DETAILS EXPLANATIONS

EE : Paper-2 (Paper-4) [Full Syllabus]

[PART : A]

1. The transducer is defined as a device which, when actuated by one form of energy, is capable of converting it into another form of energy.

2. In this method a fixed DC input voltage is given to the inverter and a controlled AC output voltage is obtained by adjusting the ON and OFF periods of the inverter components.

3. The range of measuring instrument, as an ammeter, can be extended by connecting a low resistance across it. The greater part of the current in the main circuit is then diverted around the coil through the low resistance known as shunt.

4.
   - It is capable of improving steady state response characteristic of the system i.e. elimination of steady state error between input and output.
   - It shifts the gain crossover frequency to lower values where desired phase margin is acceptable.
   - it is analogous to low pass filter
   - it is similar to PI-Controller.

5. It is absolutely necessary that the shunt coil flux lags behind the voltage exactly by 90°.

   In order to cause the resultant flux in shunt magnet to lag in phase by exactly 90° behind the applied voltage, one or more copper rings, known as copper shading bands, are provided on one limb of the shunt magnet.

6.
$$m = \sqrt{5}\sin(2000\pi t + \tan^{-1}0.5)$$

$$\frac{\Delta}{T_s} > \left|\frac{dm}{dt}\right|_{max}$$

$$\Delta > \frac{1}{f_s}\times\sqrt{5}\times 2000\pi$$

$$\Delta > \sqrt{5}\times 2\pi \text{ volts}$$

7. Hay bridge is not suited for the measurement of low Q-factor of the inductors because in that case it is required to know the bridge frequency to a very accurate limit and also with low value of Q-factor, it gives poor convergence in balancing.

8. ***Advantages of free wheeling diode :***

- The power factor is improved.
- The smoothness of output current waveform is improved i.e. extinction angle of load current (β) is increases.
- The performance of converter is improved due to free wheeling action.
- The power factor of semiconverter is better than full converter because its free wheeling action.
- Average output voltage is increases.

9. The full load speed of the rotating disc in energy meter is kept as small as possible so that the self-braking is kept as small as possible so that the self-braking action is reduced to minimum.

10. ***Principle of superposition :***

It states that the response produces by the simultaneous application of two different forcing function is the sum of the two individual response.

11. Average output voltage for resistive load

$$V_0 = \frac{3V_m}{\pi}\cos\alpha \qquad \text{...(1)}$$

Maximum possible output voltage $= \frac{3V_m}{\pi}$

Average output voltage = 50% of maximum possible output voltage

$$\Rightarrow \quad \frac{1}{2}\times\frac{3V_m}{\pi} = \frac{3V_m}{\pi}\cos\alpha$$

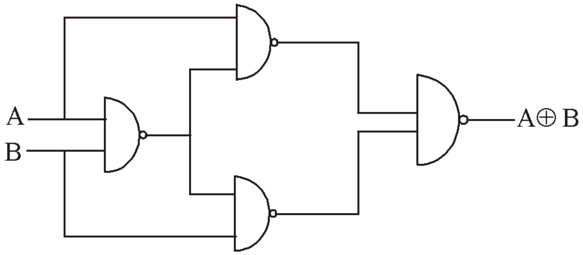
$$\cos\ \alpha = \frac{1}{2}$$

$$\alpha = \cos^{-1}(1/2)$$

$$\alpha = 60°$$

12. External noise may be defined as that type of noise which is generated external to a communication system i.e. whose sources are external to the communication system. External noise cannot be analysed quantitatively.

13.



14. Internal noise may be classified as under :

(i) Shot noise

(ii) Partition noise

(iii) Low frequency or Flicker noise

(iv) High frequency or transit time noise

(v) Thermal noise.

15. ***Applications of Power Electronics :***

- Speed control of electronic motor (variable speed drives, adjustable speed devices).

  Adjustable speed motor is more efficient than fixed speed control motor.
- Power electronic devices can be used for reactive power compensation for falling voltage, we need a capacitor and for over voltage we need inductor.
- Transportation : Rail-electric traction (AC-25 kV) 1-ϕ 50Hz and DC series motor is used in traction.
- Low Power Application : Domestic Level = Fans, Lightening, Battery Charge.
- Solar Power Generated is DC power and we need to convert DC to AC to drive AC load.

16. The gain margin is a factor by which the gain of stable system is allowed to increase before the system reaches to the verge of instability.

