The half wave rectifier engineering essay

Rectifier is a device which is used to convert alternating current/voltage into direct current/voltage. Its working is based on the fact that the resistance of p-n junction become low when it was forward biased and become high when reversed biased. Virtually all electronic devices require DC, so rectifiers find uses inside the power supplies of virtually all electronic equipment.

Types of rectifiers :-

The Half-Wave Rectifier:-

The simplest rectifier circuit is nothing more than a diode connected in series with the ac input, as shown to the right. Since a diode passes current in only one direction, only half of the incoming ac wave will reach the rectifier output. Thus, this is a basic half-wave rectifier.

The orientation of the diode matters; as shown, it passes only the positive half-cycle of the ac input, so the output voltage contains a positive dc component. If the diode were to be reversed, the negative half-cycle would be passed instead, and the dc component of the output would have a negative polarity. In either case, the DC component of the output waveform is vp/Ï€ = 0. 3183vp, where vp is the peak voltage output from the transformer secondary winding.

Full Wave Rectifier:-

While the half-wave rectifier is very simple and does work, it isn’t very efficient. It only uses half of the incoming ac cycle, and wastes all of the energy available in the other half. For greater efficiency, we would like to be able to utilize both halves of the incoming ac. One way to accomplish this is to double the size of the secondary winding and provide a connection to its center. Then we can use two separate half-wave rectifiers on alternate half-cycles, to provide full-wave rectification. The circuit is shown to the right.

Because both half-cycles are being used, the DC component of the output waveform is now 2vp/Ï€ = 0. 6366vp, where vp is the peak voltage output from half the transformer secondary winding, because only half is being used at a time.

This rectifier configuration, like the half-wave rectifier, calls for one of the transformer's secondary leads to be grounded. In this case, however, it is the center connection, generally known as the center tap on the secondary winding.

The full-wave rectifier can still be configured for a negative output voltage, rather than positive. In addition, as shown to the right, it is quite possible to use two full-wave rectifiers to get outputs of both polarities at the same time.

The full-wave rectifier passes both halves of the ac cycle to either a positive or negative output. This makes more energy available to the output, without large intervals when no energy is provided at all. Therefore, the full-wave rectifier is more efficient than the half-wave rectifier. At the same time, however, a full-wave rectifier providing only a single output polarity does require a secondary winding that is twice as big as the half-wave rectifier's secondary, because only half of the secondary winding is providing power on any one half-cycle of the incoming ac.

Actually, it isn't all that bad, because the use of both half-cycles means that the current drain on the transformer winding need not be as heavy. With power being provided on both half-cycles, one half-cycle doesn't have to provide enough power to carry the load past an unused half-cycle. Nevertheless, there are some occasions when we would like to be able to use the entire transformer winding at all times, and still get full-wave rectification with a single output polarity.

The Full-Wave Bridge Rectifier

The four-diode rectifier circuit shown to the right serves very nicely to provide full-wave rectification of the ac output of a single transformer winding. The diamond configuration of the four diodes is the same as the resistor configuration in a Wheatstone Bridge. In fact, any set of components in this configuration is identified as some sort of bridge, and this rectifier circuit is similarly known as a bridge rectifier.

If you compare this circuit with the dual-polarity full-wave rectifier above, you'll find that the connections to the diodes are the same. The only change is that we have removed the center tap on the secondary winding, and used the negative output as our ground reference instead. This means that the transformer secondary is never directly grounded, but one end or the other will always be close to ground, through a forward-biased diode. This is not usually a problem in modern circuits

To understand how the bridge rectifier can pass current to a load in only one direction, consider the figure to the right. Here we have placed a simple resistor as the load, and we have numbered the four diodes so we can identify them individually.

During the positive half-cycle, shown in red, the top end of the transformer winding is positive with respect to the bottom half. Therefore, the transformer pushes electrons from its bottom end, through D3 which is forward biased, and through the load resistor in the direction shown by the red arrows. Electrons then continue through the forward-biased D2, and from there to the top of the transformer winding. This forms a complete circuit, so current can indeed flow. At the same time, D1 and D4 are reverse biased, so they do not conduct any current.

During the negative half-cycle, the top end of the transformer winding is negative. Now, D1 and D4 are forward biased, and D2 and D3 are reverse biased. Therefore, electrons move through D1, the resistor, and D4 in the direction shown by the blue arrows. As with the positive half-cycle, electrons move through the resistor from left to right.

In this manner, the diodes keep switching the transformer connections to the resistor so that current always flows in only one direction through the resistor. We can replace the resistor with any other circuit, including more power supply circuitry (such as the filter), and still see the same behavior from the bridge rectifier.

Applications:-

Half-wave rectifier circuit:-

For most power applications, half-wave rectification is insufficient for the task. The harmonic content of the rectifier's output waveform is very large and consequently difficult to filter. Furthermore, the AC power source only supplies power to the load one half every full cycle, meaning that half of its capacity is unused. Half-wave rectification is, however, a very simple way to reduce power to a resistive load. Some two-position lamp dimmer switches apply full AC power to the lamp filament for “ full” brightness and then half-wave rectify it for a lesser light output.

