Rectifiers & Their Working

In a large number of electrical and electronic circuits, DC voltage is required for its operation. We can simply alter the AC voltage into DC voltage by using a device called a PN junction diode. One of the most significant applications of a PN junction diode is the rectification of AC into DC. A PN junction diode permits electric current in only one direction i.e, forward bias condition, and blocks electric current in reverse bias condition. This single property of the diode lets it perform like a rectifier. This article discusses different types of rectifiers, working, and their comparisons.

What are Rectifiers?

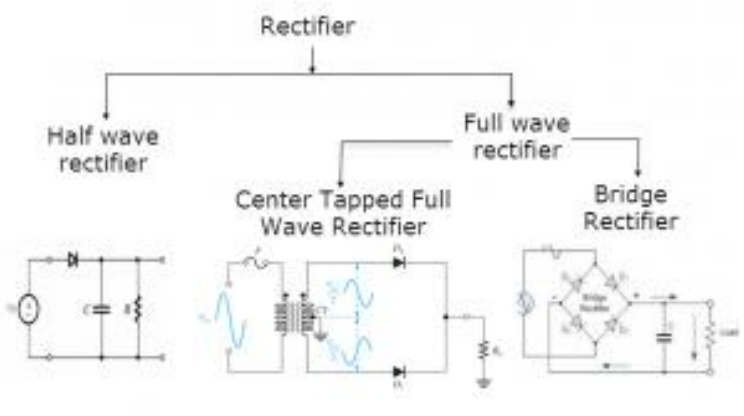
A rectifier is an electrical device comprised of one or more diodes that allow the flow of current only in one direction. It basically converts alternating current into direct current. Rectifiers can be mold in several shapes as per necessity like semiconductor diodes, SCRs (silicon controlled rectifiers), vacuum tube diodes, mercury-arc valves, etc. In our previous articles, we have explained diodes, types of diodes in detail. But in this, we are going to give details of rectifiers, types of rectifiers and their applications, etc.

Different Types of Rectifiers

For signal discovery and power rectification, diode rectifier circuits are extensively used in designing electronic circuits, which are used in various devices like radio signals or detectors, DC power supplies, household appliances like video game systems, laptops, televisions, etc.

Different Types of Rectifiers

Rectifiers are categorized into a variety of designs depends on factors namely, type of supply, bridge configuration, components used, control nature, etc. Majorly these are classified into two types they are single-phase and three-phase rectifier. Further rectifiers are classified into three types namely uncontrolled, half controlled, and full controlled rectifiers. Let us see in brief about some of these types of rectifiers. Rectifiers are classified into two types like uncontrolled rectifiers and controlled rectifiers.



Types of Rectifiers

Uncontrolled Rectifiers

The output voltage of a rectifier that cannot be controlled is known as an uncontrolled rectifier. A rectifier works with switches and these are available in different types like controllable as well as uncontrollable. A two-terminal component like a diode is a unidirectional device and the main function of this is to allow the flow of current is simply one direction. This device cannot be controlled because it will perform only if it is connected in forward biased.

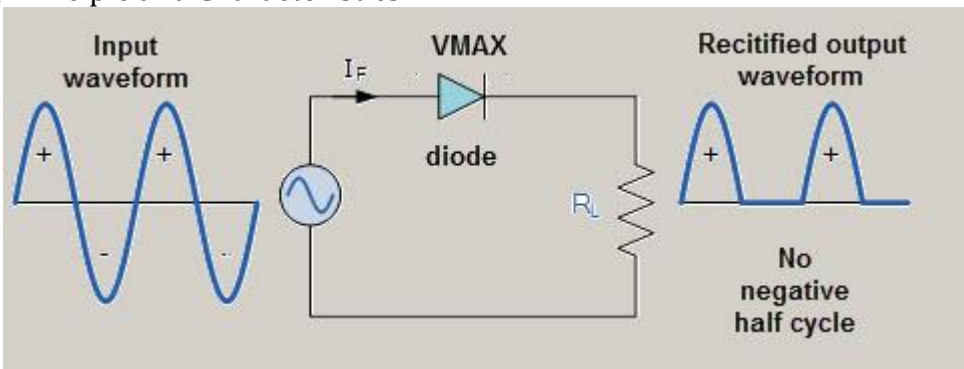
When a diode is connected with a rectifier in any configuration then the rectifier cannot completely under the control of an operator which is known as uncontrolled rectifiers. It does not let the power change based on the requirement of the load. So this kind of rectifier is normally used in fixed or stable power supplies. This kind of rectifier simply uses diodes and provides stable output voltage based on the input of AC only.

