SHEKHAWATI INSTITUTE OF ENGINEERING & TECHNOLOGY, SIKAR, (RAJASTHAN)

I MID TERM EXAMINATION 2018 (6SEM ECE)

Subject code & Name: 6EC3A, IE

(Modal Answer Paper)

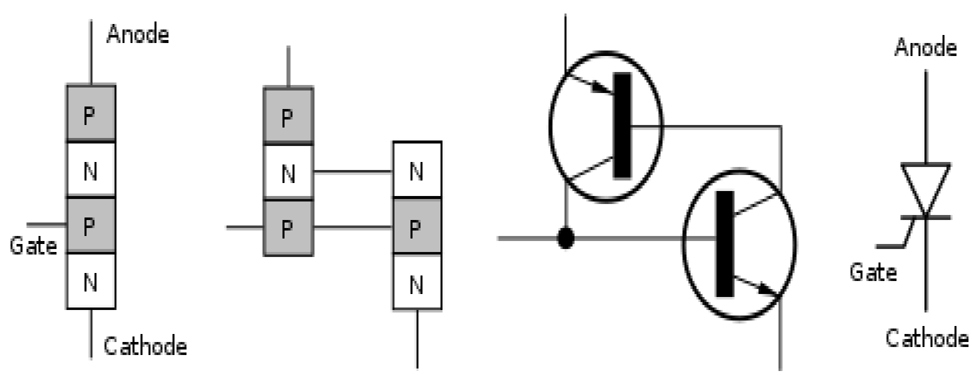
MM: 20 **Time: 1.5 Hr**

Student Instructions

1. **Use pencil for diagrams.**
2. **All questions carry equal marks.**
3. **Attempt only four questions.**

Q1.Explain the characteristics of SCR.

Ans-: A **silicon controlled rectifier** or **semiconductor-controlled rectifier** is a four-layer solid-state current-controlling device. The principle of four layer p-n-p-n switching was developed by Moll, Tanenbaum, Goldey and Holonyak of Bell Laboratories in 1956. The practical demonstration of silicon controlled switching and detailed theoretical behavior of a device in agreement with the experimental results was presented by Dr Ian M. Mackintosh of Bell Laboratories in January 1958. The name "silicon controlled rectifier" is General Electric's trade name for a type of thyristor. The SCR was developed by a team of power engineers led by Gordon Hall and commercialized by Frank W. "Bill" Gutzwiller in 1957.Some sources define silicon controlled rectifiers and thyristors as synonymous, other sources define silicon controlled rectifiers as a proper subset of the set of thyristors, those being devices with at least four layers of alternating n- and p-type material. According to Bill Gutzwiller, the terms "SCR" and "controlled rectifier" were earlier, and "thyristor" was applied later, as usage of the device spread internationally. SCRs are unidirectional devices (i.e. can conduct current only in one direction) as opposed to TRIACs, which are bidirectional (i.e. current can flow through them in either direction). SCRs can be triggered normally only by currents going into the gate as opposed to TRIACs, which can be triggered normally by either a positive or a negative current applied to its gate electrode. The silicon control rectifier (SCR) consists of four layers of semiconductors, which form **NPNP** or **PNPN** structures, having three P-N junctions labeled **J1**, **J2** and **J3**, and three terminals. The anode terminal of an SCR is connected to the p-type material of a PNPN structure, and the cathode terminal is connected to the n-type layer, while the gate of the SCR is connected to the p-type material nearest to the cathode. An SCR consists of four layers of alternating p- and n-type semiconductor materials. Silicon is used as the intrinsic semiconductor, to which the proper dopants are added. The junctions are either diffused or alloyed (alloy is a mixed semiconductor or a mixed metal). The planar construction is used for low-power SCRs (and all the junctions are diffused). The mesa-type construction is used for high-power SCRs. In this case, junction J2 is obtained by the diffusion method, and then the outer two layers are alloyed to it, since the PNPN pellet is required to handle large currents. It is properly braced with tungsten or molybdenum plates to provide greater mechanical strength. One of these plates is hard-soldered to a copper stud, which is threaded for attachment of heat sink. The doping of PNPN depends on the application of SCR, since its characteristics are similar to those of the thyristor. Today, the term "thyristor" applies to the larger family of multilayer devices that exhibit bistable state-change behavior, which is, switching either on or off.The operation of an SCR and other thyristors can be understood in terms of a pair of tightly coupled bipolar junction transistors, arranged to cause the self-latching action:



Q2 .Explain two transmitter method of SCR

Ans-: There are three modes of operation for an SCR depending upon the biasing given to it:

1. **Forward blocking mode (off state)**
2. **Forward conduction mode (on state)**
3. **Reverse blocking mode (off state)**

Forward blocking mode

In this mode of operation, the anode(+ve) is given a positive voltage while the cathode(-ve) is given a negative voltage, keeping the gate at zero(0) potential i.e. disconnected. In this case junction **J1** and **J3** are forward-biased, while **J2** is reverse-biased, due to which only a small leakage current exists from the anode to the cathode until the applied voltage reaches its breakover value, at which **J2** undergoes avalanche breakdown, and at this breakover voltage it starts conducting, but below breakover voltage it offers very high resistance to the current and is said to be in the off state.

Forward conduction mode

SCR can be brought from blocking mode to conduction mode in two ways: either by increasing the voltage across anode to cathode beyond breakover voltage or by applying positive pulse at gate. Once SCR starts conducting, no more gate voltage is required to maintain it in the on state. There are two ways to turn it off: 1. Reduce the current through it below a minimum value called the holding current and 2. With the gate turned off, short out the anode and cathode momentarily with a push-button switch or transistor across the junction.

Reverse blocking mode

SCRs are available with reverse blocking capability, which adds to the forward voltage drop because of the need to have a long, low-doped P1 region. (If one cannot determine which region is P1, a labeled diagram of layers and junctions can help). Usually, the reverse blocking voltage rating and forward blocking voltage rating are the same. The typical application for reverse blocking SCR is in current-source inverters.

SCRs incapable of blocking reverse voltage are known as **asymmetrical SCR**, abbreviated **ASCR**. They typically have a reverse breakdown rating in the tens of volts. ASCRs are used where either a reverse conducting diode is applied in parallel (for example, in voltage-source inverters) or where reverse voltage would never occur (for example, in switching power supplies or DC traction choppers).

Asymmetrical SCRs can be fabricated with a reverse conducting diode in the same package. These are known as RCTs, for reverse conducting thyristors.

Thyristor turn-on methods

1. forward-voltage triggering
2. gate triggering
3. *dv*/*dt* triggering
4. temperature triggering
5. light triggering

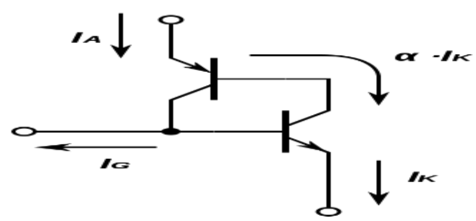
Forward-voltage triggering occurs when the anode–cathode forward voltage is increased with the gate circuit opened. This is known as avalanche breakdown, during which junction J2 will break down. At sufficient voltages, the thyristor changes to its on state with low voltage drop and large forward current. In this case, J1 and J3 are already forward-biased.

Applications

SCRs are mainly used in devices where the control of high power, possibly coupled with high voltage, is demanded. Their operation makes them suitable for use in medium- to high-voltage AC power control applications, such as lamp dimming, power regulators and motor control.SCRs and similar devices are used for rectification of high-power AC in high-voltage direct-current power transmission. They are also used in the control of welding machines, mainly MTAW (metal tungsten arc welding) and GTAW (gas tungsten arc welding) processes similar.it is used as switch in vario

Q3.Give the working principal of GTO.

