DETAILS EXPLANATIONS

EE : Paper-2 (Paper-5) [Full Syllabus]

[PART : A]

1. Thyristors require extra commutation circuits for turn off which results in increased complexity of the circuit.

   For these reasons thyristors are not preferred for inverters.

2. The difference of true value A and measured value A_m of the measurand is known as the reading correction. Absolute error and reading correction are of the same magnitude but are of opposite sign.

3. $$\omega_0 = 2000\pi = \frac{2\pi}{T}$$

   $$T = 10^{-3}$$

   $$\Rightarrow \quad T_0 = 0.5 \times 10^{-3}$$

   $$f_0 = \frac{1}{T_0} = \frac{10^3}{0.5} = 2000 \text{ Hz}$$

   Folding frequency

   $$= 2 \times 2000 = 4 \text{ kHz}$$

4. Relative error is defined as the ratio of absolute error to the true value of the measurand and is expressed in fraction or percentage.

5. $$\begin{array}{r} 1\ 0\ 1.\ 1\ 0\ 1 \\ +\ 1\ 1\ 0.\ 1\ 0\ 0 \\ \hline 1\ 1\ 0\ 0.\ 0\ 0\ 1 \\ \hline \end{array}$$

   $$(101.101)_2 + (110.100)_2 = (1100.001)_2$$

6. The limits of the deviations from the specified value, as mentioned by the manufacturer of the equipment/apparatus is known as limiting error.

7. ***External Noise may be classified as under :***

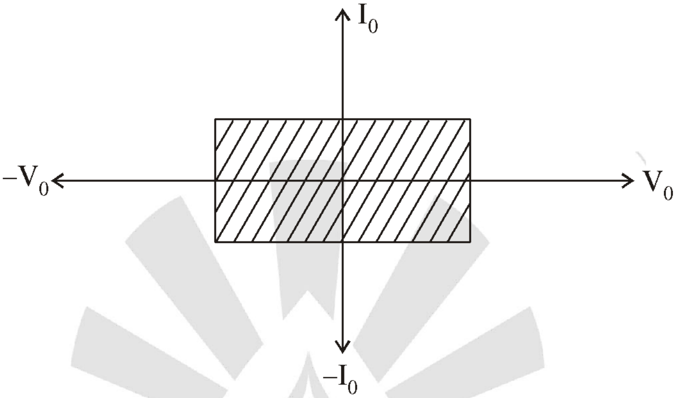
   (i) Atmospheric Noise

   (ii) Extraterrestrial Noise

   (iii) Industrial Noise.

8. An ammeter shunt is merely a low resistance that is placed across the coil circuit of the instrument in order to measure fairly large currents.

9. Four quadrant operation obtained using two full converters connected back to back providing output voltage and output current both of which can be reversed. This is called a dual converter. They are normally used in high power variable speed drives. Fig. shows the v-i characteristics of a dual converter or four quadrant converter.



10. The range of an electrostatic voltmeter is increased by employing a multiplier in the form of either a resistance or capacitor potential divider.

11. Continuous traversal of the connected branches in the direction of branch arrows, such that no node is traversed more than once.

12. Because for higher voltage the cost of resistance potential divider becomes high and wastage of power becomes excessive.

13. Internal noise is that type of noise which is generated internally or within the communication system or receiver. Internal noise may be treated quantitatively and can also be reduced or minimized by proper system design.

14. The advantage of using Ayrton or universal shunt is that it eliminates the possibility of the meter being in circuit without a shunt.

15. ***Transfer function :***

It is defined as the ratio of laplace transform of output to ratio of laplace transform of input with assumption that all inital conitions are zero.

16. ***Gain Crossover frequency :***

The frequency at which magnitude of open loop transfer function is unity

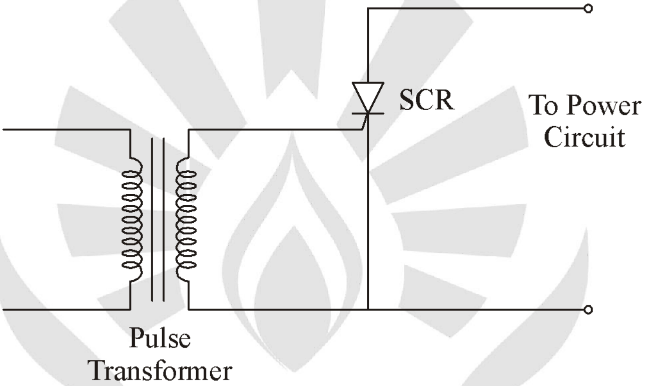
$$|G(s)H(s)|_{\omega = \omega_g} = 1$$

Phase crossover freeuency :

