Q.P. CODE:- 41203

INDUSTRIAL ELECTRONICS

SEM –IV (MAY -19)

Q1)Solve Any 4:-

a)Draw and explain V-I characteristics of SCR. [5]

Answer)

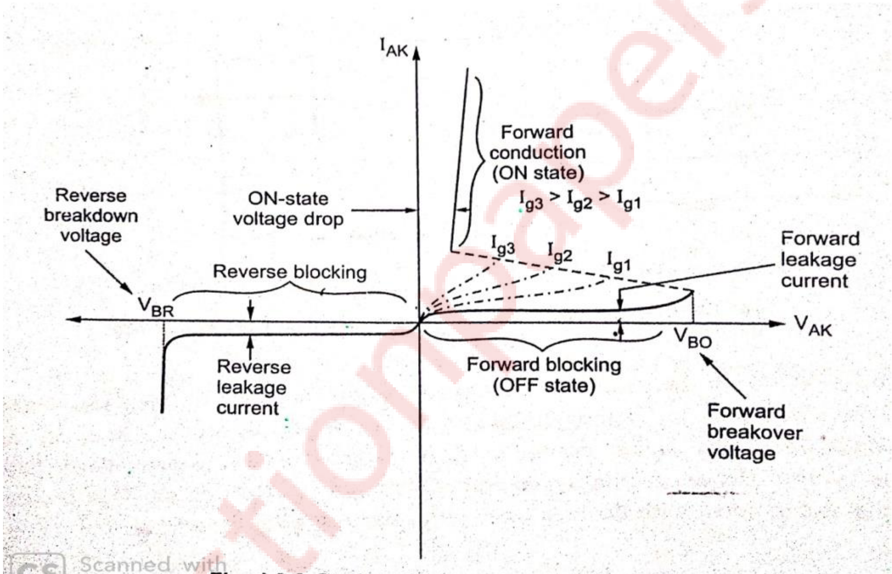


Fig. 1.3.2 Static V-I characteristics of a SCR

SCR in Normal Operation

1. The supply voltage is generally much less than breakover voltage.
2. The SCR is turned on by passing appropriate amount of gate current (a few mA) and not by breakover voltage.
3. When SCR is operated from a.c. supply, the peak reverse voltage which comes during negative half-cycle should not exceed the reverse breakdown voltage.
4. When SCR is to be turned OFF from the ON state, anode current should be reduced to holding current.

5.If gate current is increased above the required value, the SCR will close at much reduced supply voltage.

Forward Characteristics

1) When anode is positive w.r.t. cathode, the curve between V and I is called the forward characteristics.
2) If the supply voltage is increased from zero, a point reached (point A) when the SCR starts conducting.
3) Under this condition,the voltage across SCR suddenly drops as shown by dotted curve AB and most of supply voltage appears across the load resistance R_L .
4) If proper gate current is made to flow, SCR can close at much smaller supply voltage.

Reverse Characteristics

1)When anode is negative w.r.t. cathode, the curve between V and I is known as reverse characteristics.

2)The reverse voltage does come across SCR when it is operated with a.c. supply.

3)If the reverse voltage is gradually increased, at first the anode current remains small (i.e. leakage current) and at some reverse voltage, avalanche breakdown occurs and the SCR starts conducting heavily in the reverse direction as shown by the curve DE.
4)This maximum reverse voltage at which SCR starts conducting heavily is known as reverse breakdown voltage.

b) Explain the need of freewheeling diode in controlled rectifier with R-L load. [5]

Answer)

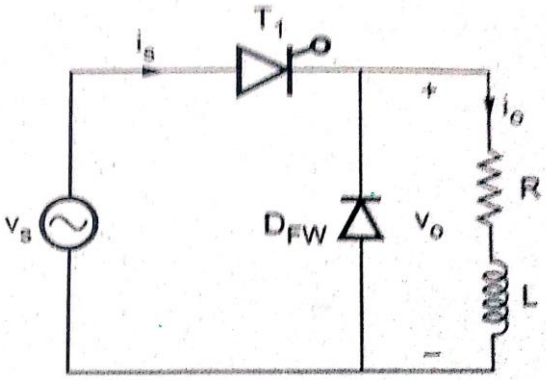


Fig. 2.6.4 Freewheeling diode in half wave controlled rectifier

1) Freewheeling diode across the RL load is shown in the 2.6.4
2) The SCR is triggered at firing angle of α in positive half cycle of supply. Hence ,$V_o = V_s$ The waveform of is shown in Fig. 2.6.5
3) Observe that from α to π ,Vo is same as supply voltage Vs . The freewheeling diode (D_{FW}) is reverse biased, hence it does not conduct. The output current i_o increases from zero as shown in Fig. 2.6.5. This is shown in equivalent circuit in Fig. 2.6.5.
4) After π, the supply voltage becomes negative. Hence SCR tries to turn-off. Therefore i_o tries to go to zero. Observe that i_o is maximum at π. But the load inductance does not allow i_o to go to zero. The energy stored in inductance generates the voltage $L(d_{io}/dt)$ with polarity as shown in Fig. 2.6.6.
5) The induced inductance voltage forward biases freewheeling diode as well as SCR. But freewheeling diode (D_{FW}) is more forward biased. Hence it starts conducting. Therefore T1 turns-off. The output current now flows through the freewheeling diode. In above figure observe that $i_o = i_{fw}$, when freewheeling diode conducts. Here i_{fw} is freewheeling current. Fig. 2.6.5 shown that $i_o=i_{fw}$ when freewheeling diode conducts.
6) The freewheeling current flows only due to energy stored in the load inductance. The output current flows in the load itself. Thus inductance energy is supplied back to the load itself. This process is called freewheeling. If load energy is feedback to the supply (mains), then it is called feedback.
7) The energy of inductance goes on decreasing after π. Hence i_o also goes on reducing. At β the inductance energy is finished. Hence i_o becomes zero at β. Thus freewheeling diode conducts from π to β.

8) The output is shorted due to freewheeling diode. Hence Vo=0 whenever freewheeling diode conducts. During freewheeling T1 is off. Hence no supply current flows. Therefore i_s =0 during freewheeling period T1 conducts from α to π. Hence i_o = is from α to π shown in fig. 2.6.5

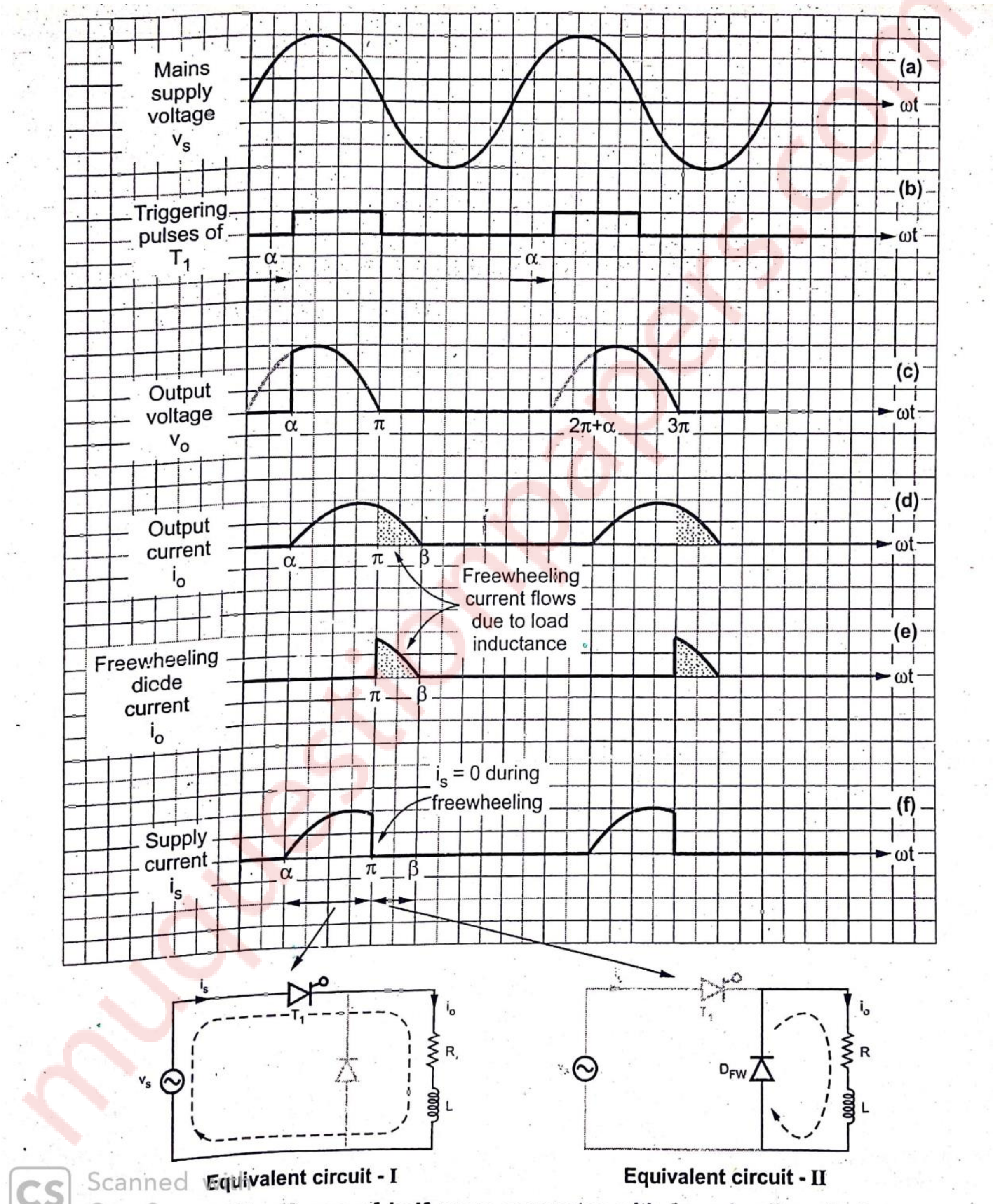


Fig. 2.6.5 Waveforms of half wave converter with freewheeling diode

c)Draw and explain equivalent circuit of OP-Amp **[5]**

Answer)

