Swami Keshvanand Institute of Technology, Management & Gramothan,
Ramnagaria, Jagatpura, Jaipur-302017

Question Paper Solution

Branch : ECE Semester: VI Subject: MW-II Midterm: I
Submitted By : Praveen Saraswat, Shubhi Jain

Q-1 (1) $Z_0 = 50\,\Omega$ $V_{max} = 2.5\,V$ $V_{min} = 1\,V$

$\frac{\lambda_g}{2} = 5\,cm$

Determine Load Impedance using Smith Chart when shift in minima is 1.25cm.

(I) when the line is shorted

① Plot SWR Circle for VSWR = 2

② $\lambda_g = 10\,cm$, minima = 1.25cm.

$\frac{d}{\lambda_g} = .125$

move $.125\lambda$ Toward the generator from S.C.

③ Draw a line from that point to the center of the Chart

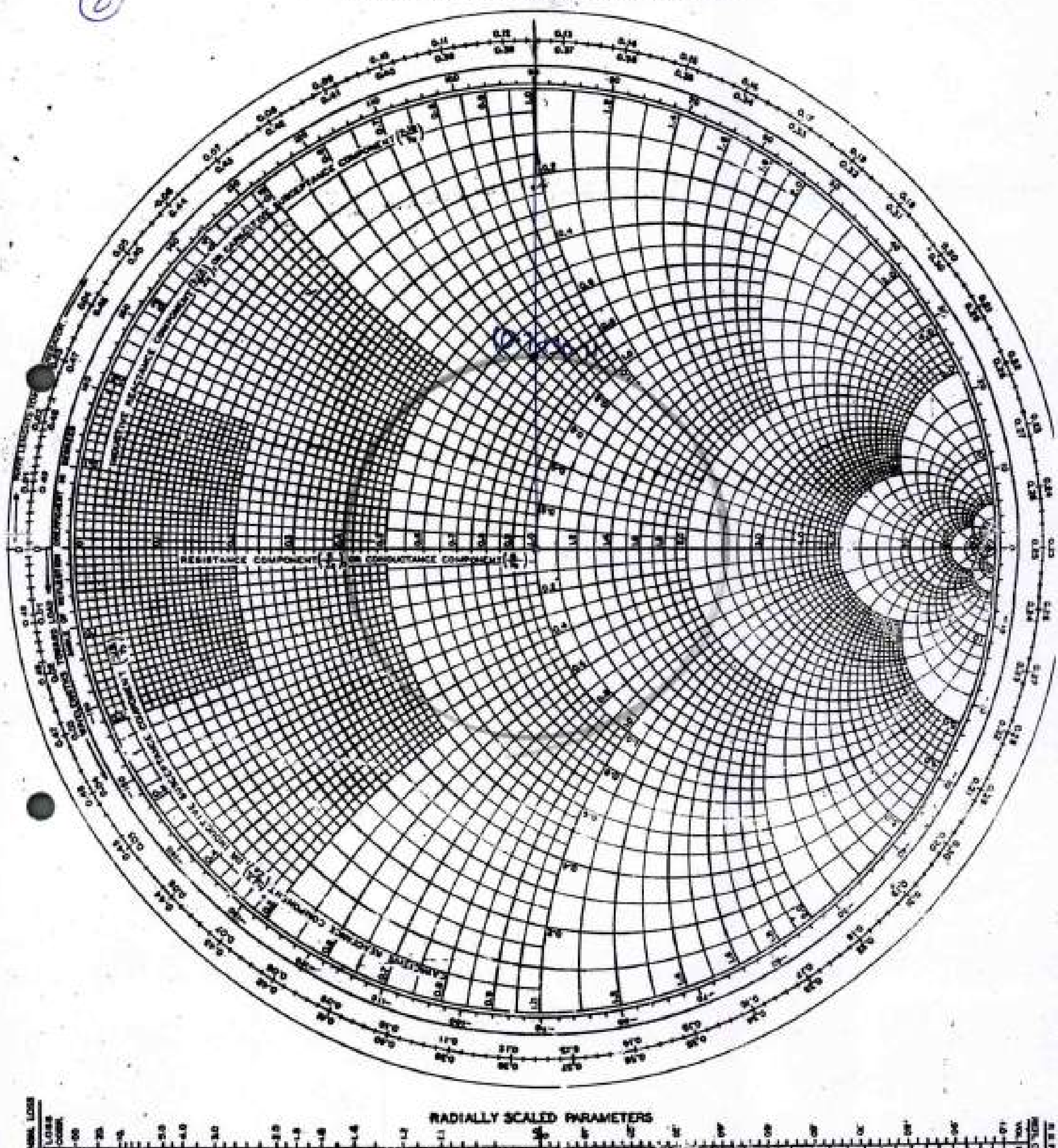
④ Locate the Intersection : $Z_{LN} = 0.7 + j0.7$

$Z_L = (0.7 + j0.7) \times 50 = 35 + j35$

SMITH-CHART

②

IMPEDANCE OR ADMITTANCE COORDINATES



CENTER

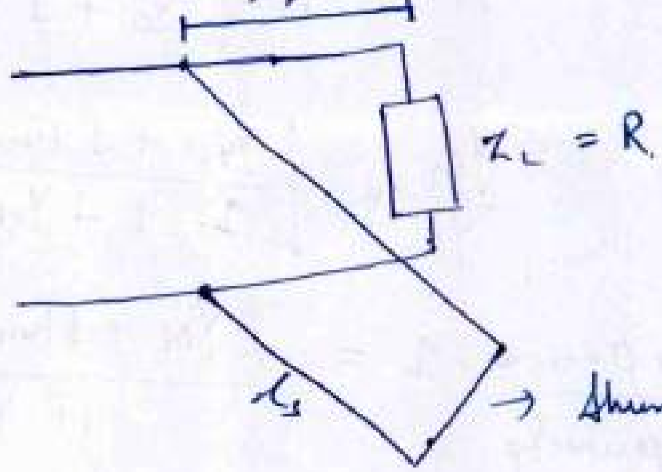
2.

(3)

Q2-1 STUB Matching:

A stub is a short circuit / open circuit line of a precalculated length placed at the precalculated position, so that the line is matched from the stub to the source.

Suppose we have a mismatched load



l_p : position of stub from load.
l_s : length of the stub

4

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Considering admittance $Y_L = Y_R$.

For no reflection at know

$$\Gamma = 0 = \frac{Z_L - Z_0}{Z_L + Z_0}$$

$$\text{i.e } \frac{Z_L}{Z_0} = 1$$

$$Y_{in} = Y_0 \left[\frac{Y_R + j Y_0 \tan\beta l}{Y_0 + j Y_L \tan\beta l} \right]$$

$$\frac{Y_{in}}{Y_0} = \left[\frac{Y_N + j \tan\beta l}{1 + j Y_N \tan\beta l} \right]$$

For $\Gamma = 0$ at position l_p

$$1 = \frac{(Y_N + j\tan\beta l_p)(1 - jY_N \tan\beta l_p)}{1 + Y_N^2 \tan^2\beta l_p}$$

$$1 + Y_N^2 \tan^2\beta l_p = Y_N + j\tan\beta l_p - jY_N^2 \tan\beta l_p + Y_N \tan^2\beta l_p$$

Eq. Real and Imaginary.

$$(1 - Y_N) = Y_N \tan^2\beta l_p (1 - Y_N)$$

$$\beta l_p = \tan^{-1}\sqrt{\frac{1}{Y_N}}$$

(6)

$$\left\{ l_p = \frac{1}{2\pi} \tan^{-1} \sqrt{\frac{1}{Y_M}} \right\}$$

Suppose we are getting susceptance of $\frac{b_s}{Y_0}$ due to load at position l_p.

$$\frac{b_s}{Y_0} = \frac{(1 - Y_M^2) \tan \beta l_p}{(1 + Y_M^2) \tan^2 \beta l_p}$$

$$\tan \beta l_p = \sqrt{\frac{1}{Y_M}}$$

$$\frac{b_s}{Y_0} = \frac{\left(1 - \left(\frac{Y_L}{Y_0}\right)^2\right) \sqrt{\frac{Y_0}{Y_L}}}{1 + \left(\frac{Y_L}{Y_0}\right)^2 \cdot \frac{Y_0}{Y_L}}$$

$$\frac{b_s}{Y_0} = \frac{(Y_0 - Y_L)}{Y_0} \sqrt{\frac{Y_0}{Y_L}}$$

$$\left[b_s = (Y_0 - Y_L) \sqrt{\frac{Y_0}{Y_L}} \right]$$

(13)

this Susceptance Bs, can be removed by adding a shunt stub of length l_t.

$$Y_{sc} = -jY_0 \cot \beta l$$

at length $l = l_t$

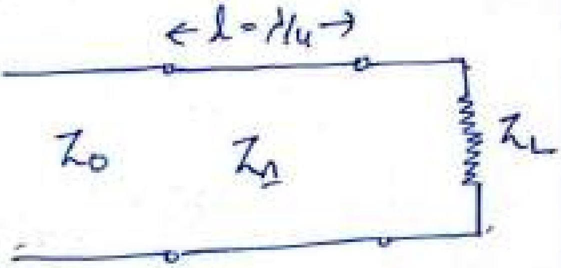
$$Y_{sc} = b_s = (Y_0 - Y_L)\sqrt{\frac{Y_0}{Y_L}} = -jY_0 \cot \beta l_t$$

$$\cot \beta l_t = \frac{Y_0 - Y_L}{\sqrt{Y_0 Y_L}}$$

$$l_t = \frac{\lambda}{2\pi} \tan^{-1} \sqrt{\frac{Z_L Z_0}{Z_L - Z_0}}$$

OR

Quarter wave Transformer:



→ At the design frequency f_0, electrical length of the matching section is $\lambda_0/4$

→ for other frequencies we try to find the variation in Reflection Coefficient and Fractional BW

(8)

⇒ Acceptable reflection coefficient in Γ_M

then.

$$\Delta\theta = 2\left(\frac{\pi}{2} - \theta_M\right)$$

$$|\Gamma_M|^2 = \frac{1}{\left\{1 + \frac{4 Z_0 Z_L}{(Z_L - Z_0)^2} \sec^2\theta_M\right\}}$$

$$\cos\theta_M = \frac{\Gamma_M}{\sqrt{1-\Gamma_M^2}} \quad \frac{2\sqrt{Z_0 Z_L}}{|Z_L - Z_0|}$$

for TEM waves

$$\theta = \beta l = \frac{\omega}{v_p} \times \frac{\lambda_0}{4}$$

$$\theta = \frac{\pi f}{2 f_0} \quad , \; f_m = \frac{2\theta_M f_0}{\pi}$$

$$\frac{\Delta f}{f_0} = \frac{2(f_0 - f_m)}{f_0}$$

$$\boxed{\frac{\Delta f}{f_0} = 2 - \frac{4\theta_M}{\pi}}$$

(8)

$$Z_{in} = Z_1 \frac{Z_L + jZ_1 t}{Z_1 + jZ_L t}$$

$t = \tan \beta l$ and $\beta l = \frac{\pi}{2}$ at design freq. f_0

$$\Gamma = \frac{Z_{in} - Z_0}{Z_{in} + Z_0} = \frac{Z_1 (Z_L - Z_0) + jt(Z_1^2 - Z_0 Z_L)}{Z_1 (Z_L + Z_0) + jt(Z_1^2 + Z_0 Z_L)}$$

$Z_1^2 = Z_0 Z_L$

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0 + j2t\sqrt{Z_0 Z_L}},$$

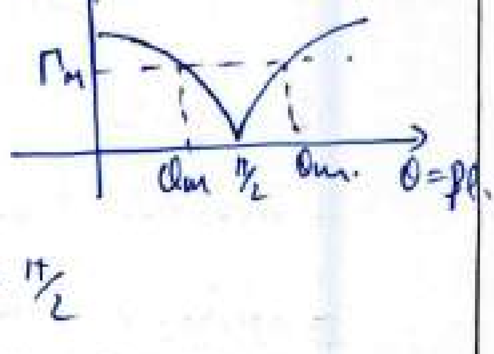
by multiplying the complex conjugate of denominator we get

$$|\Gamma| = \frac{1}{\left\{1 + \frac{4Z_L Z_0}{(Z_L - Z_0)^2}(1+t^2)\right\}^{1/2}}$$

$1 + \tan^2 \beta l = \sec^2 \beta l$

$\beta l = \theta$

$$|\Gamma| = \frac{1}{\left\{1 + \frac{4Z_L Z_0}{(Z_L - Z_0)^2}(1+\sec^2\theta)\right\}^{1/2}}$$



⇒ for $f \simeq f_0$ ⇒ $l \simeq \lambda_0/4$ and $\theta \simeq \pi/2$

$\sec^2\theta >> 1$

then $$|\Gamma| = \frac{|Z_L - Z_0|}{2\sqrt{Z_0 Z_L}} |\cos\theta|$$

Question Paper Solution

Branch : ECE Semester: VI Subject: MC-II Mid Term: I/II/Extra/Imp.
Submitted By : Praveen Jaiswal, Shubhi Jain, Pallav Paliwal

(9)

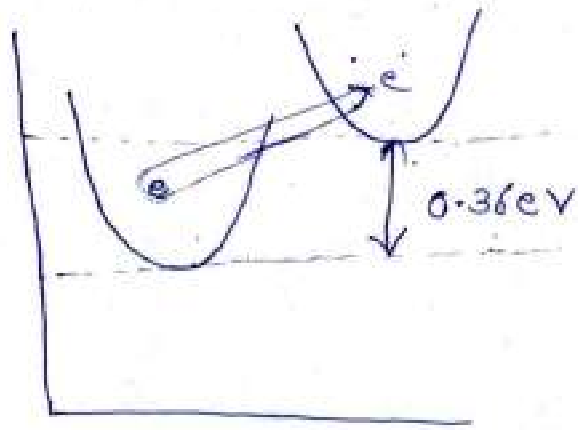
Q3 → Gunn diode

RWH Theory.

→ $E < E_l$

→ $E_l < E < E_u$

→ $E > E_u$



$$\sigma = e(\mu_l n_l + \mu_u n_u)$$

$$\frac{\partial \sigma}{\partial E} = e\left(\mu_l \frac{\partial n_l}{\partial E} + \mu_u \frac{\partial n_u}{\partial E}\right) + e\left(n_l \frac{\partial \mu_l}{\partial E} + n_u \frac{\partial \mu_u}{\partial E}\right)$$

$$n = n_u + n_l$$

$$\frac{\partial}{\partial E}(n_l + n_u) = \frac{\partial n}{\partial E} = 0 \quad \mu = E^P$$

$$\frac{\partial \mu}{\partial E} = \frac{P\mu}{E}$$

$$J = \sigma E$$

$$\frac{\partial J}{\partial E} = \sigma + \frac{\partial \sigma}{\partial E} E$$

$$\frac{1}{\sigma}\frac{\partial J}{\partial E} = 1 + \frac{\frac{\partial \sigma}{\partial E}}{\frac{\sigma}{E}} \qquad - \frac{\frac{\partial \sigma}{\partial E}}{\frac{\sigma}{E}} > 1$$

(10)

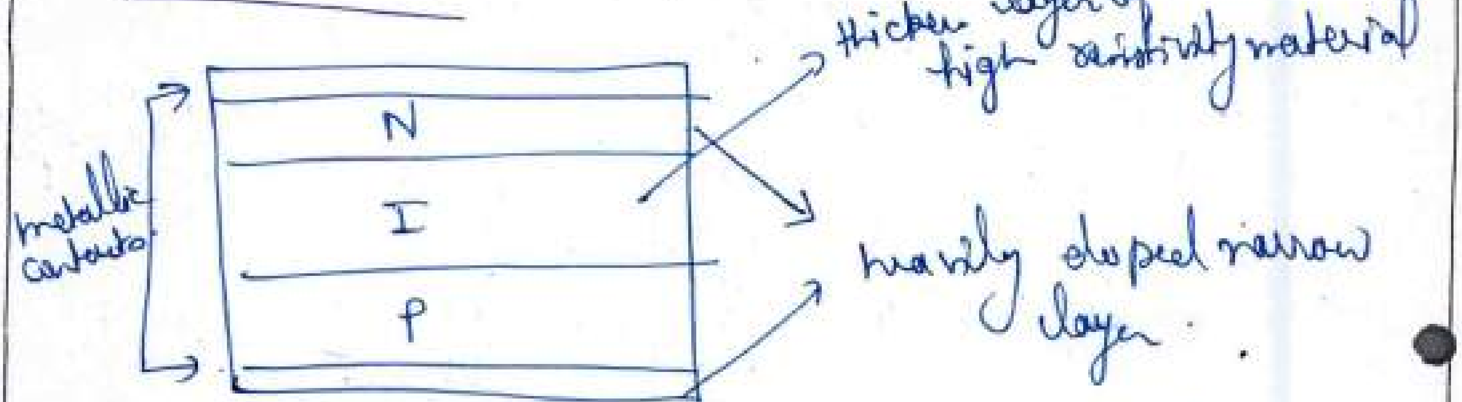
Question Paper Solution

Branch : ECE Semester: VI Subject: MC-II Mid Term: I/II/Extra/Imp.
Submitted By : Praveen Saraswat, Shubhi Jain, Pallav Rawal

Si are not used due to
① mobility is low as compare to GaAs.
② Energy level not exist at diff. level.
③ Thermal energy is large as Compare to level Energy difference.

or

PIN Diode.