The frequency at which phase angle of open loop transfer function is –180°

$$\angle G(s)H(s)|_{\omega = \omega_p} = -180°$$

17. This is the most commonly used method for AC Application where the SCR is employed for such application as a switching device. With the proper isolation between the power and control circuit the SCR is triggered by the phase shift AC voltage derived from the main supply. The firing angle is controlled by changing the phase angle of the gate signal.



18. PIV of Thyristor is not depend on voltage drop across Thyristor.

For 1-ϕ full Bridge converter PIV of Thyristor

= V_m = maximum source voltage

= $\sqrt{2} \times V_{rms} = \sqrt{2} \times 220 = 311.217$ V

19. Main disadvantage of average reading voltmeters is that they operate in audio frequency range. In radio frequency range, distributed capacitance of the high resistance R introduces error in the reading.

Another disadvantage of such a voltmeter is that due to non linear volt ampere characteristic for lower voltage the readings of the voltmeter at lower voltage are not correct.

20. The electron gun assembly consists of an indirectly heated cathode, a control grid surrounding the cathode, a focusing anode and an accelerating anode. The sole function of the electron gun assembly is to provide a focused electron beam which is accelerated towards the phosphor screen.

[PART : B]

21. The voltage across the current through any branch of a DC bilateral network being known, this branch can be replaced by any combination of element that will make the same voltage across and current through the chosen branch.

In other words, the theorem, in it's simplest from tells that for branch equivalent, the terminal voltage and current must be same, for example take a simple network show in figure.

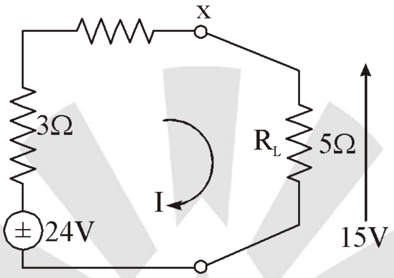


Figure : Simple DC Circuit

$$I = \frac{24}{3+5} = 3A$$

It may be observed that a known potential different and current in a branch can be replaced by an ideal voltage and current source respectively.

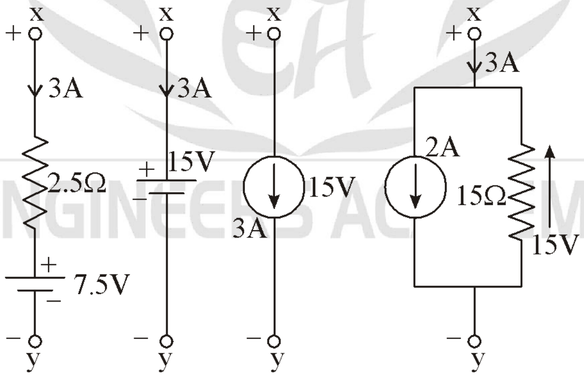


Figure : Equivalent of Branch x-y of figure.

Represent the branch equivalent of the x-y branch (R_L) where it may be noted that in all the cases of figure, the terminal voltage and through current are identical and equal to that of branch (x-y)R_L. This theorem can not be used to solve the network containing two or more source that are not in series or in paralle.

22. Programe Counter (PC) is a 16-bit special purpose user accesable register.

PC will provide address of instruction to be exicuted it also use to store starting address of program.

It can be also use to provide sequence or track of μp programe exicution.

PC is also called as instruction pointer

Stack pointer is a 16 bit special purpose register

- It will provide the address of top of stack
- Stack is a part of RAM which is used during, call, push. pop and RET
- It act normally based on in LIFO principle.

