ACE Engineering Academy
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ESE – 2019 MAINS
OFFLINE TEST SERIES

ELECTRONICS & TELECOMMUNICATION ENGINEERING (E&T)

TEST – 9
SOLUTIONS

All Queries related to **ESE – 2019 MAINS Test Series** Solutions are to be sent to the following email address
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01. (a)

Sol: Separately excited DC motor

Flux remain constant

Case (i):

At No load

$N_1 = 1000$ rpm

$V_1 = 200V$

$R_a = 1\Omega$

$I_{a1} = 0 \Rightarrow T_{a1} = 0$

$E_{b1} = V_1$

Case (ii):

Full load

$T_2 = T_{rated}$

I_{a2} = Full load armature current

$V_2 = ?$

$N_2 = 500$ rpm

$$\frac{Eb_2}{Eb_1} = \frac{N_2}{N_1} = \frac{500}{1000}$$

$$E_{b2} = \frac{1}{2} \times 200 = 100V$$

$V = E_{b2} + I_{a2}R_a$

$V = 100 + I_{a2}(1)$

$V = 100 + I_{a2}$ …………. (1)

Case (iii):

$T_3 = 50\%$ of T_{rated}

$T_3 = 0.5\, T_{rated}$

$T \propto I_a$

$$\frac{T_3}{T_2} = 0.5 = \frac{I_{a3}}{I_{a2}}$$

$I_{a3} = 0.5 I_{a2}$ ………….. (2)

But $\frac{N_3}{N_2} = \frac{E_{b3}}{E_{b2}}$

$$\frac{520}{500} = \frac{E_{b3}}{E_{b2}}$$

$$\frac{520}{500} = \frac{E_{b3}}{100}$$

$E_{b3} = 104$

$E_{b3} = V - I_{a3} R_a$

From (1) & (2)

$E_{b3} = 100 + I_{a2} - (0.5\, I_{a2})R_a$

$104 = 100 + I_{a2} - (0.5 I_{a2})1$

$4 = 0.5\, I_{a2}$

$I_{a2} = 8A$

01. (b)

Sol: $R = 120\Omega$; $G.F = \dfrac{\Delta R / R}{\varepsilon}$

$G.F = -12$, $\varepsilon = 0.01$ $\quad G.F \times \varepsilon = \dfrac{\Delta R}{R}$

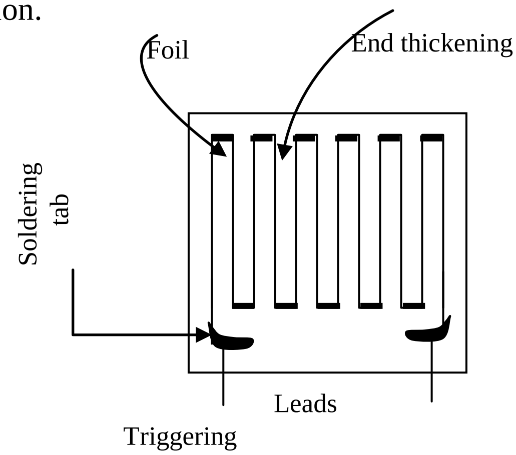
$12 \times 0.01 \times 120 = \Delta R$;

$R - \Delta R = 120\Omega - 14.4\ \Omega$

$= 105.6\ \Omega$

Metal foil gauge: The gauge is produced by printed circuit technique and consists of a foil on plastic backing. The desired grid pattern is first printed on a thin sheet of metal-alloy foil with an acid resistant ink and then the unprinted portion is etched away. This construction allows the use of varying sections throughout the grid length; larger area can be provided at the ends where lead connections are made.

The gauge has been successfully employed to fillets and sharply curved shapes because of its fine and accurate construction.

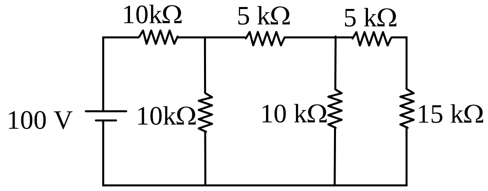


The significant advantages of the gauge over wire type are:

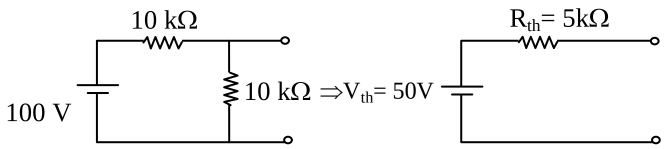
- Improved hysteresis,
- Easy soldering or welding of the leads,
- Better fatigue life,
- Very good lateral strain sensitivity,
  Improved transmission of strain from the test surface to the strain sensitive grid, and Stability at high temperature.

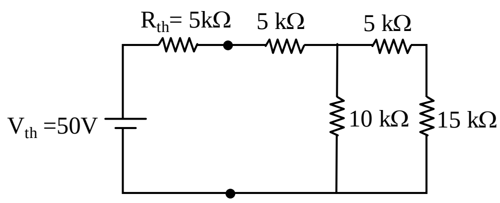
1(c).

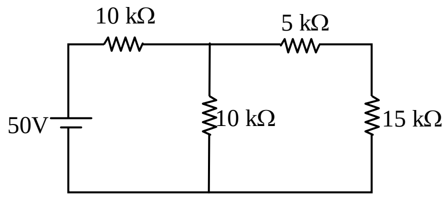
Sol:

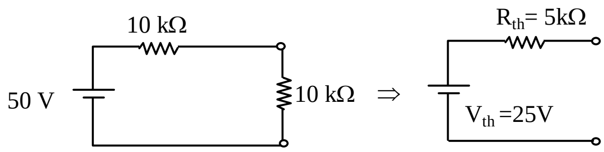


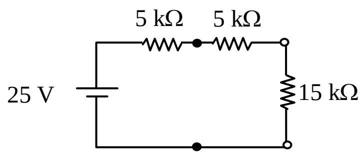
Using circuit minimizing techniques





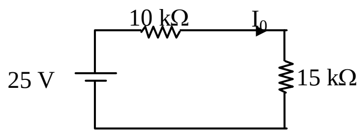




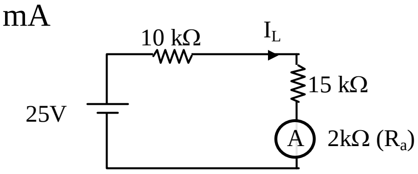


Value of current in 15kΩ

$$(I_0) = \frac{25V}{10k\Omega + 15k\Omega}$$



I_0 = 1 mA



(A) reading (I_L)

$$= \frac{25V}{10k\Omega + 15k\Omega + 2k\Omega} = 926\mu A$$

I_L = 99% I_0 (from the question data)

$I_L = 0.99\ I_{0,}$ $I_L = \dfrac{1}{1+\dfrac{R_a}{R_{ckt}}} I_0$

$$\frac{I_L}{I_0} = \frac{1}{1+\dfrac{R_a}{(10k + 15k\Omega)}}$$

$$\Rightarrow 0.99 = \frac{1}{1+\dfrac{R_a}{25k\Omega}} \Rightarrow \quad R_a = 250\ \Omega$$

01. (d)

Sol: The ac power in class A-operation, P_o is given by the relation,

$$P_o = \frac{V_{CEQ}.I_{CQ}}{2}$$

Where V_{CEQ} and I_{CQ} are voltage across collector-emitter of transistor at operating point and collector current respectively.