17. Photoelectric transducers operate on the principle of photoelectric effect, that is the relationship between collection of light energy and reflections of electrons from a metal.

18. LVDT is a differential transformer consisting of one primary winding P and two identical secondary windings S_1 and S_2 wound over a hollow bobbin of non-magnetic and insulating material. The secondary windings S_1 and S_2 are arranged concentrically and placed either side of the primary winding P.

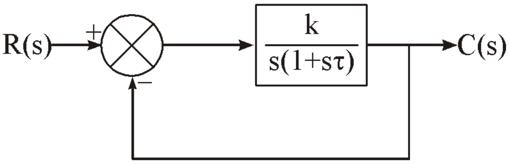
19. Electrical methods are preferred for measurement of non electrical quantities as they make it possible to measure continuously practically any non electrical quantity, transmit the obtained data over any distance and characterised by high accuracy and sensitivity.

20. Various types of oscilloscope probes are :

Direct probe, HF probe, Isolation probe, High impedance or 10 : 1 probe, Active probe and current probe.

[PART : B]

21. Characteristic equation



$$\tau s^2 + s + k = 0$$

$$s^2 + \frac{s}{\tau} + \frac{k}{\tau} = 0$$

$$\omega_n = \sqrt{\frac{k}{\tau}}$$

$$\xi = \frac{1}{2\sqrt{k\tau}}$$

Velocity error constant,

$$k_v = \lim_{s\to 0} G(s)H(s)$$

e_{ss}(steady state error) $= \frac{1}{k_v} = \frac{1}{k}$

When gain k is increased.

- ω_n increase, damping ratio reduces, stability reduces.
- Oscillation increases, peak over shoot increase, resonant peak increases.
- Error constant increases and steady state error decreases. Therefore steady response improves.

22. $S(t) = k^2a(X(t)+A_c\cos\omega_c t)^2 - b(X(t)+A_c\cos\omega_c t)^2$

$= X^2(t)(ak^2-b)+(A_c\cos\omega_c t)^2(ak^2-b)+ 2A_cX(t)\cos\omega_c t)(ak^2 + b)$

To generating DSB – SC frist two terms should be zero

$$ak^2 - b = 0$$

$$\Rightarrow \qquad k = \pm\sqrt{\frac{b}{a}}$$

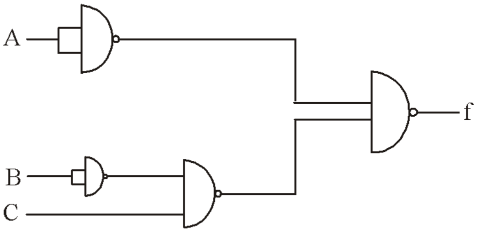
$$S(t) = 4bA_c x(t)\cos\omega_c t = \text{DSB-SC}$$

23. The CT is designed with a view to minimize the current ratio and phase angle errors and for small errors it is necessary to keep magnetizing and energy components of exciting current small. Magnetizing component of the exciting current is made small by keeping reluctance of the magnetic path low while the energy or power loss component of exciting current is made small by employing relatively low values of flux density.

24.

$$f = \overline{\overline{A + \bar{B}C}}$$

$$f = \overline{\bar{A}\cdot\overline{\bar{B}\cdot C}}$$

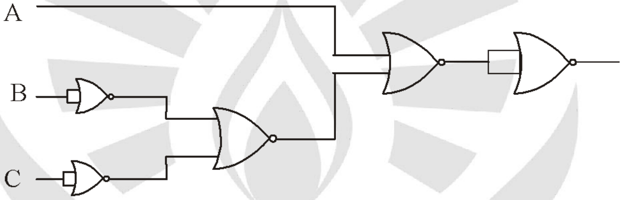


How many number of two input NOR gates are required to implement

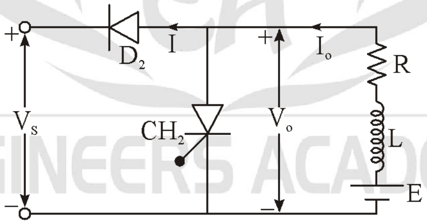
$$g(A, B, C) = A + BC$$

$$g = A + \overline{\overline{BC}}$$

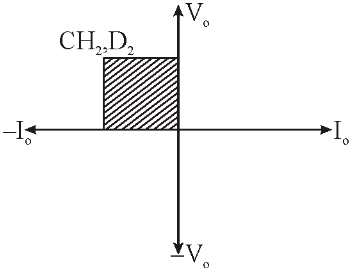
$$g = A + \overline{\bar{B} + \bar{C}}$$



25. In second quadrant $P = V_o I_o$ = Negative. So, power flow is form load to source, hence load must contain a DC source E_1 like a battery (or A DC motor) in this chopper, as shown in figure.