23.
$$A_m = 5$$
$$f_m = 1\ \text{kHz}$$
$$f_c = 100\ \text{kHz}$$

Given,

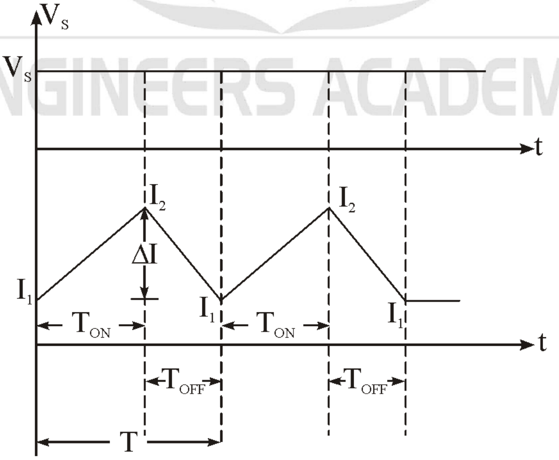
(i) $\Delta f = k_f A_m$
$$= 40 \times 5 = 200\ \text{Hz}$$
$$= 0.2\ \text{kHz}$$

(ii) $\beta_{FM} = \dfrac{\Delta f}{f_m} = \dfrac{200}{1000} = 0.2$

(iii) $f_i(t) = f_c + k_f A_m \sin 2000\pi t$
$$= (100 + 0.2 \sin 2000\pi t)$$

(iv) $S_{FM}(t)=A_c\cos[2\pi\times10^4 t+0.2\times2\pi\sin(200\pi t)]$

24. In figure when switch S is closed, current in circuit V_S, S, L rises from I_1 to I_2 during time T_{on} as shown in figure.



$$\therefore \quad L\frac{di}{dt} = V_L \text{ or } L\frac{I_2 - I_1}{T_{ON}} = V_S$$

$$\text{or} \quad L\Delta I = V_s T_{on} \qquad \ldots(1)$$

When switch S is opened, current begins to flow in L, V_o and diode D and the current falls from I_2 to I_1 during time T_{OFF}.

$$\therefore L\frac{I_2 - I_1}{T_{OFF}} = V_o \text{ or } L\Delta I = V_o T_{OFF} \qquad \ldots(2)$$

From equation (1) and (2) we get

$$L.\Delta T = V_S T_{ON} = V_o T_{OFF}$$

$$\text{or} \quad V_o = V_S \frac{T_{ON}}{T_{OFF}} = V_S \frac{T_{ON}}{T - T_{ON}}$$

$$\therefore \quad V_o = V_S \frac{T_{ON}/T}{1 - T_{ON}/T} = V_S \frac{\alpha}{1-\alpha} \qquad \ldots(3)$$

It is seen from equation (3) that when $\alpha < 0.5$ circuit of figure operates as a setp-down chopper. In case $\alpha > 0.5$, this circuit would operate as a step-up chopper.

25.

$$\begin{array}{ccccccccccc}
 & & & & & 1 & 1 & 0 & 1 & 1 & 0 \\
 & & & & \times & 0 & 1 & 0 & 1 & 1 & 1 \\
\hline
 & & & & & 1 & 1 & 0 & 1 & 1 & 0 \\
 & & & & 1 & 1 & 0 & 1 & 1 & 0 & \times \\
 & & & 1 & 1 & 0 & 1 & 1 & 0 & \times & \times \\
 & & 0 & 0 & 0 & 0 & 0 & 0 & \times & \times & \times \\
 & 1 & 1 & 0 & 1 & 1 & 0 & \times & \times & \times & \times \\
\hline
1 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 \\
\hline
\end{array}$$

$$(1101.10) \times (0101.11) = (1001101.1010)_2$$

26. We know that for a sinusoidal modulating signal, the total power is expressed as

$$P_t = P_c\left(1 + \frac{m_a^2}{2}\right)$$

where, P_t = Total power or modulated power.

P_c = Carrier power or unmodulated power

m_a = Modulation index

Given that, $P_c = 400$ watts

$m_a = 75$ percent $= 0.75$

Therefore, $$P_t = P_c\left(1+\frac{m_a^2}{2}\right)$$

$$= 400\left(1+\frac{0.75^2}{2}\right)$$

$P_t = 512.5$ watts

27. The stability of LTI system may be defined as when the system is subjected to bounded input, the output should be bounded.

A system is stable if its impulse response appraches to zero as time approaches to infinity.

Absolute Stability :

It refers to the condition whether the system is stable or unstable. The absolute stabiltiy can be determined form the locations of the roots of the characteristic equation in s-plane.