First we need the value of I_{CQ}. Now in fig above, the voltage between base and ground (point B and ground, see fig.) V_{BB}, is 10 V. $\left(\because V_{BB} = \dfrac{1k}{1k+1k} \times 20 = 10V\right)$

Then,

$$I_{CQ} = I_E = \frac{V_{BB} - V_{BE}}{R_E} = \frac{V_{BB}}{R_E}$$

$$= \frac{10V}{100\Omega} = 100mA$$

V_{CEQ} can be obtained by summing voltage (dc voltages, capacitors taken open)

$V_{CC} = V_{CEQ} + I_E(R_C + R_E)$

Or, $V_{CEQ} = V_{CC} - I_E(R_C + R_E)$

$= 20 - 100mA\ (50 + 100)\Omega$

$= 20 - 15$

Or, $V_{CEQ} = 5V$

Therefore, maximum ac power, P_o,

$$P_o = \frac{V_{CEQ}.I_{CQ}}{2} = \frac{5 \times 100mA}{2}$$

Or $P_o = 250mW$

01. (e)

Sol:

(i) The step-size is $\dfrac{2mA}{2^8 - 1} = \dfrac{2mA}{255} = 7.84\mu A$

Since, 10000000 = $(128)_{10}$, the ideal output should be $128 \times 7.84\mu A = 1024\mu A$

The error can be as much as $\pm 0.5\% \times 2mA = \pm 10\mu A$.

Thus, the actual output can deviate by this amount from the ideal 1024μA. So, the actual output can be anywhere from 1014μA to 1034μA.

(ii) $(10100)_2 = (20)_{10}$

Step-size = $\dfrac{10\text{mA}}{20} = 0.5\text{mA}$

$(11101)_2 = 29$

Output = step size × input

= 0.5mA × 29

= 14.5mA

(iii) $(00110010)_2 = (50)_{10}$

Step size = $\dfrac{1}{50} = 20\text{mV}$

Largest value produced when all the bit's are 1.

$(11111111)_2 = (255)_{10}$

Largest value of output = step size × 255 = 20mV × 255 = 5.1V

02. (a)

Sol: 1-phase alternator, $V = 2000\text{V}$, $R_a = 0.8\,\Omega$, $I_a = 100\text{A}$, $X_s = 4.94\,\Omega$

Power factor = 0.8(*l*ead) = cos ϕ

Induced emf

$= \sqrt{(v\cos\phi + I_aR_a)^2 + (v\sin\varphi \pm I_aX_S)^2}$

$+ \rightarrow$ Lag p.f

$- \rightarrow$ Lead p.f.

$E = \sqrt{(2000\times0.8+100\times0.8)^2 + (2000\times0.6-100\times4.94)^2}$

E = 1822.3v.

The voltage regulation = $\dfrac{|E|-|V|}{|V|}\times100$

$= \dfrac{1822.3-2000}{2000}\times100$

= –8.9%

02. (b)

Sol: Voltage across instrument for full scale deflection = 100mV.

Current in instrument for full scale deflection, $I = \dfrac{V}{R} = \dfrac{100\times10^{-3}}{20} = 5\times10^{-3}\,\text{A}$

Deflecting torque, $T_d = BINA = BIN(\ell\times d)$

$= 100\times B\times30\times10^{-3}\times25\times10^{-3}\times5\times10^{-3}$

$= B\times375\times10^{-6}$

$\therefore$ Controlling torque for a deflection θ = 120°

$T_c = K\theta = 0.375\times10^{-6}\times120$

$= 45\times10^{-6}$ N-m

At final steady position, $T_d = T_c$

or $375\times10^{-6}\times B = 45\times10^{-6}$

$\therefore$ Flux density in the air gap,

$B = \dfrac{45\times10^{-6}}{375\times10^{-6}} = 0.12\ \text{Wb/m}^2$

Resistance of coil winding, $R_c = 0.3 \times 20 = 6\ \Omega$

Length of mean turn

$l = 2(L + d) = 2\ (30 + 25) = 110$ mm

Let a be the area of cross-section of wire and P be the resistivity

Resistance of coil, $R_c = N\ \rho l/a$

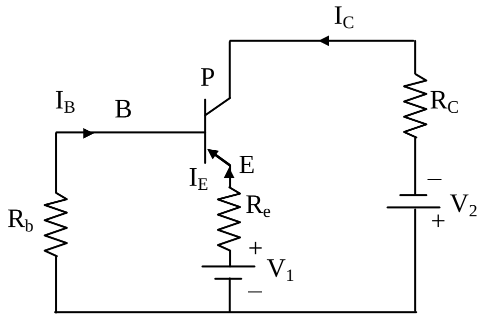
$\therefore$ Area of cross-section of wire, $a = \dfrac{100 \times 1.7 \times 10^{-8} \times 110 \times 10^{-3}}{6} \times 10^6$

$$= 31.37 \times 10^{-3}\ \text{mm}^2$$

Diameter of wire, $d = \left[(4/\pi)(31.37 \times 10^{-3})\right]^{\frac{1}{2}} = 0.2$ mm

02. (c)

Sol:



Neglecting V_{BE}, we obtain from the circuit, using KVL,

$V_1 - R_eI_E + I_BR_b = 0$

But $I_E = -(I_B + I_C)$

$\therefore\ V_1 = -(I_B + I_C)\,R_e - I_BR_b$

$\Rightarrow I_B = -\dfrac{I_CR_e + V_1}{R_e + R_b}$ ____(1)

Also, $I_c = \beta I_B + (1 + \beta)I_{co}$

$$= (1+\beta)I_{co} - \frac{\beta}{R_e + R_b}(I_cR_e + V_1)$$

$\dfrac{\beta V_1}{R_e + R_b} + I_C\left(1 + \dfrac{\beta R_e}{R_e + R_b}\right) = (1+\beta)I_{co}$ _____(2)

On partial differentiation of equation (2) wrt I_{co}

$0 + \dfrac{\partial I_c}{\partial I_{co}}\left(1 + \dfrac{\beta R_e}{R_e + R_b}\right) = 1 + \beta$

$\therefore$ stabilization factor

$S = \dfrac{\partial I_c}{\partial I_{co}} = \dfrac{1+\beta}{1 + \beta R_e/(R_e + R_b)}$

02. (d)

Sol:

(i)

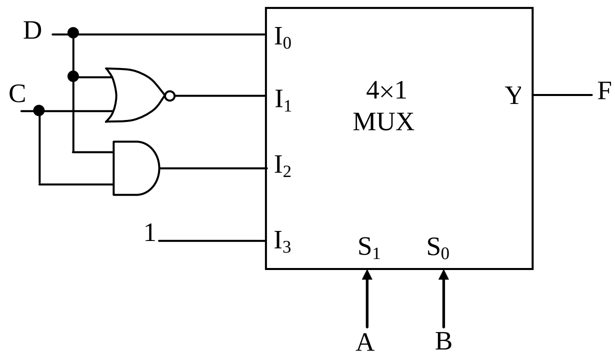
A	B	C	D	F
0	0	0	0	0
0	0	0	1	1
0	0	1	0	0
0	0	1	1	1
0	1	0	0	1
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

AB = 00
F = D

AB = 01
$F = \overline{C}\,\overline{D} = \overline{C + D}$

AB = 10
F = CD

AB = 11
F = 1



(ii)

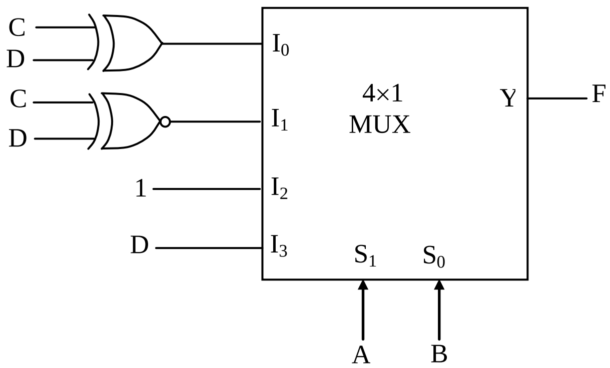
A	B	C	D	F
0	0	0	0	0
0	0	0	1	1
0	0	1	0	1
0	0	1	1	0
0	1	0	0	1
0	1	0	1	0
0	1	1	0	0
0	1	1	1	1
1	0	0	0	1
1	0	0	1	1
1	0	1	0	1
1	0	1	1	1
1	1	0	0	0
1	1	0	1	1
1	1	1	0	0
1	1	1	1	1

AB = 00
$F = C \oplus D$

AB = 01
$F = C \odot D$

AB = 10
F = 1

AB = 11
F = D



03. (a)

Sol:

(i) The diode will conduct when

$V_i = 20\sin\omega t = 10$

Or $\omega t = \sin^{-1}(1/2) = 30$

When the diode conducts,

$$\frac{V_o - V_i}{R} + \frac{V_o - V_R}{R_f} = 0 \qquad \begin{bmatrix} V_R = 10V \\ V_{i\max} = 20V \end{bmatrix}$$

$$\therefore V_{o\max} = 10\left[\frac{R + 2R_f}{R + R_f}\right] \text{\_\_\_\_(1)}$$

When the diode is non conducting.

