B.Tech. DEGREE EXAMINATION, JANUARY 2023
Second year /Third Semester
Mechanical Engineering
MET 35- Electrical and electronics Engineering
(2013-14 Regulations)
ANSWER KEY

PART-A

1. **State the conditions for maximum efficiency of transformer?**

   Copper loss is equal to iron loss   wi=pcu

2. **Give the reason why transformer in KVA? Model, internal =1**

   The total losses in a transformer depend upon volt ampere (VA)only and not on the power factor of the load. That is why the transformer rating is given in KVA and not in KW

3. **A 3phase ,20hp ,208V, 60hz, six pole wye connected induction motor delivers 15kw at slip 5% calculate synchronous speed and rotor speed?**

Given data:

Power = 20hp
Voltage = 208V
frequency = 20HZ
No. of poles = 6 pole.
Slip = 5 % = $\frac{5}{100}$ = 0.05.
O/P Power = 15KW.

To Find :
I. Synchronous Speed ?
II. Rotor Speed. ?

Solution:

Synchronous Speed $(N_s) = \frac{120 f}{P}$

$= \frac{120 \times 60}{6}$

$N_s = 1200$ rpm.

slip $= \frac{N_s - N_r}{N_s}$

$0.05 = \frac{1200 - N_r}{1200} = 0.05 \times 1200 = 1200 - N_r$

$60 - 1200 = -N_r$

$-1140 = -N_r$

$N_r = 1140$ rpm.

4. **Single phase induction motor is not self-starting justify? model**

The single-phase induction motor is not self-starting because the produced stator flux is alternating in nature and at the starting the two components of this flux cancel each other and hence there is no torque.

5. **Write down the equation for frequency of emf induced in alternator? model**

$V=4.44k_f k_c k_d f^{\Phi} t$ (volts)

k_f= form factor

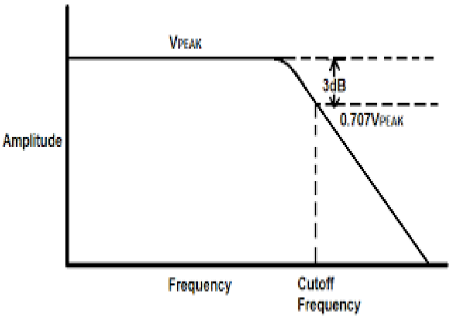
V=actual generated voltage

k_c= coil span

f=frequency

6. **List the conditions for parallel operation of alternator? model**
   - Frequency should be same
   - Phase sequency should be same
   - The voltage of the incoming alternator must be same as the bus bar voltages
   - Phase angle must be same

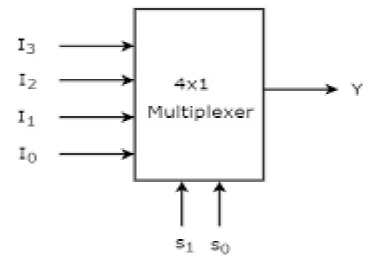
7. **Sketch the frequency response of low pass filter?**



8. **Mention the requirements of instrumentation amplifier? model**
   - high input resistance
   - , low noise
   - and accurate closed-loop gain

9. **Enlist the applications of 555 timer? model**
   - LED and lamp flashers
   - pulse generation
   - logic clock
   - tone generation
   - security alarms
   - pulse-position modulation

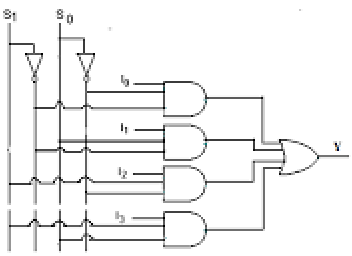
10. Draw the block diagram of 4*1 multiplexer



Or

Input	S1	S0	Y
I_0	0	0	I_0
I_1	0	1	I_1
I_2	1	0	I_2
I_3	1	1	I_3

$Y = S_1 S_0 I_3 + S_1 \overline{S_0} I_2 + \overline{S_1} S_0 I_1 + \overline{S_1}\,\overline{S_0} I_0$



4 to 1 Multiplexer and its truth table

PART-B

UNIT-I

Unit - I

11. The OC and SC test data are given below for a 1φ, 5kVA, 200V / 400V, 50HZ Transformer.

OC test from LV side : 200V 1.25A 150W

SC test from HV side : 20V 12.5A 175W

Determine the following:

1. Draw the equivalent circuit of the T/F referred to LV side.
2. At what load or kVA the t/F is to be operated for maximum efficiency?
3. calculate the value of maximum efficiency
4. Regulation of the transformer at full load 0.8 pf lagging.

I. Approximate equivalent circuit.

From OC test [Meters are connected on LV side Secondary].

$W_{oc} = 150W$, $V_{oc} = 200V$, $I_{oc} = 1.25A$.

From SC test (meters are connected on the HV side primary.

$W_{sc} = 175W$, $V_{sc} = 20V$, $I_{sc} = 12.5A$

$$Z_{01} = \frac{V_{sc}}{I_{sc}} = \frac{20}{12.5} = 1.6\Omega$$

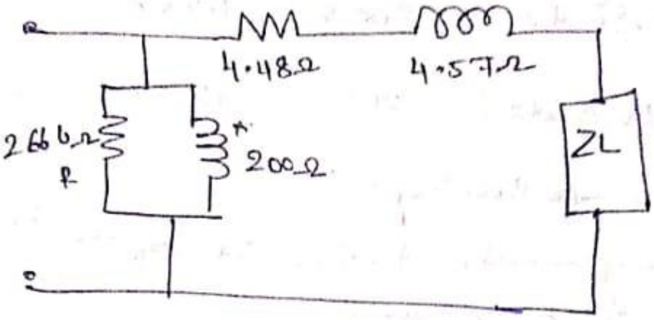
$$R_{01} = \frac{W_{sc}}{I_{sc}^2} = \frac{175}{12.5^2} = 1.12\Omega$$

$$X_{01} = \sqrt{Z_{01}^2 - R_{01}^2} = \sqrt{1.6^2 - 1.12^2} = 1.1426\Omega$$

$$K = \frac{400}{200} = 2 \cdot \quad \left[K = \frac{V_2}{V_1} \right]$$

$R_{02} = K^2 R_{01} = 2^2 \times 1.12 = 4.48\Omega$

$X_{02} = K^2 R_{01} = 2^2 \times 1.1426 = 4.57\Omega$



2. Maximum efficiency and load at which it occurs.

$W_{CU} = I_2^2 R_{02}$

$$I_2 = \frac{5 \times 1000}{400} = 12.5$$

$W_{CU} = 12.5^2 \times 4.48 = 700$

$W_{CC} = I_{ec}^2 \times R_{02}.$

$$\text{Load KVA} = \text{Full load KVA} \times \sqrt{\frac{W_I}{W_{CU}}}$$

$$= 5 \times \sqrt{\frac{150}{700}} = 2.314 \text{ KVA.}$$

3. For Maximum efficiency:

$W_i = W_{cu} = 150W = 0.150KW$

$Pf = 1.$

$$\% \eta \text{ maximum} = \frac{\text{load KVA} \times Pf}{\text{load KVA} \times Pf + W_i + W_{CU}} \times 100$$

$$\% \max \eta = \frac{5\times1}{5\times1+0.15+0.15}\times100$$

$$\% \eta_{max} = 94.3\%$$

4. The Regulation of the transformer at full load and 0.8 pf lagging.

2.5% so.