Relative stability :

Once the system is found to be stable, it is of interest to determine how stable it is, and this degree of stability is measure of relative stability. The term relative stability is used in relation to comparative analysis of the system. The maximum overshoot, damping ratio, gain margin, phase margin are measures to relative stability. Method to Determine Absolute stability

1. **Routh Hurwitz Criterion**

Method to determine relative stability

1. Root Locus
2. Polar Plot
3. Nyquist Plot
4. Bode Plot

28. It is evident from below figure that with increase in frequency of the signal at the input side, the shunt capacitive reactance decreases. This will allow more current to be returning back to the source through the low impedance path (dotted lines). At a higher frequency, the entire input current returns to the source through the shunt branch which becomes practically a short circuit link at this frequency.

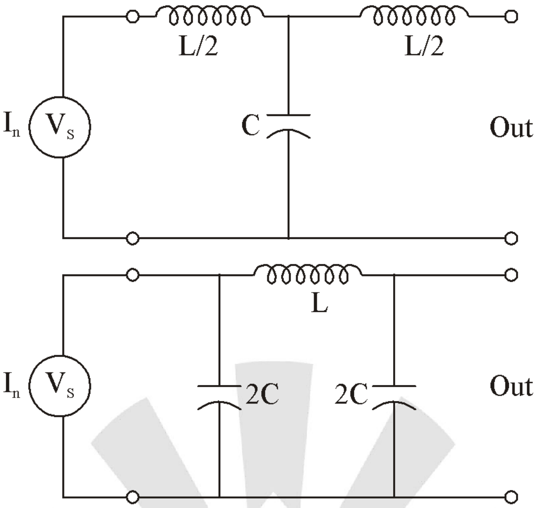


Figure : Low Pass filter section (T & π) at higher frequency

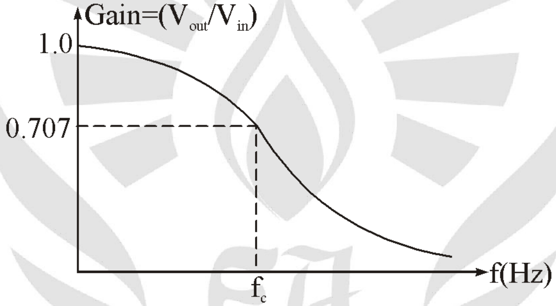


Figure : Filter response at different frequency

Thus it is evident that the low pass section can only allow passage of signal through it till the signal frequency is at lower magnitude. At high frequency, the inductive reactance in the series arm also increases to a very high value in practice, LPF operation is said to be satisfactory for increasing frequencies till the voltage gain is 0.707 p.u.

29. Wattmeter reading = 250 watts

Pressure coil circuit resistance,

$$R_p = 2000\ \Omega$$

Load voltage,

$$V_L = 200\ V$$

Power lost in pressure coil

$$= \frac{V_L^2}{R_p} = \frac{(200)^2}{2000} = 20 \text{ watts}$$

Since voltage coil is connected across the load side of the wattmeter. The power consumed by it is also included in the reading of the wattmeter and so power taken by the load is equal to wattmeter reading less power lost in the pressure coil circuit i.e.

$$250 - 20 = 230 \text{ watts}$$

30. Time, $T = 30 \text{ minutes} = \frac{1}{2} \text{ hour}$

Energy supplied

$$= \frac{VI}{1000} \times T \text{ kWh}$$

$$= \frac{220 \times 5}{1000} \times \frac{1}{2} = 0.55 \text{ kWh}$$

Consumption registered by the meter

$$= 525 \text{ Wh} = 0.525 \text{ kWh}$$

Percentage error $= \frac{0.525 - 0.55}{0.55} \times 100$

$$= -4.54\% \text{ i.e., } -4.54\% \text{ slow}$$

31. Voltmeter reading,

$$V = 80 \text{ V}$$

Ammeter reading,

$$I = 2 \text{ mA} = 0.002 \text{ A}$$

Voltmeter resistance

$$= 15 \times 10^3 \times 100 = 1500 \text{ k}\Omega$$

Apparent value of unknown resistor,

$$R_m = \frac{V}{I} = \frac{80}{0.002}$$

$$= 40000 \ \Omega \text{ or } 40 \text{ k}\Omega$$

Actual value of unknown resistor,

$$R_x = \frac{V}{I\left(1 - \frac{V}{IR_V}\right)}$$

$$= \frac{80}{0.002\left(1 - \frac{80}{0.002 \times 1500 \times 10^3}\right)}$$

$$= 41.096 \text{ k}\Omega$$

Error due to loading effect,

$$\varepsilon_v = \frac{R_m - R_x}{R_x} \times 100$$

$$= \frac{40 - 41.096}{41.096} \times 100$$

$$= -2.667\%$$

32. All the resistors used in a potentiometer, except the slide wire, are usually made of manganin owing to its high stability, low temperature coefficient and freedom from thermoelectric, effect, against copper.