Further, uncontrolled rectifiers are classified into two types a half-wave and full-wave rectifiers.

Half-wave Rectifier

In this type of rectifier, when AC supply is applied at the input, only the positive half cycle becomes visible across the load while the negative half cycle is covered up. In a single-phase supply, it needs a single diode while in a three-phase supply it needs three diodes.

It is not capable because only half of the i/p waveforms reach the output. To reduce the ripples of the AC frequency from the o/p, more filtering is required in the half-wave rectifier circuit. Please refer to the link to know more about Half-wave Rectifier Circuit Working Principle and Characteristics



Half-wave Rectifier

Positive Half Wave Rectifier

A rectifier that simply changes the positive half cycle & blocks the negative half cycle is known as. Positive Half Wave Rectifier

Negative Half Wave Rectifier

A rectifier that simply changes the negative half cycle of the AC into DC is known as a negative half-wave rectifier. As compared with all kinds of rectifiers, a half-wave rectifier is a simple type because it is designed with a single diode only.

A diode simply allows the flow of current in one direction which is called forward bias. This diode is connected with a load resistor 'RL' in series.

Positive Half Cycle

The anode terminal of a diode throughout the positive half cycle will turn into positive whereas the cathode terminal will turn into negative is known as forward bias. It will permit the positive cycle to supply through.

Negative Half Cycle

The anode terminal of a diode will turn negative throughout the negative half cycle whereas the cathode terminal will turn into positive, which is called reverse bias. So the negative cycle will be blocked by the diode.

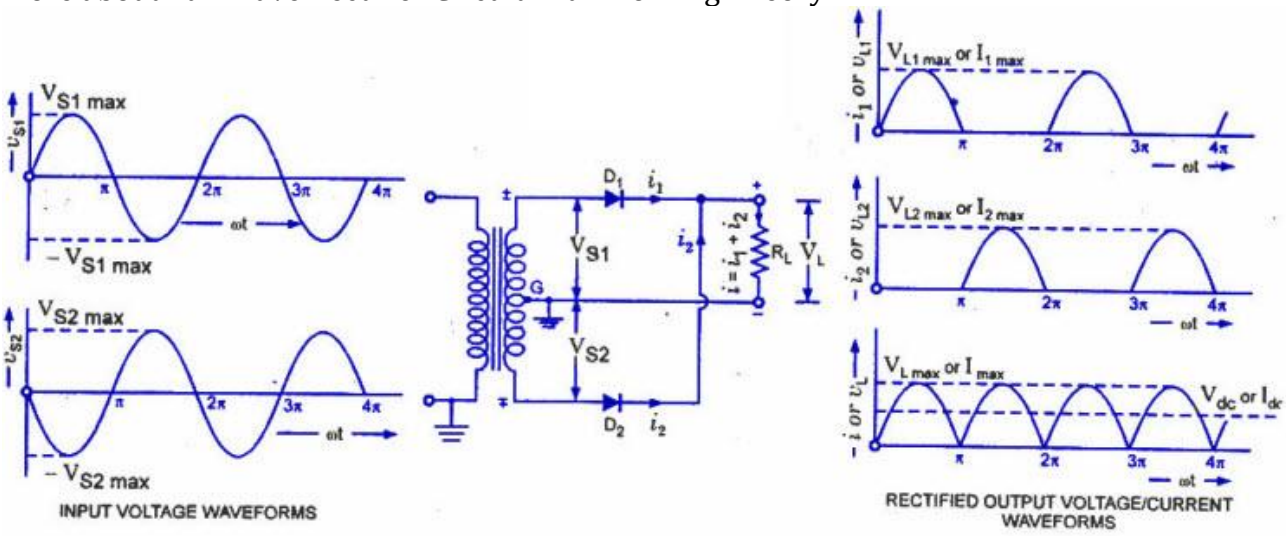
So once an AC source is connected toward the half-wave rectifier, then a half cycle will supply through it. The rectifier's output can be taken across the RL or load resistor. So output waveform of this will be a pulsating +ve half cycle of the input.

The half-wave rectifier's output has several ripples and it is not used as a DC source. To level this output, a capacitor is connected across the resistor that will charge throughout the positive cycle & discharge throughout the negative cycle to provide a level output signal.