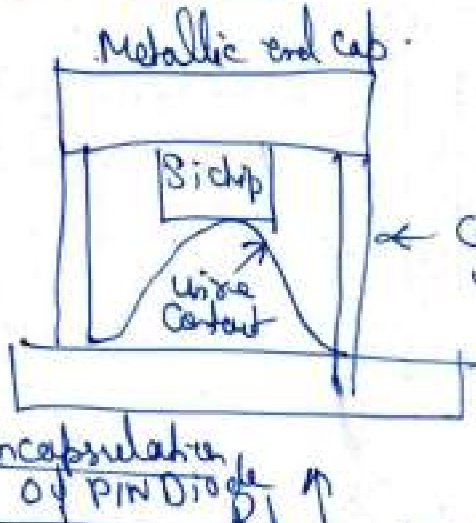


Silicon is widely used because of its power handling Capacity & high resistivity in intrinsic region.
PIN Diodes are widely used for microwave power, switching, limiting & modulation.
↳ acts as a low freq. rectifier that Could rectify more power than an ordinary P-N Junction diode.

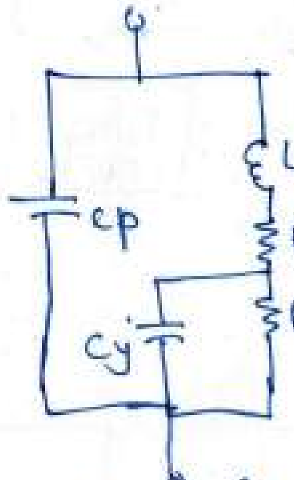
(P1)

→ up to 100 MHz, operation similar to p-n Diode
→ At F.B, very low imp. at μw freq. (1-10 Ω) when R.B, high impedance at μw freq. (5-10 kΩ)

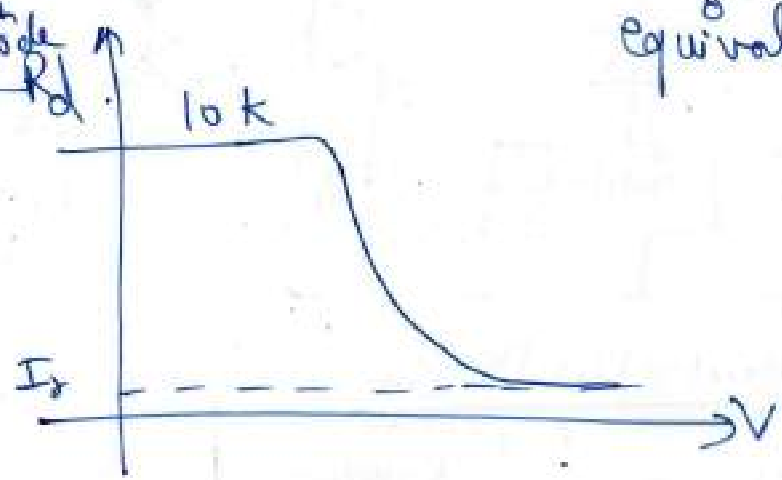
Construction



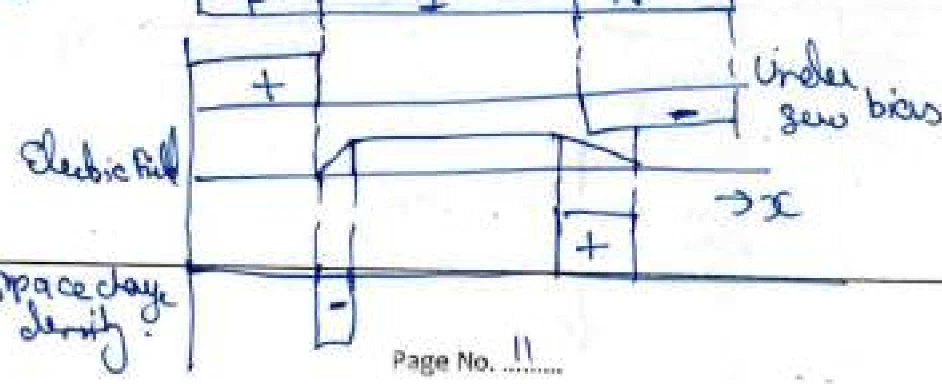
Encapsulation of PIN Diode



Equivalent ckt of PIN Diode.



Operation →



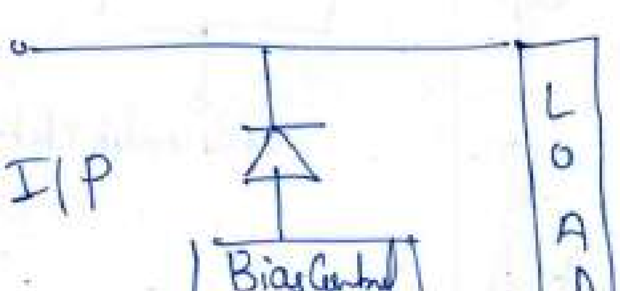
At zero bias ⇒ diffusion of holes & e^- across the junction causes space charge density region.

At R.B ⇒ Space charge region become thicker. reverse resistance ↑es.

At F.B ⇒ " " " become thinner. resistance ↓es.

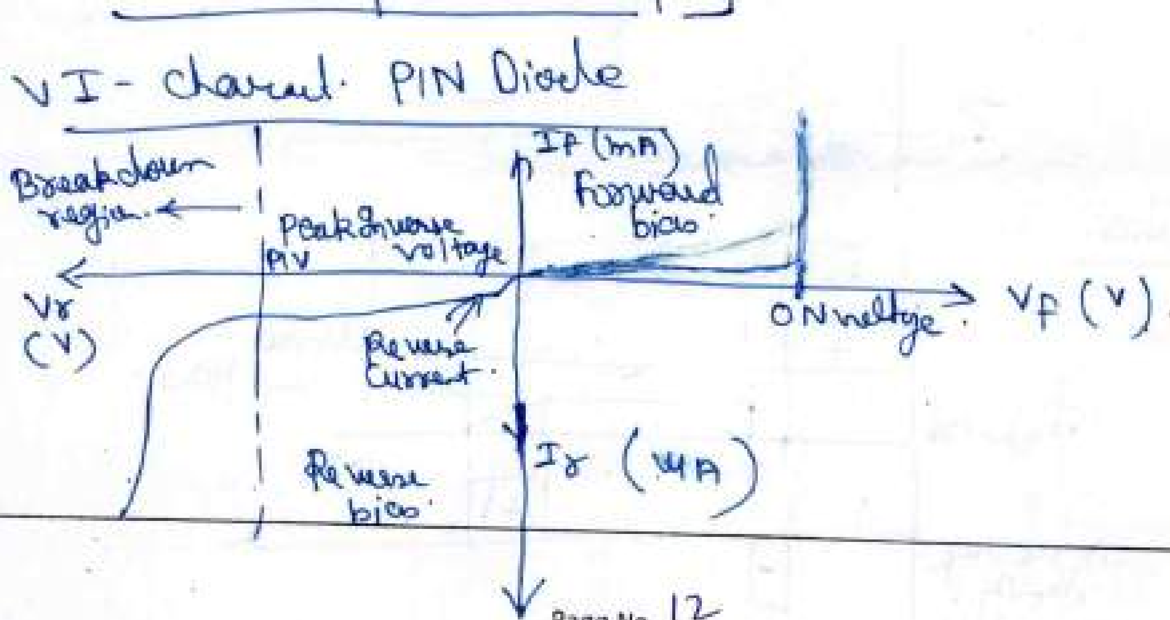
Applications of PIN Diode

When R.B, switch is off.
F.B switch is closed



When F.B switch off.
R.B switch on.

VI - charact. PIN Diode

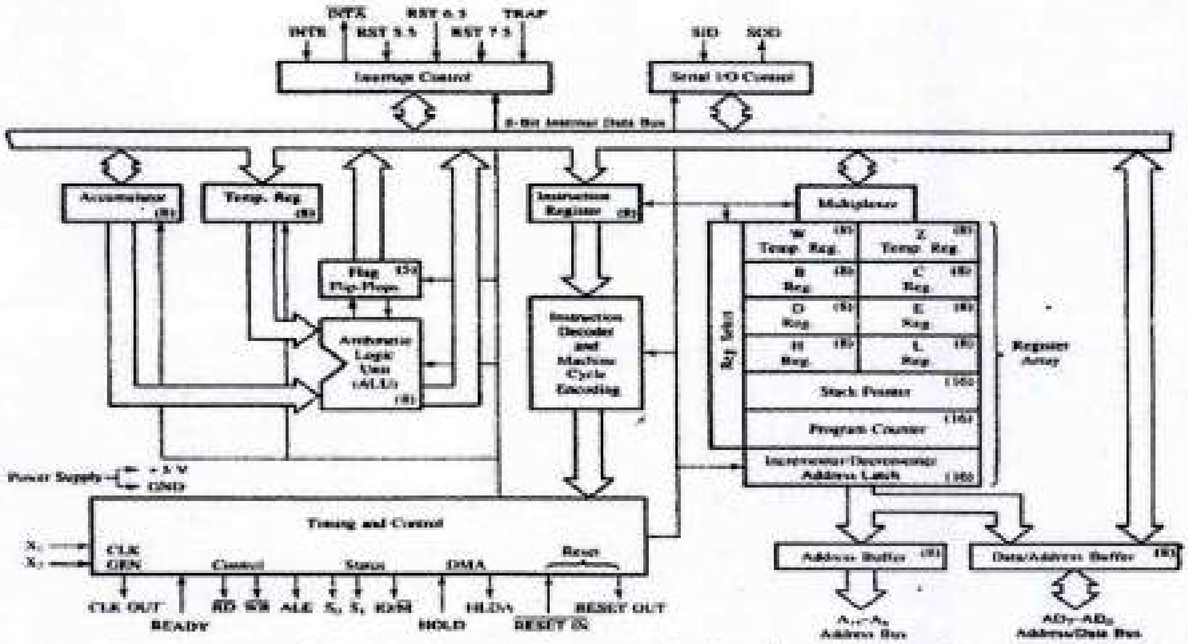


Question Paper Solution

Branch: ECE Semester: VI Subject: Microprocessor Mid Term: I

Submitted By : Abhinandan Jain/Neeraj Jain/Rahul Pandey

1.



The architecture of 8085 is shown in figure given below. The internal architecture of 8085 includes the ALU, timing and control unit, instruction register and decoder, register array, interrupt control and serial I/O control.

Arithmetic and Logical unit:

The operations performed by ALU of 8085 are addition, subtraction, increment, decrement, logical AND, OR, EXCL U8IVE -OR, compare, complement and left / right shift. The accumulator and temporary register are used to hold the data during an arithmetic / logical operation. After an operation the result is stored in the accumulator and the flags are set or reset according to the result of the operation.

FLAG REGISTER: There are five flags in 8085, which are sign flag (8), zero flag (Z), auxiliary carry flag (AC), parity flag (P) and carry flag (CY). The bit positions reserved for these flags in the flag register are shown in figure below.

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

After an ALU operation, if the most significant bit of the result is 1, then sign flag is set.

The zero flag is set, if the ALU operation results in zero and it is reset if the result is non-zero.

In an arithmetic operation, when a carry is generated by the lower nibble, the auxiliary carry flag is set.

After an arithmetic or logical operation, if the result has an even number of 1 's the parity flag is set, other wise it is reset.

If an arithmetic operation results in a carry, the carry flag is set other wise it is reset.

Among the five flags, the AC flag is used internally for BCD arithmetic and other four flags can be used by the programmer to check the conditions of the result of an operation.

TIMING & CONTROL UNIT: The timing and control unit synchronizes all the microprocessor operations with the clock and generates the control signals necessary for communication between the microprocessor and peripherals.

INSTRUCTION REGISTER & DECODER: When an instruction is fetched from memory it is placed in instruction register. Then it is decoded and encoded into various machine cycles.

REGISTER ARRAY:

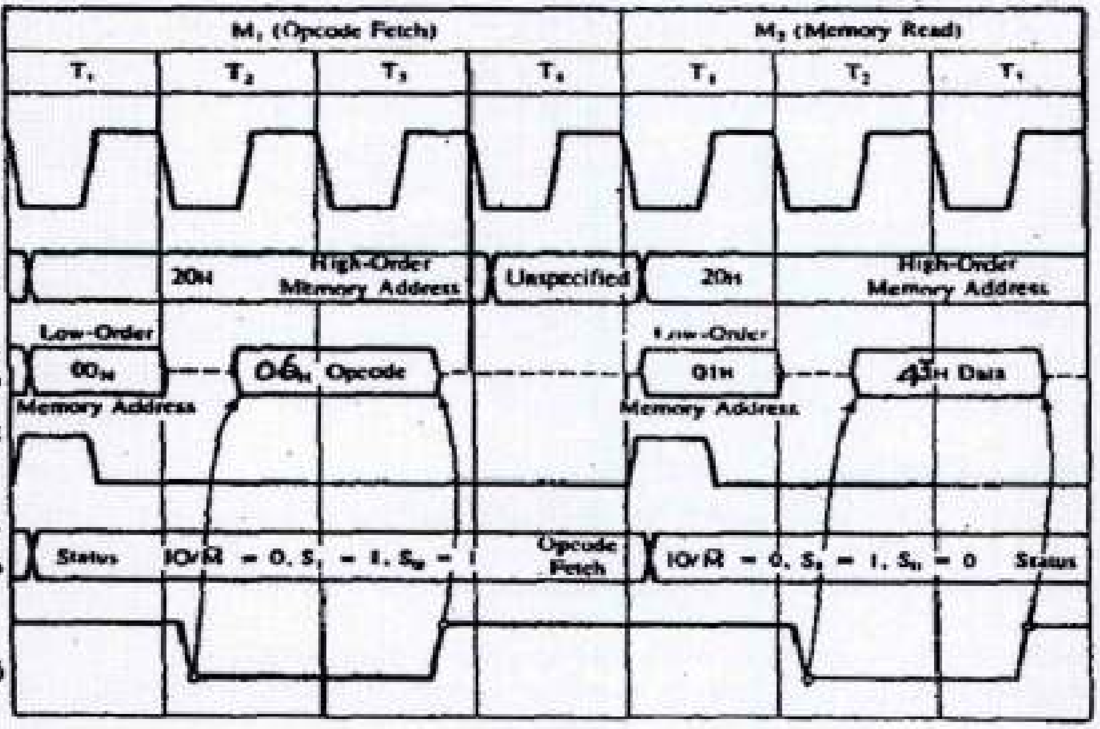
- Apart from Accumulator (A-register), there are six general-purpose programmable registers B, C, D, E, H and L.
- They can be used as 8-bit registers or paired to store l6-bit data. The allowed pairs are B-C, D-E and H-L.

- The temporary registers W and Z are intended for internal use of the processor and it cannot be used by the programmer.

STACK POINTER (SP): The stack pointer SP, holds the address of the stack top. The stack is a sequence of RAM memory locations defined by the programmer. The stack is used to save the content of registers during the execution of a program.

PROGRAM COUNTER (PC): The program counter (PC) keeps track of program execution. To execute a program the starting address of the program is loaded in program counter. The PC sends out an address to fetch a byte of instruction from memory and increment its content automatically. Hence, when a byte of instruction is fetched, the PC holds the address of the next byte of the instruction or next instruction.

2. A



2. B

(i)SUI 8bit data

The 2nd byte of the instruction is data.it is subtracted from the content of the accumulator and the result is placed in accumulator.