Half-wave rectifier application: Two level lamp dimmer.

In the “ Dim” switch position, the incandescent lamp receives approximately one-half the power it would normally receive operating on full-wave AC. Because the half-wave rectified power pulses far more rapidly than the filament has time to heat up and cool down, the lamp does not blink. Instead, its filament merely operates at a lesser temperature than normal, providing less light output. This principle of “ pulsing” power rapidly to a slow-responding load device to control the electrical power sent to it is common in the world of industrial electronics. Since the controlling device (the diode, in this case) is either fully conducting or fully nonconducting at any given time, it dissipates little heat energy while controlling load power, making this method of power control very energy-efficient. This circuit is perhaps the crudest possible method of pulsing power to a load, but it suffices as a proof-of-concept application.

If we need to rectify AC power to obtain the full use of both half-cycles of the sine wave, a different rectifier circuit configuration must be used. Such a circuit is called a full-wave rectifier. One kind of full-wave rectifier, called the center-tap design, uses a transformer with a center-tapped secondary winding and two diodes, as in figure below

Car Brake Lights

A modern application for the SCR is the “ cyclops” brake light on all cars now sold in the USA. This circuit, as shown in the schematic diagram to the right, uses two SCRs cross-connected with each other (each gate connected to the other SCR’s anode) and triggered from the regular brake lights on either side of the rear of the vehicle. The lights are connected to the two cathodes, which are connected together so that either SCR can keep both lights on once they are triggered. If only one SCR is triggered (as when you use a turn signal), the triggered SCR gets no anode voltage from the opposite brake light, so the “ cyclops” light remains off. Only if both brake lights are on together will the “ cyclops” turn on. Once it does, it remains on regardless of turn signals as long as the brake is applied. When you release the brake, power is removed from the “ cyclops” as well as from the brake lights and they all turn off.

The two resistors have a relatively high resistance, and are not critical in any case. They ensure that the gates of the two SCRs are held off while the brake lights are unpowered. The resulting circuit is simple and inexpensive, yet quite robust and easily able to handle the bumps and jolts of an automotive environment.

Telephone Hold Circuit

Another practical application is in a telephone “ hold” circuit. Triggering the SCR causes the circuit to contiuously draw current through the telephone wires, thus causing the switching station to assume a phone is still in use. You must hang up the phone while still pressing the button in order to ensure that the SCR remains triggered. Picking up the same or another receiver in the house reduces the current through the SCR enough that it turns off.

We can use multiple copies of this circuit. However, only the LED on the active “ hold” circuit will light up. Also, pressing the button while no phone is in use will engage that “ hold” circuit at once, so it should be used with care. And of course you should check with your local phone company before connecting anything to the phone line. This is to protect your circuitry as much as to protect the phone company from improper and possibly damaging connections.

12-Pulse Rectifier for More Electric Aircraft Applications

A high power density 10kW three-phase 12-pulse rectifier is analyzed for applications in future More Electric Aircrafts. The experimental results, which are in good accordance with the theory, show high efficiency and low input current harmonics for a wide operating range. Furthermore, two novel rectifier topologies, which are formed by combining the passive 12-pulse rectifier with a boost stage on the DC side are proposed. This allows to guarantee a constant output voltage and/or to overcome the problem of the dependency of output voltage on the mains voltage amplitude and output power level.

Fast Brake Rectifier (GPE & GPU)

The “ GP…” type rectifiers provide improved brake performance in both brake release time and stopping time. The GP is a two-stage “ push” design that uses both full wave and half-wave rectifier operation; when power is first applied, it operates as a full-wave rectifier for approximately 250ms, after which it operates as a halfwave rectifier. There are two ways to apply GP rectifiers. In the first method, known as “ Overexcitation,” the brake is released

very quickly. In the second method, known as “ Reduced Power Holding,” the brake is set very quickly, allowing for very fast stopping times.

Overexcitation (fast brake release)

In overexcitation the rectifier initially over-voltages the brake coil. This overexcitation of the rectifier produces a magnetic field in the brake coil that is stronger than normal, releasing the brake much more quickly. The

rectifier is then switched over to a lower holding voltage so as not to thermally overload the brake coil. In this method

the brake coil is selected as if the brake system is powered by a half-wave rectifier. Therefore, the brake coil’s DC-voltage rating should be 45% of the AC voltage applied to the rectifier. This type of brake control is also called “ Voltage Forcing” and “ Supercharging.”

Example

System voltage: 230VAC

Brake coil: 105VDC

Initial brake release voltage: 205VDC

Holding brake voltage: 105VDC

This is commonly used in very high cycling brake motor applications to reduce motor heating during motor start and brake release. In this method the brake stopping times will be the same as for the standard full-wave or half-wave methods.