$E = (E_r \cos\theta + E_x \sin\theta) \times 100.$

= [illegible]

$= (26 [illegible] \times 0.8 + 200 \times 0. [illegible]) \times 100$

$= (20.8 + 160) \times 100$

$= [illegible]\ 20.8 + 168 = 180.8 \times 100.$

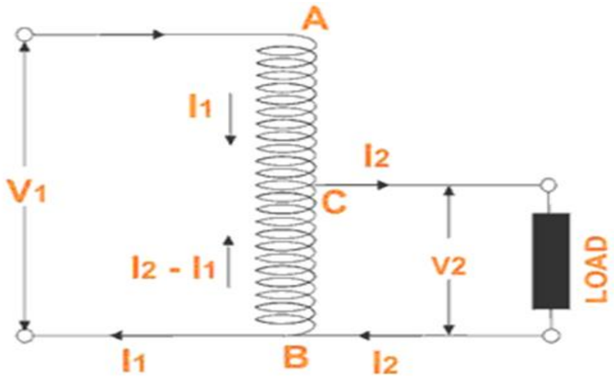
$E = 18\ \%$

12.Auto transformer is commonly used when turns ratio needed is less than or equal to two justify with required derivations and sketches? 11 (diagram =2, construction =2, derivation=6, adv,dis=1)marks (internal 1, model)

Auto transformer is a kind of electrical transformer where primary and secondary shares same common single winding.

In Auto Transformer, one single winding is used as primary winding as well as secondary winding.

But in two windings transformer two different windings are used for primary and secondary purpose. A diagram of auto transformer is shown below.



The winding AB of total turns N_1 is considered as primary winding. This winding is tapped from point 'C' and the portion BC is considered as secondary. Let's assume the number of turns in between points 'B' and 'C' is N_2.

If V_1 voltage is applied across the winding i.e. in between 'A' and 'C'

Hence, the voltage across the portion BC of the winding, will be,

So voltage per turn in this winding is $\frac{V_1}{N_1}$.

$$\frac{V_1}{N_1} \times N_2 \text{ and from the figure above, this voltage is } V_2.$$

$$\text{Hence, } \frac{V_1}{N_1} \times N_2 = V_2$$

$$\Rightarrow \frac{V_2}{V_1} = \frac{N_2}{N_1} = \text{Constant} = k$$

As BC portion of the winding is considered as secondary, it can easily be understood that value of constant 'k' is nothing but turns ratio or voltage ratio of that auto transformer.

When load is connected between secondary terminals i.e.between 'B' and 'C', load current I_2starts flowing. The current in the secondary winding or common winding is the difference of I_2 & I_1.

Copper Savings in Auto Transformer

The weight of copper of any winding depends upon its length and cross – sectional area. Again length of conductor in winding is proportional to its number of turns and cross – sectional area varies with rated current.

So weight of copper in winding is directly proportional to product of number of turns and rated current of the winding.

Therefore, weight of copper in the section AC proportional to,

$$(N_1 - N_2)I_1$$

Similarly, weight of copper in the section BC proportional to,

$$N_2(I_2 - I_1)$$

$$(N_1 - N_2)I_1 + N_2(I_2 - I_1)$$
$$\Rightarrow N_1I_1 - N_2I_1 + N_2I_2 - N_2I_1$$
$$\Rightarrow N_1I_1 + N_2I_2 - 2N_2I_1$$
$$\Rightarrow 2N_1I_1 - 2N_2I_1 \; (Since,\ N_1I_1 = N_2I_2)$$
$$\Rightarrow 2(N_1I_1 - N_2I_1)$$

In similar way it can be proved, the weight of copper in two winding transformer is proportional to,

$N_1I_1 + N_2I_2 \Rightarrow 2N_1I_1$ (Since, in a transformer $N_1I_1 = N_2I_2$)

Let's assume, W_a and W_{tw} are weight of copper in auto transformer and two winding transformer respectively,

$$\text{Hence, } \frac{W_a}{W_{tw}} = \frac{2(N_1I_1 - N_2I_1)}{2(N_1I_1)}$$
$$= \frac{N_1I_1 - N_2I_1}{N_1I_1}$$
$$= 1 - \frac{N_2I_1}{N_1I_1}$$
$$= 1 - \frac{N_2}{N_1}$$
$$= 1 - k$$
$$\therefore W_a = W_{tw}(1 - k)$$
$$\Rightarrow W_a = W_{tw} - kW_{tw}$$

∴ Saving of copper in auto transformer compared to two winding transformer,

$$\Rightarrow W_{tw} - W_a = kW_{tw}$$

Advantages of Auto Transformer

For transformation ratio = 2, the size of the auto transformer would be approximately 50% of the corresponding size of two winding transformer.

Disadvantages of Using Auto Transformer

- Because of electrical conductivity of the primary and secondary windings the lower voltage circuit is liable to be impressed upon by higher voltage. To avoid breakdown in the lower voltage circuit, it becomes necessary to design the low voltage circuit to withstand higher voltage.

- The leakage flux between the primary and secondary windings is small and hence the impedance is low. This results into severer short circuit currents under fault conditions.
- The connections on primary and secondary sides have necessarily to be same, except when using interconnected starring connections. This introduces complications due to changing primary and secondary phase angle particularly in the case-by-case of delta / delta connection.

UNIT=II

13.Discuss in detail about the various starting methods of 3 phase induction motor? 11 (diagram =6marks, working = 5 marks) model

Starting methods of an Induction motor is used to

1) Reduce heavy starting currents and prevent motor from overheating.

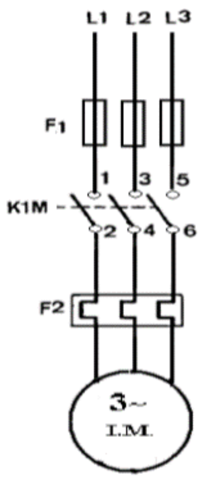
2) Provide overload and no-voltage protection

There are many methods to start 3-phase induction motors. Some of the common methods are;

1. Direct On-Line Starter (DOL)
2. Star-Delta Starter
3. Auto Transformer Starter
4. Rotor Impedance Starter
5. Power Electronics Starter

Direct On- Line Starter (DOL)

- The Direct On-Line (DOL) starter is the simplest and the most inexpensive of all starting methods and is usually used for squirrel cage induction motors.
- It directly connects the contacts of the motor to the full supply voltage.
- The starting current is very large, normally 6 to 8 times the rated current.
- The starting torque is likely to be 0.75 to 2 times the full load torque.
- In order to avoid excessive voltage drops in the supply line due to high starting currents, the DOL starter is used only for motors with a rating of less than 5KW.