Machine Cycle: 2

T states: 7

Addressing modes: immediate

(ii)Call addr :

Call addr(label):Unconditional call

Call instruction is used to call a subroutine, before the control is transferred to the subroutine; address of the next instruction of the main program is saved in the stack. The content of the stack pointer is decrement by two. Then the program jumps to subroutine starting at address specified by the label.

Machine cycle: 5

T states: 18

Addressing mode: immediate/register indirect

Conditional CALL addr

I. **CC: -** (conditional call) The program sequence is transferred to a particular level or a 16-bit address if C=1 (or carry is 1)

II. **CNC: -** (conditional call) The program sequence is transferred to a particular level or a 16-bit address if C=0 (or carry is 0)

III. **CP: -** (conditional call) The program sequence is transferred to a particular level or a 16-bit address if S=0 (or sign is 0)

IV. **CM: -** (conditional call) The program sequence is transferred to a particular level or a 16-bit address if S=1 (or sign is 1)

V. **CZ: -** (conditional call) The program sequence is transferred to a particular level or a 16-bit address if Z=1 (or zero flag is 1)

VI. **CNZ: -** (conditional call) The program sequence is transferred to a particular level or a 16-bit address if Z=0 (or zero flag is 0)

VII. **CPE: -** (conditional call) The program sequence is transferred to a particular level or a 16-bit address if P=1 (or parity is 1)

VIII. **CPO: -** (conditional call) The program sequence is transferred to a particular level or a 16-bit address if P=0 (or parity is 0)

Machine Cycle: 2/5

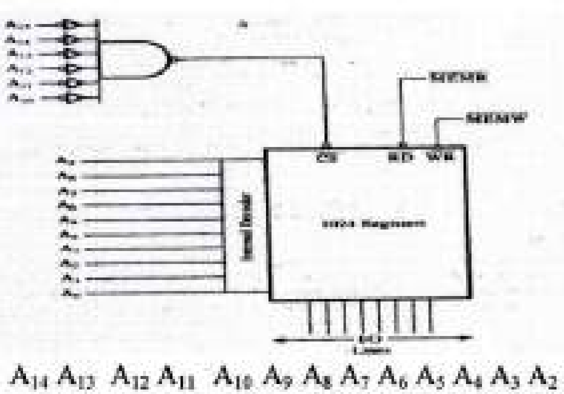
T states: 9/18

Addressing modes: immediate/Register indirect

3. A

```
     MVI A,10H;      10H move immediate into A register
     MVI C,00H ;     00H move immediate into A register
     MVI B,03H;      03H move immediate into A register
L1:  CMP M ;         compare A and M
     JC L2;          Jump if carry to L2
     SUB B;          subtract A and B
     INR C ;         increment C
     JMP L1;         jump unconditionally at L1
L2:  STA 2500H ;     store A result in 2500H
     MOV A,C ;       move C into A
     STA 2501H;      store A result in 2501H
     HLT;            Stop the program
```

3. (B) Memory address range



A_{15}	A_{14}	A_{13}	A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0	
1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	-FC00H
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1-	FFFFH

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Question Paper Solution

Branch : ECE Semester: VI Subject : Industrial Electronics Mid Term: I/II/Extra/Imp.

by: Ms. Priyanka Sharma

VI SEM A, B, II SHIFT

Ans.1 Silicon Controlled Rectifier (SCR) is a unidirectional semiconductor device made of silicon which can be used to provide a selected power to the load by switching it ON for variable amount of time. These devices are solid-state equivalent of thyratrons and are hence referred to as thyristors or thyrode transistors. In fact, SCR is a trade name of General Electric (GE) to the thyristor. Basically **SCR** is a three terminal, four-layer (hence of three junctions J1, J2 and J3) semiconductor device consisting of alternate layers of p- and n-type material doping. Figure 1a shows the SCR with the layers pnpn which has the terminals Anode (A), Cathode (K) and the Gate (G). Further it is to be noted that the Gate terminal will generally be the p-layer nearer to the Cathode terminal. The symbol of the SCR used in case of circuit diagrams is shown in Figure 1b.

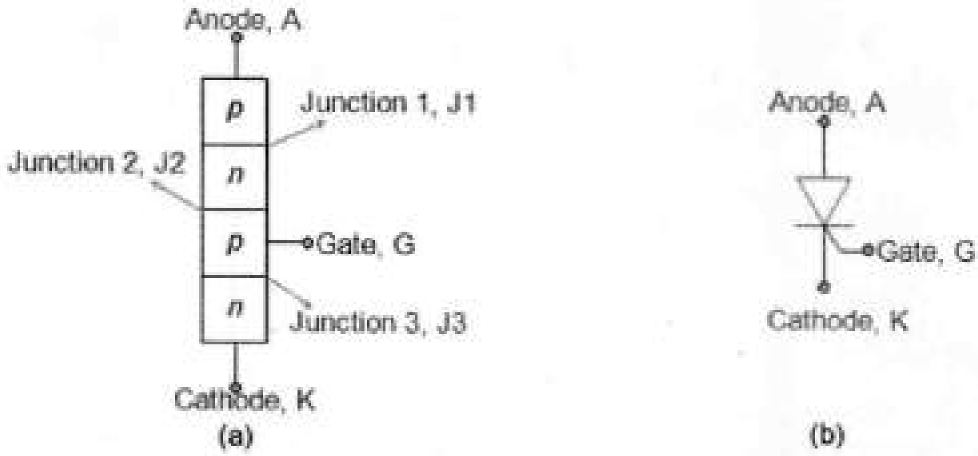


Figure 1 Silicon Controlled Rectifier (a) Layered Structure (b) Symbol

The working of SCR can be understood by analyzing its behaviour in the following modes:

Reverse Blocking Mode: In this mode, the SCR is reverse biased by connecting its Anode terminal to negative end of the battery and by providing its Cathode terminal with a positive voltage (Figure 3a). This leads to the reverse biasing of the junctions J1 and J3, which inturn prohibits the flow of current through the device, inspite of the fact that the junction J2 will be forward biased.
Further, in this state, the SCR behaviour will be identical to that of a typical diode as it exhibits both the flow of reverse saturation current (green curve in Figure 4) as well as the reverse break-down phenomenon (black curve in Figure 4).

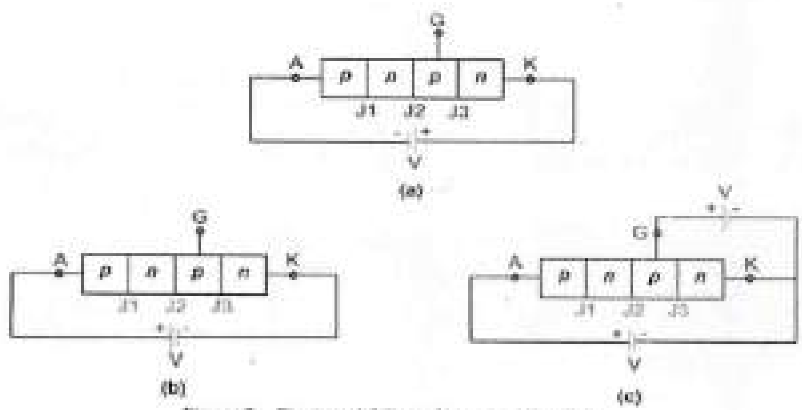


Figure 3 Biasing of Silicon Controlled Rectifier

2. **Forward Blocking Mode:** Here a positive bias is applied to the SCR by connecting its Anode to the positive of the battery and by shorting the SCR cathode to the battery's negative terminal, as shown by Figure 3b. Under this condition, the junctions J1 and J3 gets forward biased while J2 will be reverse biased which allows only a minute amount of current flow through the device as shown by the blue curve in Figure 4.

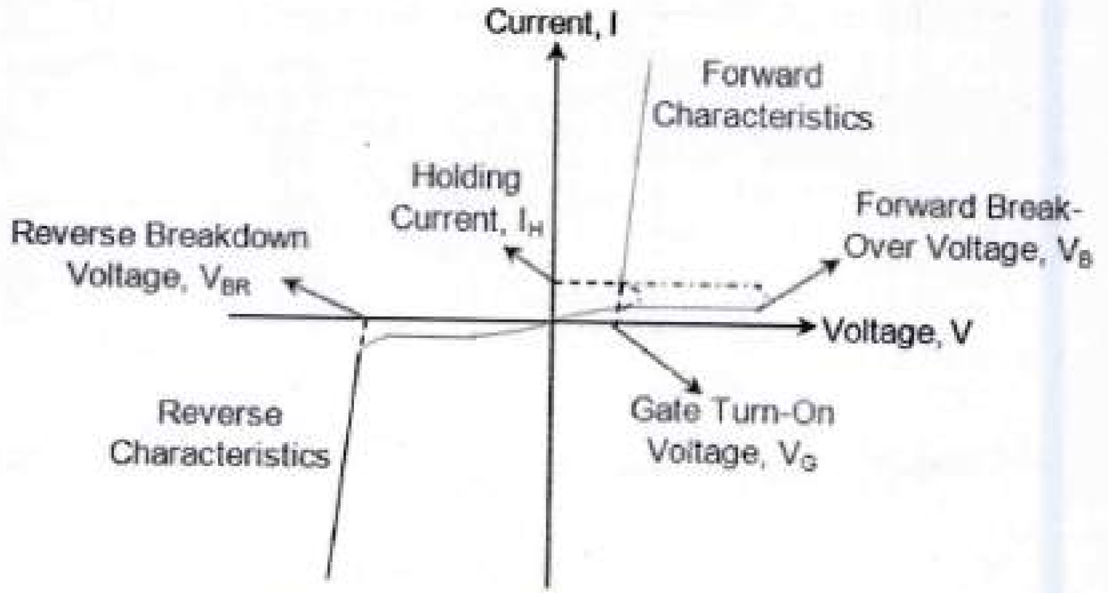


Figure 4 V-I Characteristics of SCR

3. **Forward Conduction Mode:** SCR can be made to conduct either (i) By Increasing the positive voltage applied between the Anode and Cathode terminals beyond the Break-Over Voltage, V_B or (ii) By applying positive voltage at its gate terminal as shown by Figure 3c. In the first case, the increase in the applied bias causes the initially reverse biased junction J2 to break-down at the point corresponding to Forward Break-Over Voltage, V_B. This results in the sudden increase in the current flowing through the SCR as shown by the pink curve in Figure 4, although the gate terminal of the SCR remains unbiased.

However SCRs can be made to turn-on at a much smaller voltage level by proving small positive voltage between the gate and the cathode terminals (Figure 3c). The reason behind this can be better understood by considering the transistor equivalent circuit of the SCR shown in Figure 2. Here it is seen that on applying positive voltage at the gate terminal, transistor Q_2 switches ON and its collector current flows into the base of transistor Q_1. This causes Q_1 to switch ON which in turn results in the flow of its collector current into the base of Q_2. This causes either transistor to get saturated at a very rapid rate and the action cannot be stopped even by removing the bias applied at the gate terminal, provided the current through the SCR is greater than that of the Latching current. Here the latching current is defined as the minimum current required to maintain the SCR in conducting state even after the gate pulse is removed.

In such state, the SCR is said to be latched and there will be no means to limit the current through the device, unless by using an external impedance in the circuit. This necessitates one to resort for different techniques like Natural Commutation, Forced Commutation or Reverse Bias Turn-Off and Gate Turn-Off to switch OFF the SCR. Basically all of these techniques aim at reducing the Anode Current below the Holding Current, the minimum current which is to be maintained through the SCR to keep it in its conducting mode. Similar to turn-off techniques, there also exist different turn-on techniques for the SCR like Triggering by DC Gate Signal, Triggering by AC Gate Signal and Triggering by Pulsed Gate Signal, Forward-Voltage Triggering, Gate Triggering, dv/dt Triggering, Temperature Triggering and Light Triggering.

Question Paper Solution

OR

Ans 1.

SCR Switching Characteristics or Dynamic Characteristics:

The switching characteristics are important particularly at high-frequency, to define the device velocity in changing from conduction state to blocking state and vice versa.
Losses occurring in the device during switching from ON state to OFF state and OFF state to ON state is known as Switching Losses.The device's switching characteristics tells us about the switching losses, which is very important parameter to decide the selection of device.
At high frequency, the switching losses are more.

Turn ON mechanism:-

- When a positive gate signal is applied to a forward biased SCR, the transition of SCR from blocking state to conducting state is called as turn ON mechanism.
- The time taken for SCR to traverse from the blocking state to conducting state is called as turn on time.
- Turn on time is divided into 3 periods.
  tON = td + tr + tp
  td = delay time, tp or ts = peak time (or) spread time
- when the gate current reaches 0.9IG the anode current IA starts increasing and reaches 0.1IA (10% of its max value)
- The time taken for anode current to reach 0.1IA is called as delay time(td).
- In other words, it is the time taken for anode voltage to fall from VA to 0.9VA
- The anode current further increases and reaches 0.9IA.
- The time taken by the anode current to increases from 0.1IA to 0.9IA is called as rise time(tr).
- In other words, it is the time taken by the anode voltage to fall from 0.9VA to 0.1VA

Spread Time or Peak time (ts or tp)

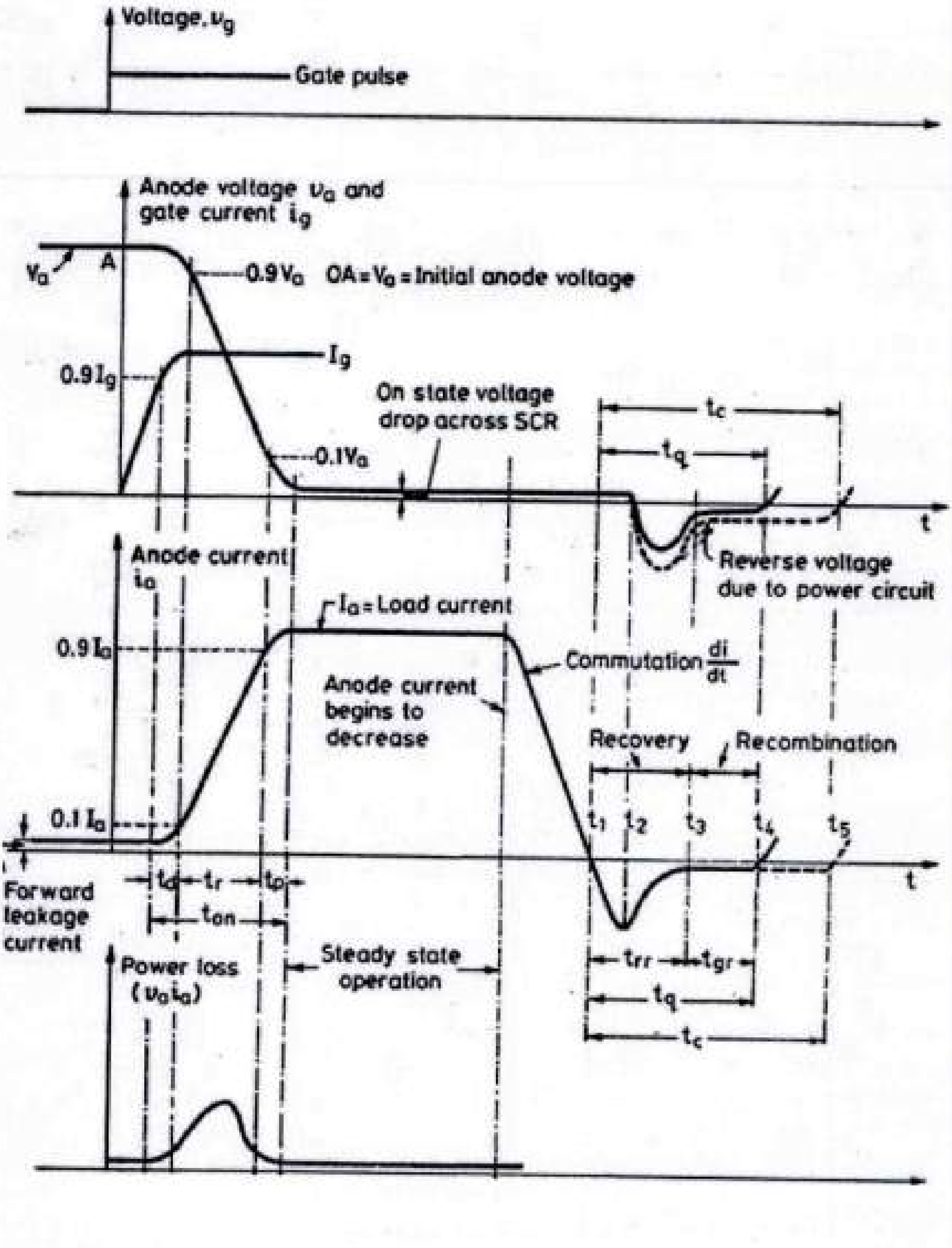
- It is time taken by the anode current to rise from (0.9IA to maximum value of IA) 90% to 100% of its full value. (or)
- It is the time taken by VA to fall from 0.1VA to it's ON state voltage drop(near by zero).
- During this time the conduction spreads over the entire cross-section of cathode and so electrons spread over all the junctions.