$V_o = V_i$

(A) R = 100Ω

$V_{omax} = 15V$ &

$V_{omin} = -20V$

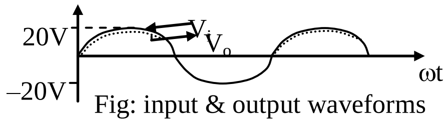


Fig: input & output waveforms

(B) R = 1kΩ

$V_{omax} = 10.9V$

$V_{omin} = -20V$

(C) R = 10kΩ

$V_{omax} = 10.1V$

$V_{omin} = -20V$

(ii) For the given circuit,

When $V_i > 10V$, equation (1) applies well.

When $V_i < 10V$,

$$\frac{V_o - 10}{R_r} + \frac{V_o - V_i}{R} = 0$$

$$V_o = \frac{10R - V_i R_r}{R + R_r}$$

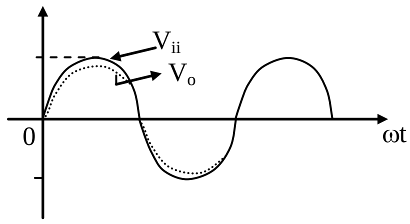
When $V_i = -20V$

$$V_{o\,min} = -\frac{10(2R_r - R)}{R + R_r}$$

(a) when R = 100Ω, $V_{omin} = -19.7V$

(b) when R = 1kΩ, $V_{omin} = -17.3V$

(c) when R = 10kΩ, $V_{omin} = -5V$



03. (b)

Sol: In order to find the number is even or odd we need to observe the last digit of binary equivalent of the given Hexadecimal number for example consider that an accumulator consists of number A3H.

A3H - $(1\,0\,1\,0\,0\,0\,1\,1)_2$

The given number is odd and for odd numbers LSB bit is always ‘1’ and for even number LSB bit is ‘0’ always. Let us consider that if the number which is stored in accumulator is even then it is stored in accumulator itself otherwise the number is stored in some location of memory whose address is 2000H. Also assume that program starts from 1000H location onwards.

```
1000H :  MOV  B, A
         ANI   01H
         JNZ    ODD
         MOV  A, B
         HLT

ODD:     MOV  A, B
         STA   2000H
         HLT
```

03. (c)

Sol: **Differential output taken from an inductive transducer:** Normally, the change in self inductance ΔL is adequate for detection for subsequent changes of instrumentation system. However, if the succeeding instrumentation responds to ΔL rather than to $L+\Delta L$ the sensitivity and accuracy will be much higher. The transducer can be designed to provide 2 outputs, one of which is an increase of self inductance. The succeeding stages of instrumentation system measures the difference between there outputs i.e., 2 ΔL. This is known as differential output.

The advantages of differential output are:

1. The sensitivity and accuracy are increased.
2. The output is less affected by external magnetic field
3. The effective variations due to temperature changes are reduced.
4. The effects of changes in supply voltage and frequency are reduced.

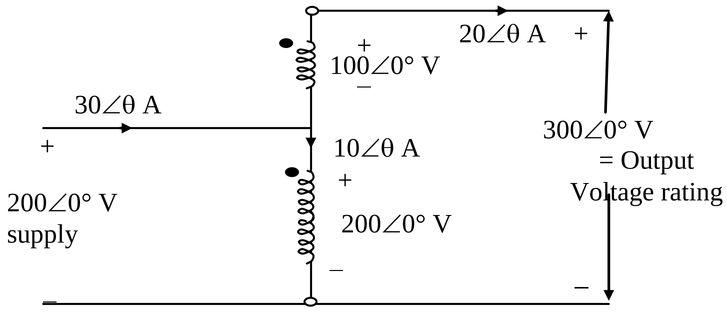
The differential arrangement consists of a coil which is divided into two parts. In response to a physical signal, which is normally a displacement, the inductance of one part increases from L to $L+\Delta L$ while that of other part decreases from L to L – ΔL. The change is measured as the difference between the two, resulting in an output as the difference between of the two resulting in an output of $2\,\Delta L$ instead of ΔL when only a single winding is used.

Example of Transducers working on Inductance:

1. LVDT 2. RVDT 3. Synchros 4. Resolver

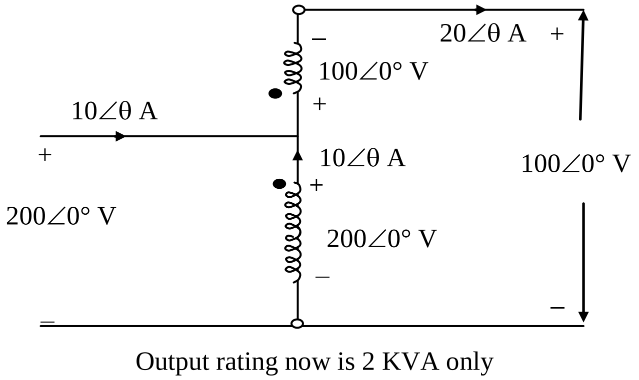
03. (d)

Sol: To obtain maximum kVA rating, the output voltage rating as well as the output current rating must be the largest possible. For this purpose, the two windings are connected as shown.



The kVA output rating (maximum possible) = 300×20 = 6 kVA

The connection must be such that dots are as shown. For example consider a connection as below.



Output rating now is 2 KVA only

03. (e)

Sol: $T_{max} = 2.25T + 1$

$J_{max} = 0.15$

$R_2 = 0.03\ \Omega$

$$S_{max} = \frac{R_2}{X_{20}}$$

$$\Rightarrow X_{20} = \frac{R_2}{J_{T\max}} = \frac{0.03}{0.15} = 0.2$$

$X_{20} = 0.2$

The additional resistance per phase in the rotor to obtain maximum torque at start.

$R_{exf} = X_{20} - R_2$

$= 0.2 - 0.03$

$= 0.17\ \Omega$

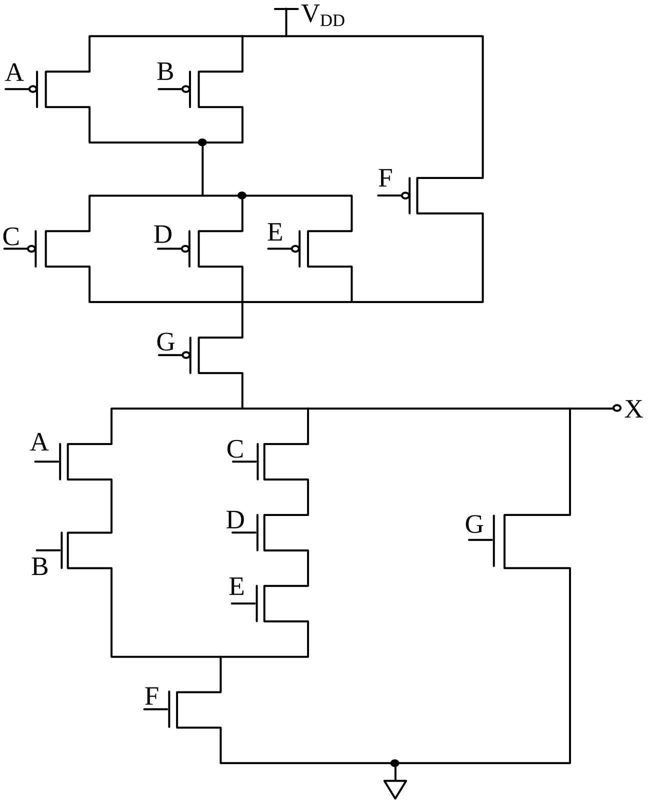
04. (a)