During T_{ON} i.e. $0 < t < T_{ON}$ CH_2 is fired. So D_2 is kept reversed biased due to V_s inloop (1)



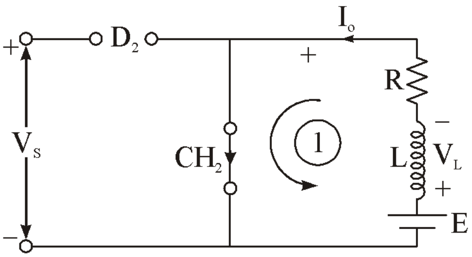
$$V_o = 0 = -E + V_L + Ri_o = 0$$

$$\Rightarrow -E + L\frac{di_o}{dt} + Ri_o = 0$$

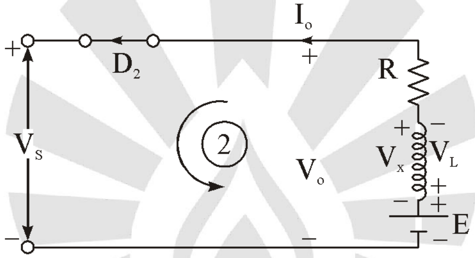
$$\Rightarrow \frac{di_o}{dt} = \frac{1}{L}(E - i_oR)$$

As $E - i_oR > 0$

$$\Rightarrow \frac{di_o}{dt} = \text{Positive}$$



- I_o increases so L stored energy from E. During T_{OFF} i.e., $T_{ON} < t < 0$ CH_2 is commutated, as i_o decreases



$$\Rightarrow \frac{di_o}{dt} = \text{Negative}$$

$$\Rightarrow V_L = L\frac{di_o}{dt} = \text{Negative say } V_L = V_x$$

As $E + V_x > V_s$

$D_2 \rightarrow$ ON

$V_o = V_s$

Using KVL in loop(2)

$$-E + V_L\ Ri_o + V_S = 0$$

$$\Rightarrow -E + L\frac{di_o}{dt} + Ri_o + V_S = 0$$

$$\Rightarrow \frac{di_o}{dt} = -\frac{1}{L}[(V_s + Ri_o) - E]$$

As $V_s + Ri_o > E \Rightarrow \frac{di_o}{dt} = \text{Negative}$

- i_o decrease so stored energy from L and energy form E is delivered to the source V_s. For this operation E must satisfy the condition $i_o R < E < V_s + i_oR$.

- When CH_2 is ON, $V_o = 0$ but load voltage E drives current through L and CH_2. Inductance L stores energy during T_{ON} of CH_2.

When CH_2 is off, $V_o = \left(E + L\frac{di_o}{dt}\right) > V_s$, stored energy of L is given to supply and $V_o > V_s$ like step up chopper.

26. Compensation for variations in supply voltage is provided by using a saturable magnet shunt which diverts a larger proportion of flux into the active path when the supply voltage increases. Such compensation can be conveniently achieved by restricting the section of the closing members of the shunt magnet core, or sometimes by saturable pieces bridged across the main poles of this core.

27. We know that the total power is expressed as

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

where, P_t = Total power or modulated power.

P_c = Carrier power or unmodulated power

m_a = Modulation index

Given that, $P_t = 10$ kW

$m_a = 60$ percent $= 0.6$

From equation (i), we get

$$P_c = \frac{P_t}{1+\frac{m_a^2}{2}} = \frac{10}{1+\frac{0.6^2}{2}} = \frac{10}{1.18}$$

$$P_c = 8.47 \text{ kW}$$

28. Status Register/Flag Register

- It is a 8 bit special purpose user accessable register
- It uses 8 Flip-flops
- Number of flags in 8085 μp are five and they are given by carry (cy), parity (P), Auxilary carry (AC), zero (Z) and sign flag (S).