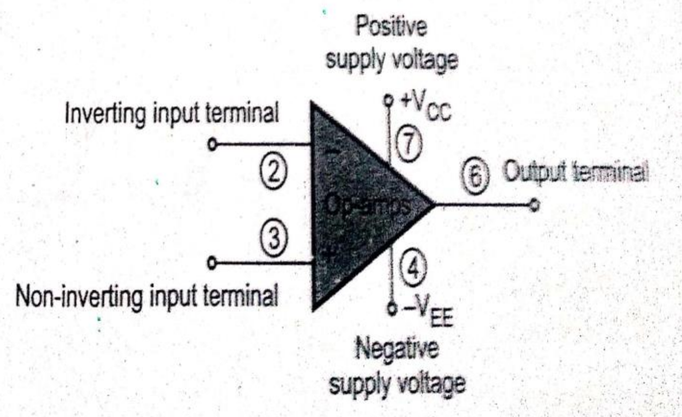


Fig. 3.2.1 Op-amp symbol

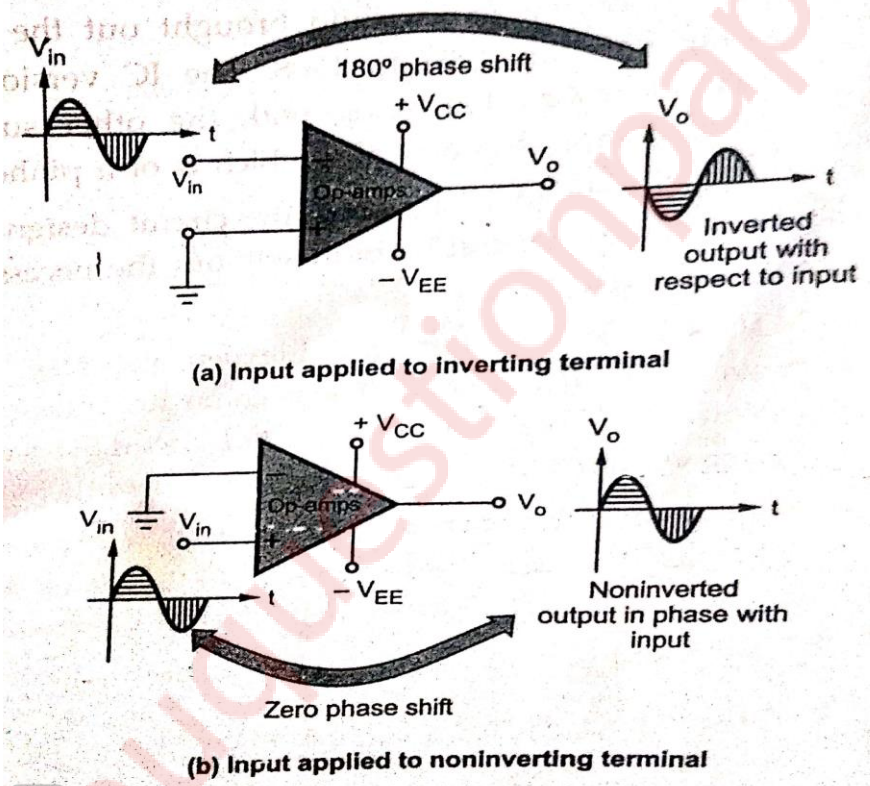


Fig. 3.2.2

1) The symbol for an op-amp along with its various terminals, is shown in the Fig. 3.2.1. The op-amp is indicated basically by a triangle which points in the direction of the signal flow.

2) The input at inverting input terminal results in opposite polarity (antiphase) output. While the input at non-inverting input terminal results in the same polarity (phase) output. This is shown in the Fig. 3.2.2 (a) and (b).

3) The input and output are in antipiase means having 180° phase difference in between them while inphase input and output means having 0 phase difference in between them.

4) The op-amp works on a dual supply. A dual supply consists of two supply voltages both d.c., whose middle point is generally the ground terminal.

5) The dual supply is generally balanced i.e. the voltages of the positive supply +Vcc and that of the negative supply - Vee are same in magnitude. The typical commercially used power supply voltages are ±15 V.

6) But if the two voltage magnitudes are not same in a dual supply it is called as unbalanced dual supply.

7) Practically in most of the op-amp circuits balanced dual supply is used. The other popular balanced dual supply voltages are ± 9 V, ±12 V, ±22 V etc.

d) Differentiate between Multiplexer and De-multiplexer. [5]

Answer)

Parameter	**Multiplexer**	**De-multiplexer**
Definition	Multiplexer is a digital switch which allows digital information from several sources to be routed onto a single output line.	Demultiplexer is a circuit that receives information on a single line and transmits this information on one of 2^n possible output lines
Number of data inputs	2^n	1
Number of data outputs	1	2^n
Relationship of inut and output	Many to one	One to many

Applications	• Used as a data selector • In time division multiplexing at the transmitting end	• Used as a data distributor • In time division multiplexing at the receiving end.

e) Compare AC and DC Motors **[5]**

Answer)

AC Motors	**DC Motors**
Ac motors are powered from AC current.	DC motors are powered from DC current
In AC motors conversion of current is not required.	In DC motors conversion of current is required like ac into dc current.
AC motors are used where power performance is sought for extended periods of time.	DC motors are used where motor speed required to be controlled externally
AC motors can be single-phase or three phases.	All DC motors are single phase.
In AC motors Armatures do not rotate while magnetic field continuously rotates.	In DC motors, the armature rotates while the magnetic field does rotate.
In AC motors Armatures do not rotate while magnetic field continuously rotates.	In DC motors, the armature rotates while the magnetic field does rotate.

Q2) a) Draw and explain functional block diagram of timer IC555. **[7]**
Answer)

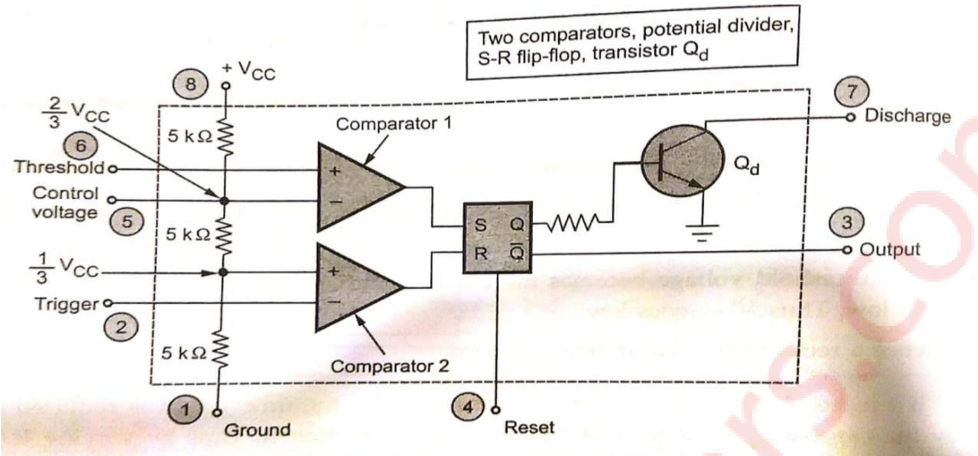


Fig. 3.25.1(b) Block diagram of IC 555 timer

There are various industrial applications for which A.C. or D.C. drives are used.Some of them are tabulated below:-

Pin 1:-Ground

All the voltages are measured with respect to this terminal.

Pin2:- Trigger

The IC555 uses two comparators . The voltage divider consists of three equal resistance .Due to voltage divider, the voltage of noninverting terminal of comparator 2 is fixed at Vcc / 3. The inverting input of comparator 2 which is compared with Voc / 3, is nothing but trigger input brought out as pin number 2.

When the trigger input is slightly less than Vcc /3 , the comparator 2 output goes high. This output is given to reset input of R-S flip-flop. So high output of comparator 2 resets the flip-flop.

Pin 3:- Output

The complementary signal output (Q) of the flip-flop goes to pin 3 which is the Output. The load can be connected in two ways. One between pin 3 and ground while other between pin 3 and pin 8.

Pin 4:-Reset

This is an interrupt to the timing device. When pin 4 is grounded, it stops the working of device and makes it off. Thus, pin4 provides on/off feature to the IC 555. This reset input overides all other functions within the timer when it is momentarily grounded.

Pin 5:- Control Voltage Input

In most of the applications, external control voltage input is not used. This pin is nothing but the inverting input termiral of comparator 1. The voltage divider holds the voltage of this input at 2/3 Vcc .This is reference level for comparator 1 with which threshold is compared. If reference level required is other than 2/2 VCC for comparator 1 then external input is given to pin 5.

If external input applied to pin 5 is alternating then the reference level for comparator 1 keeps on changing above and below 2/3 Vcc .Due to this, the variable pulse width output is possible. This is called **pulse width modulation**,which is possible due to pin5

Pin 6:- Threshold

This is the noninverting input terminal of comparator 1 .The external voltage is applied to this pin 6. When this voltage is more than 2/3 Vcc the comparator 1 output goes high. This is given to the set input of R-S flip-flop Thus high output of comparator 1 sets theflip flop. This makes Q of flip-flop high and Q low. Thus, the output of IC 555 at pin 3 goes low.