Sol:

(i) Given $X = \left(\left(\overline{A}+\overline{B}\right)\left(\overline{C}+\overline{D}+\overline{E}\right)+\overline{F}\right)\overline{G}$

$$= \left(\overline{AB}\,\overline{CDE}+\overline{F}\right)\overline{G} = \overline{\left(AB+CDE\right)F}.\overline{G}$$

$$X = \overline{\left(AB+CDE\right)F+G}$$



(ii) **Step1:** Set up the truth table

On the basis of the problem statement, the output x should be 1 whenever two or more inputs are 1. For all other cases, the output should be 0.

A	B	C	X	
0	0	0	0	
0	0	1	0	
0	1	0	0	
0	1	1	1	$\rightarrow \overline{A}BC$
1	0	0	0	
1	0	1	1	$\rightarrow A\overline{B}C$
1	1	0	1	$\rightarrow AB\overline{C}$
1	1	1	1	$\rightarrow ABC$

Step2: Write the AND term for each case where the output is 1.
There are 4 such cases.

Step3: Write the sum-of-products expression for the output

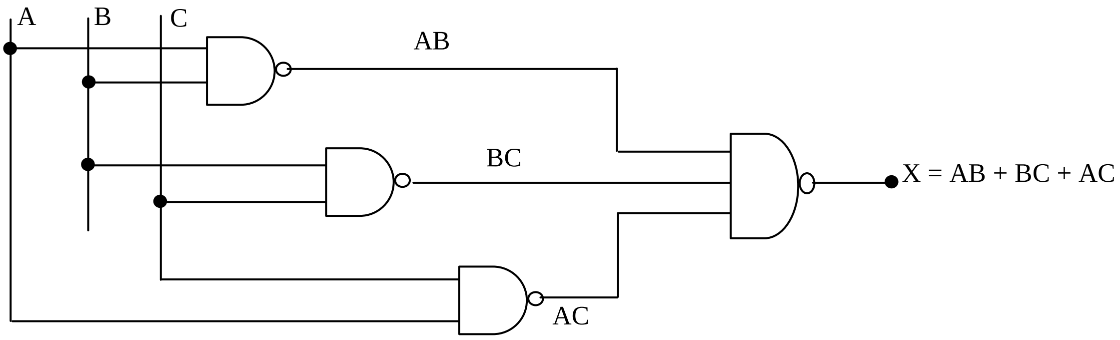
$$x = \overline{A}BC + A\overline{B}C + AB\overline{C} + ABC$$

Step4: Simplify the output expression.

$$x = (\overline{A} + A)BC + AC(B + \overline{B}) + AB(C + \overline{C})$$

$$x = AB + BC + AC$$

Step5: Implement the circuit for the final expression.



04. (b)

Sol: Trickle current which flows through resistors R_2 and produces a voltage drop of 0.7 V across base - emitter junction over comes cross – over distortion in push – pull amplifier. For analysis purposes, it is sufficient to consider only half of the circuit for reasons of symmetry, and V_{CC} of half (= $V_{CC}/2 = 30/2 = 15$ V) is to be taken for one transistor.

The current through resistors R_1 and R_2 is,

$$I = \frac{15}{R_1 + R_2} = \frac{15}{300\Omega + R_2} \text{\_\_\_\_\_(A)}$$

But,

$I \times R_2 = 0.7$ (desired voltage)

Or, $I = 0.7 / R_2$ ____(B)

Combining eqs (A) and (B),

$$\frac{0.7}{R_2} = \frac{15}{300\Omega + R_2}$$

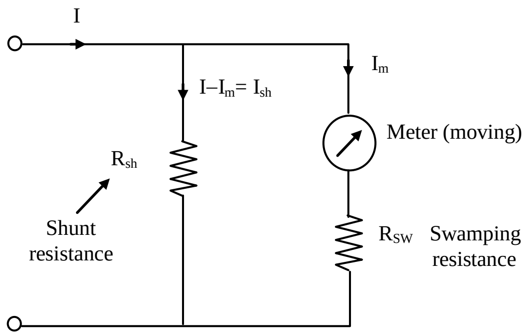
Or, $R_2 = 14.7\ \Omega$

04. (c)

Sol: Given data:

$R_m = 5\ \Omega, R_{SW} = 4\ \Omega$

$I_m = 5$ mA $\quad I = 1$ A



So, voltage across shunt coil

$= I_m R_m + I_m R_{sh}$

$= (0.005)\ [4 + 5]$

$= 45\times10^{-3}$V

The shunt should carry I_{sh}

$= I - I_m$

$= 1 - 0.005$

$= 0.995$A

$\therefore$ The shunt resistance $= \dfrac{45\times10^{-3}}{0.995}$

$= 0.045\Omega$

Compensation of Temperature Error:

The temperature error can be eliminated when the shunt and the moving-coil are made of the same material and kept at the same temperature. This method, however, is not satisfactory in practice as the temperature of the two parts are not likely to change at the same rate. Disadvantage of using copper shunt is that they are likely to be bulky as the resistivity of copper is small. Copper shunts are only occasionally used in instruments with built - in shunts.

In this case, a "swamping resistance" of manganin (which has a negligible temperature co-efficient) having a resistance 20 to 30 times the coil resistance is connected in series with the coil and a shunt of manganin is connected across this combination.

04. (d)

Sol:

(i) **Dynamic error:** It is the difference between the true value of the quantity (under measurement) changing with time and the value indicated by the measurement system if no static error is assumed. It is also called Measurement Error.

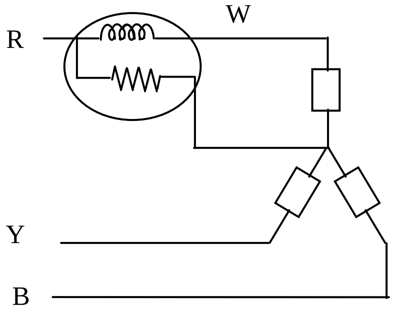
Resolution: The smallest voltage that can be measured in lowest voltage range is known as resolution of an instrument.

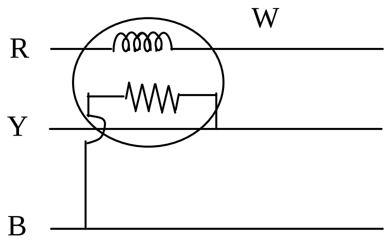
- Scale resolution $= \dfrac{1}{10^N}$
- Where N = no. of full digits
- Resolution in a selected voltage range is given as $= \dfrac{\text{Selected voltage range}}{\text{Total counts}}$

(or)

$$= \frac{\text{Full scale reading in that range}}{\text{Maximum count}}$$

(ii)





W = 400 watt.

$W = V_{ph} I_{ph} \cos\phi$

$V_{ph} I_{ph} = 400/0.8$

This type of connection gives reactive power, $W = \sqrt{3}\ V_p I_p \sin\phi$

$= \sqrt{3} \times {}^{400}\!/_{0.8} \times 0.6$

$= 519.6$ VAR

04. (e)

Sol: 1. Base Load Plants:

- It is a plant designed to take care of based load of the grid.
- The plant operated on the large portion of the load curve.
- It supplies continuous power to the grid through out the year.
- Generally it is of large capacity.
- Its load factor is high.