Full Wave Rectifier

In this type of rectifier, during both the half cycles when AC supply is applied to the i/p, the flow of current through the load flows in the same direction. This circuit yields a higher standard output voltage by altering both polarities of the i/p waveform to pulsating DC. This sort of rectification can be achieved by using at slightest two crystal diodes, conducting current differently.

During the positive as well as the negative half-cycle of the input AC, the following two circuits that is the center tap full wave rectifier and full-wave bridge rectifier is used to get the same direction of current flow in the load resistor. Please refer to the link to know more about Full-wave Rectifier Circuit with Working Theory

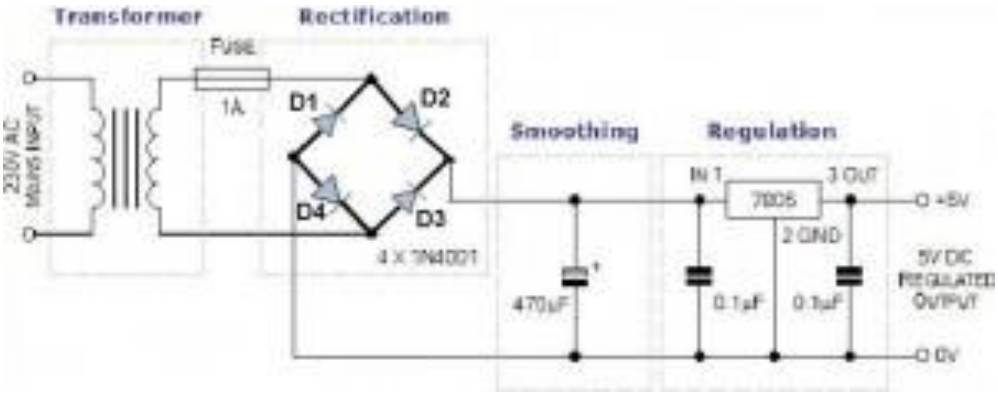


Full Wave Rectifier

A full-wave rectifier circuit is designed with above one diode. These rectifiers are classified into two types like bridge rectifier and center tap rectifier.

Bridge Rectifier

A bridge rectifier circuit can be built with four diodes which are used to change both input AC half-cycle to DC output. So, in this kind of rectifier, the four diodes are mainly connected in an exact form.
In the positive half cycle of the bridge rectifier, the two diodes like D1 & D2 will become forward bias whereas diodes D3 & D4 will become reverse bias. From a closed loop, the diodes D1 & D2 will provide a +Ve output voltage across the RL (load resistor).



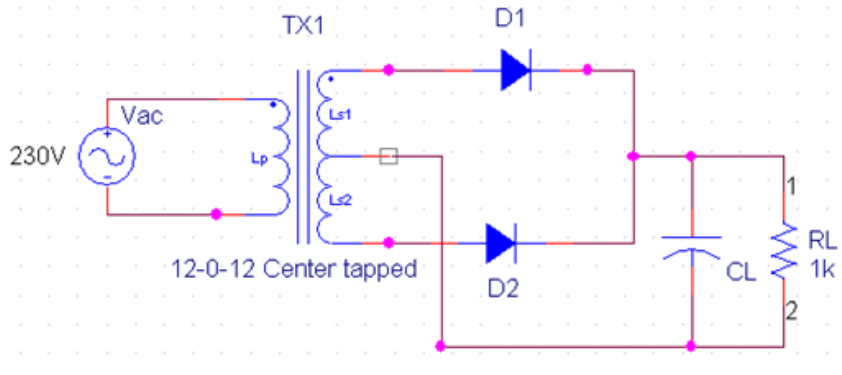
Bridge Rectifier

In the negative half cycle of the bridge rectifier, the diodes like D3 & D4 will become forward bias whereas D1 & D2 diodes will become reverse bias. However, the polarity across the RL stays the same & gives a positive o/p across the load.

The full-wave rectifier's output includes fewer ripples as compared to the half-wave rectifier although it's not level and stable. To make the o/p voltage level, a capacitor is used at the output of the circuit. The charge and discharge of this capacitor will make level transitions among the half cycles.

Center Tap Full-wave Rectifier

This type of rectifier circuit uses a transformer with secondary winding tapped at the center point. Two diodes are connected in the circuit so that each one of them uses the one-half cycle of the input AC voltage. For rectification, one diode uses the ac voltage showing the upper half of the secondary winding while the other diode uses the lower half of the secondary winding. The o/p and efficiency of this circuit are high because the AC supply brings power throughout both halves.