- K1M-Main Contactor
- The DOL starter consists of a coil operated contactor K1M controlled by start and stop push buttons.
- On pressing the start push button S1, the contactor coil K1M is energized from line L1.
- The three mains contacts (1-2), (3-4), and (5-6) are closed.
- The motor is thus connected to the supply. When the stop push button S2 is pressed, the supply through the contactor K1M is disconnected.
- Since the K1M is de-energized, the main contacts (1-2), (3-4), and (5-6) are opened. The supply to motor is disconnected and the motor stops.

Star-Delta Starter

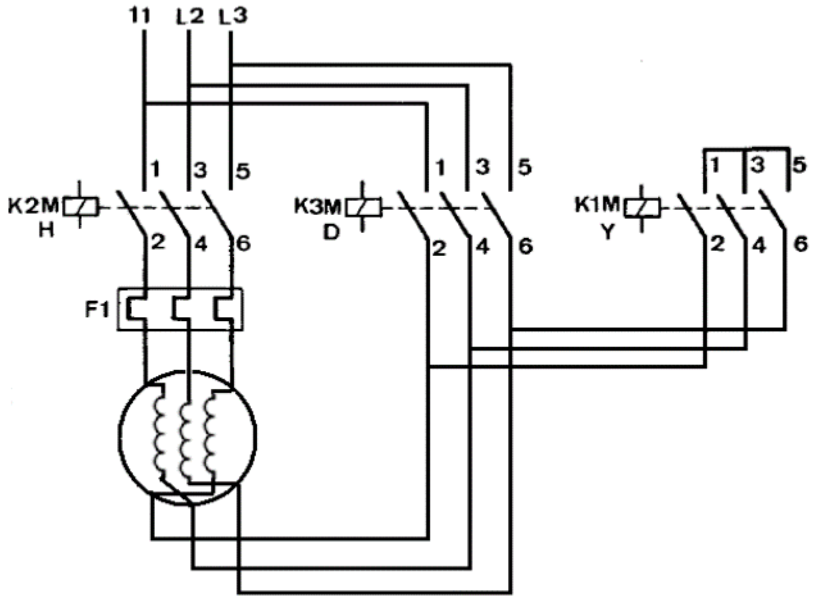
- The star delta starting is a very common type of starter and extensively used, compared to the other types of the starters.
- This method achieves low starting current by first connecting the stator winding in star configuration, and then after the motor reaches a certain speed, throw switch changes the winding arrangements from star to delta configuration.
- By connecting the stator windings, first in star and then in delta, the line current drawn by the motor at starting is reduced to one-third as compared to starting current with the windings connected in delta.
- Since the torque developed by an induction motor is proportional to the square of the applied voltage, star- delta starting reduced the starting torque to one – third that obtainable by direct delta starting.

K2M Main Contactor

K3M Delta Contactor

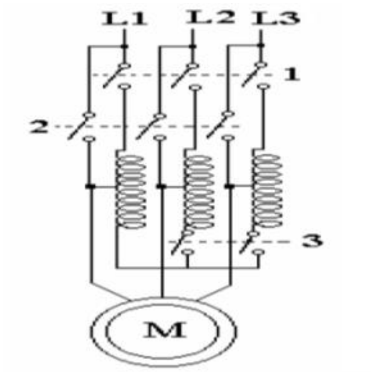
K1M Star Contactor

F1 Thermal Overload Relay



Auto Transformer Starter

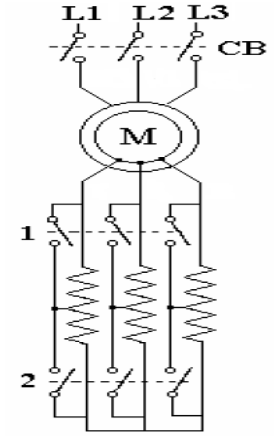
- The operation principle of auto transformer method is similar to the star delta starter method.
- The starting current is limited by (using a three phase auto transformer) reducing the initial stator applied voltage.
- The auto transformer starter is more expensive, more complicated in operation and bulkier in construction when compared with the star – delta starter method.
- But an auto transformer starter is suitable for both star and delta connected motors, and the starting current and torque can be adjusted to a desired value by taking the correct tapping from the auto transformer.



Rotor Impedance Starter

- This method allows external resistance to be connected to the rotor through slip rings and brushes.
- Initially, the rotor resistance is set to maximum and is then gradually decreased as the motor speed increases, until it becomes zero.
- The rotor impedance starting mechanism is usually very bulky and expensive when compared with other methods.

- It also has very high maintenance costs. Also, a heat is generated through the resistors when current runs through them.
- The starting frequency is also limited in this method.
- However, the rotor impedance method allows the motor to be started while on load.



14.Write in detail about the construction and various modes of excitation of PM stepper motor?
11 marks (Model) (working =3, types=2, diagram= 4,truthtable=2)

STEPPER MOTOR

- A step or stepping motor converts electronic pulses into proportionate mechanical movement. Each revolution of the stepper motor's shaft is made up of a series of discrete individual steps.
- A step is defined as the angular rotation produced by the output shaft each time the motor receives a step pulse. These types of motors are very popular in digital control circuits, such as robotics, because they are ideally suited for receiving digital pulses for step control. Each step causes the shaft to rotate a certain number of degrees.
- A step angle represents the rotation of the output shaft caused by each step, measured in degrees. The below figure illustrates a simple application for a stepper motor. Each time the controller receives an input signal, the paper is driven a certain incremental distance. In addition to the paper drive mechanism in a printer, stepper motors are also popular in machine tools, process control systems, tape and disk drive systems, and programmable controllers.

Stepper Motors Work

Stepper motors consist of rotating shaft with permanent magnet attached is called rotor and the stationary housing containing the coil-wound poles is called stator (i.e. electromagnets on the stationary portion that surrounds the motor).