2. Peak Load Plants:

- It is a plant designed to take care of peak load of the grid system.
- It operates only during the period of peak load. Hence short period of total operating time.
- Pumped storage plants are usually designed as peak load plants.

(i) **Nuclear power plant is a base load plant** as the starting time is high and load changes on a nuclear power plant cannot be done easily.

(ii) **Run-off river is also base load plant** as there is no storage of water and power is continuously generated because of run-off river so it acts as base load plant.

(iii) **Diesel and pump storage plants acts as peak load plants** as load changes can be done quickly and fuel cost of diesel plant is high.

05. (a)

Sol:

(i) $\overline{A}\,\overline{C} + ABC + A\overline{C} = \overline{C}(\overline{A} + A) + ABC = \overline{C} + ABC = AB + \overline{C}$

(ii) $\left(\overline{\overline{x}\,\overline{y} + z}\right) + z + xy + wz = \overline{\overline{x}\,\overline{y}}\,\overline{z} + xy + wz$

$= (x + y)\overline{z} + xy + z(w + 1)$

$= (x+y)\ \overline{z} + xy + z = x\overline{z} + y\overline{z}\ + z + xy$

$= x\overline{z} + y + z + xy \quad [\because\ y\overline{z}\ + z = (z + \overline{z})(z + y)]$

$= x + y + z + xy \quad [\because\ x\overline{z} + z = (z + \overline{z})(x + z)]$

$= x + y + z$

(iii) $\overline{A}B(\overline{D}+\overline{C}D)+B(A+\overline{A}CD)$

$= \overline{A}B\overline{D}+\overline{A}B\overline{C}D+AB+\overline{A}BCD$

$= \overline{A}B(\overline{D}+\overline{C}D+CD)+AB$

$= \overline{A}B(\overline{D}+D(c+\overline{c}))+AB$

$= \overline{A}B(\overline{D}+D)+AB=\overline{A}B+AB=B(A+\overline{A})=B$

(iv) $(\overline{A}+C)(\overline{A}+\overline{C})(A+B+\overline{C}D)$

$= (\overline{A}+\overline{A}\overline{C}+\overline{A}C)(A+B+\overline{C}D)$

$= A(1+\overline{C}+C)(A+B+\overline{C}D)$

$= \overline{A}(A+B+\overline{C}D)=\overline{A}(B+\overline{C}D)$

05. (b)

Sol: The gain of feedback amplifier, A_{FB}, is

$$A_{FB}=\frac{A}{1+A\beta}\cong\frac{1}{\beta}$$

Because $A\beta >> 1$

And, gain of feedback network, β, is

$$\beta=\frac{R_1}{R_1+R_2}=\frac{1k}{1k+49k}=\frac{1}{50}$$

Therefore,

$$A_{FB}=\frac{1}{\beta}=50$$

And the output voltage V_o, is

$V_o = A_{FB} \times V_S$

$= 50 \times 2$ mV

Or $V_o = 100$ mV

05. (c)

Sol: By neglecting armature resistance the active power drawn by a synchronous motor is

$$P = 3\times\frac{E_tV_t}{X_s}\sin\delta$$

(Unity Pf)

$$\Rightarrow E_t=\sqrt{V_t^2+(I_aX_s)^2}\ ,\quad V_t=\frac{6600}{\sqrt{3}}\text{ V/ph}$$

$$\cos\delta=\frac{V_t}{E_t}$$

$$\Rightarrow E_t = \frac{V_t}{\cos\delta} = \frac{\left(6.6/\sqrt{3}\right)\times 1000}{\cos(30)}$$

E_t = 4400 V/ph

$$\Rightarrow P = (3)\left[\frac{4400\times\frac{6600}{\sqrt{3}}}{30}\right]\sin(30)$$

P = 838.31 kW

05. (d)

Sol: Given,

Height, l = 25 mm = 0.025 m

Width, b = 20 mm = 0.02 m

B = 0.11 Wb/m^2

Moment of inertia, J = 0.28×10^{-6} kg-m^2

Control spring constant,

C = 31×10^{-6} N-m/rad

Deflection, θ = 135°

$$= 135 \times \frac{\pi}{180} = 2.356 \text{ rad}$$

Current, I = 0.11 mA = 0.011 A

Number of turns (N):

For steady deflection, GI = Kθ

$$\text{Displacement constant, } G = \frac{K\theta}{I} = \frac{3\times10^{-6}\times 2.356}{0.011} = 0.642\times10^{-3} \text{ N-m/A}$$

$G = NB\ell b$

$$N = \frac{G}{B\ell b} = \frac{0.642\times10^{-3}}{0.11\times0.025\times0.02} = 11.67$$

N = 12

05. (e)

Sol: Water Power equation (or) output equation:

Output Power, P = w .Q. H . η kW

where, w = specific weight of water

= 9.81 k/m^3,

H = net head of water in meter on the turbine

Q = quantity of water in m^3/sec.

η = over all efficiency of the system.

Output Power, $P = \frac{w.Q.H.\eta}{75}$ h.p.

where, w = specific weight of water

$= 1000 \text{ kg / m}^3$

Advantages of Hydroelectric power stations:

(1) No cost of fuel
(2) Low maintenance cost
(3) High plant efficiency
(4) Plant is free from pollution
(5) Used as multi-purpose projects (irrigation, flood control etc)
(6) Cost per unit is less.
(7) Suitable for variable heads and to act as a peak load plant

05. (f)

Sol: Power calculated by freshman

$P = I^2 R = (30.4)^2 \times 0.0105$

$= 9.70368$ W

True value of current (I_T) =

$30.4\text{A} + \left(\frac{1.2}{100} \times 30.4A\right) = 30.77$ A

True value of resistance (R_T) =

$0.0105\Omega + \left(\frac{0.3}{100} \times 0.0105\Omega\right) = 0.010532\Omega$

True power (P_T) = $(30.77)^2 \times 0.010532\Omega$

$= 9.971$W

$$\frac{\text{True value of power}}{\text{power calculated by freshman}} \times 100 = \frac{9.971\text{W}}{9.70368} \times 100 = 102.75\%$$

06. (a)

Sol:

(i) $P_1 = 5000$W, $P_2 = -1000$W

Total power (P_T) = $P_1 + P_2 \Rightarrow 5000 - 1000 = 4000$W

$$\text{Power Factor Angle } (\phi) = \tan^{-1}\left[\sqrt{3}\frac{P_1 - P_2}{P_1 + P_2}\right] = \tan^{-1}\left[\sqrt{3}\left[\frac{5000 - (-1000)}{5000 - 1000}\right]\right]$$

$$= \tan^{-1}\left[\sqrt{3}\left(\frac{6000}{4000}\right)\right] = \tan^{-1}\left[\frac{3\sqrt{3}}{2}\right]$$

$\phi = 68.94°$

$\therefore$ Power Factor $\cos\phi = \cos(68.94°)$

$\Rightarrow 0.3593 \approx 0.36$ Lag

(ii) Power consumed By each phase

$= \frac{P_{Total}}{3} = \frac{4000}{3}$

$= 1333.33$W

In Δ connected system, voltage of each phase

$V_{ph} = V_L = 440$V

= supply voltage

$\rightarrow$ Current in each phase

$= \dfrac{1333.33}{440 \times 0.36} = 8.41748$ Amp

$\rightarrow$ Impedance of each phase

$= \dfrac{440}{8.41748} = 52.27217\ \Omega$

$\rightarrow$ Resistance of each phase

$= \dfrac{1333.33}{(8.41748)^2} = 18.818\ \Omega$

$\rightarrow$ Reactance (X) of each phase

$= \sqrt{(52.27217)^2 - (18.818)^2} = 48.7674\Omega$

$\rightarrow$ In order that one of the wattmeter's should read zero, the power factor should be 0.5