Pin 7:- Discharge

This pin is connected to the collector of the discharge transistor Q_d

When the output is high then Q is low and transistor Q_d is off. It acts as an open circuit to the external capacitor C to be connected across it, so capacitor C can charge as described earlier.

When output is low, Q is high which drives the base of Q_d high, driving transistor Q_d in saturation. It acts as short circuit, shorting the external capacitor C to be connected across it.

Pin 8: Supply +Vcc

The IC 555 timer can work with any supply voltage between 4.5 V and 16 V.

b) Draw and explain fan regulator circuit using TRIAC and DIAC. Draw waveforms. **[7]**

Answer)

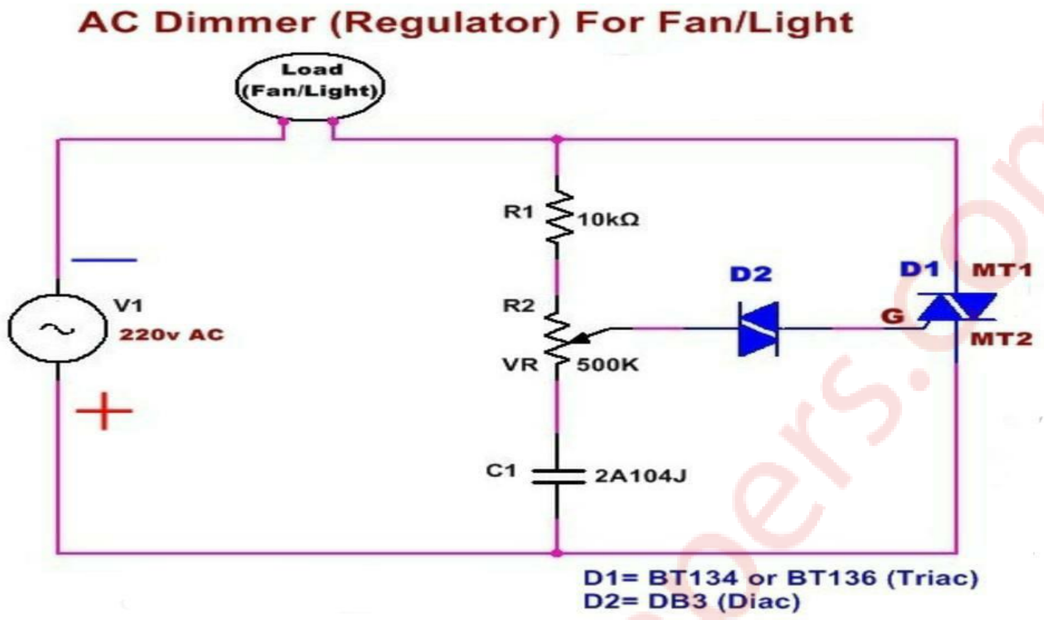


Fig. Circuit Diagram of Voltage Regulator using TRIAC, DIAC

Operation of the Electronic Voltage Regulator Circuit

- Before giving the power supply to this simple fan regulator circuit, keep the variable resistor or potentiometer in maximum resistance position so that no triggering is applied to TRIAC and hence the TRIAC will be in cutoff mode.
- Turn ON the power supply of the circuit and observe whether the fan is in standstill condition or not. Vary the potentiometer position slowly so that the capacitor starts charging at the time constant determined by the values of R1 and R2.
- Once the voltage across the capacitor is more than the break over voltage of the DIAC, DIAC starts conducting. Thus, the capacitor starts discharging towards the gate terminal of TRIAC through DIAC.
- Therefore, TRIAC starts conducting and hence the main current starts flowing into the fan through the closed path formed by TRIAC.
- By varying the potentiometer R2, the rate at which capacitor is going to be charged get varied this means that if the resistance is less, the capacitor will charge at a faster rate so the earlier will be the conduction of TRIAC.

- As the potentiometer resistance gradually increases, the conduction angle of TRIAC will be reduced. Hence the average power across the load will be varied.

- Due to the bidirectional control capability of both TRIAC and DIAC, it is possible to control the firing angle of the TRIAC in both positive and negative peaks of the input.

Advantages of Simple Fan Regulator Circuit

- Continuous and step less control of the fan speed is possible
- Power saving is achieved at all the speeds by minimizing the energy losses
- Simple circuit which requires less number of components
- Efficient as compared with resistive type due to lower power consumption
- Cost-effective

c) State and prove Demorgan's theorems in Boolean Algebra. [6]

Answer) De-Morgan suggested two theorems that an important part of Boolean Algebra. In the equation form they are as follows:-

1)

The complement of a product is equal to the sum of the compliments this is illustrated by truth table 4.2.2

$$\overline{A . B} = \bar{A} + \bar{B}$$

A	B	$\overline{AB}$	$\bar{A}+\bar{B}$
0	0	1	1
0	1	1	1
1	0	1	1
1	1	0	0

Table 4.2.2 Truth table

2)

The complement of a sum is equal to the product of the compliments .The truth table 4.2.3 shown illustrates this law

$$\overline{A + B} = \bar{A} . \bar{B}$$

A	B	$\overline{A+B}$	$\bar{A}\ \bar{B}$
0	0	1	1
0	1	0	0
1	0	0	0
1	1	0	0

Table 4.2.3 Truth table

Q3) a) Draw and explain semi-controlled rectifier. Draw waveforms. [7]

Answer)

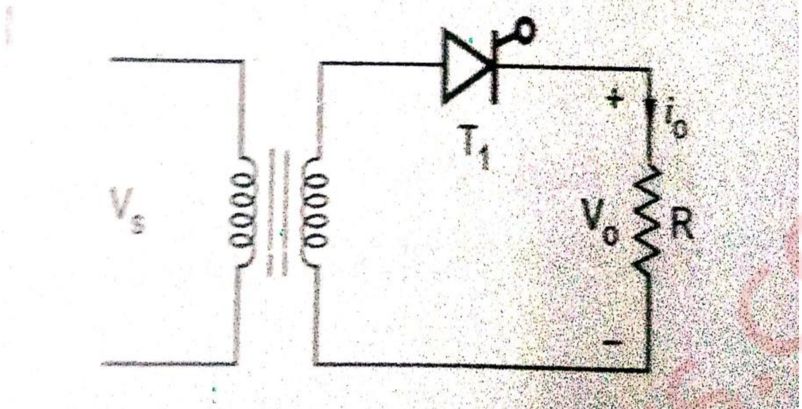


Fig. 2.2.1 Half wave controlled rectifier with R-load

1)The principle of phase controlled can be explained with the help of half wave controlled rectifier shown in Fig. 2.2.1

2) The secondary of the transformer is connected to resistive load through thyristor or SCR T1.

3) The primary of the transformer is connected to the mains supply. In the positive cycle of the supply, T1 is forward biased. T1 is triggered at an angle α. This is also called as triggering or firing delay angle. T1 conducts and secondary (i.e. supply) voltage is applied to the load. Current i_o starts flowing through the load. The output current and voltage waveforms are shown in fig. 2.2.2.

3) The shape of output current waveform is same as output voltage waveform. At π supply voltage drops to zero. Hence current i_o flowing through T1 becomes zero and it turns off. In the negative half cycle of the supply T1 is reverse biased and it does not conduct.

4) The average value of output voltage is given as,

$$Vo(avg) = \frac{Vm}{2\pi}(1 + cos\alpha)$$

5) Since output voltage and current both are always positive it is also called first quadrant or single quadrant converter. This is shown in fig. 2.2.3.