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
S	Z	X	AC	X	P	X	Cy

Cy → is '1' when carry present in addition or borrow present in subtraction otherwise zero

P → is '1' when even no. of 1's present in result otherwise zero

Ac → is '1' when carry transfer from D_3 to D_4 bit position during addition or subtraction operation.

Z → is ‘1’ when result is ‘0’ otherwise z = ‘0’

S → is 1 for negative number where S = MSB

S → is 0 for positive number

29. V = 230 V; I = 10 A; p.f. = 1

1150 revolution in 2 hours.

So, meter constant

$$k = \frac{1150 \times 1000}{2 \times 230 \times 10 \times 1} \frac{\text{rev}}{\text{kwh}}$$

$$k = 250 \text{ rev/kwh}$$

Now, pf = 0.8

$$p = 230 \times 10 \times 0.8 = 1840 \text{ W}$$

$$p = 1.84 \text{ kW}$$

So, number of revolution = 250 × 1.84 = 460 rev/hour

But in 2 hours it is = 2 × 460 = 920 rev in 2 hours.

30. P = Number of open loop poles in right side of s-plane

Z = Number of closed loop poles in right side of s-plane

N = Number of encirclement of critical point (–1 + j 0)

- Clockwise encirclement is taken as negative.
- Anticlockwise encircrement is taken as positive

Applying N = P–Z

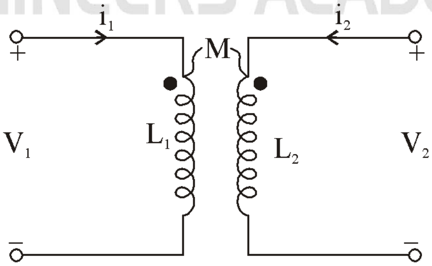
The Value of P can be inspected directly from the given open loop transfer function and the value of N can be found after plotting the Nyquist path in P(s) plane.

So, after putting the values of P and N, the value of Z can be calculated

If Z > 0 Closed loop system is unstable

Z = 0 Closed loop system is stable

31. Consider two matually coupled coils, with self inductance L_1, L_2 and matual inductance M as shown in figure.



According to the faraday’s law of inductance, a current i changing with time in one coil induces a voltage, $M\frac{di}{dt}$ in the second coil.

$$\therefore \quad V_1(t) = L\frac{di_1}{dt} \pm M\frac{di_2}{dt} \text{ and}$$

$$V_2(t) = \pm M\frac{di_1}{dt} + L_2\frac{di_2}{dt}$$

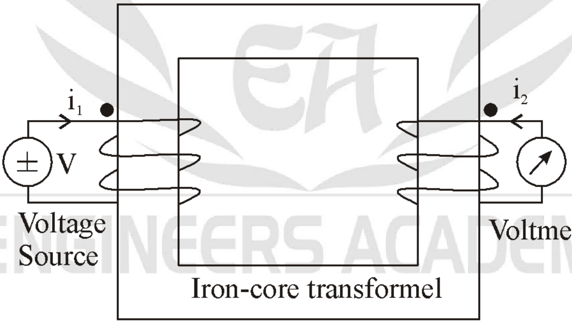
Where $M = k\sqrt{L_1L}$ and k is called the cofficient of coupling $0 < k \leq 1$. To indicate the polarity of the induced voltage (+ve or –ve). Polarity marks indiciated by dots are placed on the terminals of the coils.

The convention is dotted terminals have the same polarity. If both currents are flowing into the dots, or away from the dots, then the sign of the matual voltage term is $M\frac{di}{dt}$ is positive.

When one current flows into first dot and other current flows away from the second dot and vice-versa, then the sign of $M\frac{di}{dt}$ is negative.

Two coils wound on a common magnetic core is shown in figure. The dot or polarity marks are also shown.

The experiment to determine the DOT reference is also illustrated in figure.



An experiment to determine dot references.

32. One of the main problem in high resistance measurement is the leakage that occurs over and around the component or specimen under test, or over the binding post by which the component is attached to the instrument or within the instrument itself. Other problems are stray changes, absorption effects of insulating materials and variation in insulation resistance of insulating materials with the change in temperature.