$\therefore$ $\cos\phi = 0.5$, & $\tan\phi = 1.73$

$\therefore$ Reactance of circuit $\Rightarrow X = R\tan\phi$

$X = 18.818 \times 1.73 \Rightarrow X = 32.55514\Omega$

$\therefore$ Capacitive Reactance Required

$= 48.7674 - 32.55514$

$= 16.21226$

Capacitance (C) = $\dfrac{1}{2\pi \times 50 \times 16.21226}$

$C = 196.33\ \mu F$

06. (b)

Sol:

(i) $V_t = 220V$; $N = 900$ rpm

$T_e = 70$ N-m $\quad T_e = K_a \phi I_a = 70$ N-m

$\therefore$ Developed power = $T_e\omega = E_b I_a$

$(70)\left(\dfrac{2\pi \times 900}{60}\right) = E_b I_a$

$\Rightarrow (V_t - I_a r_a)\ I_a = 6597.3$

$[220 - I_a(0.02)]\ I_a = 6597.3$

$220I_a - 0.02\ I_a^2 = 6597.3$

$0.02I_a^2 - 220I_a + 6597.3 = 0$

Solving above equation

$I_a = 30.06A$

(ii) Given a DC series motor

$V_t = 220$ V

Before adding extra resistor

$I_{a1} = 30$ A

$E_{b1} = V_t - I_{a1}(r_a + r_f)$

$= 220 - (30)(0.4 + 0.1)$

$= 205$ V

After adding extra resistor speed reduced by 50%

$T \propto N^2$; $\quad N_2 = 0.5\ N_1$

$$\frac{T_1}{T_2} = \left(\frac{N_1}{N_2}\right)^2$$

$$\frac{T_1}{T_2} = \left(\frac{1}{0.5}\right)^2$$

$$\frac{T_1}{T_2} = 4$$

$T = Ka\phi\ Ia;\ \phi \propto Ia$

$\Rightarrow T \propto Ia^2$

$$\frac{T_1}{T_2} = 4 = \left(\frac{30}{Ia_2}\right)^2$$

$Ia_2 = 30/\sqrt{4} = 15$ A

$\Rightarrow E_{b2} = V_t - Ia_2 (r_a + r_f + r_{ex})$

$E_{b2} = 220 - 15\,(0.4 + 0.1 + r_{ex})$ …………(1)

$$\frac{E_{b1}}{E_{b2}} = \frac{Ia_1}{Ia_2} \times \frac{N_1}{N_2}$$

$$\frac{205}{E_{b2}} = \left(\frac{30}{15}\right)\left(\frac{N_1}{0.5N_1}\right)$$

$E_{b2} = 51.25$ Volts ………………(2)

Replace E_{b2} in equation (1)

$51.25 = 220 - (15)\,(0.4 + 0.1 + r_{ex})$

$\Rightarrow r_{ex} = 10.75\ \Omega$

06. (c)

Sol:

(i) MOD number = $2^6 = 64$

(ii) The frequency at the last FF will be equal to the input clock frequency divided by the MOD number i.e., $f(\text{at } Q_6) = \frac{1\text{MHz}}{64} = 15.625\text{kHz}$

(iii) Counter will count from 000000_2 to 111111_2 (0 to 63_{10}) for a total of 64 states. Note that the number of states is the same as the MOD number.

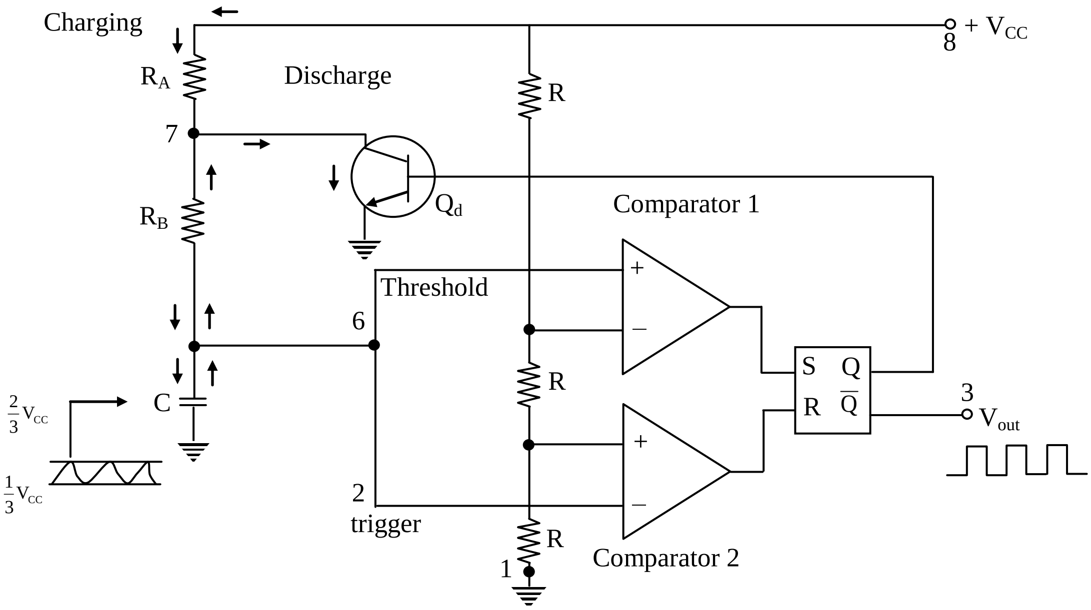
(iv) Because this is a MOD-64 counter every 64 clock pulses will bring the counter back to its starting state. Therefore, after 128 pulses, the counter is back to 000000. The 131^{th} pulse brings the counter to the 000011 state.

07. (a)

Sol:

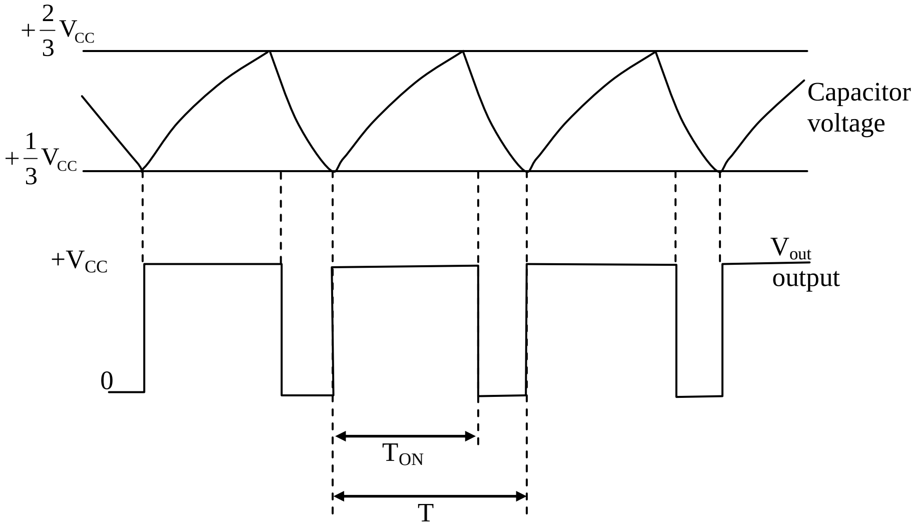
(i) <u>Astable multivibrator using IC 555:</u>

An astable multivibrator, often called a free-running multivibrator, is a rectangular-wave generating circuit. Unlike the monostable multivibrator, this circuit does not require any external trigger to change the state of the output, hence the name free-running Figure below shows the functional diagram of IC 555 used in astable mode of operation.