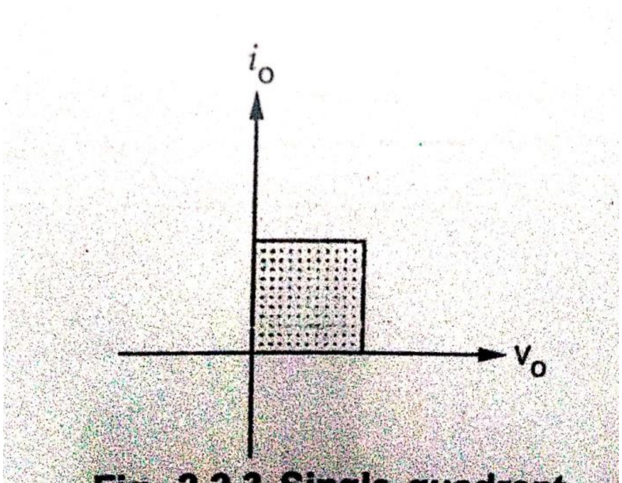


Fig. 2.2.3 Single quadrant operation

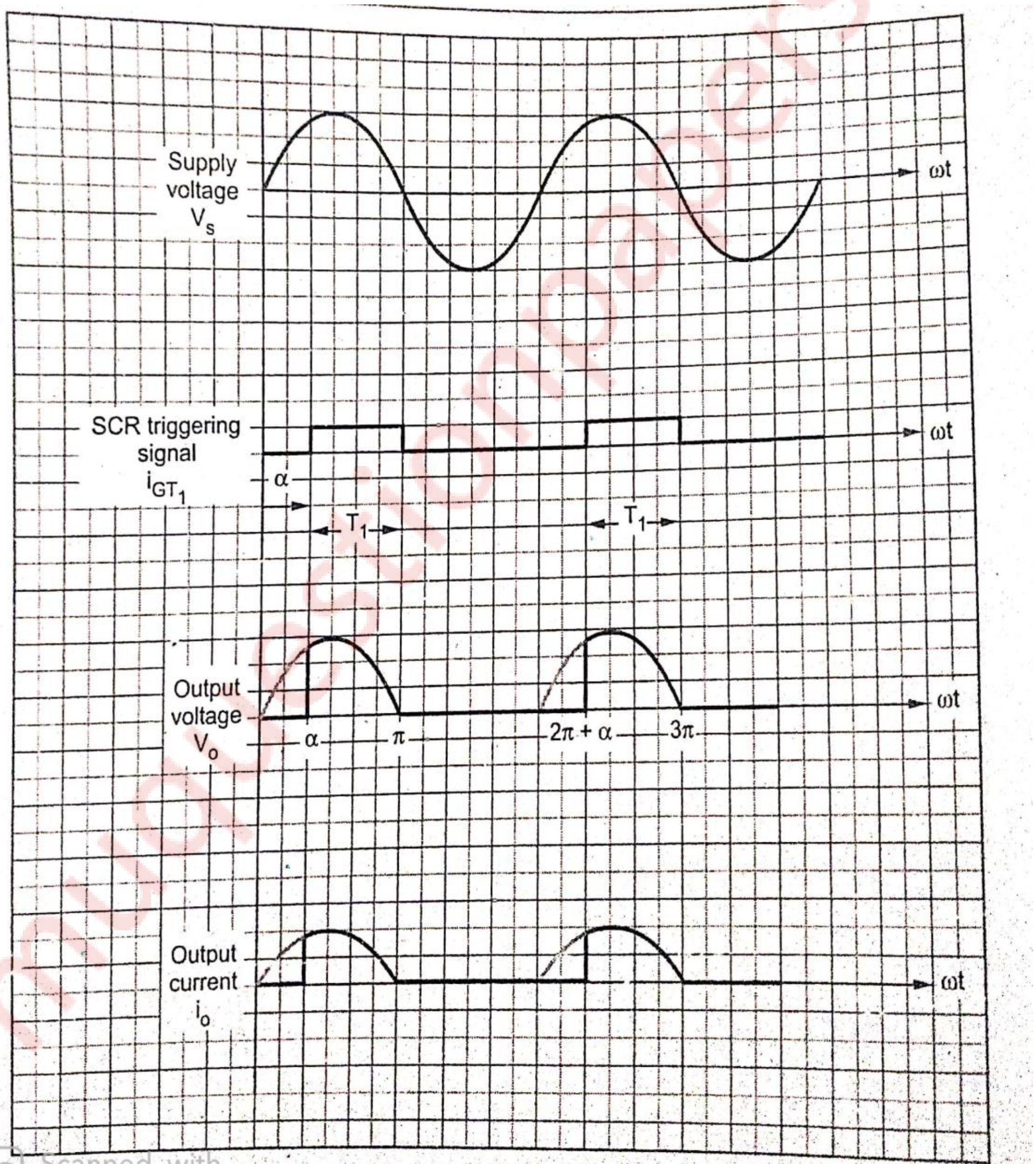
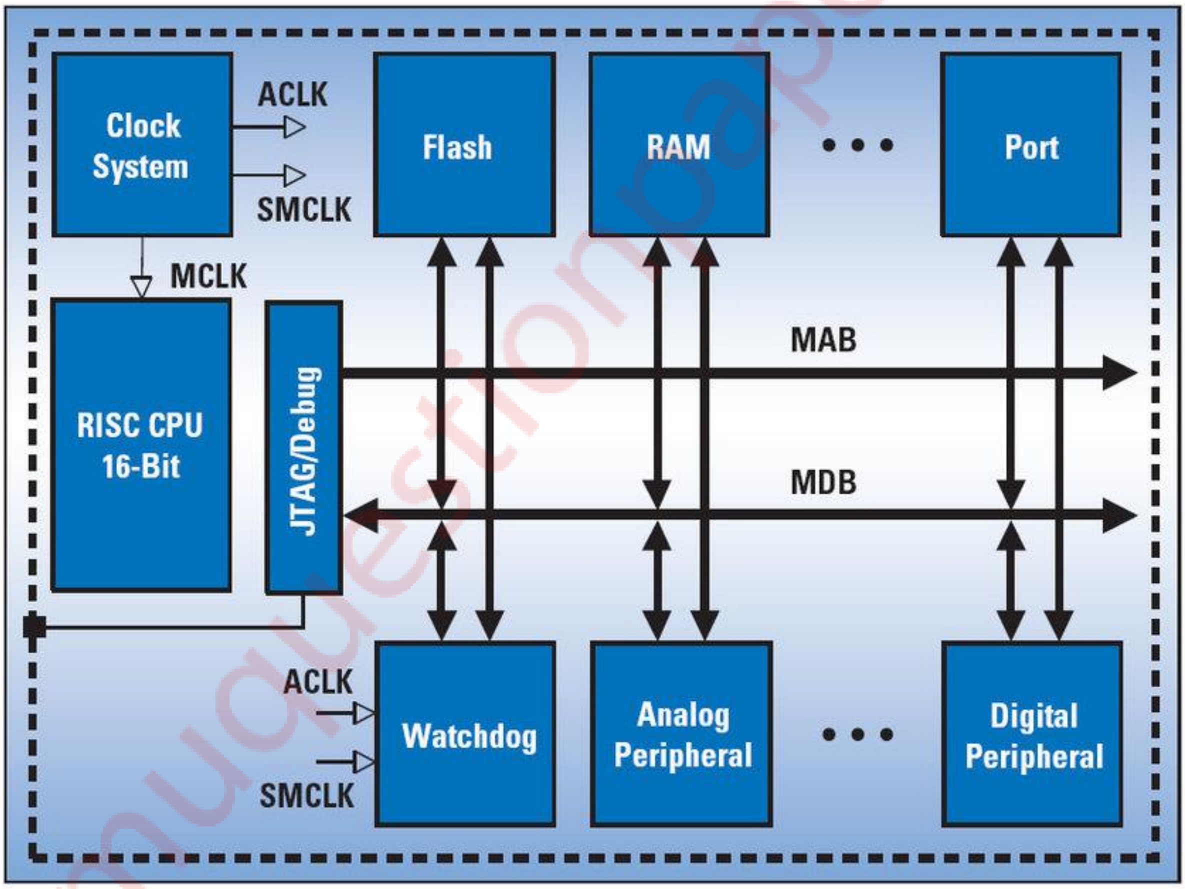


Fig. 2.2.2 Phase control principle as applied to half wave controlled rectifier

b)Draw and explain architecture of MSP430 Microcontroller [7]

Answer) <u>Architecture of MSP430 Microcontroller</u>

The MSP430 is a family of 16-bit RISC microcontrollers produced by Texas Instruments. The MSP430 microcontroller was developed at Texas Instruments in 1993. At the beginning ,Texas Instruments only offered the MSP430 in Europe. Since 1997, the MSP430 microcontroller family is offered world wide. The most important feature of the MSP430 is its low power consumption. However, the flexibility of its peripheral modules and the easy way to use it is the reason why this microcontroller is also used as a general purpose microcontroller.



<u>FIGURE:- ARCHITECTURE OF MSP430 MICROCONTROLLER</u>

The MSP430 microcontroller is based on a von-Neumann architecture. The MSP430 von-Neumann architecture has one address space shared with special function registers (SFRs), peripheral control registers, RAM, and Flash/ROM memory. At the moment, there are two compatible CPUs existing within the MSP430 microcontroller family. The MSP430 CPU uses 16-bit CPU register and 16-bit Program Counter.

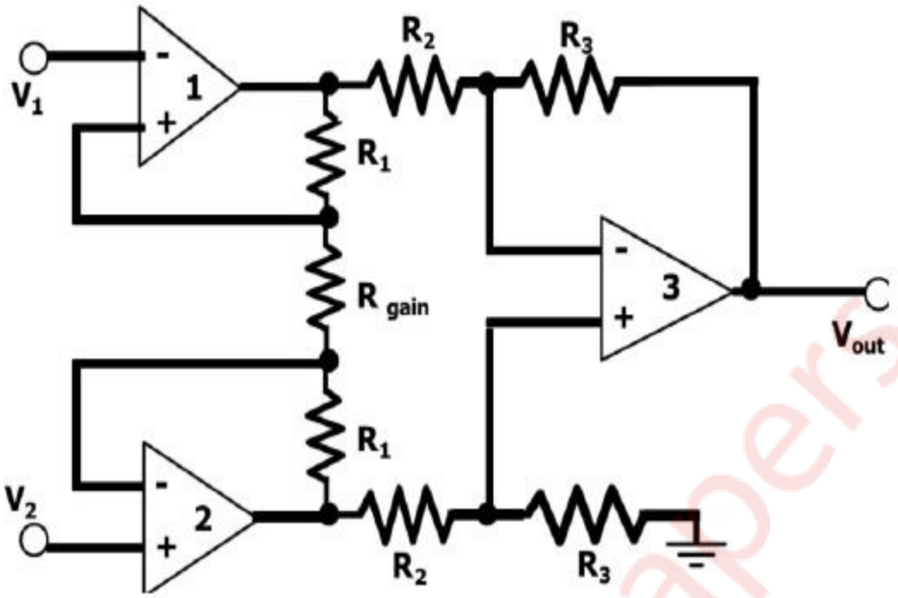
This basically means that with such a CPU an address range of 64kBytes could be addressed. Due to the von-Neumann architecture, the address range covers peripheral control registers (address 0x0000 to 0x01FF), RAM (starting at address 0x0200), and for example Flash memory (e.g. for an MSP430F169 the Flash memory starts at address 0x1000). So the MSP430 derivatives with the MSP430 CPU usually have a maximum Flash memory of 60KByte. The other CPU is the MSP430 CPUx (or MSP430X). This is an extended CPU. The CPU registers are 20-bit registers. Also the Program Counter is a 20-bit register, which allows to address memory above the 64KByte limit. Usually all MSP430s with a Flash memory above 60kByte Flash have the CPUx. Because the CPUx is based on MSP430 CPU the software that was written on a MSP430 CPU device is also running on MSP430 CPUx chips.