Turn OFF mechanism:

Turning OFF an SCR means bringing the SCR from conducting state to blocking state.

- To turn off an SCR two things are to be done
  (1) Reduce the anode current below its holding current level.
  (2) Application of reverse voltage.
- When the anode current is zero, if we apply forward voltage to the SCR, the device will not be able to block this forward voltage due to the fact that excess charge carriers are still at the junctions, so the device will start conducting even when the gate signal is not applied.
- In order to avoid this, reverse biasing of SCR is done to remove the excess charge carriers from all four layers.

Question Paper Solution



- The turn OFF time is defined as the time from the instant the anode current becomes zero to the instant SCR reaches its forward blocking ability.
- Turn off time tOFF = trr + tgr
  trr = Reverse recovery time
  tgr =Gate recovery time
- Reverse recovery process is the removal of excessive charge carries from the top and bottom layers of SCR.
  At t1; current IA = 0
  After t1; IA build up in the reverse direction, due to the charge carriers stored in the four layers.
- Reverse recovery current removes the excessive carriers from junctions J1 and J3 during the time t1 to t3. (Reverse recovery current flows due sweeping out of holes from top p-layer and electrons from bottom n layer)

Reverse Recovery Time (trr):-

- It is the time taken for the removal of excessive carriers from top and bottom layer of SCR.
- At t2: When nearly 60% of charges are removed from the outer two layers, the reverse recovery current decreases.
- This decaying causes a reverse voltage to be applied across the SCR.
- At t3 all excessive carriers from J1 and J3 is removed.
- The reverse voltage across SCR removes the excessive carriers from junction J2.
- Gate recovery process is the removal of excessive carriers from J2 junction by application of reverse voltage.
- Time taken for removal of trapped charges from J2 is called gate recovery time(tgr).
- At t4 all the carriers are removed and the device moves to the forward blocking mode.

Question Paper Solution By. Ms. PRIYANKA SHARMA

Branch : ECE Semester: 6th Subject : IE Mid Term: I/II/Extra/Imp.

Solution 2 (a). When load consists of pure inductance L, voltage eqn is

$$E = L\frac{di}{dt} \quad \text{or} \quad \frac{di}{dt} = \frac{E}{L} \quad \text{or} \quad i = \frac{E}{L}t$$

$$\Rightarrow 0.100 = \frac{200}{0.2}t \quad \text{or} \quad t = \frac{0.1 \times 0.2}{200} = 100\,\mu\text{sec}$$

Thus, minimum gate pulse is 100μs.

(b) The voltage equation for RL load

$$E = Ri + L\frac{di}{dt}$$

$$i = \frac{E}{R}(1 - e^{-R/L\,t}) \quad \text{or} \quad .100 = \frac{200}{20}(1 - e^{-100t})$$

$$t = 100.503\,\mu\text{sec}$$

∴ Minimum gate pulse width is 100.503 μsec.

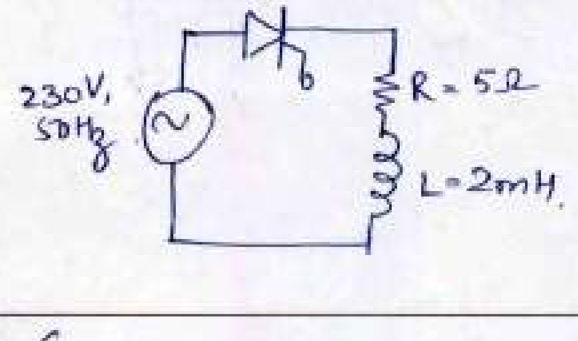
2.(b). It is seen from the figure that circuit turn off time $t_c = \frac{2\pi - \beta}{\omega}$

$$= \frac{360 - 210}{180 \times 2\pi \times 50} = 8.333\,\text{ms}.$$

From average o/p voltage waveform.

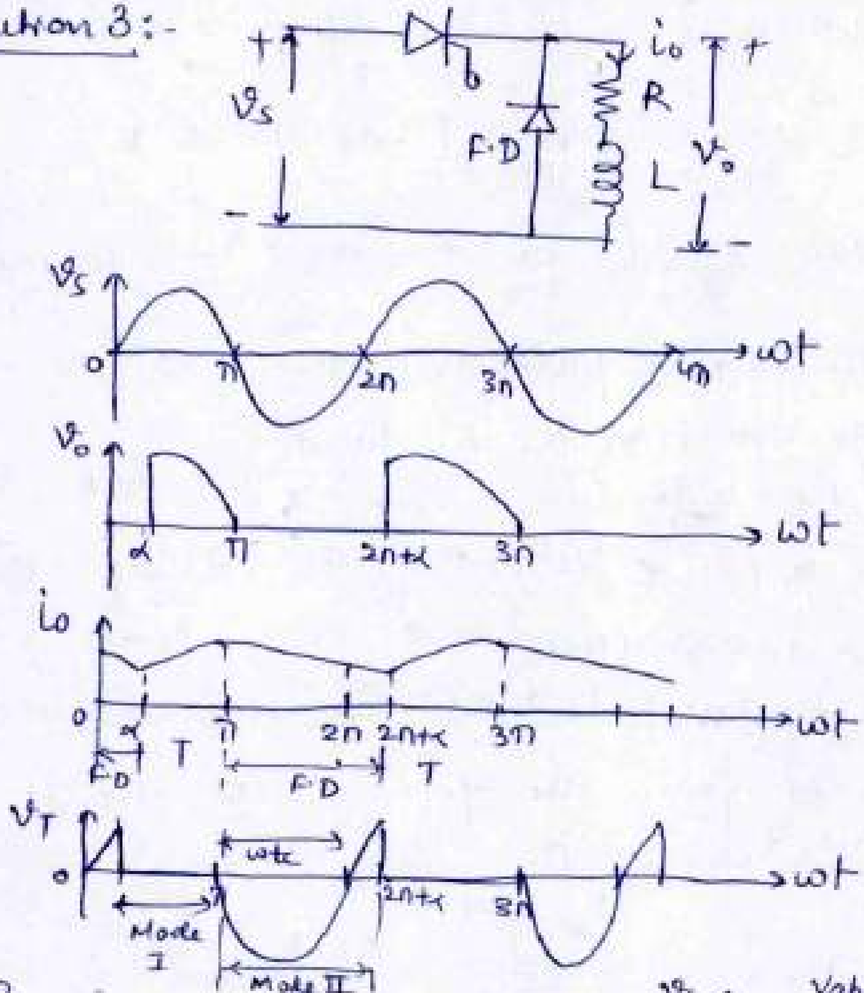
$$V_0 = \frac{\sqrt{2} \cdot 230}{2\pi}[\cos 40^\circ - \cos 210^\circ] = 84.477\,V.$$

Average load current $I_0 = \frac{V_0}{R} = \frac{84.477}{5} = 16.8954\,A$

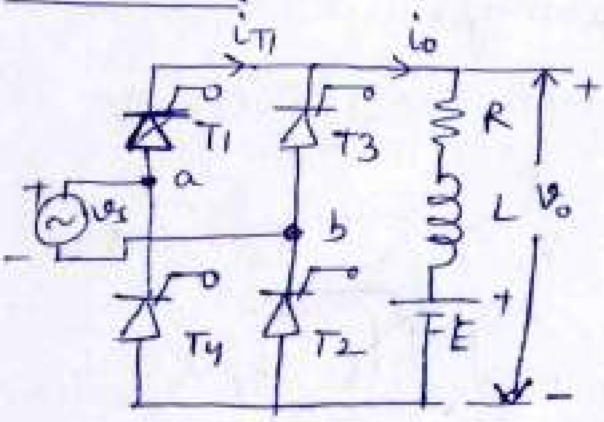


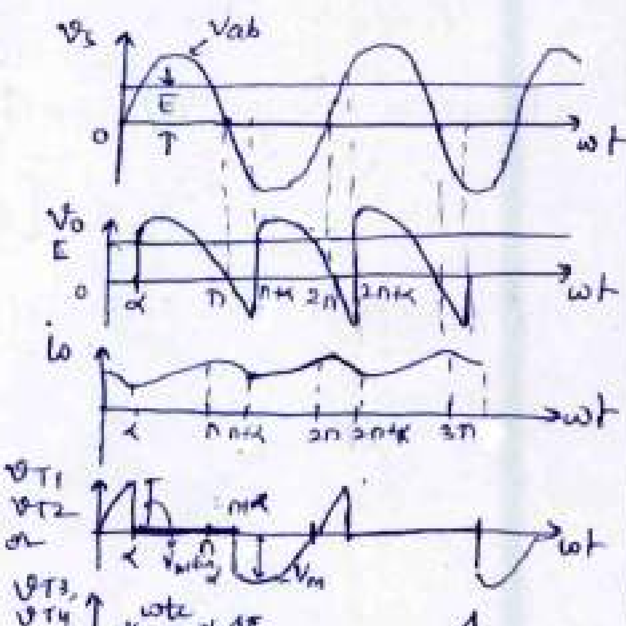
Branch : ECE Semester: 6th Subject : IE Mid Term: I/II/Extra/Imp.

Solution 3:-



OR
solution 3:-



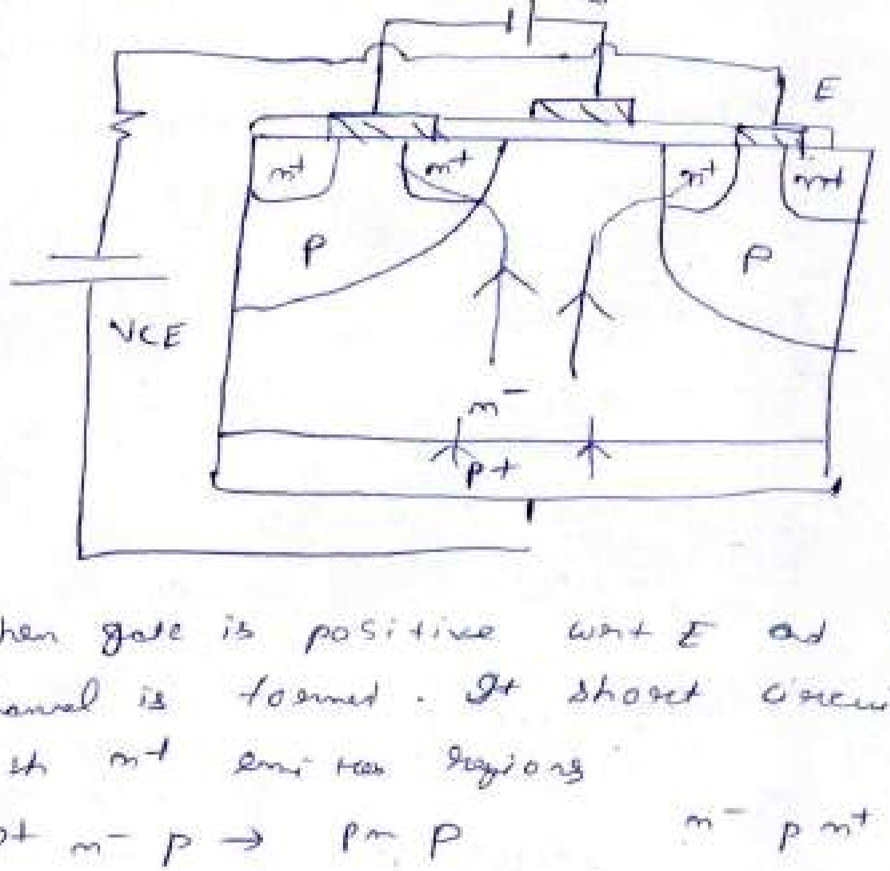


Q4

a) IGBT

→ Combines advantage of both power MOSFET & BJT

→ High i/p impedance like MOSFET and low on state power loss like BJT



When gate is positive w.r.t E and $V_{GE} > V_{GET}$ n channel is formed. It short circuits n region with n^+ emitter regions

$p^+ n^- p \rightarrow pnp$ $n^- p n^+ \rightarrow npn$ device

Applications

1) used in medium power applications
2) UPS, power supplies

b) Power electronic converters

1) Diode rectifier (AC i/p to fixed DC)
↳ (Power supplies, electroplating, battery charging)

2) AC to DC convertor (Phase controlled rectifiers)
   Constant AC to variable DC o/p

3) DC to DC convertor (DC chopper)
   fixed DC to controllable DC o/p

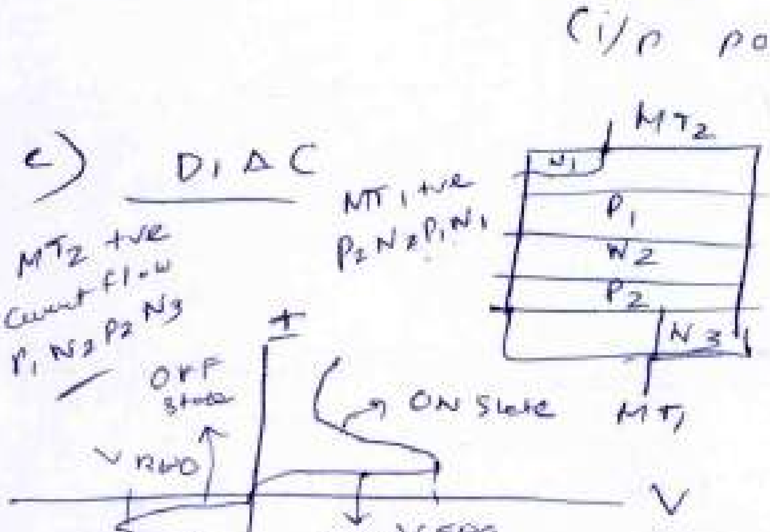
4) DC to AC convertor (inverters)
   (fixed DC to variable AC)
   UPS

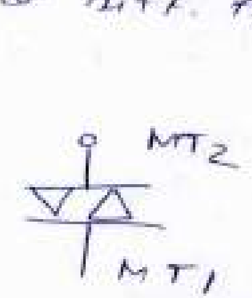
5) AC to AC convertors
   (fixed AC to variable AC o/p)

   a) AC voltage controllers
      (fixed AC to variable AC at same freq.)

   b) Cycloconvertor
      (i/p power at diff. freq.)

c) DIAC





It can be switched from off to on state for either polarity of applied voltage

Question Paper Solution

Branch : ECE Semester: VI Subject: DC Mid Term: I
Submitted By : Ravi Jangir, Rajni Idiwal, Mukesh Arora

Q 1. A. What are the drawbacks of Delta Modulation and how it is removed in ADM **(3)**

B. Consider an audio signal with spectral components in the range 300 to 3000 Hz. Assume that a sampling rate of 7000 samples per second will be used to generate PCM signals. **(2)**

1. **For SNR=30dB, what is the number of quantization levels needed?**
2. **What data rate is required?**

Soln 1 A Delta modulation has two major drawbacks that are:

1. **Slope overload distortion**

This distortion arises because of large dynamic range of input signal. To reduce this error, the step size must be increased when slope of signal x(t) is high. Since the step size of delta modulator remains fixed, its maximum or minimum slopes occur along straight lines. Therefore, this modulator is known as Linear Delta Modulator (LDM).