[PART : C]

33. A single phase semiconverter bridge consist with two thyristor, two diode along with freewheeling diode as shown in figure, where load current is assume continous with RLE load.

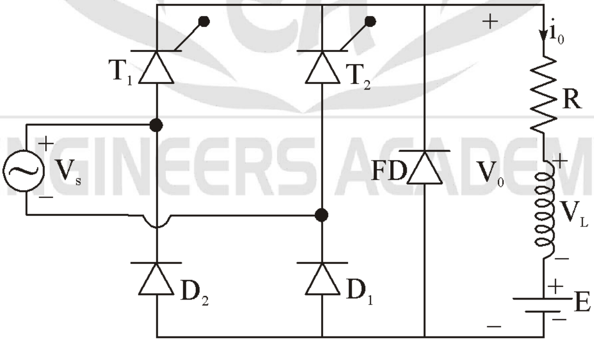


Figure: 1-ϕ Semiconverter Bridge

T_1 is forward biased only when $V_S = V_m \sin \omega t$ exceeds E and T_1 is triggered at a firing angle delay a such that $V_m \sin \alpha > E$.

When T_1 D_1 → ON i.e. load gets connected to V_s : Output voltage $V_o = V_S$ and $i_S = i_o$ after $\theta = \pi$, load voltage V_o tends to reverse as the AC source voltage changes polarity i.e. V_o tends to reverse (at $\theta = \pi+$) FD gets forward biased and starts conducting as shown in figure.

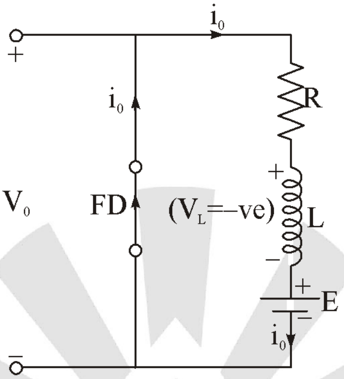


Figure : During FD Conduction

$\pi < \theta < (\pi + \alpha)$

The load current i_o is transferred from T_1D_1 to FD, as SCR T_1 is RB at $\omega t = \pi +$ through FD, T_1 is turned OFF at $\theta = \pi+$. i.e. At $\theta \geq \pi$; source voltage V_s = –ve half cycle load current start decreasing, voltage across inductor is V_L = Negative, FD → ON and T_1D_1 OFF. The load terminals are short circuit through FD so output voltage $V_o = 0$ during $\pi < \theta < (\pi + \alpha)$

After $\theta = \pi$, during the negative half cycle, T_2 will be FB only when source voltage V_s is more than E. At $\theta = \pi + \theta$, source voltage excess E, T_2 is therefore triggered soon after $(\pi + \alpha)$, FD is RB i.e. turned off; load current now shifts from FD to T_2D_2.

During the interval α to π; T_1D_1 → ON, V_s delivers energy to load this energy is partially stored in inductance L, partially stored as electric energy in load-circuit emf E and partially dissipated as heat in R.

During the freewheeling period π to $(\pi + \alpha)$, energy stored in inductance is recovered and is recovered and is partially dissipated in R and Partially added to the energy stored in load emf E. No energy feedback to the source during free wheeling period.