Features Of MSP430 Microcontroller:-

- These are some features of MSP430.
- It is available in a 20 pin plastic small outline widebody package.
- Its operating voltage range is 2.5v to 5.5v. Its active mode is 330 µA at 1 MHz, 3 V.
- Its stands by mode are 1.5 µA. It's off mode (Ram Retention) is 0.1 µA.
- It has serial onboard programming.

c)Draw and explain Instrumentation amplifier. State its advantages and disadvantages. **[6]**

Answer) Instrumentation Amplifier using Op Amp



1)The **instrumentation amplifier using** **<u>op-amp circuit</u>** is shown above.
2)The **op-amps** 1 & 2 are non-inverting amplifiers and op-amp 3 is a **difference amplifier**.
3)These three op-amps together, form an instrumentation amplifier. Instrumentation amplifier's final output Vout is the amplified difference of the input signals applied to the input terminals of op-amp 3.Let the outputs of op-amp 1 and op-amp 2 be Vo1 and Vo2 respectively.
4)Then, **Vout = (R3/R2)(Vo1-Vo2)**
5)Look at the input stage of the instrumentation amplifier as shown in the figure below. The **instrumentation amplifier derivation** is discussed below.
6)The potential at node A is the input voltage V1. Hence the potential at node B is also V1, from the virtual short concept. Thus, the potential at node G is also V1.

7)The potential at node D is the input voltage V2. Hence the potential at node C is also V2, from the virtual short. Thus, the potential at node H is also V2.

The **working of the instrumentation amplifier** is, Ideally the current to the input stage op-amps is zero. Therefore the current I through the resistors R1, Rgain, and R1 remain the same.

Applying **Ohm's law** between nodes E and F,

I = (Vo1-Vo2)/(R1+Rgain+R1) ……………………….(1)

I = (Vo1-Vo2)/(2R1+Rgain)

Since no current is flowing to the input of the op-amps 1 & 2, the current I between the nodes G and H can be given as,

I = (VG-VH) / Rgain = (V1-V2) / Rgain……………………….(2)

Equating equations 1 and 2,

(Vo1-Vo2)/(2R1+Rgain) = (V1-V2)/Rgain

(Vo1-Vo2) = (2R1+Rgain)(V1-V2)/Rgain ……………………….(3)

The output of the difference amplifier is given as,

Vout = (R3/R2) (Vo1-Vo2)

Therefore, **(Vo1 – Vo2) = (R2/R3)Vout**

Substituting **(Vo1 – Vo2)** value in equation 3, we get

(R2/R3)Vout = (2R1+Rgain)(V1-V2)/Rgain

i.e. **Vout = (R3/R2){(2R1+Rgain)/Rgain}(V1-V2)**

This above equation gives the output voltage of an instrumentation amplifier.

The overall gain of the amplifier is given by the term **(R3/R2){(2R1+Rgain)/Rgain}**.

The overall voltage gain of an **instrumentation amplifier** can be controlled by adjusting the value of resistor Rgain.

The common mode signal attenuation for the instrumentation amplifier is provided by the difference amplifier.

Advantages of Instrumentation Amplifier

The **advantages of the instrumentation amplifier** include the following.

- The gain of a three op-amp **instrumentation amplifier circuit** can be easily varied by adjusting the value of only one resistor Rgain.
- The gain of the amplifier depends only on the external resistors used.
- The input impedance is very high due to the emitter follower configurations of amplifiers 1 and 2
- The output impedance of the instrumentation amplifier is very low due to the difference amplifier3.
- The CMRR of the **op-amp** 3 is very high and almost all of the common mode signal will be rejected.

Disadvantage of Instrumentation Amplifier

- The biggest disadvantage of Instrumentation Amplifier is the occurrence of noise when used for long range transmission purpose.

Q.4) a) Draw and explain BLDC motor. State its advantages. [7]

Answer)

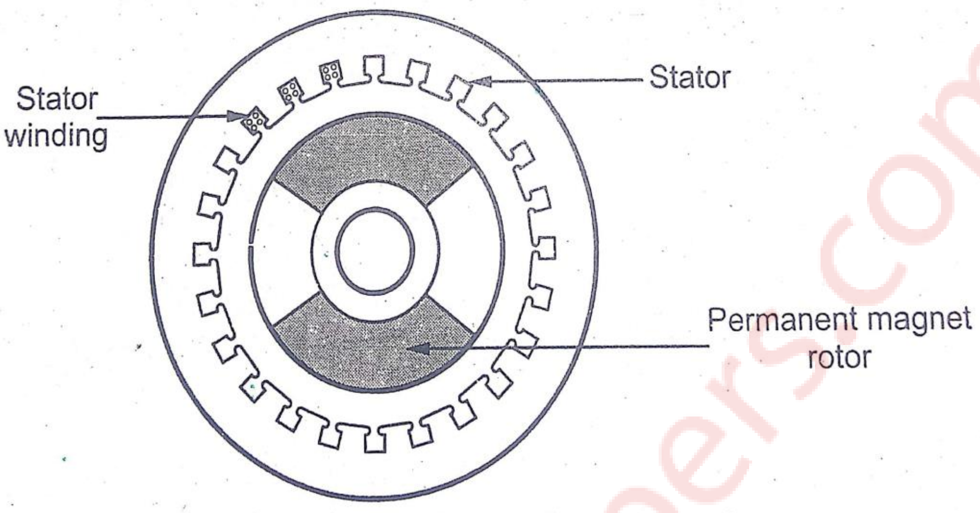


Fig. 9.22.1 Cross-section of brushless d.c. motor

1)The brushless d.c. motor differ from normal dc. motor in that it employs electrical commutation of the armature current rather than the mechanical commutation.

2) Thee construction of brushless d.c. motor is similar to a permanent magnet synchronous motor.

3) The polyphase winding is placed on the stator (armature) while rotor consists of permanent magnets.

4) The Fig. 9.22.1 shows the cross-sectional view winding of a permanent magnet brushless d.c motor.

5) The word brushless d.c. motor is used to define the combination of motor, its electronic drive circuit and rotor position sensor.

6) The electronic drive is an inverter which consists of transistors, which feeds stator windings.

7) The transistors are controlled by the pulses generated by rotor position sensors: This ensures that rotor revolves at angular speed which is equal to the average speed of the field produced by the stator.

8) Like a d.c. motor, the driver circuit is fed from a d.c. supply.

9) The stator and rotor fields remain stationary with respect to each other, at all the speeds.

10) The torque-speed characteristics are similar to a d.c motor.

11) The speed can be controlled by controlling the input d.c. voltage.

12) Because of these similarities and as it does not have brushes, it is known as brushless d.c. motor.

Advantages of BLDC motor:-

1)Due to absence of brushes and commutator, they require practically no maintenance.

2)They have long life.

3)The operation is highly reliable.

4)They have low inertia and friction.

b) State and define specification parameters of digital logic family. [7]

Answer) Specification parameters of digital logic family are as follows:-

1) Fan in

2) Fan out

3) Noise immunity

4) Noise Margin

5) Propagation Delay

6) Threshold Voltage

7) Operating speed

8) Power dissipation

1) Fan in:-

The number of inputs that the gate can handle properly with out disturbing the output level.

2) Fan out :

The number of inputs that can driven simultaneously by the output with out disturbing the output level.

3) Noise immunity:

Noise immunity is the ability of the logic circuit to tolerate the noise voltage.

4) Noise Margin:

The quantitative measure of noise immunity is called noise margin.

5) Propagation Delay :

The propagation delay of gate is the average transition delay time for the signal to propagate from input to output It is measured in nanoseconds.

6) Threshold Voltage:

The voltage at which the circuit changes from one state to another state.

7) Operating Speed:

The speed of operation of the logic gate is the time that elapses between giving input and getting output.

8) Power Dissipation :

The power dissipation is defined as power needed by the logic circuit.

c) Explain construction and characteristics of Power BJT. [6]

Answer)

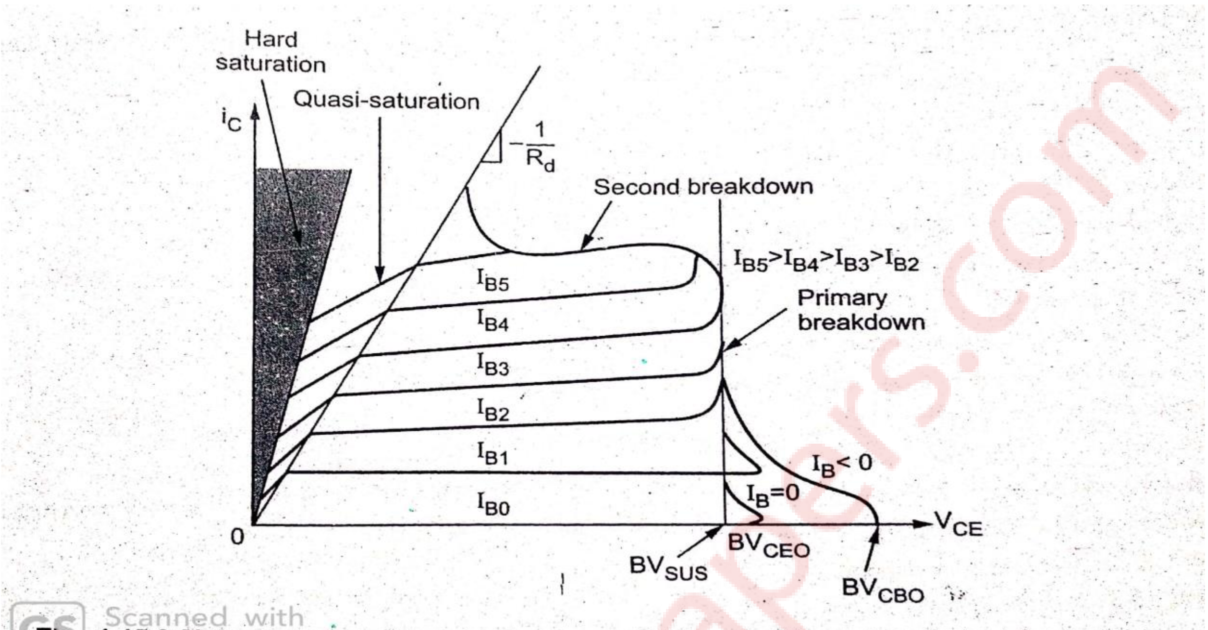


Fig. 1.15.3 V- I characteristics of npn power BJT and different regions of operation

Construction of Power BJT:

1)The power BJT has three terminals **Collector (C), Emitter (E)** and **Base (B).** It has a vertically oriented four-layers structure. The vertical structure uses to increase the cross-sectional area.