Center Tap Full-wave Rectifier

This transformer has dual-voltage and also two inputs like I1 & I2 7 3 output terminals like T1, T2, and T3. The terminal likeT2 is connected to the middle of the output coil that works like a reference ground. The terminal like T1 generates +Ve voltage & the terminal 'T3' generates negative voltage to the terminal 'T2'.

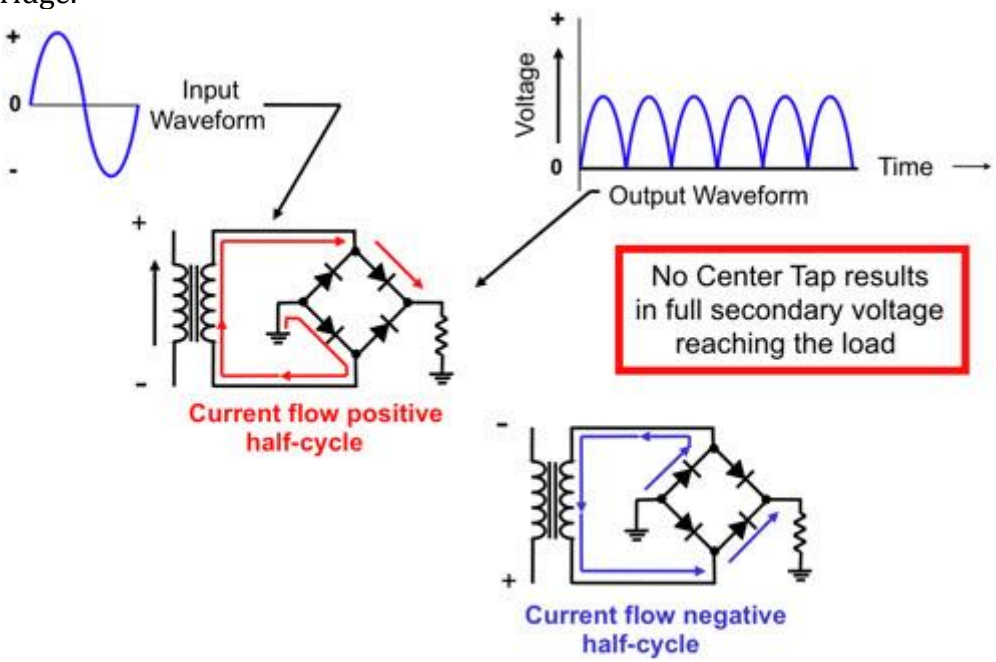
Throughout the positive half cycle, the terminals like T1& t2 will generate positive & negative voltage. So, the D1 diode will turn into forward bias and the D2 diode will turn into a reverse bias. From terminals T1 to T2, it will make s close path using the load resistor.

Throughout the negative half cycle, the terminal 'T1' will produce a negative cycle and terminal 'T2' will produce a positive cycle. This will connect the D1 diode into reverse bias and the D2 diode will connect into forward bias.

However, the polarity across the RL is similar to the flow of current obtains the lane from the terminalsT3 to T1. This rectifier's DC output also includes ripples but it is not level as well as steady DC. At the output of the circuit, a capacitor will eliminate the ripple to make a stable DC output.

Full Wave Bridge Rectifier

A Bridge rectifier circuit is one of the capable forms of a full-wave rectifier that uses four diodes in a bridge topology. In place of the center tap transformer, a normal transformer is used. The AC supply to be rectified is applied to the diagonally differing ends of the bridge and the load resistor is connected across the residual two diagonally differing ends of the bridge.



Full Wave Bridge Rectifier

Controlled Rectifiers

When the output voltage of a rectifier changes or varies then it is known as a controlled rectifier. The need for a controlled rectifier is clear once we look into the faults of an uncontrolled bridge rectifier. The current controlled devices like SCRs, IGBTs, MOSFETs are used to change a rectifier from uncontrolled to controlled.

Once SCRs are turned ON/OFF depending on the applied gate signals then we will have complete control. Generally, these are preferred mostly as compared to their counterparts which are uncontrolled. A silicon-controlled rectifier (SCR) is also called a thyristor. It is a three-terminal diode where the terminals are Anode, Cathode & Gate.

Similar to a normal diode, this will perform in forward bias whereas, in reverse bias, it blocks current however it starts only in forward conduction once there is a signal at the input of the gate terminal. So this gate output plays a key role in controlling the output voltage.