Types of Stepper Motors

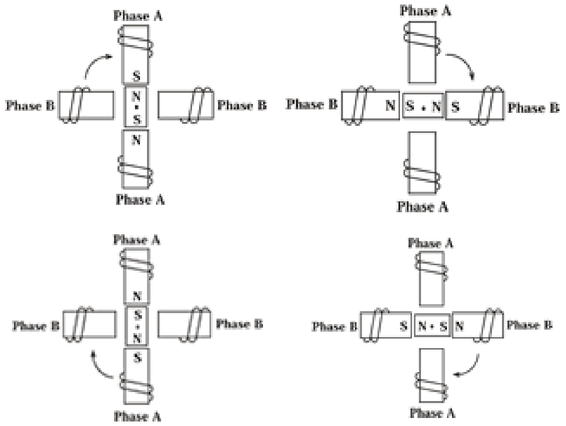
There are basically three types of stepping motors;

- variable reluctance stepper motor
- permanent magnet stepper motor

- Hybrid stepper motor

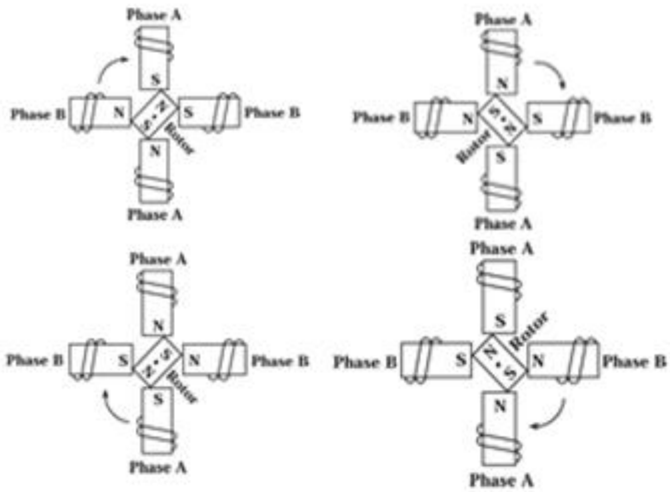
Full Stepping

The below figure illustrates a typical step sequence for a two phase motor. In Step 1 phase A of a two phase stator is energized. This magnetically locks the rotor in the position shown, since unlike poles attract. When phase A is turned off and phase B is turned on, the rotor rotates 90° clockwise. In Step 3, phase B is turned off and phase A is turned on but with the polarity reversed from Step 1. This causes another 90° rotation. In Step 4, phase A is turned off and phase B is turned on, with polarity reversed from Step 2. Repeating this sequence causes the rotor to rotate clockwise in 90° steps.



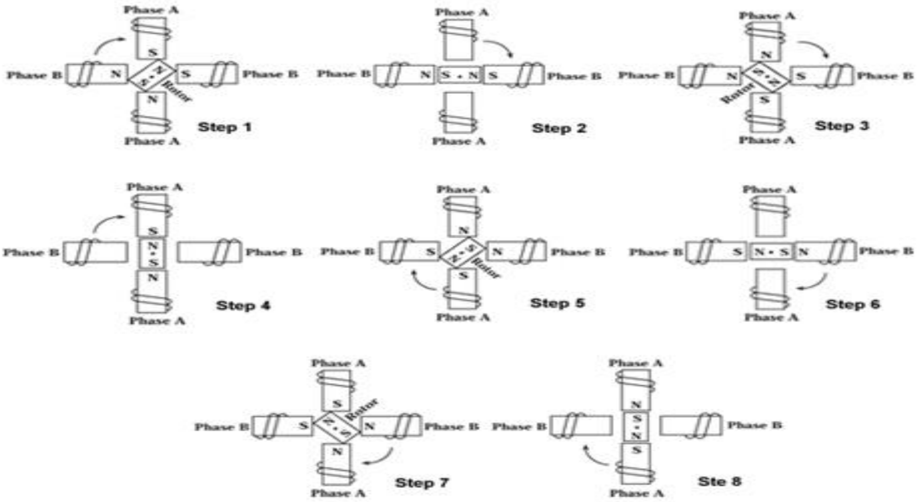
Two stepping

The stepping sequence illustrated in the above figure is called “one phase on” stepping. A more common method of stepping is “two phase on” where both phases of the motor are always energized. However, only the polarity of one phase is switched at a time, as shown in figure 2.3. With two phases on stepping the rotor aligns itself between the “average” north and “average” south magnetic poles. Since both phases are always on, this method gives 41.4% more torque than “one phase on” stepping, but with twice the power input.



Half Stepping

The motor can also be “half stepped” by inserting an off state between transitioning phases. This cuts a stepper’s full step angle in half. For example, a 90° stepping motor would move 45° on each half step, in the below figure. However, half stepping typically results in a 15% - 30% loss of torque depending on step rate when compared to the two phase on stepping sequence. Since one of the windings is not energized during each alternating half step there is less electromagnetic force exerted on the rotor resulting in a net loss of torque.



UNIT=III

15. List the methods used to pre-determine voltage regulation of synchronous machine and discuss in detail about determining regulation using EMF method? Voltageregulation =6 mark(diagram 3, theory 3 marks) emf method = 5 marks(diagram 2, derivation ,2, theory1 marks)

Determination of Voltage Regulation

1. Synchronous impedance or E.M.F. method

2. Ampere-turn or M.M.F. method

For either method, the following data are required:

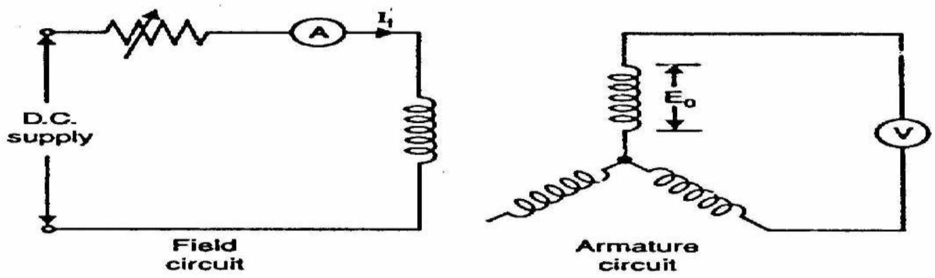
(i) Armature resistance

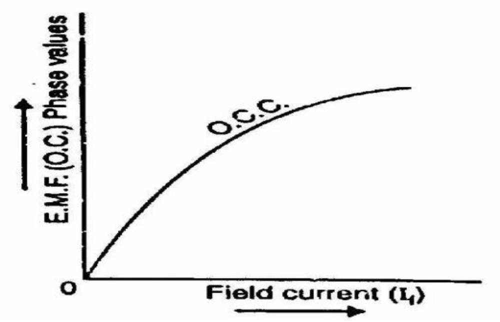
(ii) Open-circuit characteristic (O.C.C.)

(iii) Short-Circuit characteristic (S.C.C.)

