver coil is placed in proximity of the magnetic field, the magnetic field can make an AC (alternating current) in the receiving coil. Electronics in the receiving coil then alters the AC back into DC which becomes operating power.

Calculating Parameters:

Peak Current: The instantaneous value of the voltage applied to the rectifier is given as

$$vs = Vsmax\ Sin\ wt$$

If the diode is assumed to have a forward resistance of R_F ohms and a reverse resistance equal to infinity, the current flowing through the load resistance is given as

i1 = Imax Sin wt and i2 = *0 for the first half cycle*
and ***i1 = 0 and i2 = Imax Sin wt*** *for second half cycle*

The total current flowing through the load resistance R_L, being the sum of currents i1 and i2 is given as

i = i1 + i2 = Imax Sin wt for the whole cycle.

Where the peak value of the current flowing through the load resistance R_L is given as

$$Imax = Vsmax/(2R_F + R_L)$$

Output Current: Since the current is the same through the load resistance RL in the two halves of the ac cycle, magnitude of dc current Idc, which is equal to the average value of ac current, can be obtained by integrating the current i1 between 0 and pi or current i2 between pi and 2pi.

$$\text{So } I_{dc} = 1/\pi \int_0^{\pi} i1\ d(wt) = 1/\pi \left[\int_0^{\pi} Imax\ Sin\ wt d(wt)\right] = 2I_{MAX}/\pi$$