[PART : C]

33. Deflection torque,

$$T_d \propto I^2$$

(i) In Spring controlled instruments

Since controlling torque,

$$T_c \propto \theta$$

deflection, $\theta \propto I^2$

or $$\frac{\theta_2}{\theta_1} = \left(\frac{I_2}{I_1}\right)^2$$

or deflection for 3 A current,

$$\theta_2 = \theta_1 \times \left(\frac{I_2}{I_1}\right)^2 = 90° \times \left(\frac{3}{5}\right)^2 = 32.4°$$

(ii) In gravity controlled instruments

Since controlling torque

$$T_c \propto \sin\theta$$

$$\sin\theta \propto I^2$$

or $$\frac{\sin\theta_2}{\sin\theta_1} = \left(\frac{I_2}{I_1}\right)^2$$

or deflection for 3 A current,

$$\theta_2 = \sin^{-1}\left[\left(\frac{I_2}{I_1}\right)^2 \sin\theta_1\right] = \sin^{-1}\left[\left(\frac{3}{5}\right)^2 \times 1\right]$$

$$= \sin^{-1}(0.36) = 21.1°$$

34. System differential equation is

$$\frac{d^2y}{dt^2} + 4\frac{dy}{dt} + 8y = 8x$$

to final T.F. $\frac{Y(s)}{X(s)}$ take laplace transform from above equation and neglect initial conditions.

$s^2Y(s) + 4s\,Y(s) + 8Y(s) = 8X(s)$

$\Rightarrow Y(s)[s^2 + 4s + 8] = 8X(s)$

$$\Rightarrow \text{T.F. } \frac{Y(s)}{X(s)} = \frac{8}{s^2+4s+8}$$

Comparing this with standard T.F. of second order system.

$$\frac{\omega_n^2}{s^2 + 2\xi\omega_n^2 s + \omega_n^2}$$

$$\omega_n^2 = 8 \Rightarrow \omega_n = \sqrt{8} \text{ rad/sec}$$

$$2\xi\omega_n = 4 \therefore \xi = 0.7067$$

$$\phi = \tan^{-1}\sqrt{\frac{1-\xi^2}{\xi}} = 450^\circ = \frac{\pi}{4} \text{ rad}$$

$$\omega_d = \omega_n\sqrt{1-\zeta^2} = 2.83\sqrt{1-(0.7067)^2}$$

$$= 2.002 \text{ rad/sec}$$

$$\text{Rise time } t_r = \frac{\pi-\phi}{\omega_d} = \frac{\pi-\pi/4}{2} = \frac{3\pi}{8} \text{ sec}$$

Time for peak over shoot

$$t_p = \frac{\pi}{\omega_d} = \frac{\pi}{2.002} = 1.57 \text{ sec}$$

$$\%M_p = e^{-\pi\xi\sqrt{1-\xi^2}} \times 100$$

$$= e^{-\pi 0.7067\sqrt{1-(0.7067)}} \times 100 = 4.33\%$$

$$t_s = \text{Settling time} = \frac{4}{\xi\omega_n}$$

$$= \frac{4}{0.7067 \times 2.83} = 2 \text{ sec}$$

$$c(t) = 1 - \frac{e^{-\xi w_n t}}{\sqrt{1-\xi^2}}\sin(\omega_o t + \phi)$$

$$= 1 - 1.41e^{-2t} \sin\left(2t + \frac{\pi}{4}\right)$$

35. ***Classification of Communication :***

Regarding the mode of propagation, communication may be divided in the following two forms:

(i) Line Communication :

In line communication, the medium of transmission is a pair of conductors called transmission line. This is also called as line channel. This means that in line communication, the transmitter and and the receiver are connected through a wire or line. However, the installation and maintenance of a line is not only costly and complex but also overcrowds the open space. Apart from this message transmission capability is also limited.

(ii) Wireless or Radio Communication :

In wireless or radio communication, a message is transmitted through open space by electromagnetic waves called as radio waves. Radio waves are radiated from the transmitter in open space through a device called antenna. A receiving antenna intercepts the radio waves at the receiver. All the radio TV and satellite broadcasting are wireless or radio communication. The advantages of wireless communication are cost effectiveness, possible long distance communication and simplicity.