Open-circuit characteristic (O.C.C)

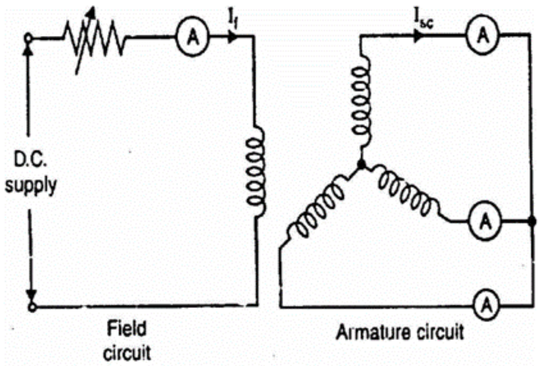
- Like the magnetization curve for a D.C. machine, the (Open-circuit characteristic of an alternator is the curve between armature terminal voltage (phase value) on open circuit and the field current when the alternator is running at rated speed.

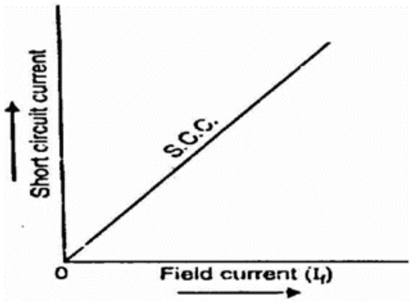




a. Short-circuit characteristic (S.C.C.)

- In a short-circuit test, the alternator is run at rated speed and the armature terminals are short-circuited through identical ammeters. Only one ammeter need be read; but three are used for balance. The field current If is gradually increased from zero until the short-circuit armature current





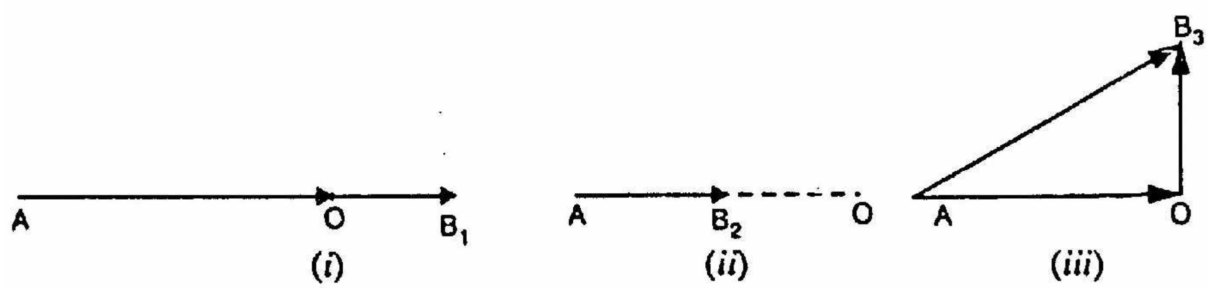
- There is no need to take more than one reading because S.C.C. is a straight line passing through the origin. The reason is simple. Since armature resistance is much smaller than the synchronous reactance, the short-circuit armature current lags the induced voltage by very nearly 90°. Consequently, the armature flux and field flux are in direct opposition and the resultant flux is small.

b. Ampere-Turn Method

- This method of finding voltage regulation considers the opposite view to the synchronous impedance method. It assumes the armature leakage reactance to be additional armature reaction. Neglecting armature resistance (always small), this method assumes that change in terminal p.d. on load is due entirely to armature reaction. The same two tests (viz open-circuit and short-circuit test) are required as for synchronous reactance determination; the interpretation of the results only is different. Under short-circuit, the current lags by 90° (R_a considered zero) and the power factor is zero. Hence the armature reaction is entirely demagnetizing. Since the terminal p.d. is zero, all the field AT (ampere-turns) are neutralized by armature AT produced by the short circuit armature current, (i) Suppose the alternator is supplying full-load current at normal voltage V

➢ It assumes the armature leakage reactance to be additional armature reaction.

➢ This method assumes that change in terminal p.d. on load is due entirely to armature reaction.



zero p.f. lagging

Total field AT, $AB_1 = AO + OB_1$

AO = field AT required to produce the normal voltage V (or $V + I_aR_a \cos \phi$) at no-load

OB_1 = fielder required to neutralize the armature reaction

The AO can be found from O.C.C. and OB_1 can be determined from S.C.C.

zero p.f. leading

Total field AT, $AB_2 = AO - B_2O$

B_2O = fielder required to neutralize armature reaction

16. what is synchronizing power of alternator? derive an expression for synchronizing power between two alternators connected in parallel? Model 11(condition=4, expression=3, operation=5 marks)

PARALLEL OPERATION OF ALTERNATORS

- It is rare to find a 3-phase alternator supplying its own load independently except under test conditions.
- In practice, a very large number of 3-phase alternators operate in parallel because the various power stations are interconnected through the national grid.
- Therefore, the output of any single alternator is small compared with the total interconnected

capacity. For example, the total capacity of the interconnected system may be over 40,000 MW while the capacity of the biggest single alternator may be 500 MW.

- For this reason, the performance of a single alternator is unlikely to affect appreciably the voltage and frequency of the whole system.
- An alternator connected to such a system is said to be connected to infinite bus bars.
- The outstanding electrical characteristics of such bus bars are that they are constant-voltage, constant-frequency bus bars.
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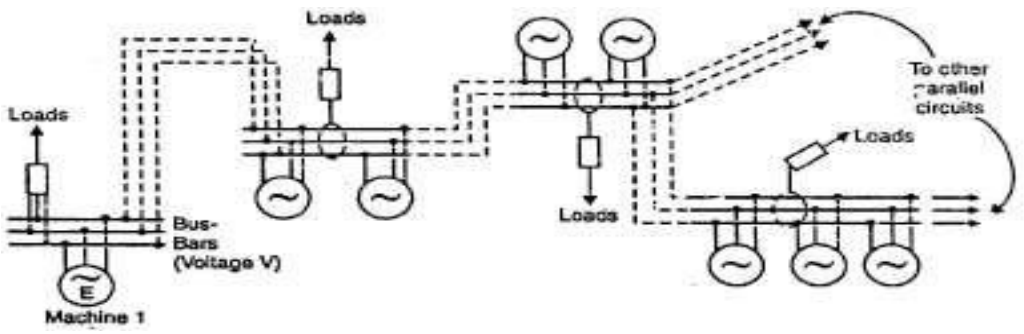


The following are the advantages of operating alternators in parallel:

(i) **Continuity of service.** The continuity of service is one of the important requirements of any electrical apparatus. If one alternator fails, the continuity of supply can be maintained through the other healthy units. This will ensure uninterrupted supply to the consumers.

(ii) **Efficiency.** The load on the power system varies during the whole day; being minimum during die late night hours. Since alternators operate most efficiently when delivering full-load, units can be added or put off depending upon the load requirement. This permits the efficient operation of the power system.

(iii) **Maintenance and repair.** It is often desirable to carry out routine maintenance and repair of one or more units. For this purpose, the desired unit/units can be shut down and the continuity of supply is maintained through the other units.