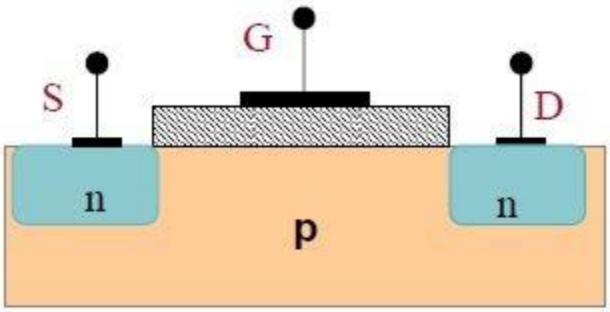
Ans-: A **gate turn-off thyristor (GTO)** is a special type of thyristor, which is a high-power semiconductor device. It was invented at General Electric.[1] GTOs, as opposed to normal thyristors, are fully controllable switches which can be turned on and off by their third lead, the gate lead.Normal thyristors (silicon-controlled rectifiers) are not fully controllable switches (a "fully controllable switch" can be turned on and off at will). Thyristors can only be turned ON using the gate lead, but cannot be turned OFF using the gate lead. Thyristors are switched ON by a gate signal, but even after the gate signal is de-asserted (removed), the thyristor remains in the ON-state until a turn-off condition occurs (which can be the application of a reverse voltage to the terminals, or a decrease of the forward current below a certain threshold value known as the "holding current"). Thus, a thyristor behaves like a normal semiconductor diode after it is turned on or "fired".The GTO can be turned on by a gate signal, and can also be turned off by a gate signal of negative polarity.Turn on is accomplished by a "positive current" pulse between the gate and cathode terminals. As the gate-cathode behaves like PN junction, there will be some relatively small voltage between the terminals. The turn on phenomenon in GTO is however, not as reliable as an SCR (thyristor) and small positive gate current must be maintained even after turn on to improve reliability.Turn off is accomplished by a "negative voltage" pulse between the gate and cathode terminals. Some of the forward current (about one-third to one-fifth) is "stolen" and used to induce a cathode-gate voltage which in turn causes the forward current to fall and the GTO will switch off (transitioning to the 'blocking' state.)GTO thyristors suffer from long switch off times, whereby after the forward current falls, there is a long tail time where residual current continues to flow until all remaining charge from the device is taken away. This restricts the maximum switching frequency to approx 1 kHz. It may be noted however, that the turn off time of a GTO is approximately ten times faster than that of a comparable SCR. To assist with the turn-off process, GTO thyristors are usually constructed from a large number (hundreds or thousands) of small thyristor cells connected in parallel.



Q4.Explain the working MOSFET

Ans-: **metal-oxide-semiconductor field-effect transistor** (**MOSFET**, **MOS-FET**, or **MOS FET**) is a type of field-effect transistor (FET), most commonly fabricated by the controlled oxidation of silicon. It has an insulated gate, whose voltage determines the conductivity of the device. This ability to change conductivity with the amount of applied voltage can be used for amplifying or switching electronic signals. A metal-insulator-semiconductor field-effect transistor or MISFET is a term almost synonymous with MOSFET. Another synonym is IGFET for insulated-gate field-effect transistor.The basic principle of the field-effect transistor was first patented by Julius Edgar Lilienfeld in 1925 The main advantage of a MOSFET is that it requires almost no input current to control the load current, when compared with bipolar transistors. In an *enhancement mode* MOSFET, voltage applied to the gate terminal increases the conductivity of the device. In *depletion mode* transistors, voltage applied at the gate reduces the conductivity. The "metal" in the name MOSFET is now often a misnomer because the gate material is often a layer of polysilicon (polycrystalline silicon). Similarly, "oxide" in the name can also be a misnomer, as different dielectric materials are used with the aim of obtaining strong channels with smaller applied voltages. The MOSFET is by far the most common transistor in digital circuits, as hundreds of thousands or millions of them may be included in a memory chip or microprocessor. Since MOSFETs can be made with either p-type or n-type semiconductors, complementary pairs of MOS transistors can be used to make switching circuits with very low power consumption, in the form of CMOS logic.