Advantages and Disadvantages of Digital Communication :

Advantages :

- The digital communication systems are simpler and cheaper compared to analog communication systems because of the advances made in the IC technologies.
- In digital communication, the speech, video and other data may be merged and transmitted over a common channel using multiplexing.
- Using data encryption, only permitted receivers may be allowed to detect the transmitted data. This property is of its most importance in military applications.
- Since the transmission is digital and the channel encoding is used, therefore the noise does not accumulate from repeater to repeater in long distance communications.
- Since the transmitted signal is digital in nature, therefore a large amount of noise interference may be tolerated.
- Since in digital communication, channel coding is used, therefore the errors may be detected and corrected in the receivers.
- Digital communication is adaptive to other advanced branches of data processing such as digital signal processing, image processing and data compression etc.

Disadvantages :

Although digital communication offers, so many advantages as discussed above, it has some drawbacks also. However, the advantages of digital communication outweight disadvantages.

The disadvantages are as under :

- Due to analog to digital conversion, the data rate becomes high. Therefore more transmission bandwidth is required for digital communication.
- Digital communication needs synchronization in case of synchronous modulation.

36. Current drawn by instrument when connected across 300 V AC,

$$I_{AC} = 100 \text{ mA} = 0.1 \text{ A}$$

At 50 Hz supply

Instrument reactance,

$$X_L = 2\pi f L = 2\pi \times 50 \times 0.8 = 251.33\ \Omega$$

Instrument impedance,

$$Z = \frac{V_{AC}}{I_{AC}} = \frac{300}{0.1} = 3000\ \Omega$$

Instrument resistance,

$$(R + r) = \sqrt{Z^2 - X_L^2}$$

$$= \sqrt{(3000)^2 - (251.33)^2} = 2989.45\ \Omega$$

Instrument current when connected to 200 V DC supply,

$$I_{DC} = \frac{V_{DC}}{R + r} = \frac{200}{2989.45} = 0.0669 \text{ A}$$

Reading of instrument when connected to 200 V DC supply,

$$= \frac{\text{Current with 200 V DC supply} \times \text{Reading with 300V AC}}{\text{Current with 300 V AC}}$$

[$\because$ Deflection is proportional to operating current]

$$= 0.0669 \times \frac{300}{0.1} = 200.7 \text{ V}$$

Percentage error,

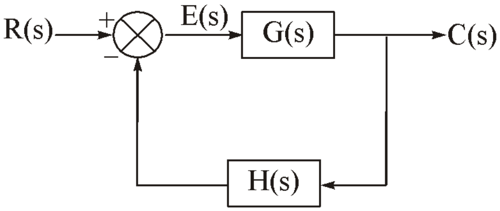
$$= \frac{\text{Measured Value} - \text{True value}}{\text{True value}} \times 100$$

$$= \frac{200.7 - 200}{200} \times 100 = 0.35\%$$

37. As the steady state error for a control system is considered during the steady state period, the error is also called static error. For evaluating steady state error. The input function is specified as either unit step (displacement)or unit ramp (velocity) or unit parabolic (acceleration).

The steady state error is defined as

$$e_{ss} = \lim_{t \to \infty} e(t)$$



If the steady state response of the output does not agree with the desired reference exactly. The system is said to have steady state error.

$$E(s) = R(s) - H(s)C(s)$$

$$E(s) = R(s) - H(s)G(s)E(s)$$

$$\Rightarrow [1+G(s)H(s)]E(s) = R(s)$$

$$\Rightarrow \quad E(s) = \frac{R(s)}{1+G(s)H(s)}$$

$$e_{ss} = \lim_{s\to 0} SE(s) \qquad \ldots(1)$$

Static error coefficients associated with inputs are determined below:

- ***Static Positional Error Coefficient :***

Static positional error Co-efficient k_p is associated with unit step input applied to a close-loop control system and is determined below:

$$e_{ss} = \lim_{s\to 0} \frac{sR(s)}{1+G(s)H(s)} \qquad \ldots(2)$$

As the input is $R(s) = \frac{1}{s}$

$$e_{ss} = \lim_{s\to 0} s.\frac{1}{s}\frac{1}{[1+G(s)H(s)]} = \frac{1}{1+\lim_{s\to 0} G(s)H(s)}$$