(iv) Load growth. The load demand is increasing due to the increasing use of electrical energy. The load growth can be met by adding more units without disturbing the original installation.

Conditions for Paralleling Alternator with Infinite Busbars

The proper method of connecting an alternator to the infinite busbars is called synchronizing. A stationary alternator must not be connected to live busbars. It is because the induced e.m.f. is zero at standstill and a short-circuit will result. In order to connect an alternator safely to the infinite busbars, the following conditions are met:

(i) The terminal voltage (r.m.s. value) of the incoming alternator must be the same as busbars voltage,

(ii) The frequency of the generated voltage of the incoming alternator must be equal to the busbars frequency,

(iii) The phase of the incoming alternator voltage must be identical with the phase of the bus bars voltage. In other words, the two voltages must be in phase with each other,

(iv) The phase sequence of the voltage of the incoming alternator should be the same as that of the busbars.

The magnitude of the voltage of the incoming alternator can be adjusted by changing its field excitation. The frequency of the incoming alternator can be changed by adjusting the speed of the prime mover driving the alternator.

Condition (i) is indicated by a voltmeter, conditions (ii) and (iii) are indicated by synchronizing lamps or a synchroscope. The condition (iv) is indicated by a phase sequence indicator.

an expression for synchronizing power between two alternators connected in parallel

synchronizing current I_{SY}= ESY/Zs

where

ESY=synchronizing emf

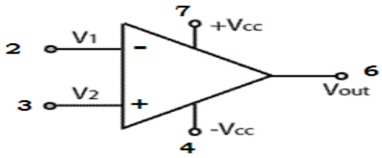
Zs= synchronizing impedance

Synchronizing power P_{SY}=mEiδ

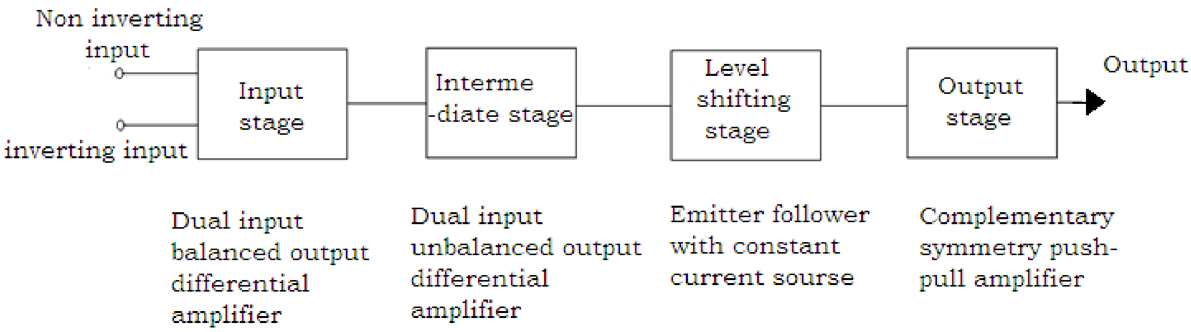
UNIT-IV

17.Draw the circuit diagram of op-amp differentiator and derive an expression for output in terms of input? 11 mark (model) (circuit 4. Operation=4, derivation=3)

- An operational amplifier or OP-AMP is a DC-coupled voltage amplifier with a very high voltage gain.
- Op-amp is basically a multistage amplifier in which a number of amplifier stages are interconnected to each other in a very complicated manner.
- Its internal circuit consists of many transistors, FETs and resistors. All this occupies a very little space.
- So, it is packed in a small package and is available in the Integrated Circuit (IC) form.
- The term Op-Amp is used to denote an amplifier which can be configured to perform various operations like amplification, subtraction, differentiation, addition, integration etc.
- An op-amp has two input terminals and one output terminal.
- The op-amp also has two voltage supply terminal.
- It has a differential input and a single ended output.
- The terminal marked as negative (-) is called as an inverting terminal
- And the terminal marked as positive (+) is called as a non-inverting terminal of the operational amplifier.
- If we connect an input signal at the inverting terminal (-) of the op-amp than the amplified output signal is π radians (180°) out of phase with respect to the applied input signal.
- If an input is connected to the non-inverting terminal (+) than the output signal obtained will be in phase i.e. it will have no phase shift with respect to the input signal.



BLOCK DIAGRAM OF OP-AMP



This contains four stages,

INPUT STAGE

- The first stage of an op-amp is almost a differential amplifier and the last stage is usually a class-B Push- Pull emitter follower.
- The input stage should have the following characteristics
  (a) High input resistance (typically 10Mohm)
  (b) Low input bias current (typically 0.5microamps)
  (c) Small input offset voltage (typically 10mV)
  (d) High CMRR (typically 70db)
  (e) High open- loop voltage gain (typically10^4)

INTERMEDIATE STAGE

- In most of the amplifier, an intermediate stage (dual input, unbalanced output differential amplifier) is provided which increases the overall gain of the op-amp.
- Because of direct coupling between the first two stage, the dc level at the output of the intermediate stage, is well above the ground potential.
- This require a level translator as the succussing stage in order to bring the DC level back to the ground potential.

LEVEL SHIFTING STAGE

- The level shifter (translator) circuit is used after the intermediate stage to shift the DC level at the output of the intermediate stage downward to zero volts with respect to ground.
- Usually, the third stage is an emitter follower using constant current source.
- It step up the input impedance of the stage consisting of Q_6 by a factor of T_A. Note that Q_6 is the drives for the output stage.
- Incidentally, the plus sign ‘0’. The Q_5 collector means it is connected to the V_{cc} supply.
- Similarly, the minus sign at the bottom of R_2 and R_3 means these are connected to the V_{EF} supply.

OUTPUT STAGE

- The last stage is a complementary Push amplifier (Q_9 and Q_{10}).
- Q_{11} is a part of current mirror sources, current through the compensating diodes (Q_7 and Q_8). Q_n is the input volt of the mirror and biasing resistor R_3 sets up the desired mirror current.
- CC is called the compensating capacitor (typically 30pico Farad), has a prounced on the frequency response.
- It is needed to prevent oscillations and wanted signals within the amplifier.
- The output stage should have the following desirable properties
  i. Large output voltage shift capability
  ii. Large output current shift capability
  iii. Low output resistance
  iv. Short circuit protaloic
- An emitter follower as the output stage can provide low output resistance and class B and class AB stage can provide large amount of output power.**Advantages of Op-Amp**
- Good thermal stability
- Low offset voltage
- Low offset current
- High reliability

Disadvantages of Op-Amp

- It is difficult to realize the large values of resistance and capacitance.
- No methods to fabricate transformer using linear IC’s.

Applications

The integrated op-amp's offers all the advantages of IC's such as high reliability, small size, cheap, less power consumption. They are used in variety of applications such as Inverting & Non-inverting amplifiers, Unity gain buffer, Summing amplifier, Differentiator, Integrator, Adder, Instrumentation amplifier, Wien bridge oscillator, Filters etc.