2)There are two types of BJT; **n-p-n transistor** and **p-n-p transistor.** Out of these two types, the n-p-n transistors widely use compare to the p-n-p transistor.

3) It has four layers. The first layer is a heavily doped **emitter layer (n+).** The second layer is moderately doped the **base layer (p).** The third region is lightly doped **collector drift region (n-).** The last layer is a highly doped **collector region (n+).**

4) The drift layer (n-) increase the voltage blocking capacity of the transistor due to the low doping level. The width of this layer decides the breakdown voltage. The disadvantage of this layer is that the increase on state voltage drops and increase on state device resistance, which increases power loss.

5) The power handling capacity of the power transistor is very large. So, they have to dissipate power in the form of heat. Sometimes, heatsink uses to increase effective area and therefore increase power dissipation capacity. the heatsink made from metal.

I-V characteristic:

In the structure of BJT, there are two junctions; Emitter junction (BE) and Collector junction (CB).

1. Cut-off region:

The BE and CB both junctions are reverse bias. The base current I_B=0 and collector current I_C is equal to the reverse leakage current I_{CEO}. The region below the characteristic for I_B=0 is cut-off region. In this region, BJT offers large resistance to the flow of current. Hence it is equivalent to an open circuit.

2. Active region:

The BE junction is forward bias and CB junction is reverse bias. The collector current IC increase slightly with an increase in the voltage V_{CE} if I_B is increased. The relation of IB and IC is, $I_C=\beta_{dc}I_B$ is true in the active region.
If BJT uses as an amplifier or as a series pass transistor in the voltage regulator, it operates in this region. The dynamic resistance in this region is large. The power dissipation is maximum.

3. Quasi-saturation region:

Quasi-saturation region is between the hard saturation and active region. This region exists due to the lightly doped drift layer. When the BJT operates at high frequency, it is operated in this region. Both junctions are forward bias. The device offers low resistance compared to the active region. So, power loss is less. In this region, the device does not go into deep saturation. So, it can turn off quickly. Therefore, we can use for higher frequency applications.

4. Hard-saturation region:

The Power BJT push into the hard-saturation region from the quasi-saturation region by increasing the base current. This region is also known as deep saturation region. The resistance offers in this region is minimum. It is even less than the quasi-saturation region. So, when the BJT operates in this region, power dissipation is minimum. The device acts as a closed switch when it operates in this region. But it needs more time to turn off. So, this region is suitable only for low-frequency switching application. In this region, both junctions are forward bias. The collector current is not proportional to the base current, I_C remains almost constant at $I_{C(sat)}$ and independent from the value of base current.

Q.5) a) With the help of connection diagram, derive the relation for voltage gain in inverting mode of operation of operational amplifier. [7]

Answer)

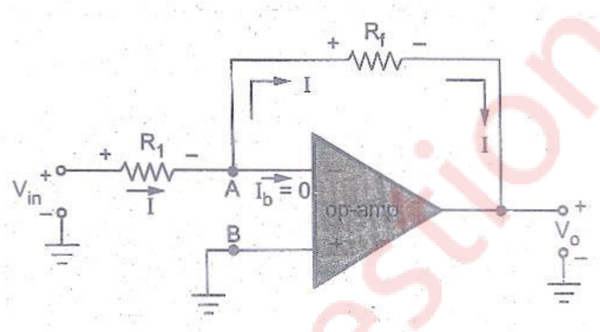


Fig. 3.12.1 (a) Inverting amplifier

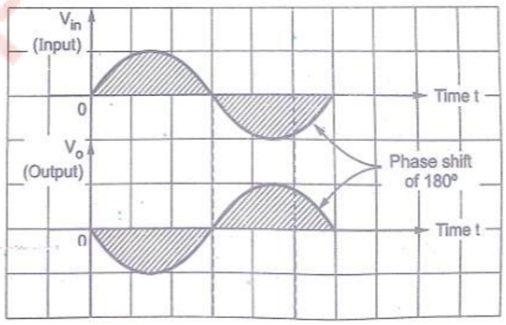


Fig. 3.12.1 (b) Waveforms of inverting amplifier

1)As the name suggests the output of such an amplifier is inverted as compared to the input signal.

2) The inverted output signal means having a phase shift of 180° as compared to the input signal.

3) So, an amplifier which provides a phase shift of 180° between input in and output is called **inverting amplifier.**

4) The basic circuit diagram of an inverting amplifier using op-amp is shown in the Fig. 3.12.1 (a).

Derivation:-

As node B is grounded, node A is also at ground potential, from the concept of virtual ground, so V_A=0

$$I = \frac{Vin - VA}{R1}$$

$$I = \frac{Vin}{R1} \qquad \text{...(1)}$$

Now, from the output side, considering the direction of current I we can write,

$$I = \frac{VA - Vo}{Rf} = \frac{-Vo}{Rf} \qquad \text{...(2)}$$

Entire current I passes through Rf as op-amp input current is zero.

Equating equations (1) and (2), we get,

$$\frac{Vin}{R1} = -\frac{Vo}{Rf}$$

$$Avf = \frac{Vo}{Vin} = -\frac{Rf}{R1}$$

The $\frac{Rf}{R1}$ is the gain of the amplifier while negative sign indicates that the polarity of output is opposite is opposite is opposite to that of input. Hence it is called inverting amplifier.

b)With the help of circuit diagram and waveforms, explain the generation of output voltage in three phase inverter in 180^0 conduction mode of operation. [7]

Answer)