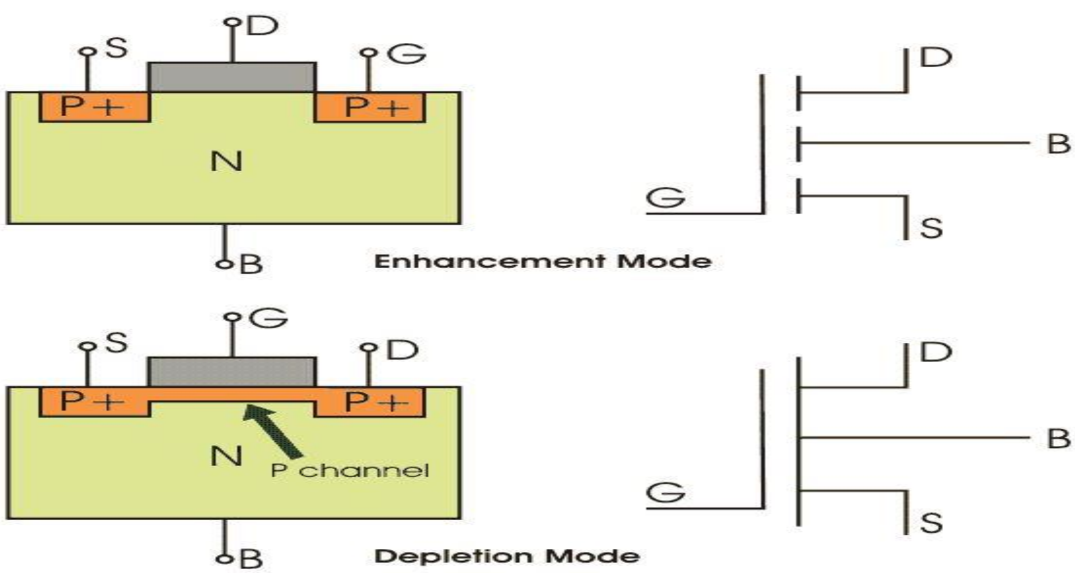
A metal–oxide–semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) is a field-effect transistor (FET with an insulated gate) where the voltage determines the conductivity of the device. It is used for switching or amplifying signals. The ability to change conductivity with the amount of applied voltage can be used for amplifying or switching electronic signals. MOSFETs are now even more common than BJTs (bipolar junction transistors) in digital and analog circuits**.**



MOSFET Structure

The working of a MOSFET depends upon the MOS capacitor. The MOS capacitor is the main part of MOSFET. The semiconductor surface at the below oxide layer which is located between source and drain terminals. It can be inverted from p-type to n-type by applying positive or negative gate voltages.
When we apply positive gate voltage the holes present under the oxide layer with a repulsive force and holes are pushed downward with the substrate. The depletion region populated by the bound negative charges which are associated with the acceptor atoms. The electrons reach channel is formed. The positive voltage also attracts electrons from the n+ source and drain regions into the channel. Now, if a voltage is applied between the drain and source, the current flows freely between the source and drain and the gate voltage controls the electrons in the channel. If we apply negative voltage, a hole channel will be formed under the oxide layer.