Inverting Amplifier

$$V_i = I_1 R_1$$

$$I_1 = V_i / R_1$$

$$V_o = I_o * R_f$$

$$V_o = -I_1 * R_f \quad (I_o = -I_1)$$

Here the –ve sign indicates that the input and the output are in the opposite direction

$$V_o = -V_i * R_f / R_1$$

$$Av = -R_f / R_1$$

NON-INVERTING AMPLIFIER:

$$V_i = I_1 . R_1$$

- Since the voltage drop across R1 is equal ot the difference between Vi and Vo,

$$I_0 = \frac{V_0 - V_i}{R_f}$$

$$I_o * R_f = V_o - V_i$$

$$V_o = V_i + I_o .* R_f$$

We know that, $I_1 = I_o$,

$$V_o = V_i + I_1 . R_f$$

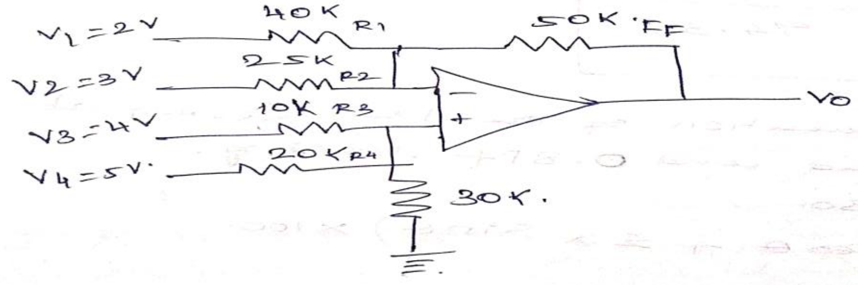
From (1) & (2)=

$$A_V = \frac{V_0}{V_i}$$

$$A_V = \frac{V_i + I_1 * R_f}{I_1 * R_1} = \frac{I_1 * R_1 + I_1 * R_f}{I_1 * R_1} = \frac{R_1 + R_f}{R_1}$$

18 .problem

18. Find the Vo for the adder Subtractor shown in figure.



Adder: $R_f \left[\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \frac{V_4}{R_4} \right) = 0$

$V_O = (V_3 + V_4) + (V_1 + V_2)$.

$V_O = V_{O1} + V_{O2} + V_{O3} + V_{O4}$.

$V_O =$ ~~2 + 3 + 4 + 5~~

$V_O = + \left(50/40 \; V_1 + \frac{25}{40} V_2\right) + \left(10/20 \, V_3 + 30/20 \, V_4\right)$

$V_O = +(2.5 + 1.875) + (2 + 7.5)$.

$V_O = + 4.375 + 9.5$.

$V_O =$ ~~5.125~~. 13.875.

Subtractor:

$V_O = -(V_1 + V_2) + (V_3 + V_4)$

$= \; = -(2.5 + 1.875) + (2 + 7.5)$.

$= \; = - 4.375 + 9.5$

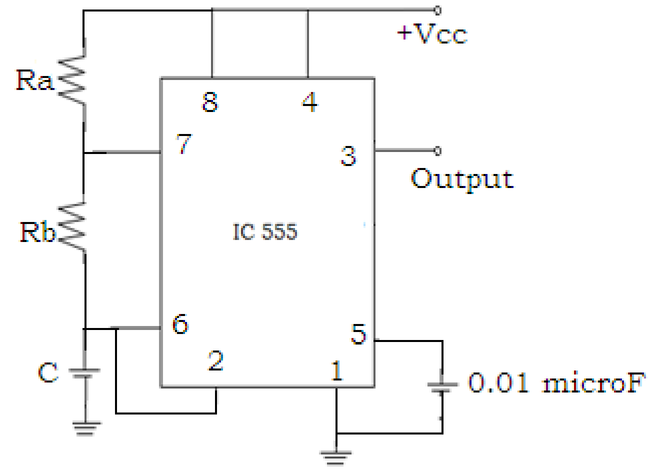
$V_O = - 5.125$

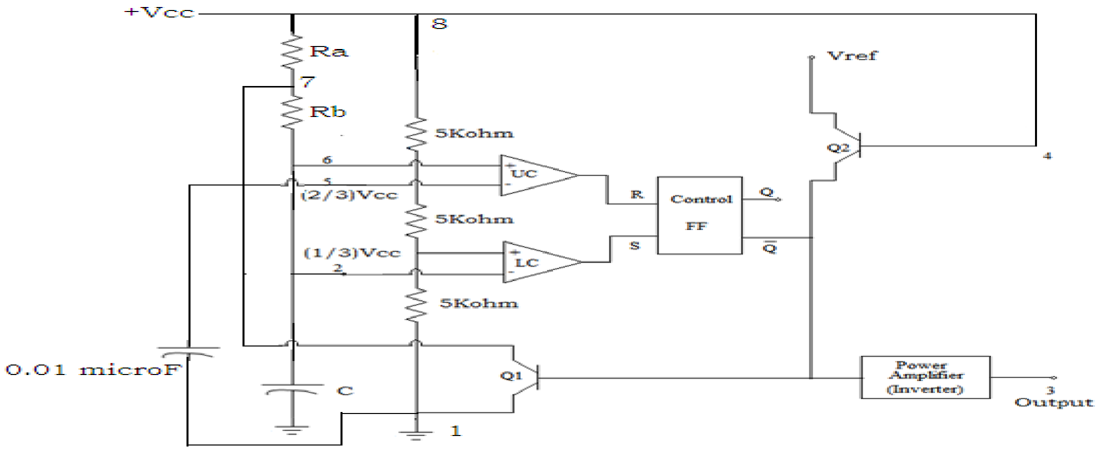
UNIT-V

19.derive the expression for frequency and total time period of astable multivibrator design using 555IC? 11 model (circuit 3,waveform2, block diagram 2,theory4) marks

ASTABLE MULTIVIBRATOR USING IC 555

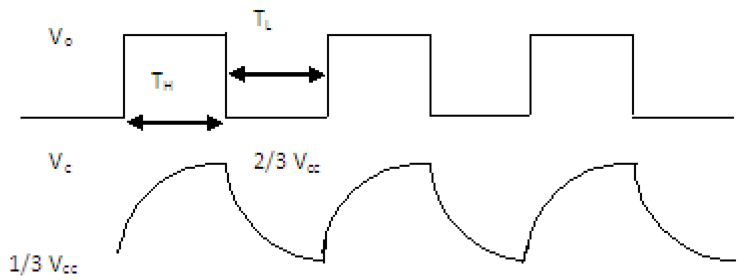
- An astable multivibrator is a regenerative comparator having no stable states but two quasistable states.
- It is also called free-running multivibrator, because it does not require an external trigger pulse to change its output.
- The output continuously alternates between high & low states.
  - The time period for which the output remains in either of the states is determined by two timing resistors & a capacitor that are externally connected to the circuit.