2. **Granular noise**

Granular noise occurs when step size is too large compared to small variations in the input signal. This means that for very small variations in the input signal, the staircase signal is changed by large amount because of large step size. The error between the input and approximated signal is called granular noise. The solution to this problem is to make step size small. Adaptive Delta Modulation

To overcome the quantization error due to slope overload distortion and granular noise, the step size (Δ) is made adaptive to variations in input signal x(t). Particularly in the step segment of the x(t) , the step size is increased. Also, if the input is varying slowly, the step size is reduced. Then this method is known as Adaptive Delta Modulation (ADM). The adaptive delta modulators can take continuous changes in the step size or discrete changes in the step size

Soln 1 B Given that

SNR=30 dB

Sampling rate = 7kHz

(S/N) = 1.76+6n

30 = 1.76+6n

n=5

i) **Quantization Level**

$L=2^n$

$n = 2^5 = 32$

ii) **Since each sample is represented by 5 bits**

7000x5 bits/sec = 35 kbps

OR

Question Paper Solution

Branch : ECE Semester: VI Subject: DC Mid Term: I
Submitted By : Ravi Jangir, Rajni Idiwal, Mukesh Arora

Q 1. **A.** Derive the expression for signal to quantization noise ratio for PCM system that employs linear quantization technique. (3)

B. A DM system is designed to operate at 3 times the Nyquist rate for a signal with a 3.3kHz bandwidth. The quantizing step size is 250 mV (2)

i. Determine the maximum amplitude of a 1 kHz input sinusoid for which the delta modulator does not show slope overload.

ii. Determine the post filtered output signal to quantizing noise ratio for the signal of part i.

Soln1 A

Assume that the modulating signal be a sinusoidal voltage, having peak amplitude A_m. Let this signal cover the complete excursion of representation levels.

The power of this signal will be,

$$P = \frac{V^2}{R},$$ Here V = R.M.S. value

$$= [A_m / \sqrt{2}]^2$$

When $R = 1$, the power P is normalized, i.e.,

Normalized power : $P = \frac{A_m^2}{2}$ **With $R = 1$ in above equation.**

∴ **Signal to quantization noise ratio is given by equation**

$$\frac{S}{N} = \frac{3P}{x_{max}^2} \times 2^{2v}$$

Here $P = \frac{A_m^2}{2}$ and $x_{max} = A_m$

Putting these values in the above equation,

$$\frac{S}{N} = \frac{3 \times \frac{A_m^2}{2}}{A_m^2} \times 2^{2v} = \frac{3}{2} \times 2^{2v} = 1.5 \times 2^{2v}$$

Expressing signal to noise power ratio in dB,

$$\left(\frac{S}{N}\right)dB = 10\log_{10}\left(\frac{S}{N}\right) = 10\log_{10}(1.5 \times 2^{2v})$$

$$= 10\log_{10}(1.5) + 10\log_{10} 2^{2v}$$

$$= 1.76 + 2v \times 10 \times 0.3$$

Thus,

$$\left(\frac{S}{N}\right)dB \text{ in PCM : } \left(\frac{S}{N}\right)dB = 1.8 + 6v \text{ ; for sinusoidal signal}$$

Soln 1.B Given that W=3.3 kHz , f_m= 1 KHz, Δ = 250mV, f_s=3x2W=19.8kHz

i) Let the maximum amplitude of 1 kHz input sinusoid be A

The condition to avoid slope overload distortion is given by

$$A \leq \frac{\Delta}{w_m T_s}$$

Hence maximum value of $A = \frac{\Delta}{w_m T_s} = \frac{\Delta f_s}{2\pi f_m}$

Substituting the values we get,

$$A_{max} = \frac{250X10^{-3}X6X3.3X10^{-3}}{2\pi x1x10^{-3}} = 0.787\,V\,Ans$$

ii) $$SNR = \frac{3f_s^3}{8\pi^2 f_m^2\, f_M} = 24.7dB$$

Q 2. Explain the generation and detection of ASK with neat and clean diagram. Draw the waveform of ASK, FSK and PSK for the given data pattern 10101100

Soln 2 The simplest digital modulation technique is *amplitude-shift keying* (ASK), where a binary information signal directly modulates the amplitude of an analog carrier.

ASK is similar to standard amplitude modulation except there are only two output amplitudes possible. Amplitude-shift keying is sometimes called *digital amplitude modulation* (DAM).

Mathematically, amplitude-shift keying is

$$v_{(ask)}(t) = [1 + v_m(t)]\left[\frac{A}{2}\cos(\omega_c t)\right]$$

where

$v_{ask}(t)$ = amplitude-shift keying wave
$v_m(t)$ = digital information (modulating) signal (volts)
A/2 = unmodulated carrier amplitude (volts)
ω_c = analog carrier radian frequency (radians per second, $2\pi f_c t$)

In Equation, the modulating signal [$v_m(t)$] *is* a normalized binary waveform, where + 1 V = logic 1 and -1 V = logic 0. Therefore, for a logic 1 input, $v_m(t)$ = + 1 V, Equation reduces to

$$v_{(ask)}(t) = [1 + 1]\left[\frac{A}{2}\cos(\omega_c t)\right]$$

$$= A\cos(\omega_c t)$$

and for a logic 0 input, $v_m(t) = -1$ V, Equation

$$v_{(ask)}(t) = [1-1]\left[\frac{A}{2}\cos(\omega_c t)\right]$$

Thus, the modulated wave $v_{ask}(t)$, is either A $\cos(\omega_c t)$ or 0. Hence, the carrier is either *"on"* or *"off,"* which is why amplitude-shift keying is sometimes referred to as *on-off keying*(OOK).

Figure 1 shows the input and output waveforms from an ASK modulator.

From the figure, it can be seen that for every change in the input binary data stream, there is one change in the ASK waveform, and the time of one bit *(t_b)* equals the time of one analog signaling element (t_s).

$B = f_b/1 = f_b$ baud $= f_b/1 = f_b$

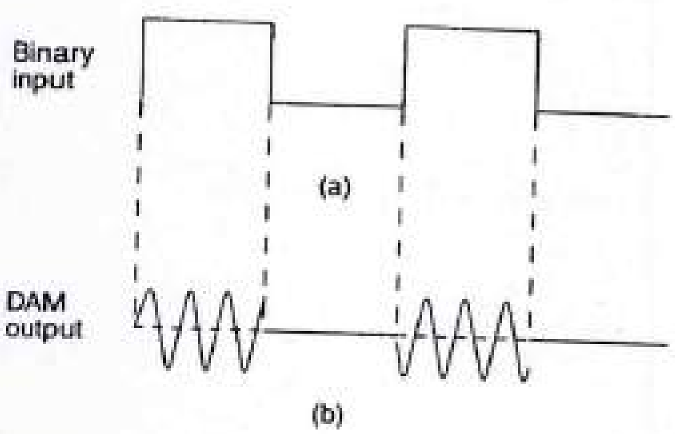
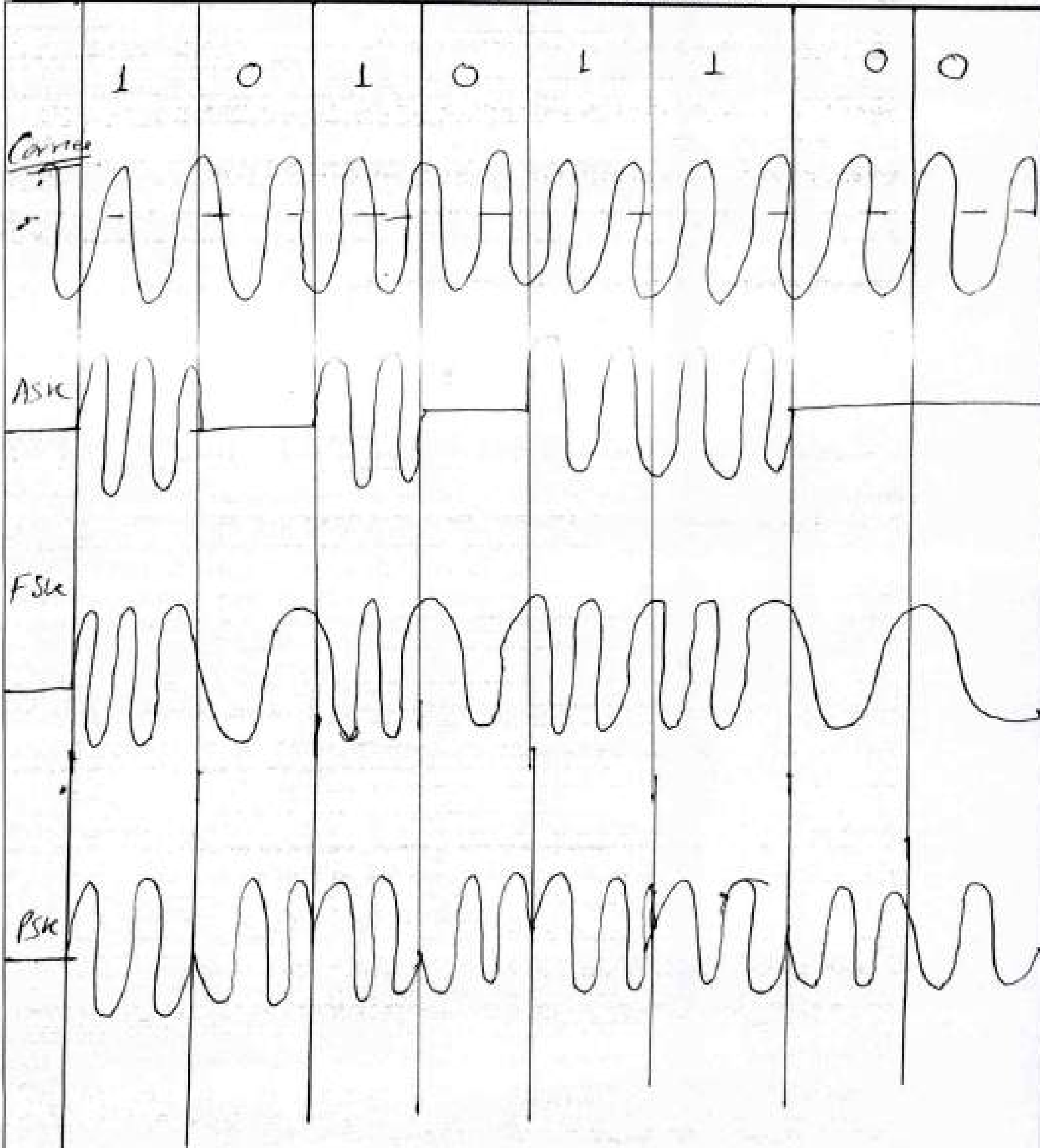


FIGURE 1 Digital amplitude modulation: (a) input binary; (b) output DAM waveform

The entire time the binary input is high, the output is a constant-amplitude, constant-frequency signal, and for the entire time the binary input is low, the carrier is off.

The rate of change of the ASK waveform (baud) is the same as the rate of change of the binary input (bps).

Question Paper Solution

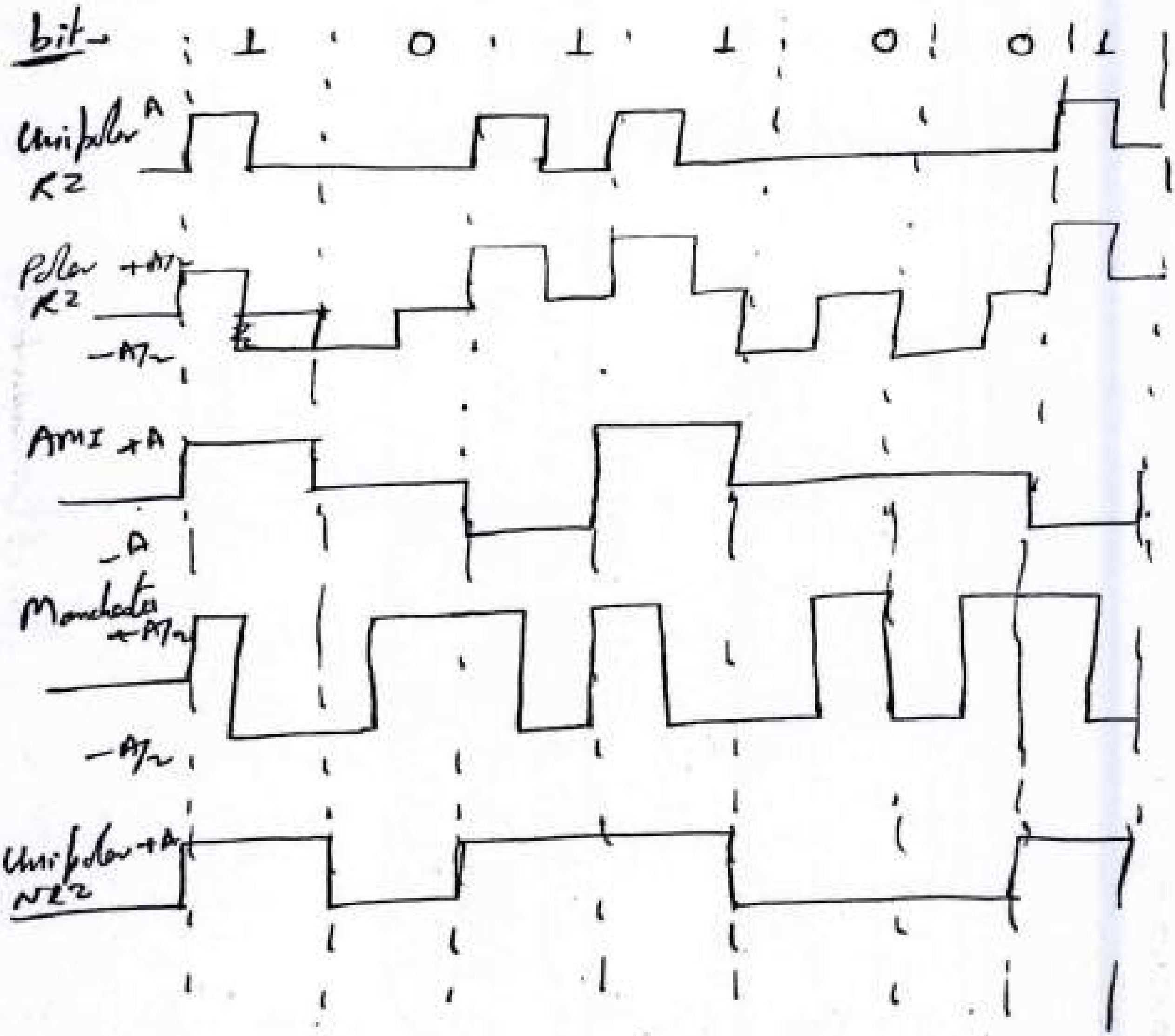


OR

Question Paper Solution

Q 2. Line Coding

Solution



(a) Unipolar RZ

DC Component :- exist (high value)

B.W = R_b

Synchronization - Poor.

(b) Polar RZ :-

DC Component :- May exist (less)
Bandwidth :- Rb
Synchronization :- good.

(c) AMI

DC Component :- almost zero.
B.W = Rb/2
Synchronization :- good for 1, but not for '0'.

(d) Manchester

D.C. Component :- 0
B.W = Rb
Synchronization = very high.

(e) Unipolar NRZ :-

DC Component = high.
BW = Rb/2
Synchronization = very poor.

Q 3

Solution A. Matched Filter

Solution → When the noise is white Gaussian noise, then the optimum filter is known as Matched filter.

→ But in optimum filter the noise is generalized noise.

→ PSD of white Gaussian noise is

$$\boxed{S_{ni}(f) = N_0/2}$$

Calculation of Probability of Error for Matched filter.

→ Error probability of optimum filter is expressed as

$$P_e = \frac{1}{2}\,\mathrm{erfc}\left[\frac{x_{01}(T) - x_{02}(T)}{2\sqrt{2}\sigma}\right]$$

In this eq.

$$\left[\frac{x_{01}(T) - x_{02}(T)}{\sigma}\right]^2_{max} = \int_{-\infty}^{\infty} \frac{|X(f)|^2}{S_{ni}(f)}\,df$$

Put value of $S_{ni}(f)$ for white Gaussian noise

$$S_{ni}(f) = N_0/2$$

Hence.

$$\left[\frac{x_{01}(T) - x_{02}(T)}{\sigma}\right]^2_{max} = \frac{2}{N_0}\int_{-\infty}^{\infty} |X(f)|^2\,df.$$

Also, Parseval's power theorem.

$$\int_{-\infty}^{\infty} |X(f)|^2\,df = \int_{-\infty}^{\infty} x^2(t)\,dt = \int_0^T x^2(t)\,dt$$

Now

$$\int_{-\infty}^{\infty} |X(f)|^2 df = \int_0^T [x_1(t) - x_2(t)]^2 dt$$

$$= \underbrace{\int_0^T x_1^2(t)dt}_{E_1} + \underbrace{\int_0^T x_2^2(t)\,dt}_{E_2} - 2\underbrace{\int_0^T x_1(t)\,x_2(t)\,dt}_{E_{12}}$$

Energy →

If $x_1(t) = -x_2(t)$.