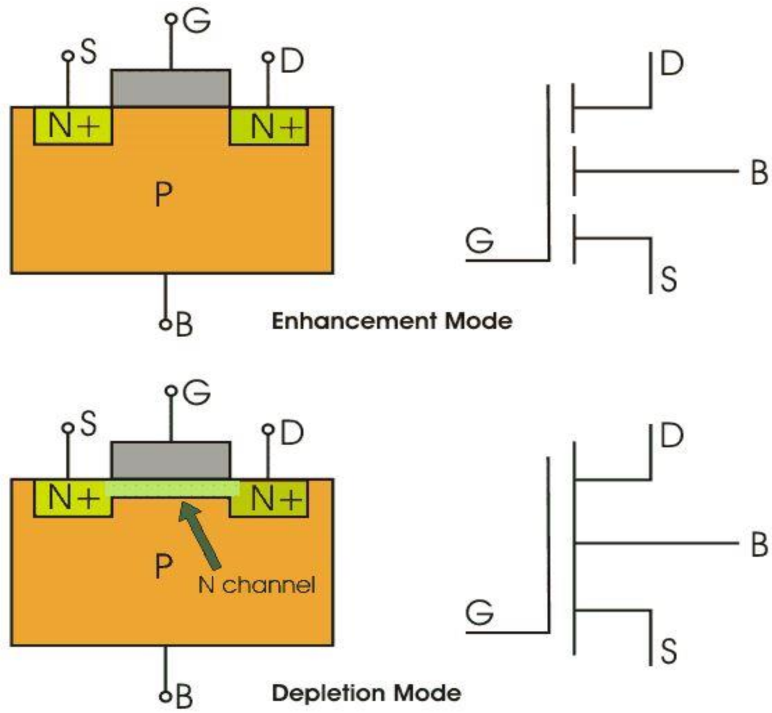
P-Channel MOSFET



P-Channel MOSFET

The drain and source are heavily doped p+ region and the substrate is in n-type. The current flows due to the flow of positively charged holes also known as p-channel MOSFET. When we apply negative gate voltage, the electrons present beneath the oxide layer experience repulsive force and they are pushed downward in to the substrate, the depletion region is populated by the bound positive charges which are associated with the donor atoms. The negative gate voltage also attracts holes from p+ source and drain region into the channel region.

N-Channel MOSFET



N-Channel MOSFET

The drain and source are heavily doped n+ region and the substrate is p-type. The current flows due to the flow of negatively charged electrons, also known as n-channel MOSFET. When we apply the positive gate voltage the holes present beneath the oxide layer experience repulsive force and the holes are pushed downwards in to the bound negative charges which are associated with the acceptor atoms. The positive gate voltage also attracts electrons from n+ source and drain region in to the channel thus an electron reach channel is formed.

Q5.Explain voltage control technique inveter

Ans-:Voltage Control of Single Phase Inverter

The single phase DC-AC inverter considered in this section

Single Pulse Width ModulationIn this modulation only one pulse per half cycle exists and the width of the pulse is varied to control the inverter output voltage. The generation of the gating signals and the output voltage of single phase full-bridge inverters are shown in . The gating signals are generated by comparing a rectangular reference signal of amplitude A_r with a triangular carrier wave of amplitude A_c. ***The frequency of the reference signal determines the fundamental frequency of the output voltage*** . The ratio of A_r to A_c is the control variable and defined as the amplitude ***modulation index*** or ***modulation index*** and is given by

$$M = \frac{A_r}{A_c} \qquad (1)$$

The output voltage shown in **Figure 3** can be expressed as

$$v_o = \sum_{n=1,3,5,\ldots}^{\infty} \frac{4V_{in}}{n\pi} \sin\frac{n\pi}{2} \sin\frac{n\delta}{2} \sin n\omega t \qquad (2)$$

And the rms value of the output voltage is

$$V_{o,rms} = \left[\frac{2}{2\pi} \int_{\frac{\pi-\delta}{2}}^{\frac{\pi+\delta}{2}} V_{in}^2 d(\omega t) \right]^{1/2} = V_{in}\sqrt{\frac{\delta}{\pi}} \qquad (3)$$

The relation between δ and modulation index M is:

$$M = \frac{\delta}{\pi} = \frac{A_r}{A_c} \qquad (4)$$

Using **equation 4** , the rms voltage can be expressed as

$$V_{o,rms} = V_{in}\sqrt{M} \qquad (5)$$

The load current in case of resistive load is

$$i_L = \sum_{n=1,3,5,\ldots}^{\infty} \frac{4V_{in}}{n\pi R} \sin\frac{n\pi}{2} \sin\frac{n\delta}{2} \sin n\omega t \qquad (6)$$

For ***R-L*** load, the load current is given by

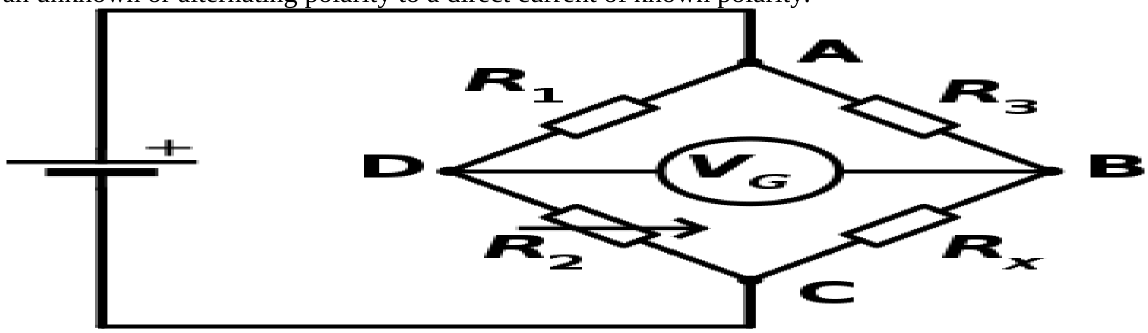
$$i_L = \sum_{n=1,3,5,\ldots}^{\infty} \frac{4V_{in}}{n\pi\sqrt{R^2 + (n\omega L)^2}} \sin\frac{n\pi}{2} \sin\frac{n\delta}{2} \sin(n\omega t - \theta_n)$$