Reduced Power Holding (very fast brake stop)

In reduced power holding, the rectifier initially supplies the rated DC voltage to the brake coil. When voltage is first applied, the rectifier operates as a full-wave rectifier (90% of the applied AC voltage), releasing the brake in the standard time. After the brake is released, the rectifier switches to half-wave mode (45% of the applied DC

voltage), weakening the brake's magnetic field. The weaker field will allow the brake to stop more quickly when power is removed. In this method the brake coil is selected as if the brake system is powered by a full-wave rectifier. Therefore, the brake coil's DC-voltage rating should be 90% of the AC voltage applied to the rectifier.

Example

System voltage: 230VAC

Brake coil: 205VDC

Initial brake release voltage: 205VDC

Holding brake voltage: 105VDC

DC-Switching Fast Brake Engagement (stopping)

The GP brake rectifier can also be wired for faster stopping. This method is called DC switching. DC switching directly interrupts the current flow in the rectifier's DC circuit and provides much faster stopping. DC Switching is essential for hoisting or lifting applications.

To implement DC switching, a contact must be installed in between terminals 3 and 4 on the brake rectifier in place of the factory-installed jumper. This switch must close when power is supplied to the rectifier (terminals 1 and 2), and open when power is removed. The IR relay can be used in place of the external switch between terminals 3 and 4, and provides automatic DC switching once power is removed from the motor. However, since it is based on motor current, the IR relay can only be used under two conditions: when the motor is directly powered across the line, and when the brake power is provided via the motor's power terminal. The contact between terminals 3 & 4 must be capable of switching inductive loads, and/or be IEC AC3 rated.

These GPU rectifiers integrate DC Switching, which istriggered by sensing the AC voltage supplied to the

rectifier. When no voltage is present the rectifier automatically opens the DC circuit.

Note: It is not preferred to use the motor terminal block to supply the brake rectifier's AC power due to the motor's slow energy dissipation when switched off.

This type of GP rectifier is primarily designed for use with a separate brake power source, such as inverter-powered

motors, soft-start motors, and two-speed motors. The DC-switching function of the brake rectifier can be disabled by shorting terminals 3 & 4 via a jumper or an external switch.

Some Other Applications Of Rectifier:-

Rectifiers also find a use in detction of amplitude modulated radio signals. The signal may or may not be amplified before detection but if un-amplified a very low voltage drop diode must be used. When using a rectifier for demodulation the capacitor and load resistance must be carefully matched. Too low a capacitance will result in the high frequency carrier passing to the output and too high will result in the capacitor just charging and staying charged.

Rectifiers are also used to supply polarised voltage for welding. In such circuits control of the output current is required and this is sometimes achieved by replacing some of the diodes in bridge rectifier with thyristors, whose voltage output can be regulated by means of phase fired contrroler.

Thyristors are used in various classes of railway rolling stock systems so that fine control of the traction motors can be achieved. Gate Turn Off Thyristors (GTO) are used to produce alternating current from a DC supply, e. g. on the Eurostar Trains to power the three-phase traction motors

Electromechanical

Early power conversion systems were purely electro-mechanical in design, since electronic devices were not available to handle significant power. Mechanical rectification systems usually rely on some form of rotation or resonant vibration in order to move quickly enough to match the frequency of the input power source, and cannot operate beyond several thousand cycles per second.

Due to the complexity of mechanical systems, they have traditionally needed a high level of maintenance to keep operating correctly. Moving parts will have friction, which requires lubrication and replacement due to wear. Opening mechanical contacts under load results in electrical arcs and sparks that heat and erode the contacts.

Synchronous rectifier

To convert AC currents into DC current in electric locomotives, a synchronous rectifier may be used. It consists of a synchronous motor driving a set of heavy-duty electrical contacts. The motor spins in time with the AC frequency and periodically reverses the connections to the load just when the sinusoidal current goes through a zero-crossing. The contacts do not have to switch a large current, but they need to be able to carry a large current to supply the locomotive’s DC traction motors.

Vibrator

In the past, the vibrators used in battery-to-high-voltage-DC power supplies often contained a second set of contacts that performed synchronous mechanical rectification of the stepped-up volt

Motor-generator set

A motor-generator set or the similar rotary converter, is not a rectifier in the sense that it doesn't actually rectify current, but rather generates DC from an AC source. In an " M-G set", the shaft of an AC motor is mechanically coupled to that of a DC generator. The DC generator produces multiphase alternating currents in its armature windings, and a commentator on the armature shaft converts these alternating currents into a direct current output; or a homopolar generator produces a direct current without the need for a commutator. M-G sets are useful for producing DC for railway traction motors, industrial motors and other high-current applications, and were common in many high power D. C. uses before high-power semiconductors became widely available.

Electrolytic

The electrolytic rectifier was an early device from the 1900s that is now no longer used. When two different metals are suspended in an electrolyte solution.

Refrence:-

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