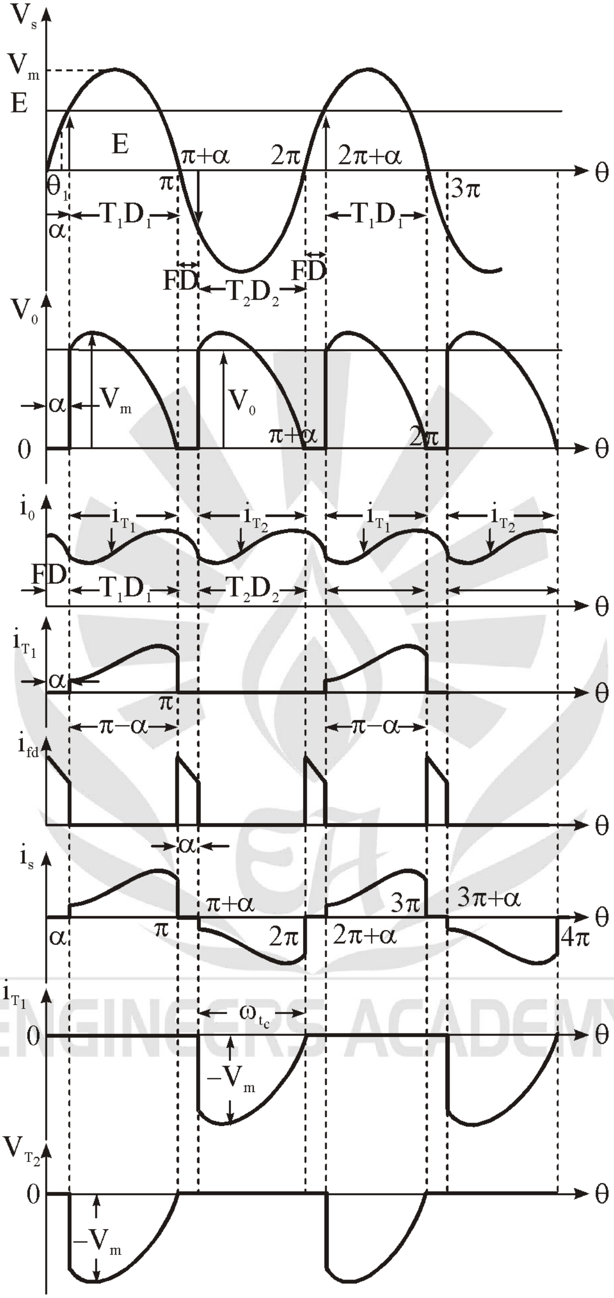


Figure : Voltage and Current Waveform for continuous load current

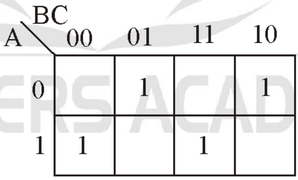
The average output voltage V_o

$$V_o = \frac{1}{\pi}\int_{\alpha}^{\pi} V_m \sin\theta \, d\theta = \frac{V_m}{\pi}(1+\cos\alpha)$$

34. A full adder is a combinational circuit that performs the arithmetic sum of three input bits. It consists of three input variables designated by aqugend, addend and the carry bit. The two output variables produce the sum and CARRY.

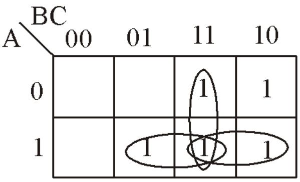
A	B	C	Sum	Carry
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Truth table for full order



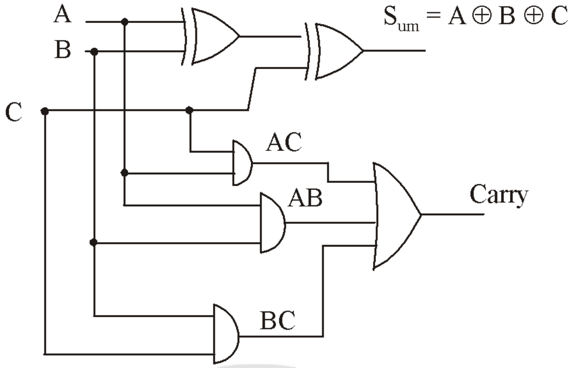
A \ BC	00	01	11	10
0		1		1
1	1		1	

Sum = A ⊕ B ⊕ C



A \ BC	00	01	11	10
0			1	1
1		1	1	1

Carry = AB + BC + CA



35. A point on the nyquist plot gives the magnitude of open loop transfer function $|G(j\omega)H(j\omega)|$ as well as its phase $\angle G(j\omega)H(j\omega)$ at a particular value of frequency ω. thus the nyquist plot also represents frequency response of $G(j\omega)H(j\omega)$ in polar form.

From the open-loop frequency response as given by the nyquist plot, the closed-loop frequency response of a unity feedback control system can be obtained. For a unity feedback system $H(j\omega) = 1$. the overall sinusoidal transfer function of a unity feedback control system is given by

$$\frac{C(j\omega)}{R(j\omega)} = \frac{G(j\omega)}{1+G(j\omega)} \qquad \ldots(1)$$

The frequency response (polar plot) for transfer function can be obtained as shown in figure.