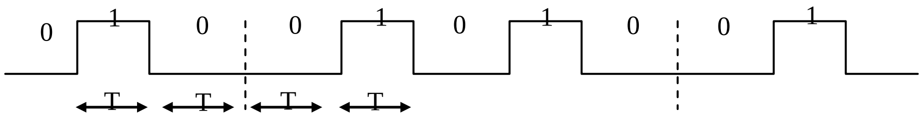


Operation:
When the flip-flop is set, Q is high which drives the transistor Q_d in saturation and the capacitor gets discharged. Now the capacitor voltage is nothing but the trigger voltage. So while discharging, when it becomes less than (1/3) V_{CC}, comparator 2 output goes high. This resets the flip-flop hence Q goes low and Q goes high. The low Q makes the transistor off. Thus capacitor starts charging through the resistances R_A, R_B and V_{CC}. Total resistance in the charging path is $(R_A + R_B)$, the charging time constant is $(R_A + R_B)C$.
Now the capacitor voltage is also a threshold voltage. While charging, capacitor voltage increases i.e. the threshold voltage increases. When it exceeds 2/3 V_{CC}, then the comparator 1 output goes high which sets the flip-flop. The flip-flop output Q becomes high and output at pin 3 i.e. Q becomes low. High Q drives transistor Q_d in saturation and capacitor starts discharging through resistance R_B and transistor Q_d. Thus the discharging time constant is R_B C. when capacitor voltage becomes less than (1/3) V_{CC}, comparator 2 output goes high, resetting the flip-flop. This cycle repeats. Thus when capacitor is charging, output is high while when it is discharging the output is low. The output is a rectangular wave. The capacitor voltage is exponentially rising and falling.

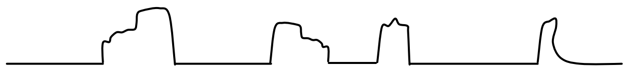
(ii) The waveforms are shown in the figure.



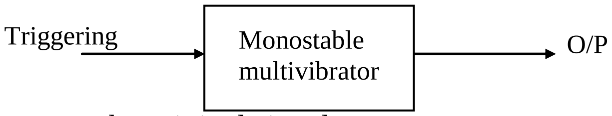
(iii) Monostable multivibrator is used to regenerate the signal from its distorted digital signal.
Let us consider a digital signal shown in below.



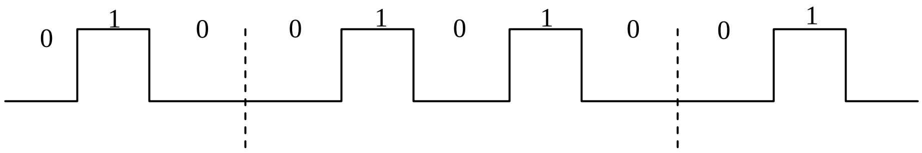
After transmission, the signal may get distorted shown in below



We know that, in monostable multi vibrator, when a triggering is given it produces a pulse of width 'T'.
So by giving the above distorted signal as input (triggering) to the monostable multi vibrator we regenerate the original signal from its distorted form.



So, we get the original signal



07. (b)

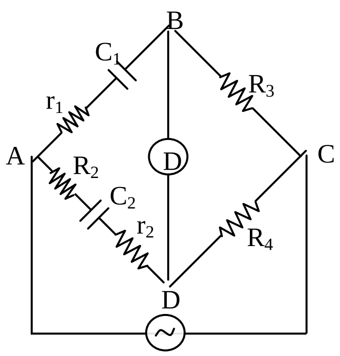
Sol: **Factors leading to in accuracies in measurements by A.C. bridges:**

1) Mutual inductance effect due to magnetic coupling between various components of the bridge.
2) Stray capacitance effects, due to electrostatic fields between conductors at different potentials.
3) Stray conductance effect due to imperfect insulation
4) Residual in-components, the existence of small amount of series inductance or shunt capacitance in nominally non-reactive resistors.

Problem:

Given Data:

r_1 =?, $r_2 = 0.4\ \Omega$, $R_3 = 2000\Omega$,
$R_4 = 2950\ \Omega$, $R_2 = 5\Omega$,
$C_2 = 0.5\ \mu F$, $C_1 = ?$



F = 450 Hz

At balance,

$$\left(r_1 + \frac{1}{j\omega C_1}\right)R_4 = \left(R_2 + r_2 + \frac{1}{j\omega C_2}\right)R_3$$

$$r_1R_4 + \frac{R_4}{j\omega C_1} = (R_2 + r_2)R_3 + \frac{R_3}{j\omega C_2}$$

By equating real and imaginary terms on both sides,

$$r_1R_4 = (R_2 + r_2)R_3 \quad \text{and} \quad \frac{R_4}{\omega C_1} = \frac{R_3}{\omega C_2}$$

$$\Rightarrow \frac{R_4}{R_3} = \frac{(R_2 + r_2)}{r_1} \quad \text{and} \quad \frac{R_4}{R_3} = \frac{C_1}{C_2}$$

$$\therefore C_1 = \frac{R_4}{R_3}C_2 = \frac{2950}{2000} \times 0.5 \times 10^{-6} = 0.74\mu F$$

$$r_1 = \frac{R_3}{R_4}(R_2 + r_2) = \frac{2000}{2950}(5 + 0.4) = 3.66\Omega$$

Dissipation factor of capacitor C_1:

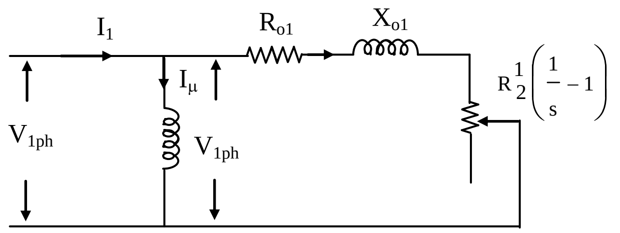
$D = \tan\delta = \omega C_1 r_1$

$= 2\pi \times 450 \times 0.74 \times 10^{-6} \times 3.66$

$= 0.00765$

07. (c)

Sol: The approximate equivalent circuit model of Induction motor is



$x_{01} = x_1 + x_2^1$

$R_{01} = R_1 + R_2^1$

$$R_2^1 + R_2^1\left(\frac{1}{s} - 1\right) = \frac{R_2^1}{s}$$

During starting slip = 1

$$I_r^1 = \frac{V_{1ph}}{\sqrt{\left(R_1 + \frac{R_2^1}{s}\right)^2 + (X_1 + X_2^1)^2}}$$

$$I_r' = \frac{(400\sqrt{3})}{\sqrt{\left(1 + \frac{0.5}{1}\right)^2 + (1.2 + 1.2)^2}}$$

$I_r^1 = 81.6A$

Starting Torque

$$T_{st} = \frac{60}{2\pi N_S}\times 3\left(I_r^1\right)^2 \times \frac{R_2^1}{S}$$

$$T_{st} = \frac{60}{2\pi\times 1500}\times 3\times(81.6)^2 \times\frac{0.5}{1} \qquad [\because N_S = 1500\text{rpm}]$$

T_{st} = 63.6 N-m

08. (a)

Sol:

(i) The following equation should hold good to avoid thermal runaway:

$$\frac{\partial P_c}{\partial T_j} < \frac{1}{\theta}$$

$P_c = I_c.V_{CE} = I_c\,(V_{cc} - I_cR_c)$

For the transistor in cutoff, $I_c = I_{co}$

$P_c = I_{co}V_{CC} - I_{co}^2R_c$

$$\text{Hence, } \frac{\partial P_c}{\partial T_j} = \frac{\partial P_c}{\partial I_{co}} = \frac{\partial I_{co}}{\partial T_j} < \frac{1}{\theta}$$

$$= \left(V_{cc} - 2I_{co}R_c\right)\left(0.07I_{co}\right) < \frac{1}{\theta}$$

$$\Rightarrow 0.14I_{co}^2R_c - 0.07I_{co}V_{cc} + \frac{1}{\theta} > 0$$

From the roots of this equation of I_{co}

(quadratic form), we find:

$$\frac{V_{cc} - \sqrt{V_{cc}^2 - 8R_c/0.07\theta}}{4R_c} \le I_{co} \le \frac{V_{cc} + \sqrt{V_{cc}^2 - 8R_c/0.07\theta}}{4R_c}$$

$$\left(\begin{array}{l}\because ax^2 + bx + c = 0 \\ \text{roots are } \dfrac{-b\pm\sqrt{b^2-4ac}}{2a}\end{array}\right)$$