Put $k_p = \lim_{s\to 0} G(s)H(s)$

k_p is called static positional error cofficient, therefore

$$e_{ss} = \frac{1}{1+k_p} \qquad \ldots(3)$$

- ***Static velocity error Coefficient :***

It is associated with unit ramp input applied to a closed-loop control system and is determined below :

$$e_{ss} = \frac{sR(s)}{1+G(s)H(s)}$$

As the input is $R(s) = \frac{1}{s^2}$

So, $$e_{ss} = \lim_{s\to 0} s\frac{1}{s^2}\frac{1}{1+G(s)H(s)} = \lim_{s\to 0} \frac{1}{s+sG(s)H(s)}$$

$$= \lim_{s\to 0} \frac{1}{sG(s)H(s)} \qquad \ldots(4)$$

Put $k_v = \lim_{s\to 0} sG(s)H(s)$,

k_v is called static velocity error coefficient.

$$\text{Therefore, } e_{ss} = \frac{1}{k_v} \qquad \text{...(5)}$$

- ***Static Acceleration Error Coefficient :***

  It is associated with unit parabolic input applied to a closed-loop control system and is determined below :

$$e_{ss} = \lim_{s\to 0} sR(s)\frac{1}{[1+G(s)H(s)]}$$

As the input

$$R(s) = \frac{1}{s^3}$$

Then

$$e_{ss} = \lim_{s\to 0} s.\frac{1}{s^3}\frac{1}{[1+G(s)H(s)]}$$

$$e_{ss} = \lim_{s\to 0}\frac{1}{s^2+s^2G(s)H(s)} = \lim_{s\to 0}\frac{1}{s^2G(s)H(s)}$$

Put $k_a = \lim_{s\to 0} s^2G(s)H(s)$, k_a is called static acceleration error coefficient, therefore,

$$e_{ss} = \frac{1}{k_a}$$

38. Three phase balance supply is given to the three input terminals A, B, C and a free wheeling diode FD, in parallel with RLE load is connected across the output terminals of the semiconverter as shown in figure.

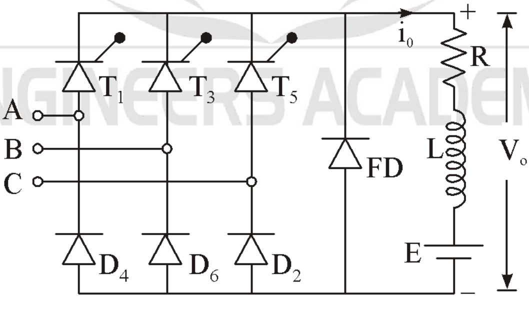


Figure : 3-Phase semiconverter with RLE load

The output voltage V_o across the load terminals is controlled by varying the firing angles of SCRs T_1, T_3 and T_5. The diode D_4, D_6 and D_2 provide merely a return path for the current to the most negative line terminals for a firing angle delay of $\alpha = 0^\circ$, thyristor

T_1, T_3, T_5 would behave as diodes and the output voltage of semiconverter would be symmetrical six-pulse per cycle. For a firing angle delay of $\alpha = 15^o$, the triggering of SCR T_1, T_2, T_3 is delayed but return diode D_1, D_2, D_3 remain an affected so that only alternate pulse are obtained. The load current is continious and has little ripple.