$\therefore \quad E_1 = E_2 = -E_{12} = E$

Put these values

$$\int_{-\infty}^{\infty} |X(f)|^2 df = [E + E - 2(-E)] = 4E$$

Put value.

$$\left[\frac{x_{o1}(T) - x_{o2}(T)}{\sigma}\right]_{max} = 2\sqrt{2}\sqrt{\frac{E}{N_0}}$$

put this value in P_e.

$$\boxed{P_e = \frac{1}{2}\, erfc \sqrt{E/N_0}}$$

→ P_e depends upon signal energy not shape.

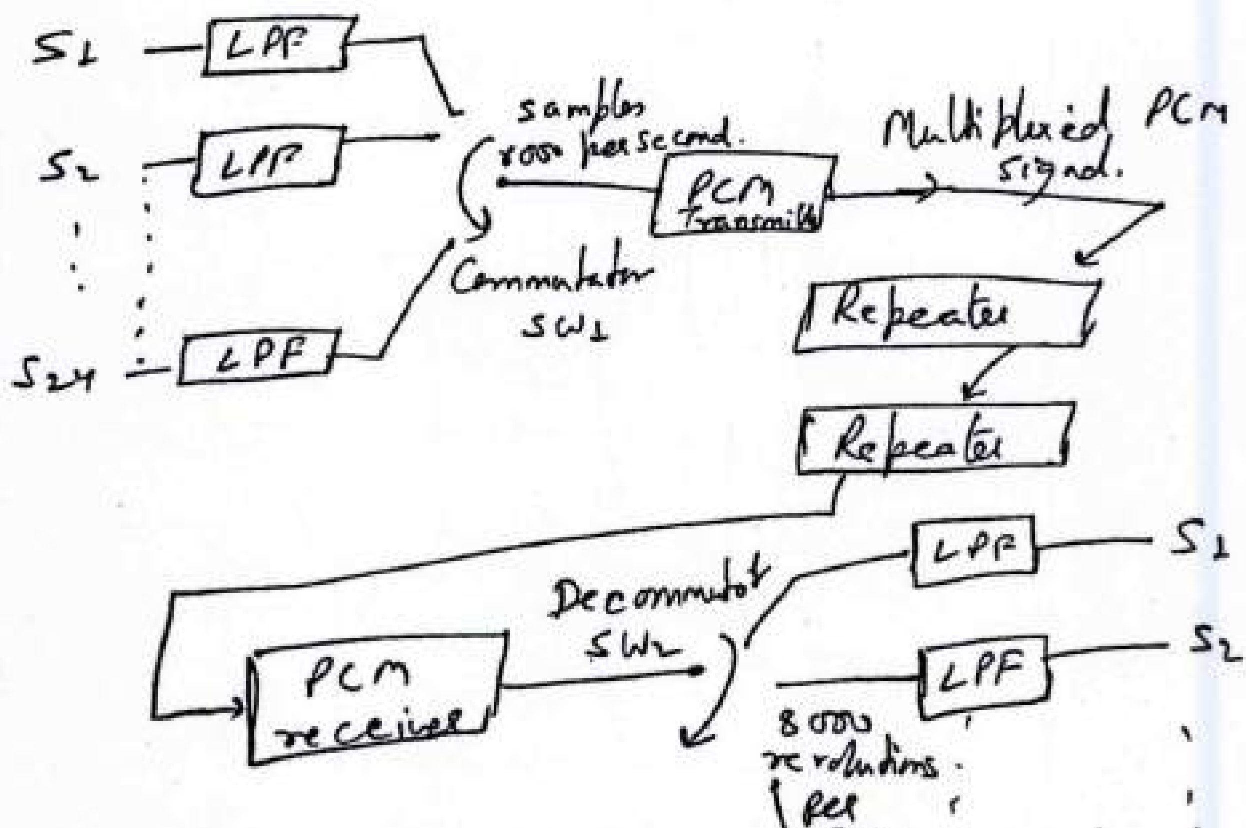
→ if N_0 increases this will the P_e also increases.

Question Paper Solution

Branch : ECE Semester: VI Subject: DC Mid Term: I
Submitted By : Ravi Jangir, Rajni Idiwal, Mukesh Arora

Q 3. Solution B: T1 Carrier System

Ans When a large no. of PCM signals are to be transmitted over a Common channel, multiplexing of these PCM Signal is required.



Working operation

1. System has been designed to accommodate 24 voice channels S_1 to S_{24}. & sampling is done at a standard rate of 8 kHz. sampling is done by the commutator switch SW_1.

(ii) These voice signals are selected one by one and connected to a PCM transmitter by the commutator switch SW_1. and converted into a Digital Signal

(iii) The resulting signal is transmitted over a co-axial cable

(iv) Repeaters are applied they will eliminate the distortion introduced by the channel.

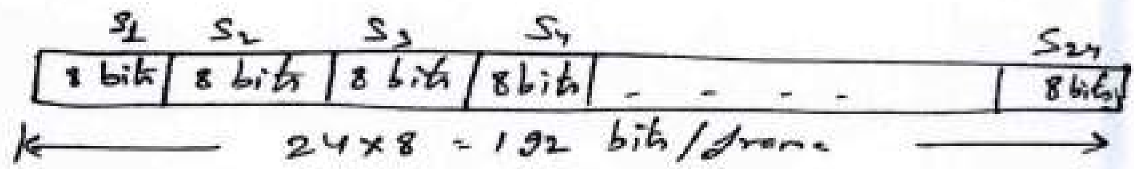
(v) At the destination signal is companded, decoded and demultiplexed, using a PCM receiver. The PCM receiver o/p is is connected to different low pass filter via the decommutator switch SW_2.

(vi) The transmitter & receiver commutator SW_1 and SW_2 should be perfectly synchronized.

(1) **Bits / Frame :-**

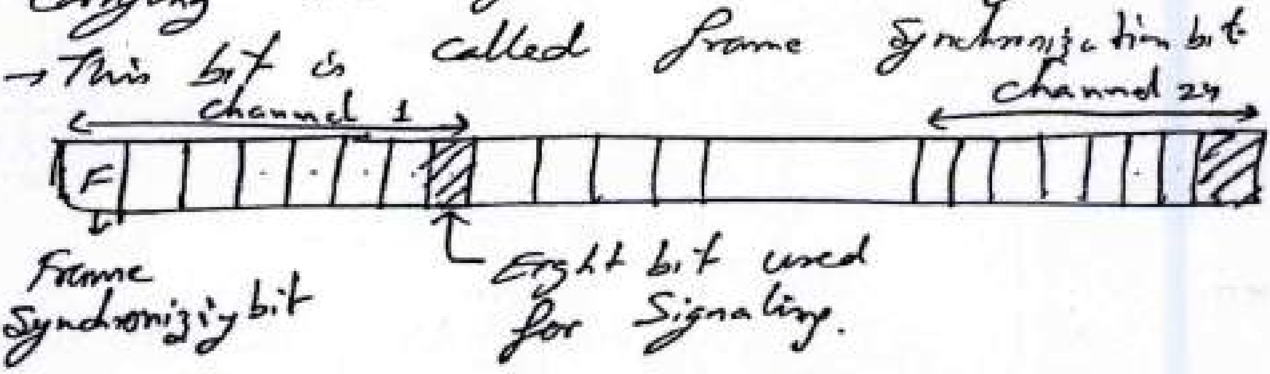
→ The Commutators sweep Continuously from S_1 to S_{24} and back to S_1 at the rate of 8000 revolutions per second. This will generate 8000 samples per second of each signal. (S_1 to S_{24})

∴ 1 Frame = 1 revolution = 24 channels
= 24 × 8 bits = 192



Frame Synchronization :-

→ Synchronization b/w transmitter and receiver commutator is essential.
→ To provide such synchronization, an extra bit is transmitted preceding the 192 bits carrying the information in each frame.
→ This bit is called frame synchronization bit



Bit Rate

→ bit rate means no. of bits transmitted by a system per second.

→ $f_s = 8000$

∴ 1 revolution of Commutator $= \frac{1}{8000} = 125\ \mu sec$

no. of bits in 1 sec. $\frac{193}{125 \times 10^{-6}} = 1.544 \times 10^6$

∴ bit rate is 1.544 Mbits/sec

Bandwidth

Minimum B.W $= \frac{1}{2}$ (bit rate) $= \frac{1}{2} \times 1.544$ Mbits/sec

$= 772$ kHz.

Q 3 : Solution C.

Non-Uniform Quantization :→

→ If the quantizer characteristics is non-linear & the step size is not constant instead if it is variable, dependent on the amplitude of input signal then the quantization is known as non-uniform quantization

→ Signals having smaller amplitudes should be amplified

→ Signals having high amplitudes should be attenuated.

→ It is achieved through a process called Companding.

Companding = Compressing + Expanding

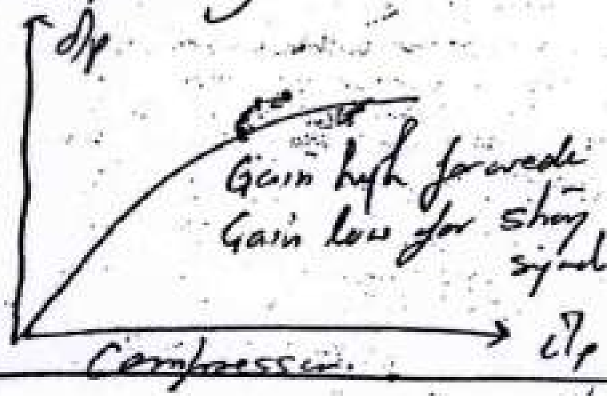
→ In practice it is difficult to implement the non-uniform Quantization because it is not known in advance about the changes in the signal. Therefore

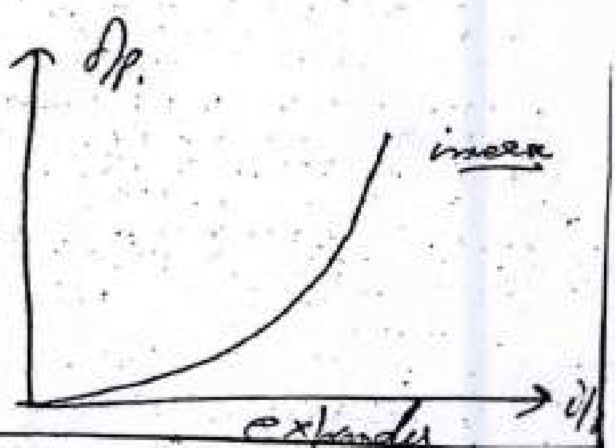
→ Weak signals are amplified & strong signals are attenuated before applying them to a uniform quantizer.

→ This is called Compression & the block that provides it is called as a Compressor.

→ At receiver exactly opposite is followed which is called expansion. & block is called expander.

→ Compression at transmitter & expansion at receiver in combined to be called Companding.

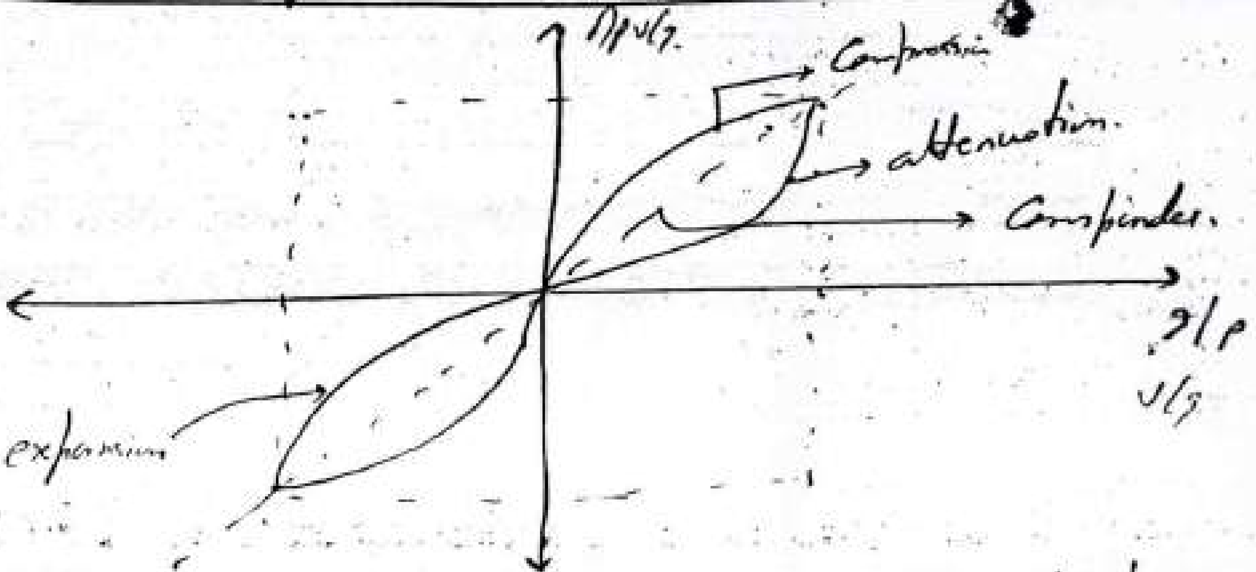




Swami Keshvanand Institute of Technology, Management &Gramothan,
Ramnagaria, Jagatpura, Jaipur-302017

Question Paper Solution

Branch : ECE Semester: VI Subject: DC Mid Term: I
Submitted By : Ravi Jangir, Rajni Idiwal, Mukesh Arora



Different types of Compressor Characteristics :→

1. μ- law Compounding Compressor
2. A-law Compounding Compressor

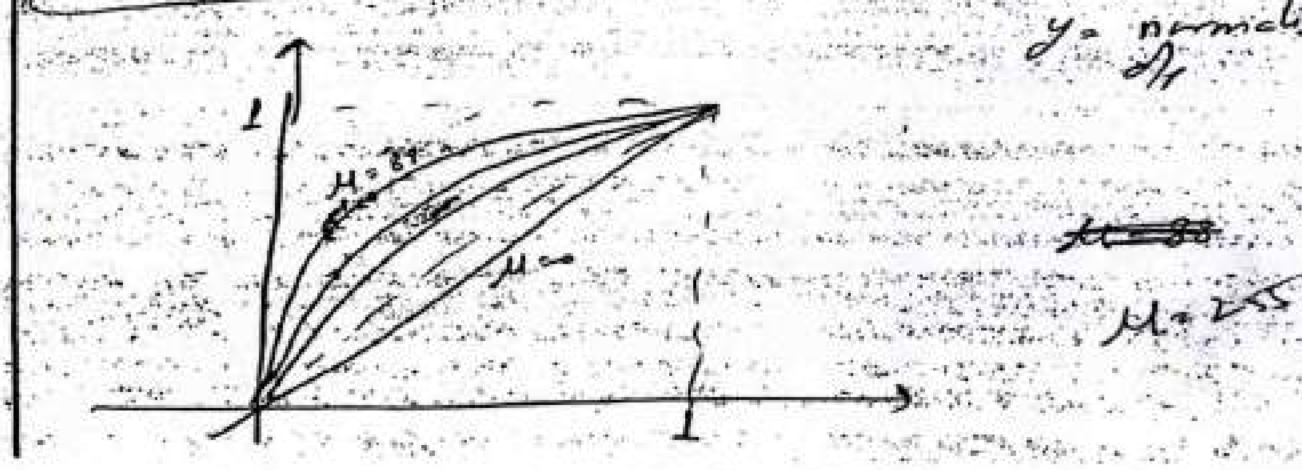
1. μ- law Compressor (North America & Japan, Canada)

$$y = \frac{\ln(1+\mu x)}{\ln(1+\mu)}$$ μ = Constant

normalized = $\frac{|x|}{x_{max}}$

x → normalized i/p

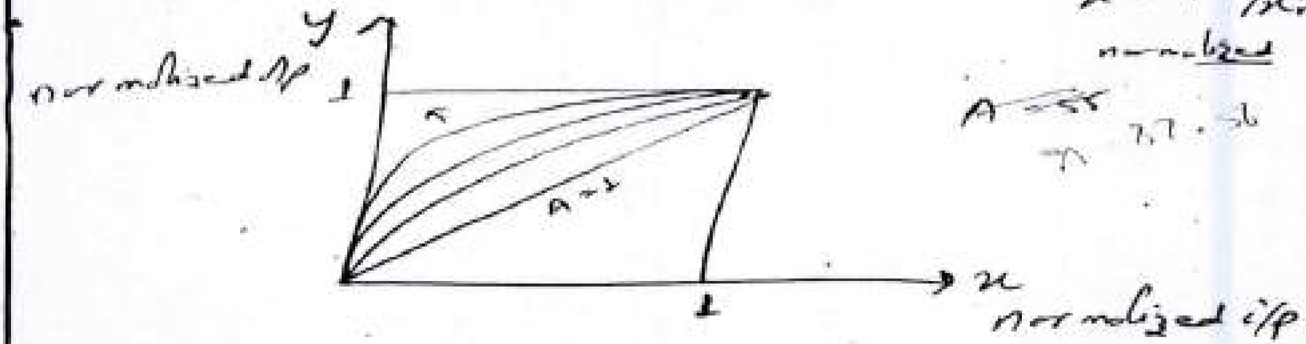
y → normalized o/p



(2) A - law Compressor (Europe)

$$y = \begin{cases} \frac{Ax}{1+\ln A} & 0 \le x \le 1/A \\ \frac{1+\ln Ax}{1+\ln A} & 1/A \le x < 1 \end{cases}$$

$x = |x|/x_{max}$ normalized



Q 3 : Solution: D.

i. Information

Information :- The message associated with the least likelihood ~~or probability of occurrence of that event~~ event thus consists of maximum information.