Output Voltage: Average or dc value of voltage across the load is given as

$$Vdc = Idc\ R_L = 2/\pi\ Imax\ R_L$$

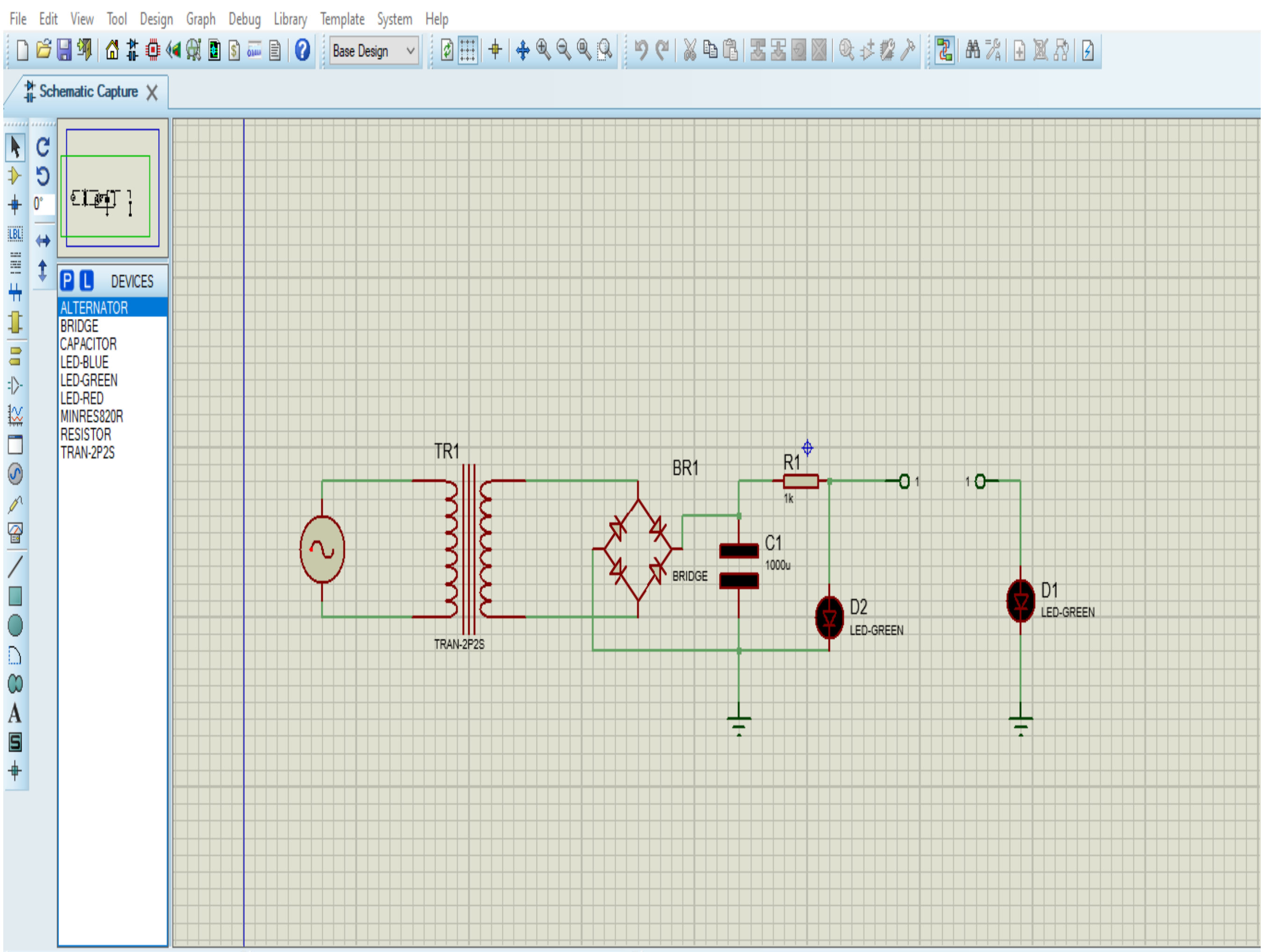
https://en.wikipedia.org/wiki/Diode

https://electronics.stackexchange.com/questions/44846/

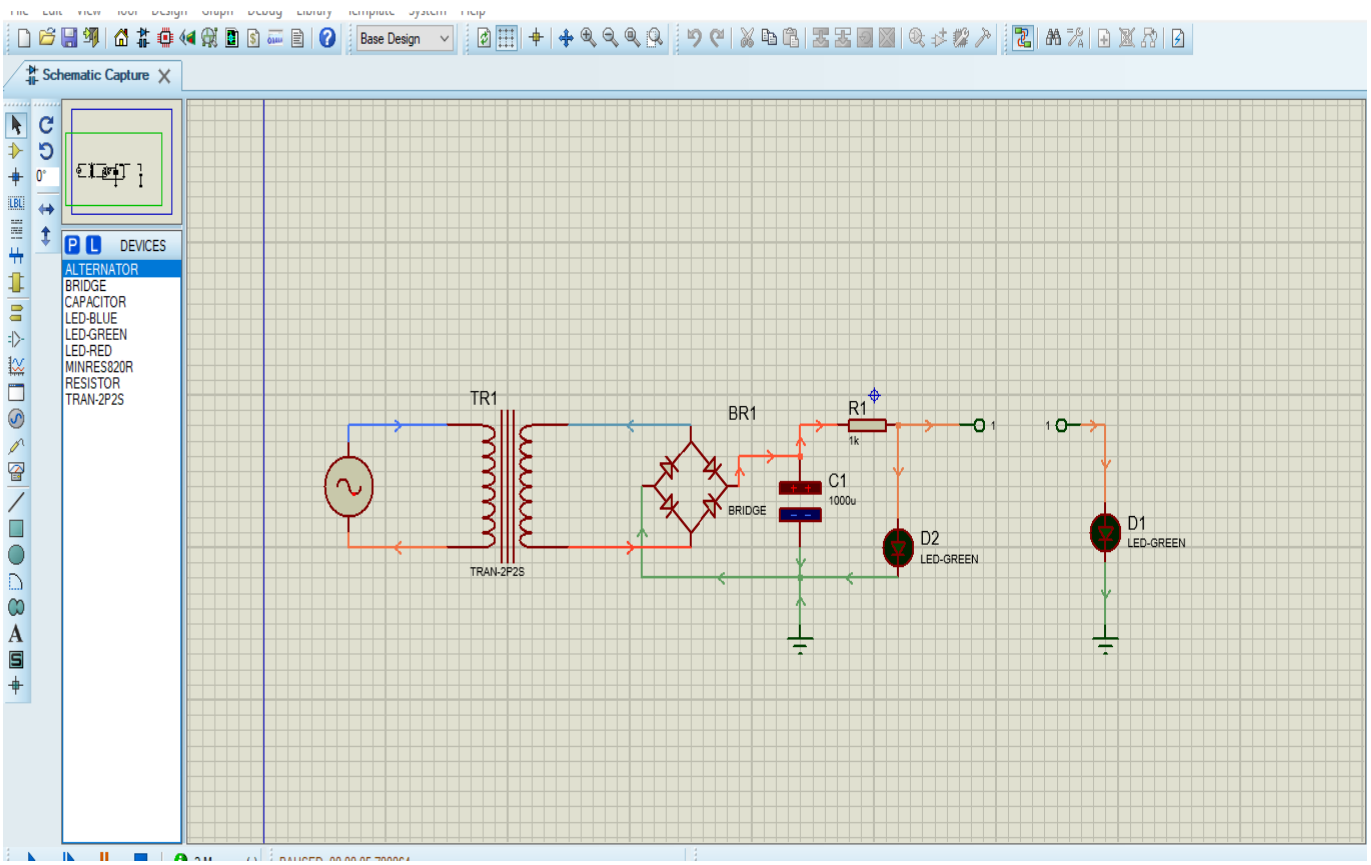
https://www.engineersgarage.com/electronics/simple-ac-to-dc-converter-using-bridge-rectifier/

Simulation of wireless power transfer technology:

When the circuit is in OFF condition:



When the circuit is in on condtion:



Conclusion:

The technology for **wireless power transmission or wireless power transfer** (**WPT**) is in the forefront of electronic development. Applications involving microwaves, solar cells, lasers, and resonance of electromagnetic waves have had the most recent success with WPT. The main function of wireless power transfer is to allow electrical devices to be continuously charged and lose the constraint of a power cord. Although the idea is only a theory and not widely implemented yet, extensive research dating back to the 1850's has led to the conclusion that WPT is possible.

THANK YOU