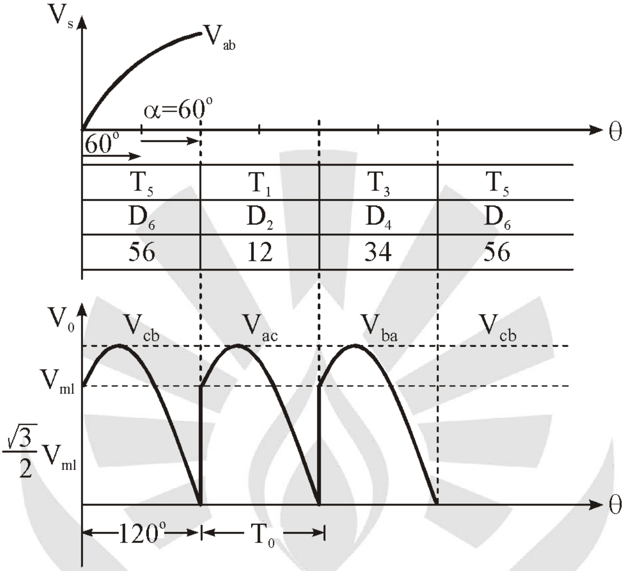


Figure: Waveform for $\alpha = 60^o$

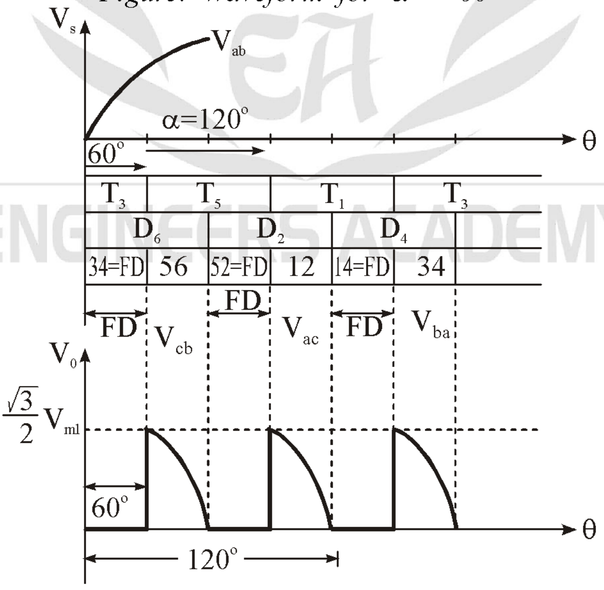


Figure : Wave Form for $\alpha = 120^o$

The freewheeling diode does not come into play for $\alpha = 15°$, each SCR and diode conduct for 120°.

For voltage V_{ac}, T_1 and D_3 conduct simultaneously for 120°. Similarly, other elements conduct. FD does not come into play for $\alpha \leq 60°$.

For $\alpha \leq 60°$ conduction pattern of only thyristor T_1, T_3 and T_5 gets shifted while that of D_2, D_4 and D_6 remains same.

For $\alpha < 60°$ it behaves as 6-pulse converter and least ripple frequency $f_o = 6f$.

For $\alpha \geq 60°$ it behaves as 3-pulse converter and least ripple frequency $f_0 = 3f$.

For $\alpha = 120°$ whenever same phase T & D i.e. T_3D_4, T_5D_2 & T_1D_4 appears in the conduction pattern it represents short circuit of load i.e. conduction of FD.

For $\alpha > 60°$ FD conduct during $(\alpha - 60°)$ in each cycle of output (i.e. 120°).

As V_o reaches zero and tends to become negative, FD gets forward biased and therefore starts conducting for same angle and helds the load voltages to zero. When all the energy stored in inductance is discharge, FD stops conducting and as result, load voltage rises to load counter emf E. When $V_o = E$, none of the elements of semi converter bridge is conducting.

It may be seen from above that in a 3-phase semiconverter, SCRs are gated at an interval of 120° in a proper sequence in order to obtain full control of the DC output voltage V_o, the range of firing angle is from 0° to 180°.

It has the unique feature of working as a six-pulse converter for $\alpha < 60°$ and as a three pulse converter for $\alpha \geq 60°$.

For a 3-phase semiconverter, each periodic cycle of output voltage has a peridicity of 120°. Average output voltage should, therefore, be calculate over 120° only.

Average output voltage

$$V_o = \frac{3V_{ml}}{2\pi}(1 + \cos\alpha)$$

39. Fixed resistance,

$$R_4 = 1000\ \Omega$$

Fixed capacitance,

$$C_3 = 50\ \text{pF} = 50 \times 10^{-12}\ \text{F}$$

Unknown capacitance,

$$C_1 = \frac{\varepsilon_r \varepsilon_0 A}{d}$$

$$= \frac{2.3 \times 8.854 \times 10^{-12} \times 314 \times 10^{-4}}{0.3 \times 10^{-2}} = 213.15 \text{ pF}$$

$$\tan\delta = \frac{1}{\omega C_1 R_1}$$

So unknown resistance,

$$R_1 = \frac{1}{\omega C_1 \tan\delta} = \frac{1}{2\pi \times 50 \times 213.15 \times 10^{-12} \times \tan 9^\circ} = 94.3 \text{ M}\Omega$$

Variable capacitor,

$$C_4 = \frac{1}{\omega^2 C_1 R_1 R_4} = \frac{1}{(2\pi \times 50)^2 \times 213.15 \times 10^{-12} \times 94.3 \times 10^6 \times 1000}$$

$= 0.5\ \mu F$

Variable resistance,

$$R_2 = \frac{C_3 R_4 \cos^2\delta}{C_1} = \frac{50 \times 10^{-12} \times 1000 \times (\cos 9^\circ)^2}{213.15 \times 10^{-12}} = 230\ \Omega$$

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