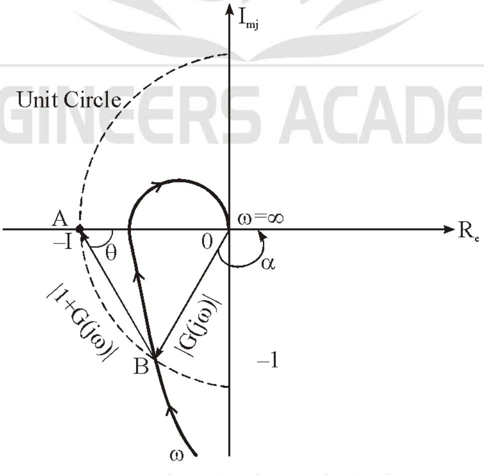


Figure : Nyquist Plot (Polar Plot) for transfer function

$$\overrightarrow{OB} = G(j\omega)$$

$$\overrightarrow{OA} = -1$$

$$\therefore \quad \overrightarrow{AB} = G(j\omega) - (-1) = 1 + G(j\omega)$$

$$\therefore \quad M(\omega) = \frac{C(j\omega)}{R(j\omega)} = \frac{G(j\omega)}{1+G(j\omega)}$$

$$M(\omega) = \frac{\overrightarrow{OB}}{|\overrightarrow{AB}|} \qquad \ldots(2)$$

$$\text{and } \angle\frac{C(j\omega)}{R(j\omega)} = \frac{\angle\overrightarrow{OB}}{\angle\overrightarrow{AB}} = \frac{\angle\alpha}{\angle\theta}$$

$$= \angle(\alpha - \theta) \qquad \ldots(3)$$

As per equation (2) and (3) the equation given below is obtained

$$\frac{C(j\omega)}{R(j\omega)} = me^{j\phi}$$

Where $\phi = (\alpha - \theta)$

The magnitude of $\frac{C(j\omega)}{R(j\omega)}$ is given by M and the phase by ϕ, by taking measurements of phasors $\overrightarrow{OB}, \overrightarrow{AB}$ and θ, α at different values of ω on nyquist plot the close-loop frequency response canbe obtained. The close-loop frequency response consist of two parts

(i) A graph between $\frac{|C(j\omega)|}{|R(j\omega)|}$ and ω.

(ii) A graph between $\angle\frac{C(j\omega)}{R(j\omega)}$ and ω.

The loci of constant magnitude and constant phase angle of close loop transfer function $\frac{C(j\omega)}{R(j\omega)}$ can be drawn in a complex G(jω)-phase and from these loci the closed loop frequency response can be obtained.

36. Time period of oscillation

$$= \frac{\pi}{\sqrt{\frac{1}{LC}-\left(\frac{R}{2L}\right)^2}} = \left[\frac{\pi}{\frac{10^3\times10^6}{6\times1.2}-\frac{100^2\times10^6}{4\times36}}\right]^{1/2}$$

$$= \frac{\pi}{1000(8.333)} = 0.377 \text{ ms}$$

Output frequency f

$$= \frac{1}{\frac{2\pi}{\sqrt{\frac{1}{LC}-\left(\frac{R}{2L}\right)^2}}+2T_{off}} = \frac{10^3}{0.377\times2+2\times0.2} = 866.55 \text{ Hz}$$

When $R = 40\Omega$ output frequency

$$= \frac{1}{\frac{2\pi}{\sqrt{\frac{10^3\times10^6}{6\times1.2}-\frac{1600\times10^6}{4\times36}}}+0.4\times10^{-3}} = 1046.2 \text{ Hz}$$

When $R = 140\ \Omega$ output frequency

$$= \frac{1}{\frac{2\pi}{\sqrt{\frac{10^3\times10^6}{6\times1.2}-\frac{140^2\times10^6}{4\times36}}}+0.4\times10^{-3}} = 239.8 \text{ Hz}$$