Working

- Comparing monostable operation, timing resistor is now split into two parts R_a&R_b. Pin 7, collector of discharging transistor Q1 is connected to the junction of R_a &R_b.
- Assume initially output is high. Output of FF, Q=0. The discharge transistor Q1 is off .Now the external timing capacitor charges towards V_{cc} with a time constant (R_a+ R_b) C.
- As the capacitor Voltage rises just above $2/3V_{cc}$, the output of UC becomes 1 & that of LC becomes 0 thereby setting the output of control FF to 1.Hence final output at pin 3 becomes 0.
- Now the discharge transistor Q1 is on & the capacitor discharges with a time constant (R_b)C.As the capacitor voltage just reaches below $1/3V_{cc}$ LC is triggered on & output of UC becomes 0 thereby making the output of FF 0 & final output high.
- This unclamps the timing capacitor C which now starts getting charged again repetitively.



Expression for T

The instantaneous voltage across the capacitor is given by,

$$V_c=V_f + (V_i - V_f)e^{-t/T}$$

Here V_f is the final voltage the capacitor can reach

V_i is the initial voltage of the capacitor

Consider the charging time of capacitor as T_C

Now for charging,

$$V_f=V_{cc} \& V_i=1/3V_{cc}$$

Therefore,

$$V_c=V_{cc}+ (1/3V_{cc}-V_{cc})\, e^{-t/(Ra+Rb)C}$$

But

$$V_c=2/3V_{cc} \text{ at } t=T_C, \text{ the charging time.}$$

Therefore,

$$2/3V_{cc}=V_{cc}+ (1/3V_{cc}-V_{cc})\, e^{-T_C/(Ra+Rb)C}$$

$$1/3V_{cc}=2/3V_{cc}e^{-T_C/(Ra+Rb)C}$$

$$e^{-T_C/(Ra+Rb)C} = 1/2$$

$$T_C/(Ra+Rb)C = 0.693$$

$$T_C = 0.693(R_a + R_b)C$$

Now consider the discharging time of capacitor as T_D

For discharging,

$$V_f = 0 \ \& \ V_i = 2/3V_{cc}$$

Therefore,

$$V_c = 0 + (2/3V_{cc} - 0)\ e^{-t/RbC}$$

But

$V_c = 1/3V_{cc}$ at $t = T_D$, the discharging time.

Therefore,

$$1/3V_{cc} = 0 + (2/3V_{cc} - 0)e^{-T_D/RbC}$$

$$e^{-T_D/RbC} = 1/2$$

$$T_D/R_bC = 0.693$$

$$T_D = 0.693R_bC$$

$$T = T_C + T_D$$

$$T = 0.693(R_a + 2R_b)\ C$$

$$f = 1/T = 1.45/(R_a + 2R_b)C$$

Duty Cycle

The ratio of the time duration for which the output is high to the total time period T is called the duty cycle of the astable multivibrator denoted by D.

$$D = T_C/T$$

$$D = (R_a + R_b)/\ (R_a + 2R_b)$$

20.Eplicate in detail about design of up/down counters? Model (diagram 4, theory 5, truth table 2 marks)

COUNTERS

A counter is a device which stores (and sometimes displays) the number of times a particular event or process has occurred, often in relationship to a clock signal. In practice, there are two types of counters:

- Up counters, which increase (increment) in value
- Down counters, which decrease (decrement) in value

Counters can be implemented easily using register-type circuits such as the flip-flop. The types of counters are

- Asynchronous (ripple) counter – changing state bits are used as clocks to subsequent state flip-flops
- Synchronous counter – all state bits change under control of a single clock
- Decade counter – counts through ten states per stage
- Up–down counter – counts both up and down, under command of a control input
- Ring counter – formed by a shift register with feedback connection in a ring
- Johnson counter – a twisted ring counter
- Cascaded counter

5.9.1. Up Down counters

- A circuit of a 3-bit synchronous up-down counter and a table of its sequence are shown below.
- It is used to control the direction of the counter through a certain sequence.

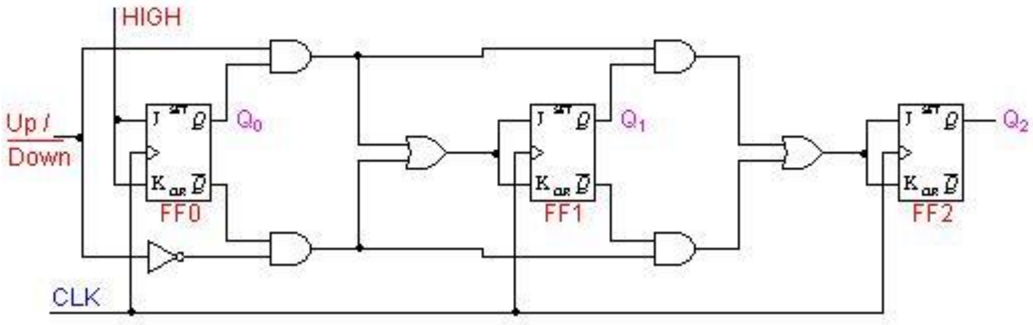


Figure 5.14. Synchronous counter

Q2	Q1	Q0
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

Figure 5.15. Bit Sequence

- For both the UP and DOWN sequences, Q0 toggles on each clock pulse.
- For the UP sequence, Q1 changes state on the next clock pulse when Q0=1.
- For the DOWN sequence, Q1 changes state on the next clock pulse when Q0=0.
- For the UP sequence, Q2 changes state on the next clock pulse when Q0=Q1=1.
- For the DOWN sequence, Q2 changes state on the next clock pulse when Q0=Q1=0.

These characteristics are implemented with the AND, OR & NOT logic connected as shown in the logic diagram above.

Shift registers

- In digital circuits, a shift register is a cascade of flip flops, sharing the same clock, which has the output of any one but the last flip-flop connected to the "data" input of the next one in the chain, resulting in a circuit that shifts by one position the one-dimensional "bit array" stored in it, shifting in the data present at its input and shifting out the last bit in the array, when enabled to do so by a transition of the clock input.
- A shift register may be multidimensional; such that its "data in" input and stage outputs are themselves bit arrays: this is implemented simply by running several shift registers of the same bit-length in parallel.
- Shift registers can have both parallel and serial inputs and outputs. These are often configured as serial-in, parallel-out (SIPO) or as parallel-in, serial-out (PISO). There are also types that have both serial and parallel input and types with serial and parallel output.

There are also bi-directional shift registers which allow shifting in both directions: L→R or R→L. The serial input and last output of a shift register can also be connected together to create a circular shift register.