Types of Controlled Rectifier

Controlled rectifiers are two types like half wave controlled rectifier and full wave controlled rectifier.

Half Wave Controlled Rectifier

The half-wave controller rectifier can be designed with a single Silicon Controlled Rectifier (SCR). Similar to the design of a half-wave uncontrolled rectifier, the half-wave controlled rectifier is the same apart from we alter the diode through an SCR.

In reverse bias, a silicon-controlled rectifier does not perform, so it will block the negative half cycle. Throughout the positive half cycle, the SCR will conduct current on only a single condition once a pulse is given to the input of the gate terminal like a periodic pulse signal. The main function of this signal is to turn on the SCR at every positive half cycle.

In this method, the output voltage can be controlled for the rectifier. The output of the silicon-controlled rectifier is a pulsating DC or voltage. These pulses are detached with the help of a capacitor which is connected parallel to the RL.

Full Wave Controlled Rectifier

The rectifier which changes both the half cycles of the AC into DC like positive and negative and controls the o/p amplitude is called a full-wave controlled rectifier. Similar to the uncontrolled rectifier, the classification of a controlled full-wave rectifier can be done into two types like controlled bridge and controlled center tapped.

Controlled Bridge Rectifier

In a controlled bridge rectifier, the diode bridge can be changed with an SCR bridge using a similar configuration to the bridge rectifier.

Throughout the positive cycle, the terminals of SCR like T1 & T2 will perform once the gate signal is applied and the terminals likeT3 & T4 will be connected in reversed bias because they will block the flow of current. So the o/p voltage will be created across the RL.

Throughout the positive cycle, the terminals of thyristor like T3 & T4 will turn into forward bias by considering the input pulse of the gate and the terminals like T1 & T2 will turn into a reverse bias. So, across the RL, the output will come into view. At the output

end, a capacitor can be connected to eliminate the ripples so that the output will be smooth and stable

Controlled Center-Tap Rectifier

Similar to the center-tap uncontrolled rectifier, controlled center tap rectifier design mainly utilizes two SCR in place of the two diodes. The switching of these SCRs will be differently timed based on the i/p AC frequency. Its operation is the same as the uncontrolled rectifier.

Single Phase & Three Phase Types of Rectifiers

The classification of a rectifier can be done depending on the working of an input type. Once the input of the rectifier is a single-phase, then it is called a single-phase rectifier. Similarly, when the input of the rectifier is 3-phase, then it is known as a 3-phase rectifier.

The designing of a single-phase bridge rectifier can be done by using four diodes, while a 3-phase rectifier can be done with six diodes which are arranged in a specific pattern to obtain the required output.

These rectifiers are controlled/uncontrolled rectifiers based on the switching components utilized in every kind of rectifier like thyristors, diodes, etc.

Comparison of Different Types of Rectifiers

The comparisons between different types of rectifiers on the various points are tabulated below.

Properties	Half wave rectifier	Full-wave center-tap rectifier	Full-wave bridge rectifier
Number of Diodes	1	2	4
D.C Current	Im / π	2 Im / π	2 Im / π
Transformer Necessary	No	Yes	No
Max Value of Current	Vm / (rf + RL)	Vm / (rf + RL)	Vm / (2rf + RL)
Ripple Factor	1.21	0.482	0.482
O/p Frequency	fin	2 fin	2 fin
Max Efficiency	40.6%	81.2%	81.2%
Peak Inverse Voltage	Vm	2 Vm	2 Vm

Types of Filters used in Types of Rectifiers

Rectifier circuits provide DC-like output but when we use a Bridge rectifier then the output will include some AC component with DC component. So to decrease the AC component, different types of filters are used at the output face of the rectifier. The filters which are used in rectifiers mainly include capacitors and inductors.

In a filter circuit, the connection of a capacitor can be done in parallel because it allows AC and blocks DC. At the output, any AC component will go by the capacitor in the direction of the ground & we acquire the low amount of ac within the output.

In a filter circuit, the connection of an inductor can be done in series as Inductor includes inductive reactance. This reactance is an opposition toward any changes & it provides high impedance toward AC & low impedance to DC as DC is a stable signal whereas AC will change over time.

Based on the arrangement of a capacitor and inductor, we can use an L-Section filter. This kind of filter includes one inductor connected in series & a capacitor connected in parallel. Pi section filter mainly includes two capacitors in parallel through an inductor which is connected in series.