where

$$\theta_n = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

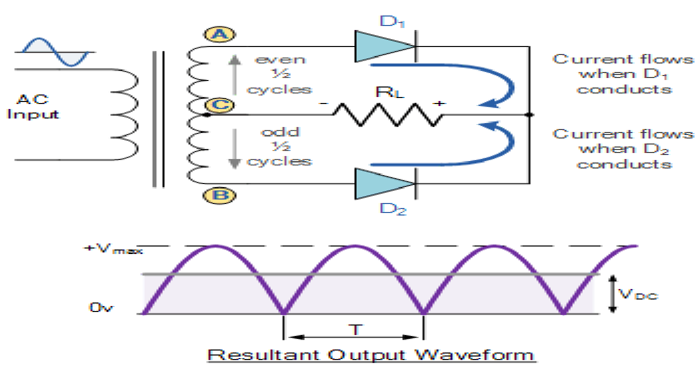
Q6.Explain the various waveform of bridge rectifier

Ans-: A bridge rectifier is an arrangement of four or more diodes in a bridge circuit configuration which provides the same output polarity for either input polarity. It is used for converting an alternating current (AC) input into a direct current (DC) output**.**The best-known bridge circuit, the Wheatstone bridge, was invented by Samuel Hunter Christie and popularized by Charles Wheatstone, and is used for measuring resistance. It is constructed from four resistors, two of known values R_1 and R_3 (see diagram), one whose resistance is to be determined R_x, and one which is variable and calibrated R_2. Two opposite vertices are connected to a source of electric current, such as a battery, and a galvanometer is connected across the other two vertices. The variable resistor is adjusted until the galvanometer reads zero. It is then known that the ratio between the variable resistor and its neighbour R1 is equal to the ratio between the unknown resistor and its neighbour R3, which enables the value of the unknown resistor to be calculated.The Wheatstone bridge has also been generalised to measure impedance in AC circuits, and to measure resistance, inductance, capacitance, and dissipation factor separately. Variants are known as the Wien bridge**,** Maxwell bridge, and Heaviside bridge (used to measure the effect of mutual inductance). [3] All are based on the same principle, which is to compare the output of two potentiometerssharing a common source.In power supply design, a bridge circuit or bridge rectifier is an arrangement of diodes or similar devices used to rectify an electric current, i.e. to convert it from an unknown or alternating polarity to a direct current of known polarity.



In a **Full Wave Rectifier** circuit two diodes are now used, one for each half of the cycle. A multiple winding transformer is used whose secondary winding is split equally into two halves with a common centre tapped connection, (C). This configuration results in each diode conducting in turn when its anode terminal is positive with respect to the transformer centre point C producing an output during both half-cycles, twice that for the half wave rectifier so it is 100% efficient as shown below.

Full Wave Rectifier Circuit

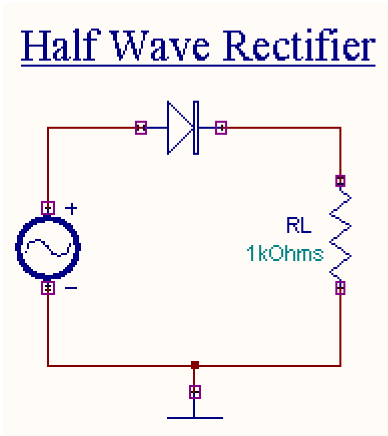


The full wave rectifier circuit consists of two *power diodes* connected to a single load resistance (R_L) with each diode taking it in turn to supply current to the load. When point Aof the transformer is positive with respect to point C, diode D_1 conducts in the forward direction as indicated by the arrows.When point B is positive (in the negative half of the cycle) with respect to point C, diode D_2conducts in the forward direction and the current flowing through resistor R is in the same direction for both half-cycles. As the output voltage across the resistor R is the phasor sum of the two waveforms combined, this type of full wave rectifier circuit is also known as a “bi-phase” circuit.