Information Sources :- It is a device which produces message, it can be either analog ~~analog~~ or discrete, analog → discrete by sampling & quantization.

Measure of Information

→ Let us consider a discrete memoryless source denoted by X & having alphabet $\{x_1, x_2, \ldots, x_n\}$.

→ The information content of a symbol x_i, denoted by $I(x_i)$ is defined by

$$I(x_i) = \log_b \frac{1}{P(x_i)} = -\log_b P(x_i)$$

where $P(x_i)$ is the probability of occurrence of symbol x_i

Properties of $I(x_i)$:

$$I(x_i) = 0 \quad \text{for } P(x_i) = 1$$

$$I(x_i) \geq 0$$

$$I(x_i) > I(x_j) \text{ if } P(x_i) < P(x_j)$$

$$I(x_i, x_j) = I(x_i) + I(x_j) \text{ if } x_i \text{ \& } x_j \text{ are independent}$$

Unit of $I(x_i)$:

→ Unit of $I(x_i)$ is bit (binary unit) if $b = 2$, Hartley or decit if $b = 10$ & nat if $b = e$. (nat (natural unit)

→ standard to use $b = 2$.

ii. ENTROPY

Entropy is defined as the average information per message. A practical communication system is not only deal with a single message, but with all possible messages. We usually transmit long sequences of symbols from an information source. Thus, we are more interested in the average information that a source produces than the single message.

The mean value of $I(x_i)$ over the alphabet of source X with m different symbols is given by

$$H(X) = E[I(x_i)]$$

$$H(X) = \sum_{i=1}^{m} P(x_i) I(x_i)$$

We know

$$H(X) = \sum_{i=1}^{m} P(x_i) \log_2 \frac{1}{P(x_i)}$$

$$\boxed{H(X) = -\sum_{i=1}^{m} P(x_i) \log_2 P(x_i) \text{ bit/symbol}}$$

$H(X)$ is known as the entropy of the source 'X'

- **Properties of Entropy -**

(i) $0 \leq H(X) \leq \log_2 m$

where m is the number of symbols of the alphabet of source X.

(ii) $H(X) = 0$ if all the $P(x_i) = 0$ except for one symbol with $P = 1$.

(iii) When all the events are equally likely the average uncertainty must have largest value i.e. $\log_2 m \geq H(X)$

(iv) If the probability of occurrence of events are slightly changed, the measure of uncertainty associated with the system should vary accordingly in a continuous manner.

(v) Bifurcation of symbols into subsymbols can not decrease the entropy.

(vi) $H(P_1, P_2, \dots P_n) = H(P_2, P_1 \dots P_n)$

The measure of entropy must not be changed with respect to the order of these events.

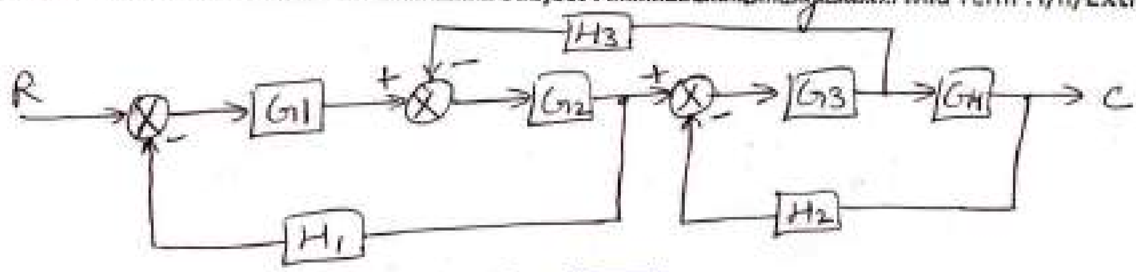
Swami Keshvanand Institute of Technology, Management & Gramothan,
Ramnagaria, Jagatpura, Jaipur-302017

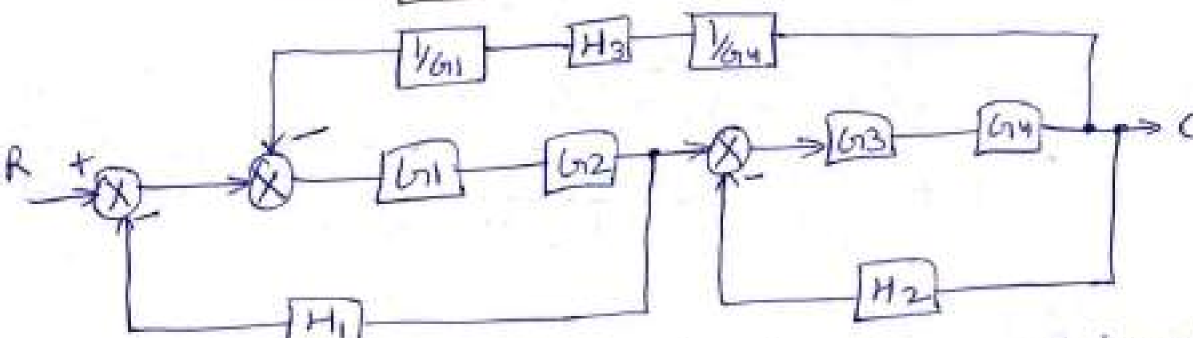
Submitted by → Abhilasha yadav, Abhinandan Jain, Namrata Joshi

Question Paper Solution

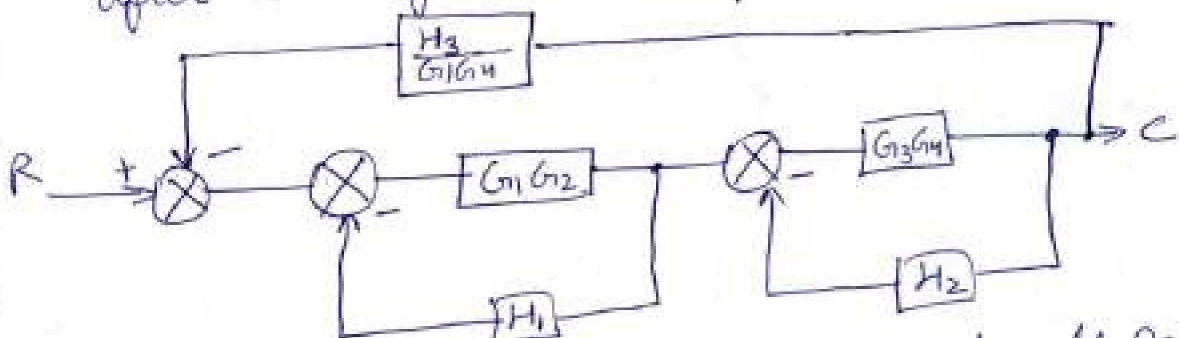
Branch : ECE Semester: VI Subject : Control System Mid Term : I/II/Extra/Imp.

Que (1)

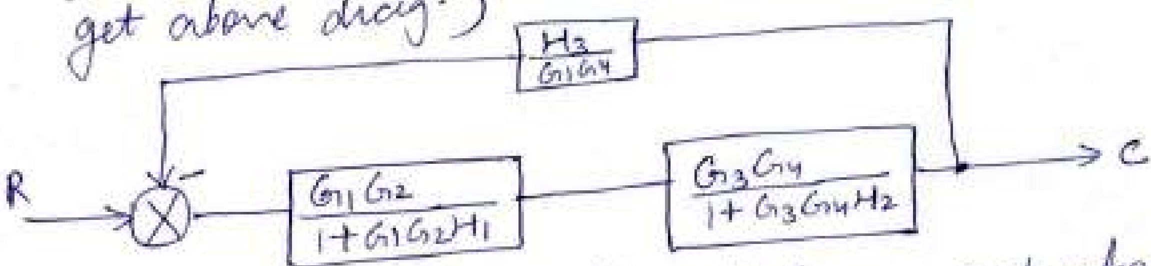




(Shifting of summing point before G1 and take off point after G4 we get above diag.)



(Exchanging summing points and take off points using associative law and combining series blocks we get above diag.)



(Eliminating minor feedback loops we get above diag.)

Submitted by: Abhilasha Yadav
Namrata Joshi
Abhinandan Jain

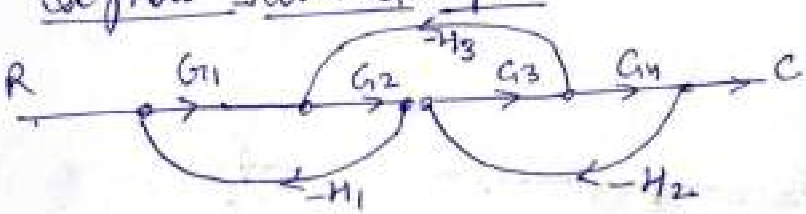
Question Paper Solution

Branch: ECE Semester: VI Subject: Control System Mid Term: I/II/Extra/Imp.

$$\frac{C(s)}{R(s)} = \frac{\left[\frac{G_1G_2}{1+G_1G_2H_1}\right]\left[\frac{G_3G_4}{1+G_3G_4H_2}\right]}{1+\left[\frac{G_1G_2}{1+G_1G_2H_1}\right]\left[\frac{G_3G_4}{1+G_3G_4H_2}\right]\left[\frac{H_3}{G_1G_4}\right]}$$

$$\frac{C(s)}{R(s)} = \frac{\frac{G_1G_2G_3G_4}{(1+G_1G_2H_1)(1+G_3G_4H_2)}}{1+\frac{G_1G_2G_3G_4H_3}{(1+G_1G_2H_1)(1+G_3G_4H_2)(G_1G_4)}} = \frac{G_1G_2G_3G_4}{1+G_1G_2H_1+G_3G_4H_2+G_1G_2G_3G_4H_1H_2+G_2G_3H_3}$$

Signal Flow Graph



$T_1 = G_1G_2G_3G_4$

$L_1 = -G_1G_2H_1$, $L_2 = -G_3G_4H_2$, $L_3 = -G_2G_3H_3$

$\Delta_1 = 1$

$\Delta = 1 - [L_1 + L_2 + L_3] + [G_1G_2G_3G_4H_1H_2]$

$\Delta = 1 - [-G_1G_2H_1 - G_3G_4H_2 - G_2G_3H_3]$

Mason's Gain formula →

$$T.F. = \frac{T_1\Delta_1}{\Delta}$$

$$\text{Transfer function} = \frac{G_1G_2G_3G_4}{1+G_1G_2H_1+G_3G_4H_2+G_2G_3H_3+G_1G_2G_3G_4H_1H_2}$$

Question Paper Solution

Branch:ECE **Semester: VI** **Subject: Control System** **Mid Term: II**

Submitted By : Abhinandan Jain, Namrata Joshi, Abhilasha Yadav

Q→2 $G(s) = \frac{24}{s(s+1)(0.25s+1)}$ & $H(s) = \frac{5}{6}$

the characteristic equation : $1+G(s)H(s) = 0$

$$1+ \frac{24}{s(s+1)(0.25s+1)} \times \frac{5}{6} = 0$$

$$\Rightarrow s^2+6s+25 = 0 \quad -(1)$$

i) Damping ratio & Natural frequency of oscillation:

$$s^2+2\xi\omega_n s+\omega_n^2 = 0 \quad -(2)$$

compare (1) & (2)

$2\xi\omega_n = 6$, $\boxed{\omega_n = 5}$

$\boxed{\xi = 0.6}$

ii) Damped frequency of oscillation:

$$\omega_d = \omega_n\sqrt{1-\xi^2}$$

$$= 5\sqrt{1-(0.6)^2} = 4 \text{ rad/sec}$$

iii) Peak time:

$$t_p = \frac{\pi}{\omega_d} = \frac{\pi}{\omega_n\sqrt{1-\xi^2}} = \frac{3.14}{4} = 0.785 \text{ sec}$$

iv) maximum overshoot of a unit step input

$$\% M_p = e^{\frac{-\xi\pi}{\sqrt{1-\xi^2}}} \times 100 = e^{-\frac{3.14\times0.6}{0.8}}$$
$$= 0.095$$

v) settling time (2% tolerance)

$$t_s = \frac{4}{\xi\omega_n} = \frac{4}{3} = 1.33 \text{ sec}$$

Question Paper Solution

Branch:ECE **Semester: VI** **Subject: Control System** **Mid Term: I**

Submitted By : Abhilasha Yadav, Abhinandan Jain, Namrata Joshi

OR

Q→2

- Characteristic equation:

$$s^5+2s^4+24s^3+48s^2-25s-50=0$$

s^5	1	24	-25
s^4	2	48	-50
	1	24	-25
s^3	0	0	0
	8	96	0
	1	12	0
s^2	12	-25	0
s^1	$\frac{169}{12}$	0	0
s^0	-25	0	0

All the element of s^3 row are zero then the auxiliary equation:

$$2s^4+48s^2-50=0$$

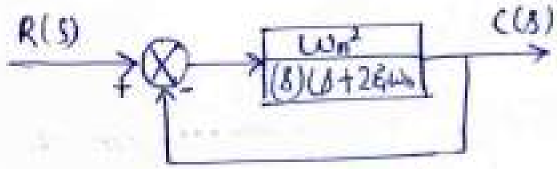
$$8s^3+96s=0$$

In the first column; one time sign change so that the system is unstable.

Question Paper Solution

Branch : ECE Semester: VI Subject: Control systems Mid Term: I/II/Extra/Imp.
Submitted By : Abhinandan Jain, Namrata Joshi, Abhilasha Yadav

Ques③ Time Response of second order control system subjected to unit step input function.