(ii) The condition to avoid thermal runaway is

$$\frac{\partial P_c}{\partial T_j} < \frac{1}{\theta}$$

$$\text{i.e } \frac{\partial P_c}{\partial I_c}.\frac{\partial I_c}{\partial T_j} < \frac{1}{\theta} \text{\_\_\_\_\_(1)}$$

Since θ and $\frac{\partial I_c}{\partial T_j}$ are positive, eq (1) is always satisfied if $\frac{\partial P_c}{\partial I_c}$ is negative

$$\left[\frac{\partial P_c}{\partial I_c} = V_{CC} - 2I_cR_c\right] < 0$$

$$\therefore I_c > \frac{V_{ce}}{2R_c}, \text{ to avoid thermal run away}$$

If thermal run away occur, then

$$I_c \le \frac{V_{ce}}{2R_c}$$

Given transistor is in cutoff, $I_c = I_{co}$

$$\therefore I_{co} \le \frac{V_{cc}}{2R_c}$$

$\therefore$ collector current I_{co} after runaway can never exceed $I_{co} = \frac{V_{cc}}{2R_c}$

08. (b)

Sol:

(i) 8085 uses a time multiplexed address-data bus. This is due to limited number of pins on 8085. lower order 8 bits of the address appear on the AD bus during the first clock cycle i.e., T_1 state of a machine cycle. It then becomes the data bus during the second and third clock cycles i.e., T_2 & T_3 states.

ALE stands for Address Latch Enable. It is used to distinguish whether the $AD_0 - AD_7$ bus contains address bits $A_7 - A_0$ or data bits D_7 to D_0. It is a single pulse issued during every T_1 state of the microprocessor.

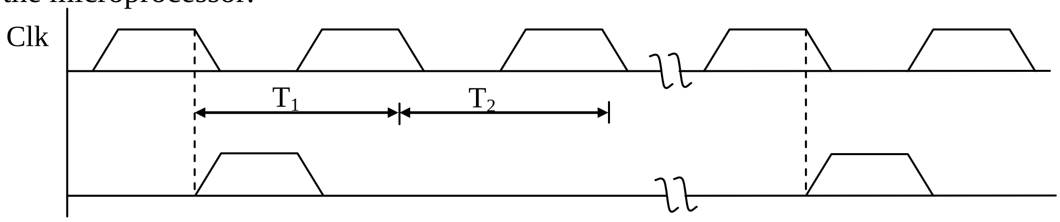


Fig: ALE signal issued in every T_1 state.

Since the lower 8-bits of the address information A_7 to A_0 is available only during T_1 period, therefore, ALE pulse can be used to latch address A_7 to A_0 in an external latch. ALE output is high during first half of the T_1 period and it's falling edge can be used to latch the address bits A_7 to A_0 in an external latch.

Below figure shows a schematic that uses a latch and the ALE signal to be multiplex the bus. The $AD_7 - AD_0$ is connected as the input to the Latch. The ALE signal is connected to the enable (E) pin of the latch, and the output control [OC] signal of the latch is grounded. When ALE goes high during the T_1 state of a machine cycle, the latch is transparent and the output of the latch changes according to the input. The CPU is putting lower order bits of address during this time. When the ALE goes Low, the address bits get latched on the output and remain so until the next ALE signal.

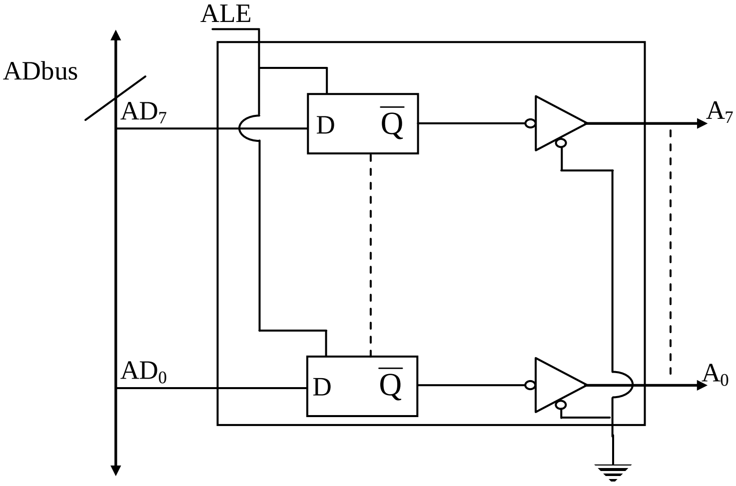


Fig: Latching of lower order address in external latch

(ii) $IO/\overline{M}$ is an output tri-state control signal. It is active both ways (High as well as low). Whenever the address issued by the microprocessor on the address lines refers to the memory then the microprocessor makes $IO/\overline{M}$ Low throughout T_1, T_2, T_3, T_4, T_5 and T_6 states of the machine cycle to indicate the external world that the address sent belongs to the memory and data on the BDB (Bi-Directional Bus) refers to the memory.

Whenever the address on the address lines refers to an I/O device the microprocessor makes $IO/\overline{M}$ control signal output HIGH to tell the external world that the address on the address bus refers to I/O device and the data on the Bi-directional bus refers to an I/O device.

Note that $IO/\overline{M}$ signal is Low or High as the case may be throughout six timing slots T_1, T_2, T_3, T_4, T_5 & T_6 states. It is for the user to make use of this feature to develop proper interfacing circuitry i.e., to generate the chip selected signals. In other words, a Low $IO/\overline{M}$ signal enables the memory chips and a High $IO/\overline{M}$ signal enables the $IO/\overline{M}$ device.

08. (c)

Sol: Given,

Power rating at transformer $= (VA)_{3\phi}$

$= 900$ kVA

Core loss or Iron Loss (P_c) = 10 kW

Primary side = delta wound

Secondary side = star wound

$V_{L1} = 3$ kV

$V_{L2} = \sqrt{3}$ kV

$$I_{L1} = \frac{(VA)_{3\phi}}{\sqrt{3}V_{L1}} = \frac{900\times10^3}{\sqrt{3}\times3\times10^3} = 173.2 \text{ A}$$

$$I_{L2} = \frac{(VA)_{3\phi}}{\sqrt{3}V_{L2}} = \frac{900\times10^3}{\sqrt{3}\times\sqrt{3}\times10^3} = 300 \text{ A}$$

On delta side:

$$I_P = \frac{I_L}{\sqrt{3}} = I_{p1} = \frac{I_{L1}}{\sqrt{3}} = \frac{173.2}{\sqrt{3}} = 100 \text{ A}$$

$\therefore$ $I_{p1} = 100$ A

On star side:

$I_{p2} = I_{L2} = 300$ A

$\therefore$ $I_{p2} = 300$ A

Rated copper losses (P_{cu}) = $3I_{p1}^2r_1 + 3I_{p2}^2r_2$ = 3 × (100)^2 (0.3) + 3(300)^2 (0.02)

= 9000 + 5400

$P_{cu} = 14.4$ kW

Given

VA rating (VA) = 900 kVA

Loading factor $x = 1$

pf = 1

core loss (P_c) = 10 kW

full load copper loss (P_{cu}) = 14.4 kW

$$\text{efficiency } (\eta) = \frac{x(VA)pf}{x(VA)pf + P_c + x^2P_{cu}}$$

$$= \frac{1\times 900\times 10^{3}\times 1}{1\times 900\times 10^{3}\times 1+10\times 10^{3}+1^{2}\times 14.4\times 10^{3}}$$

$$= \frac{900}{924.4} = 0.9736$$

$\therefore$ % Efficiency of the given transformer at full load and upf is, η = 97.36% (Rounded off to two decimals)