$\because$ Range of output frequency = 239.8 Hz to 1046.2 Hz

37. $L = (10 + 5\theta - 2\theta^2)\ \mu H$

$$\frac{dL}{d\theta} = (5 - 4\theta)\ \mu H \text{ per radian}$$

and also $\frac{dL}{d\theta} = \frac{2K\theta}{I^2}$

$$\therefore\ (5-4\theta)\times10^{-6} = \frac{2K\theta}{I^2}$$

Substituting $\theta = 30°$ or $\frac{\pi}{6}$ radian

and $I = 5$ A

in above expression, we have

$$\left(5-4\times\frac{\pi}{6}\right)\times10^{-6} = \frac{2K\times(\pi/6)}{(5)^2}$$

or $K = 69.36 \times 10^{-6}$ N-m/radian

i.e., Spring constant = 69.36×10^{-6} N-m/radian

Substituting $I = 10$ A and $K = 69.36 \times 10^{-6}$

we have,

$$(5 - 4\theta)\times10^{-6} = \frac{2\times69.36\times10^{-6}}{10^2}\theta$$

or $\theta = 0.928$ radian or 53.2°

38. Allowable maximum stress,

$$S_{max} = 3.0 \text{ kg/mm}^2 = 3.0 \times 10^6 \text{ kg/m}^2$$

Young's modulus of spring material,

$$E = 1.2 \times 10^4 \text{ kg/mm}^2$$

$$= 1.2 \times 10^{10} \text{ kg/m}^2$$

Width of spring,

$$w = 0.6 \text{ mm} = 0.0006 \text{ m}$$

As there are two controlling springs, the controlling torque caused by each spring is equal to half of the deflecting torque i.e. controlling torque of each spring,

$$T_c = \frac{1.2\times10^{-4}}{2}$$

$$= 0.6 \times 10^{-4} \text{ kg-m}$$

Let the length of spring strip be l metre and thickness of the spring strip be t metre

Deflection, $\theta = 90°$ or $\frac{\pi}{2}$ radians

Since torque exerted by the spring is given by the expression

$$T_c = \frac{Ewt^3\theta}{12l}$$

$$\frac{t^3}{l} = \frac{12T_c}{Ew\theta} = \frac{12\times0.6\times10^{-4}}{1.2\times10^{10}\times0.0006\times(\pi/2)}$$

$$= 0.63662 \times 10^{-10} \text{ m}^2 \qquad ...(1)$$

Since the stress developed in the spring must be well below the elastic limit of the spring material at the maximum deflection of the moving system in order to avoid fatigue and to preserve long period stability, maximum stress developed in the spring must be well below the elastic limit and is given by expression

$$\frac{l}{t} = \frac{E\theta}{2S_{max}} = \frac{1.2\times10^{10}\times(\pi/2)}{2\times3\times10^{6}}$$

$$= 3142 \qquad ...(2)$$

Multiplying expressions (1) and (2) we get

$$t^2 = 0.63662 \times 10^{-10} \times 3142 = 0.2 \times 10^{-6}\ m^2$$

or thickness of spring strip,

$$t = \sqrt{0.2\times10^{-6}} = 0.447 \times 10^{-3}\ m \text{ or } 0.45\ mm$$

Substituting $t = 0.447 \times 10^{-3}$ in expression (2) we get

$$l = 3142\ t = 3142 \times 0.447 \times 10^{-3} = 1.4\ m$$

39. Voltmeter sensitivity,

$$s = \frac{1}{I_{fsd}}\Omega/V = \frac{1}{50\times10^{-6}} = 20\ k\Omega/V$$

Meter internal resistance,

$$R_m = 100\ \Omega$$

0 - 5 V range:

Total resistance required,

R_T = Voltmeter sensitivity in kΩ/V × Full scale deflection voltage

$$= (20\ k\Omega/V) \times 5\ V = 100\ k\Omega$$

Additional resistance required,

$$R_1 = R_T - R_m = 100 - 0.1 = 99.9\ k\Omega$$

0 - 10 V range :

Total resistance required

$$= (20\ k\Omega/V) \times 10\ V = 200\ k\Omega$$

Additional resistance required,

$$R_2 = 200 - (R_1 + R_m) = 200 - (99.9 + 0.1) = 100\ k\Omega$$

0 - 50 V range :

Total resistance required,

$$= (20\ k\Omega/V) \times 50\ V = 1000\ k\Omega$$

Additional resistance required,

$$R_3 = 1000 - (R_m + R_1 + R_2)$$
$$= 1000 - (0.1 + 99.9 + 100) = 800\ k\Omega$$

0 - 500 V range :

Additional resistance required,

$R_4 = (20\ k\Omega/V) \times 500\ V - (R_m+R_1+R_2+R_3)$

$= 10000 - (0.1 + 99.9 + 100 + 800) = 9000\ k\Omega$

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