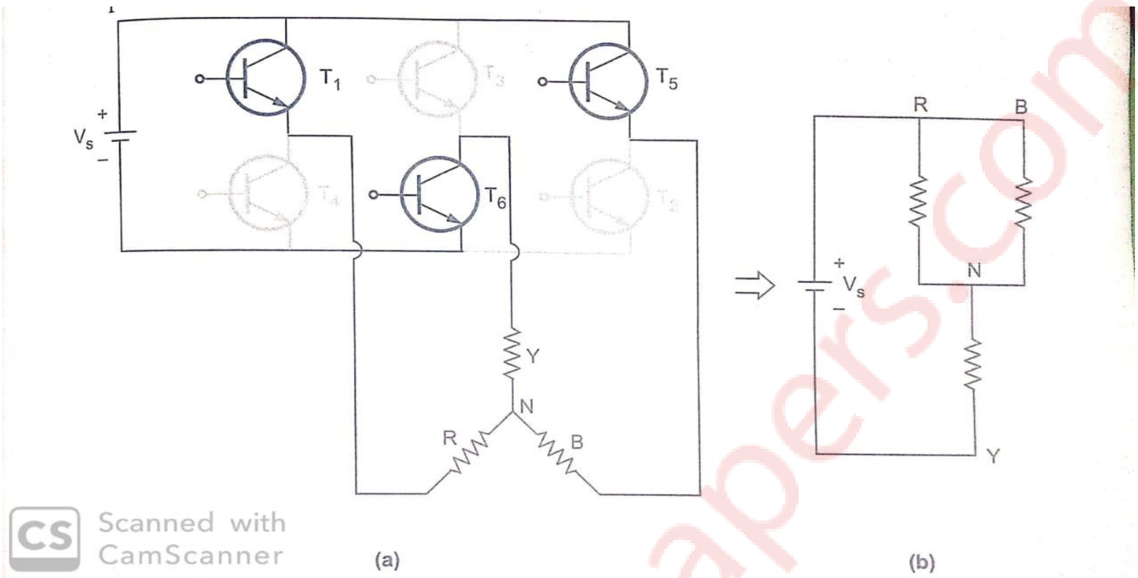


FIGURE:- CIRCUIT DIAGRAM FOR 180 DEGREE CONDUCTION TYPE 3 PHASE INVERTER

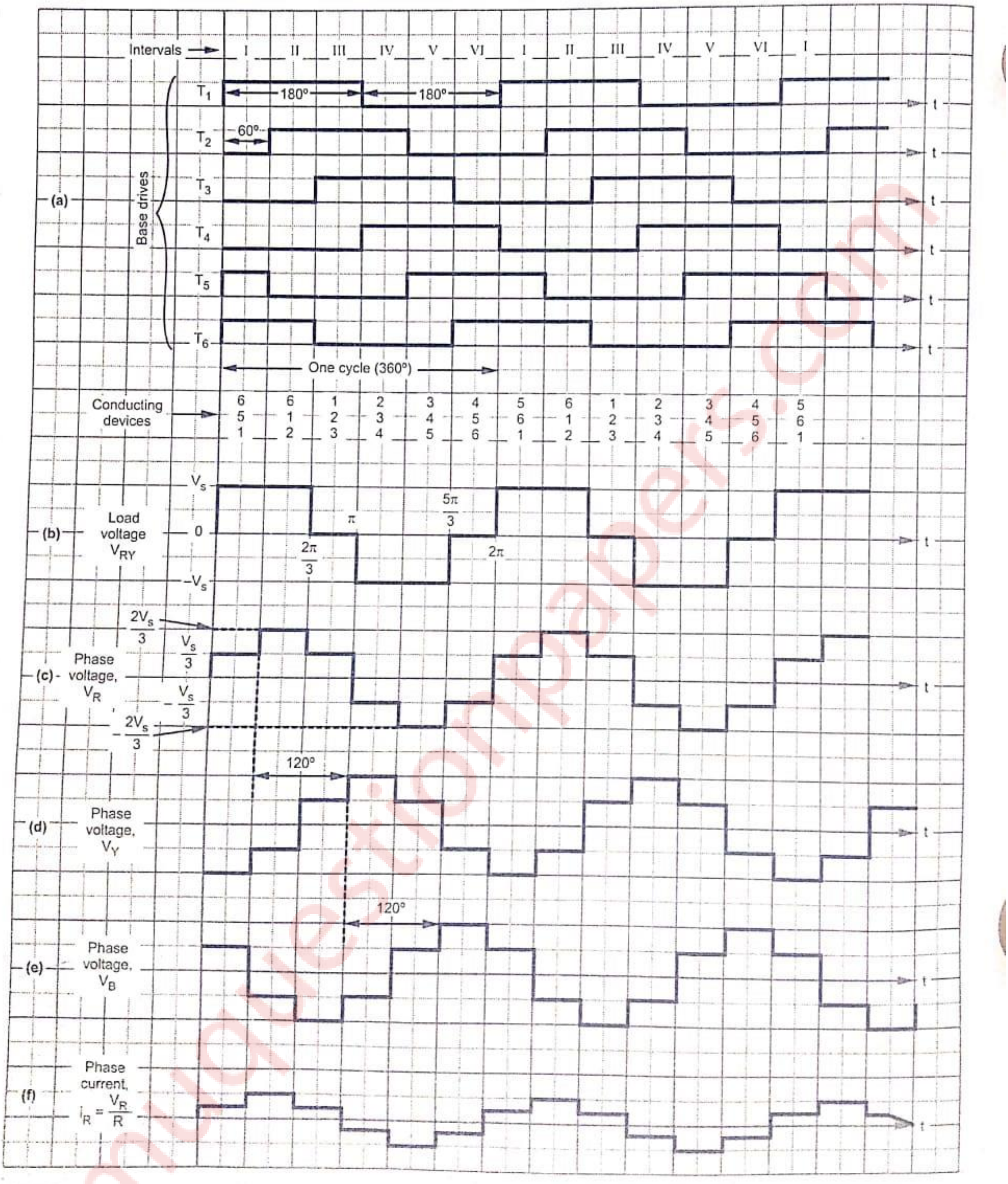


Fig. 2.9.3 Waveforms of 180° mode inverter

c)What do you understand by servomotor. State its applications.

[6]

Answer)

1)A servo system is one in which the output is some mechanical variable like position, velocity or acceleration. Such systems are automatic control systems in which output is some mechanical function such as controlling the position of the shaft, controlling angular speed of the shaft etc.

2) The motors used in such control systems are driven by the signal which is derived based on the error information supplied to the controller. These motors used in such servosystems or servomechanisms are called servomotors.

3) These motors are low power rating motors and can drive the load directly, hence these motors are usually coupled to the load through a gear train for power matching purpose.

Requirement of a Good Servomotor

The servo motor which are designed for use in servo system must have following requirements:

1) Linear relationship between electrical control signal and the rotor speed, over a wide range.

2) Inertia of the rotor should be as small as possible. A servomotor must stop running without any time delay, if control signal to it is removed.

3) Its response should be very fast. For quickly changing error signals, it must react with good response. This is achieved by keeping torque to weight ratio high. Hence these motors can be started, stopped or reversed very quickly compared to normal motors.

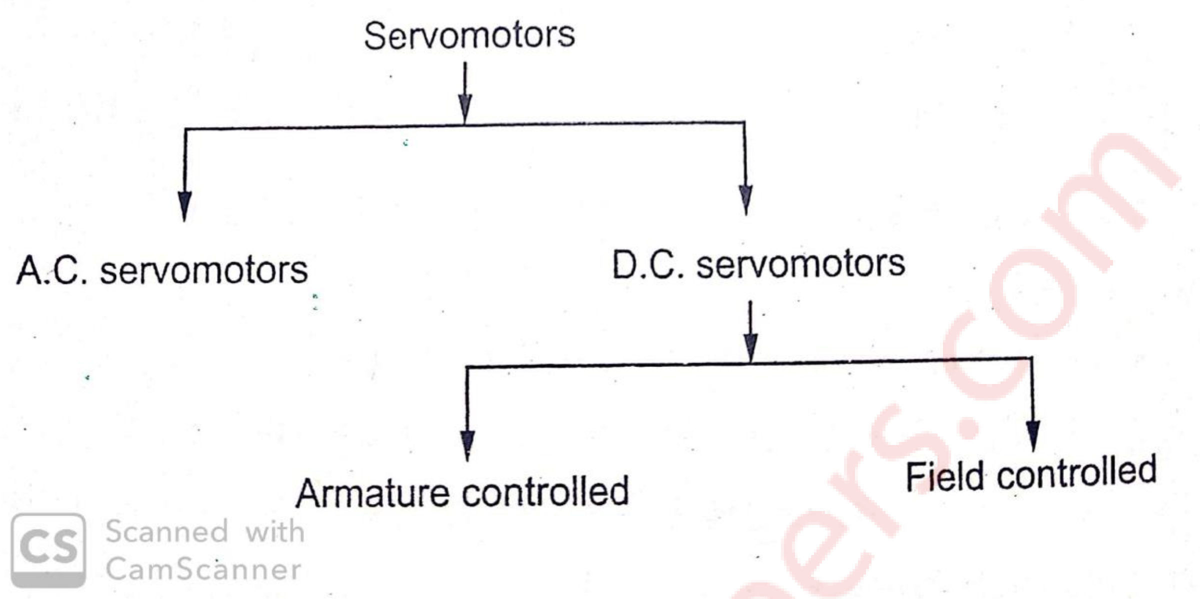
4) It should be quickly reversible.

5) It should have linear torque-speed characteristics.

6) The output torque at any speed should be roughly proportional to the applied control signal.

7) Its operation should be stable without any oscillations or overshoots.

Types of servomotors



Applications:-

1)Servostabilizer

2) Position control system

3)Instrument servos

4)Process controllers

5)Robotics

6)Self balancing recorders.

5)Machine tools

Q.6)a) Draw and explain slip-torque characteristics of three phase AC motor. [7]

Answer)

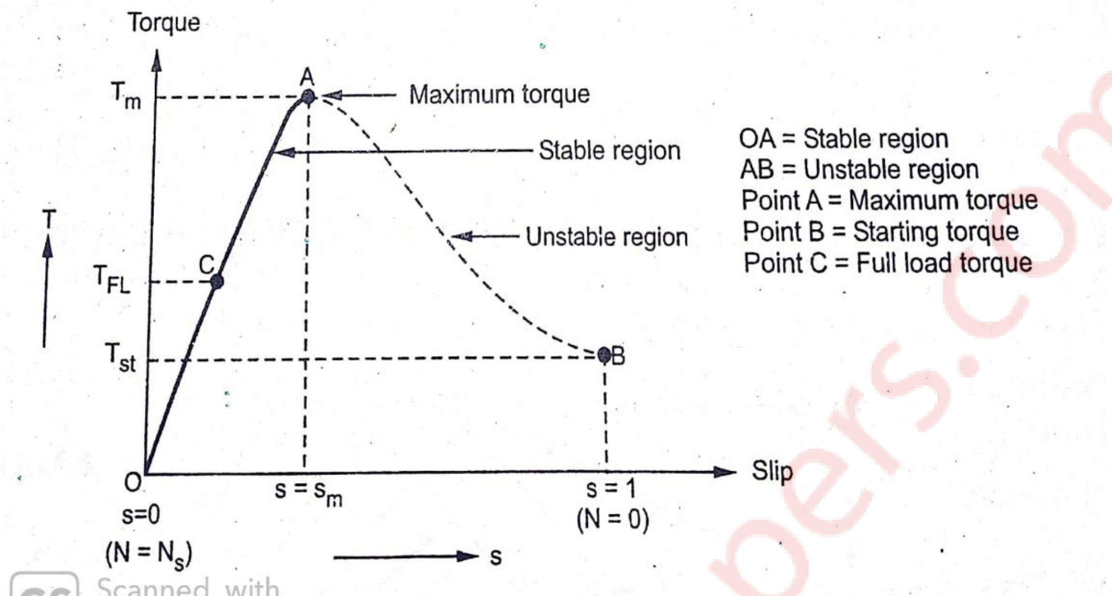


Fig. 9.15.1 Torque-slip characteristics

1) As the induction motor is loaded from no load to full load, its speed decreases hence slip increases.

2) Due to the increased load, motor has to produce more torque to satisfy load demand.

3) The behaviour of motor can be easily judged by sketching a curve obtained by plotting torque produced against slip of induction motor. The curve obtained by plotting torque against slip from s = 1 (at start) to s = 0 (at synchronous speed) is called torque-slip characteristics of the induction motor.