The **Half wave rectifier** is a circuit, which converts an ac voltage to dc voltage.
In the Half wave rectifier circuit shown above the transformer serves two purposes.

1. It can be used to obtain the desired level of dc voltage (using step up or step down transformers).
2. It provides isolation from the power line.

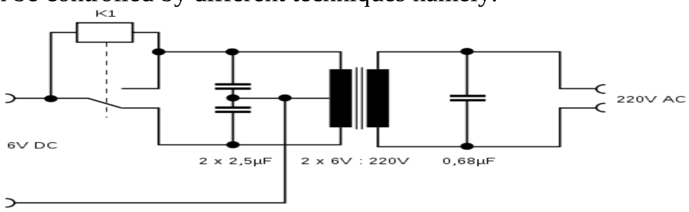
The primary of the transformer is connected to ac supply. This induces an ac voltage across the secondary of the transformer.During the positive half cycle of the input voltage the polarity of the voltage across the secondary forward biases the diode. As a result a current I_L flows through the load resistor, R_L. The forward biased diode offers a very low resistance and hence the voltage drop across it is very small. Thus the voltage appearing across the load is practically the same as the input voltage at every instant.



During the negative half cycle of the input voltage the polarity of the secondary voltage gets reversed. As a result, the diode is reverse biased. Practically no current flows through the circuit and almost no voltage is developed across the resistor. All input voltage appears across the diode itself. Hence we conclude that when the input voltage is going through its positive half cycle, output voltage is almost the same as the input voltage and during the negative half cycle no voltage is available across the load. This explains the unidirectional pulsating dc waveform obtained as output. The process of removing one half the input signal to establish a dc level is aptly called half wave rectification.

Q7.Explain the step up chopper.

Ans-: In electronics, a **chopper** circuit is used to refer to numerous types of electronic switching devices and circuits used in power control and signal applications. A chopper is a device that converts fixed DC input to a variable DC output voltage directly. Essentially, a chopper is an electronic switch that is used to interrupt one signal under the control of another.In power electronics applications, since the switching element is either fully on or fully off, its losses are low, and the circuit can provide high efficiency. However, the current supplied to the load is discontinuous and may require smoothing or a high switching frequency to avoid undesirable effects. In signal processing circuits, use of a chopper stabilizes a system against drift of electronic components; the original signal can be recovered after amplification or other processing by a synchronous demodulator that essentially un-does the "chopping" process.For all the chopper configurations operating from a fixed DC input voltage, the average value of the output voltage is controlled by periodic opening and closing of the switches used in the chopper circuit. The average output voltage can be controlled by different techniques namely:



- Pulse-width modulation
- Frequency modulation
- Variable frequency, variable pulse width
- CLC control

In pulse-width modulation the switches are turned on at a constant chopping frequency. The total time period of one cycle of output waveform is constant. The average output voltage is directly proportional to the ON time of chopper. The ratio of ON time to total time is defined as duty cycle. It can be varied between 0 and 1 or between 0 and 100%. Pulse-width modulation (PWM), or pulse-duration modulation (PDM), is a technique used to encode a message into a pulsing signal. Although this modulation technique can be used to encode information for transmission, its main use is to allow the control of the power supplied to electrical devices, especially to inertial loads such as motors. The average value of voltage (and current) fed to the load is controlled by turning the switch between supply and load on and off at a fast rate. The longer the switch is on compared to the off periods, the higher the total power supplied to the load. The PWM switching frequency has to be much higher than what would affect the load (the device that uses the power), which is to say that the resultant waveform perceived by the load must be as smooth as possible. Typically switching has to be done several times a minute in an electric stove, 120 Hz in a lamp dimmer, from few kilohertz (kHz) to tens of kHz for a motor drive and well into the tens or hundreds of kHz in audio amplifiers and computer power supplies.In frequency modulation, pulses of a fixed amplitude and duration are generated and the average value of output is adjusted by changing how often the pulses are generated.Variable pulse width and frequency combines both changes in the pulse width and repetition rate.

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