4) We have seen that for a constant supply voltage, E_2 is also constant. So we can write torque equation as,

$$T \propto \frac{sR2}{R2^2 + (sX2)^2}$$

5) Now to judge the nature of torque-slip characteristics let us divide the slip range (s = 0 to s = 1) into two parts and analyze them independently.

Low slip region:-

1)In Low slip region, ‘s’ is very very small. Due to this, the term (sX2)^2 is so small as compared to R_2^2 that it can be neglected.

T α $\frac{sR2}{R_2^2}$ α s ....As R2 is constant.

2) Hence in low slip region torque is directly proportional to slip. So as load increases. speed decreases, increasing the slip. This increases the torque which satisfies the load demand.

3) Hence the graph is straight line in nature.

4) At N =Ns ,s = 0 hence T = 0.As no torque is generated at N=Ns, motor stops if it tries to achieve the synchronous speed.

5) Torque increases linearly in this region of low slip values.

High slip region:-

1) In this region, slip is high i.e. slip value is approaching to 1. Here it can be assumed that the term R_2^2 is very very small as compared to (s X2)^2. Hence neglecting R_2^2 from the denominator, we get,

T α $\frac{sR2}{(sX2)^2}$ α $\frac{1}{s}$ ....where R2 and X2 are constants.

2) So in high slip region torque is inversely proportional to the slip. Hence its nature is like rectangular hyperbola.

3) When load increases, load demand increases but speed decreases. As speed decreases, slip increases.

4) In high slip region as T α 1/s, torque decreases as slip increases.

5) But torque must increase to satisfy the load demand.

6) As torque decreases, due to extra loading effect, speed further decreases and slip further increases.

7) Again torque decreases as T α 1/s hence same load acts as an extra load due to reduction in torque produced. Hence speed further drops.

8) Eventually motor comes to standstill condition.

9) The motor cannot continue to rotate at any point in this high slip region. Hence this region is called unstable region of operation.

• So torque - slip characteristics has two parts.

1) Straight line called stable region of operation.

2) Rectangular hyperbola called unstable region of operation.

Now the obvious question is upto which value of slip, torque-slip characteristics represents stable operation ?

The maximum torque, the motor can produce as load increases is Tm which occurs at s= Sm So linear behaviour continues till $s = s_m$

If load is increased beyond this limit, motor slip acts dominantly pushing motor into high slip region. Due to unstable conditions, motor comes to standstill condition at such a load. Hence The maximum torque which motor can produce is also called breakdown torque or pull out torque.

So range s = 0 to s = sm is called low slip region, known as stable region of operation. Motor always operates at a point in this region.

And range s = Sm to s = 1 is called high slip region which is rectangular hyperbola, called unstable region of operation. Motor cannot continue to rotate at any point in this region.

At s=1, N = 0 i.e. at start, motor produces a torque called starting torque denoted as T_{st}.

b) Draw and explain CMOS NAND gate with the help of truth table. [7]

Answer)

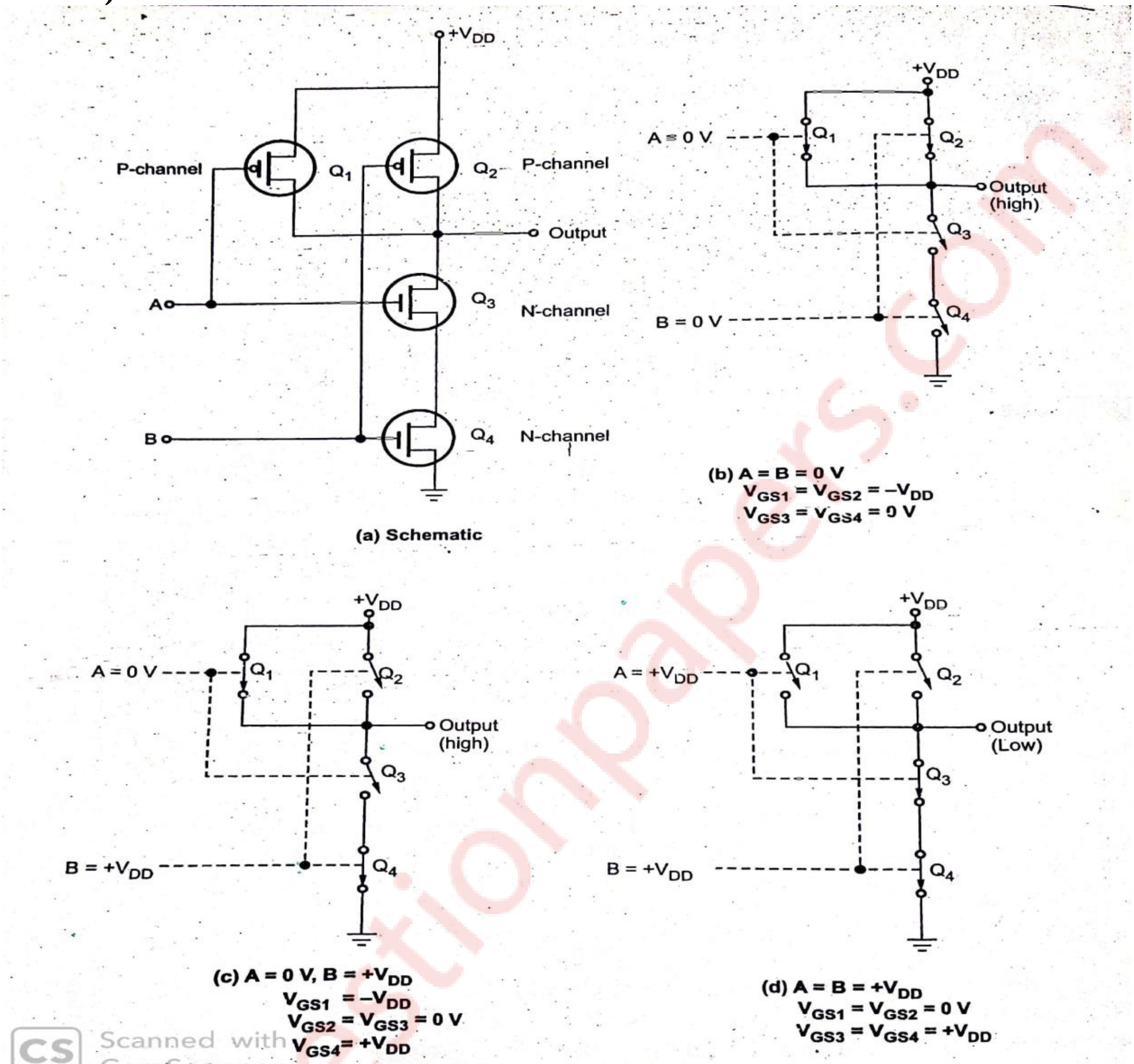


Fig. 5.4.4 CMOS NAND gate

1) Fig. 5.4.4 shows CMOS 2-input NAND gate. It consists of two P-channel MOSFETs, Q1 And Q2, connected in parallel and two N-channel MOSFETs, Q3 and Q4 connected in series.

2) Fig. 5.4.4 (a) shows the equivalent switching circuit when both inputs are low. Here, the gates of both P-channel MOSFETs are negative with respect to their sources, since the sources are connected to + Vdd. Thus, Q1 and Q2 are both ON. Since the gate - to - source voltage of Q3 and Q4 (N-channel MOSFETs) are both 0 V, those MOSFETs are OFF. The output is therefore

connected to +VDD (HIGH) through Q1 and Q2 and is disconnected from ground, as shown in the Fig. 5.4.4 (b).

3) Fig. 5.4.4 (c) shows the equivalent switching circuit when A=0 & B= +VDD. In this case, Q1 is on because VGS1 = -VDD and Q4 is ON because VGS4 = +VDD. MOSFETs Q2 and Q3 are off because their gate-to-source voltage are 0 V. Since Q1 is ON and Q3 is OFF, the output is connected to + VDD and it is disconnected from ground. When A = +VDD and B = 0 V, the situation is similar; the output is connected to + VDD through Q2 and it is disconnected from ground because Q4 is OFF. Finally, when both inputs are high (A=B=+ VDD), MOSFETs Q1 and Q2 are both OFF and Q3 and Q4 are both ON. Thus, the output is connected to the ground through Q3 and Q4 and it is disconnected from +VDD.

4)The table 5.4.2 summarizes the operation of 2-input CMOS NAND gate.

A	B	Q_1	Q_2	Q_3	Q_4	Output
0	0	ON	ON	OFF	OFF	1
0	1	ON	OFF	OFF	ON	1
1	0	OFF	ON	ON	OFF	1
1	1	OFF	OFF	ON	ON	0

Table 5.4.2 Truth table of NAND gate

5) P-channel MOSFET is ON when its gate voltage is negative with respect to its source whereas N-channel MOSFET is ON when its gate voltage is positive with respect to its source.

c) Compare Microprocessor and Microcontroller **[6]**

Answer)

Microprocessor	**Microcontroller**
1)Microprocessor contains ALU,control unit,different register and interrupt circuit	1)Microcontroller contains microprocessor,memory,I/O interfacing circuit and peripheral devices
2)It has many instructions to move data between memory and CPU	2) It has one or two instructions to move data between memory and CPU
3) It has one or two bit handling instructions	3) It has many bit handling instructions
4)Access times for memory and I/O devices are more	4) Less access time for built-in memory and I/O Devices
5) Microprocessor based system requires more hardware	Microcontroller based system requires less hardware
6) Microprocessor based system is more flexible in design point of view	6) Less flexible in design point of view
7)It has single memory map for data and code	7)It has separate memory map for data and code
8)Less number of pins are multifunctioned	8) More number of pins are multifunctioned