Block diag of IInd order C.S.

general expression for transfer function of a second order control system is $\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$

$\omega_n \Rightarrow$ natural frequency

Output for the system is given by:

$$C(s) = R(s) \cdot \frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$$

if $r(t) = 1$ (unit step ip)

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

$$\therefore C(s) = \frac{1}{s} \cdot \frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2} = \frac{1}{s} - \frac{(s+2\xi\omega_n)}{s+2\xi\omega_n s+(\xi\omega_n)^2-(\xi\omega_n)^2+\omega_n^2}$$

$$= \frac{1}{s} - \frac{s+2\xi\omega_n}{(s+\xi\omega_n)^2+\omega_n^2(1-\xi^2)}$$

put, $\omega_d = \omega_n\sqrt{1-\xi^2}$ {damping frequency}

$$C(s) = \frac{1}{s} - \frac{s+\xi\omega_n}{(s+\xi\omega_n)^2+\omega_d^2} - \frac{\xi\omega_n}{(s+\xi\omega_n)^2+\omega_d^2} \times \frac{\omega_d}{\omega_d}$$

$$C(s) = \frac{1}{s} - \frac{s+\xi\omega_n}{(s+\xi\omega_n)^2+\omega_d^2} - \frac{\xi\omega_n}{\omega_n\sqrt{1-\xi^2}}\left[\frac{\omega_d}{(s+\xi\omega_n)^2+\omega_d^2}\right]$$

taking inverse laplace transform on both sides.

$$L^{-1}(C(s)) = L^{-1}\left[\frac{1}{s} - \frac{s+\xi\omega_n}{(s+\xi\omega_n)^2+\omega_d^2} - \frac{\xi}{\sqrt{1-\xi^2}}\left[\frac{\omega_d}{(s+\xi\omega_n)^2+\omega_d^2}\right]\right.$$

$$\because \frac{s+a}{(s+a)^2+b^2} \xleftrightarrow{L.T.} e^{-at}\cos bt$$

$$\because \frac{b}{(s+a)^2+b^2} \xleftrightarrow{L.T.} e^{-at}\sin bt.$$

$$c(t) = 1 - e^{-\xi\omega_n t}\cdot\cos\omega_d t - \frac{\xi}{\sqrt{1-\xi^2}} e^{-\xi\omega_n t}\sin\omega_d t$$

$$= 1 - \frac{e^{-\xi\omega_n t}}{\sqrt{1-\xi^2}}\left[\sqrt{1-\xi^2}\cos\omega_d t + \xi\sin\omega_d t\right]$$

put $\sin\phi = \sqrt{1-\xi^2}$, $\cos\phi = \xi$

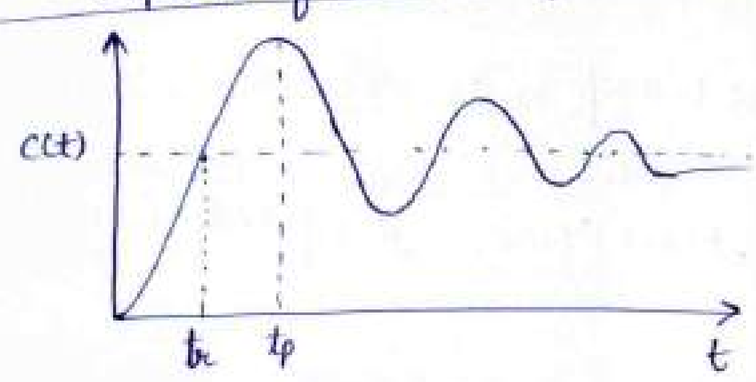
$$c(t) = 1 - \frac{e^{-\xi\omega_n t}}{\sqrt{1-\xi^2}}\left(\sin\phi\cos\omega_d t + \cos\phi\sin\omega_d t\right)$$

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

where $\omega_d = \omega_n\sqrt{1-\xi^2}$ & $\phi = \tan^{-1}\left(\frac{\sqrt{1-\xi^2}}{\xi}\right)$

$$c(t) = 1 - \frac{e^{-\xi\omega_n t}}{\sqrt{1-\xi^2}}\sin\left((\omega_n\sqrt{1-\xi^2})t + \tan^{-1}\left(\frac{\sqrt{1-\xi^2}}{\xi}\right)\right)$$

Time Response of underdamped control system



⇒ Rise time (t_r):-

The time needed for the response to reach from 10 to 90% or 0 to 100% of the desired value of the o/p at the very first instant is called rise time.

0-100% basis for underdamped system.
10-90% basis for overdamped system.

$$t_r = \frac{\pi - \phi}{\omega_n\sqrt{1-\xi^2}} \qquad \phi = \tan^{-1}\left(\frac{\sqrt{1-\xi^2}}{\xi}\right)$$

for underdamped system.

⇒ Peak time (t_p):-

The time needed to reach the maximum overshoot is called peak time. It is observed that M_p occurs when the slope of time response curve after initiation of i/p signal is zero.

$$t_p = \frac{\pi}{\omega_d} = \frac{\pi}{\omega_n\sqrt{1-\xi^2}}$$

(OR)

Ques ③

open loop transfer function $G(s)H(s) = \frac{2(s^2+3s+20)}{(s)(s+2)(s^2+4s+10)}$

ⓐ i/p = 5 (step i/p) $R(s) = \frac{5}{s}$

positional error coefficient.

$$K_p = \lim_{s\to 0} G(s)H(s) = \lim_{s\to 0} \frac{(2)(s^2+3s+20)}{(s)(s+2)(s^2+4s+10)}$$

$$= \infty$$

steady state error $e_{ss} = \frac{A}{1+K_p} = \frac{5}{1+\infty} = \underline{0}$ Ans

(b) i/p is 4t (ramp i/p) $R(s) = \frac{4}{s^2}$

Velocity error coefficient $= K_v = \lim_{s \to 0} s \cdot G(s)H(s)$

$$= \lim_{s \to 0} \frac{2 s (s^2+3s+20)}{(s)(s+2)(s^2+4s+10)} = \underline{\underline{2}} \text{ Ans.}$$

Steady state error

$$e_{ss} = \frac{A}{K_v} = \frac{4}{2} = \underline{\underline{2}} \text{ Ans}$$

(c) i/p is $\frac{4t^2}{2}$ (parabolic i/p) $R(s) = \frac{4}{s^3}$

acceleration error coefficient $= K_a = \lim_{s \to 0} s^2 \cdot G(s)H(s)$

$$= \lim_{s \to 0} \frac{s^2\, 2(s^2+3s+20)}{(s)(s+2)(s^2+4s+10)} = \underline{\underline{0}}$$

steady state error

$$e_{ss} = \frac{A}{K_a} = \frac{4}{0} = \underline{\underline{\infty}} \text{ Ans.}$$

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Ramnagaria, Jagatpura, Jaipur-302017

Question Paper Solution

Branch : ECE **Semester: ...VI...... Subject: ....OFC............................ Mid Term: I**

Submitted By :.......J.P.VIJAY...........

1.

Chemical Vapour Deposition technique- One of the most important methods for preparing thin films and coatings.The fiber fabrication process must realize a glass composition obeying to the core-cladding guiding structure, through the manufacture of an intermediate called preform, which has the same structure of the final optical fibre, and which will be drawn into a fibre at the correct diameter, maintaining the same refractive index profile of the preform.

GLASS DEPOSITION ⟶ PREFORM FABRICATION ⟶ PREFORM DRAWING ⟶ OPTICAL FIBRE

Different techniques based on chemical vapour deposition have been employed to manufacture optical fibres. **Chemical vapor deposition (CVD)** is used to deposit solid material onto a substrate. This involves the reaction or decomposition of one or more precursor gases in a chamber containing one or more heated objects to be coated. The reactions occur on and near the hot surfaces, resulting in the deposition of a thin film on the surface. The chemical by-products or unreacted gases are then eliminated from the reactor chamber via the exhausting system. CVD must take place under vacuum to avoid the inclusion in the film, or creation of side products from the reaction of the ambient components with the precursor gases.

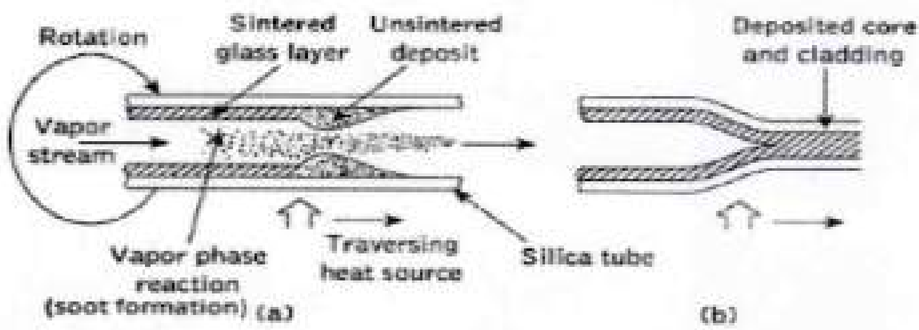


Fig. CVD method for generation of optical fiber (a) deposition (b) collapse to produce to perform

- Chemical Vapour Deposition produces the preform in two steps.
- First, reactant gases flow through a rotating glass tube made from fused silica while a burner heats its narrow zone by travelling back and forth along the tube. Silica and dopants form soot that is deposited on the inner surface of the target tube.
- A burner heats a narrow zone of this deposit and sintering (heating without melting) occurs within this

zone. The result is a layer of sintered glass. Operating temperature is kept at around 1600□.

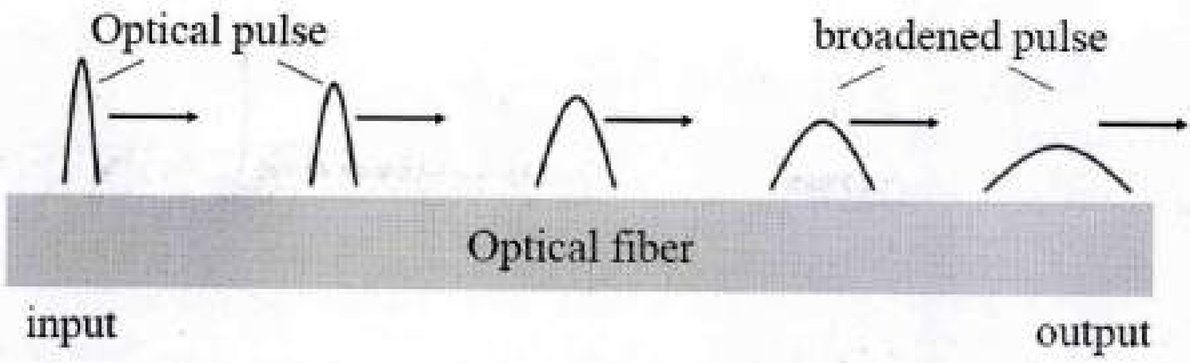
- The second step involves heating the soot perform to 2000□, thus collapsing the tube into solid glass perform.
- The fiber that is subsequently drawn from this preform rod will have a core that consists of the vapor-deposited material and a cladding that consists of the original silica tube.
- The tube is then collapsed to give a solid preform which may then be drawn into fiber at temperatures of 2000 to 2200 °C.
- A graded refractive index profile can be created by changing the composition of the layers as the glass is deposited.
- This technique is the most widely used at present as it allows the fabrication of fiber with the lowest losses.

OR

1.

Intermodal and Intramodal Dispersion phenomenon:

Dispersion of the transmitted optical signal causes distortion for both digital and analog transmission along optical fibers. The dispersion mechanisms within the fiber cause broadening of the transmitted light pulses as they travel along the channel.



Dispersion mechanisms:

1. Intramodal dispersion or chromatic dispersion
   a. Material dispersion b. waveguide dispersion
2. Intermodal or modal dispersion

The total fiber dispersion is a combination of the material and waveguide dispersion. For silica glass, the material dispersion is dominating and the zero dispersion value occurs approximately at 1300 nm.

Intramodal dispersion or chromatic dispersion :

- Intramodal dispersion or chromatic dispersion is pulse spreading that occurs within single mode fiber.
- The spreading arises from the finite spectral emission width of an optical source.[LASER & LED]
- An ideal perfectly coherent source emits light at a single wavelength. It has zero linewidth and is perfectly monochromatic.

Light sources	Linewidth (nm)
Light-emitting diodes	20 nm – 100 nm
Semiconductor laser diodes	1 nm – 5 nm
Nd:YAG solid-state lasers	0.1 nm
HeNe gas lasers	0.002 nm

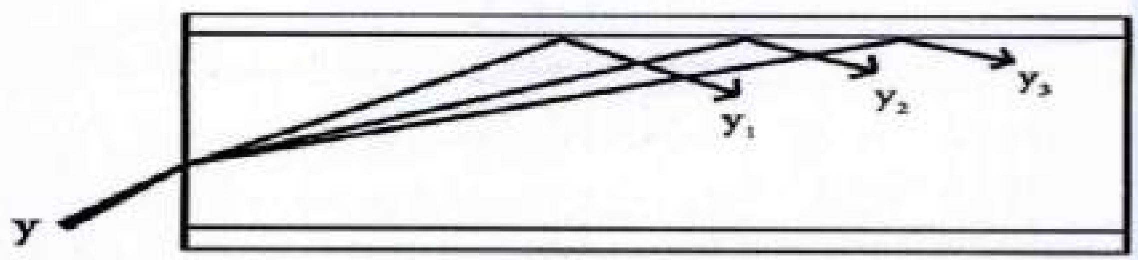
This phenomenon is also known as group velocity dispersion (GVD), since the dispersion is a result of group velocity being a function of the wavelength. Because the Intramodal dispersion depends on the wavelength, its effect of signal distortion increases with the spectral width of optical source.

Pulse broadening occurs because there may be propagation delay differences among the spectral components of the transmitted signal

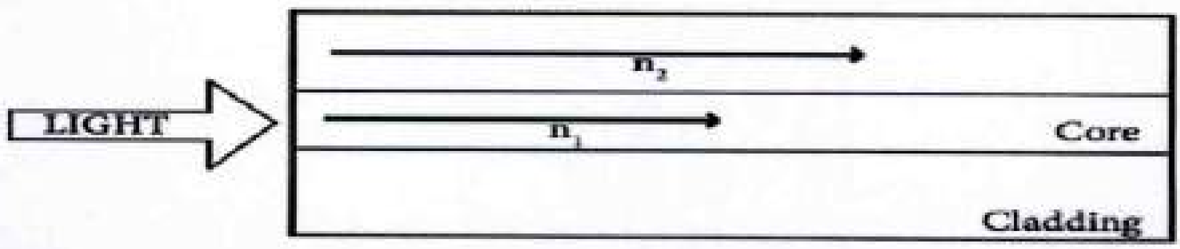
Chromatic dispersion arises for two reasons.

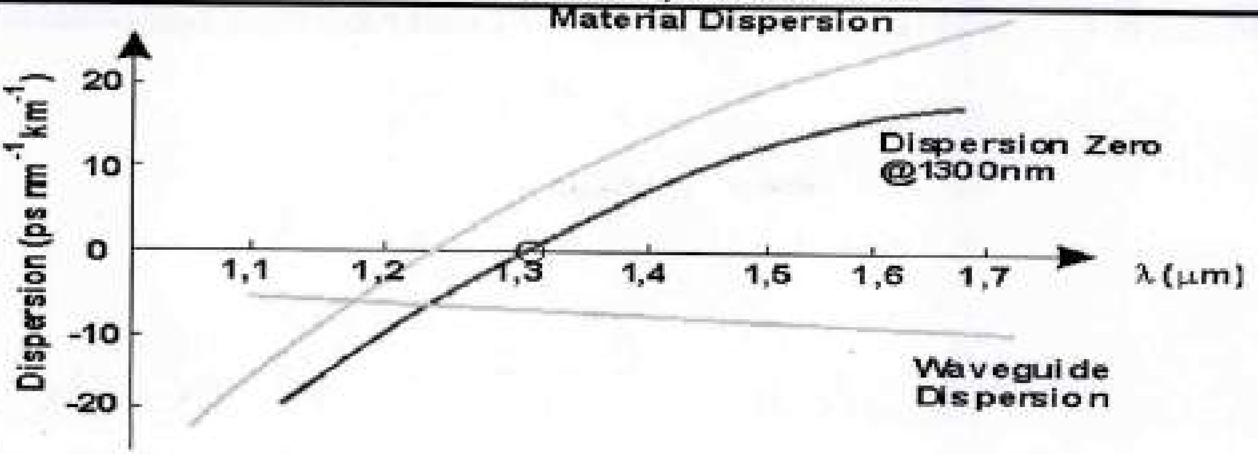
1. The first reason is that the refractive index of silica, the material used to make optical fiber, is frequency dependent. Thus different frequency components travel at different speeds in silica. This component of chromatic dispersion is called material dispersion.
2. Waveguide dispersion: This occurs because a single mode fiber confines only about 80 percent of optical fiber in the core. Dispersion thus arises, since the 20 percent of light propagating in the cladding travels faster than the light confined to the core.

Material Dispersion



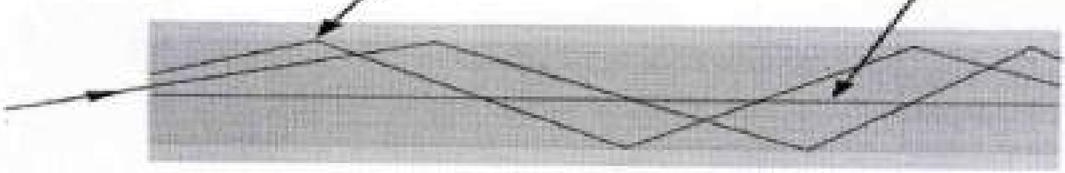
Waveguide Dispersion





Intermodal dispersion: It is also known as modal dispersion, is the phenomenon that the group velocity of light propagating in a multimode fiber (or other waveguide) depends not only on the optical frequency (→ chromatic dispersion) but also on the propagation mode involved.

Modal dispersion is a distortion mechanism occurring in multimode fibers and other waveguides, in which the signal is spread in time because the propagation velocity of the optical signal is not the same for all modes



Step-Index Multimode Fiber

Question Paper Solution

Submitted by: Ankit Agarwal

Branch : ECE Semester: VI Subject : OFC Mid Term : I/II/Extra/Imp.

Q2 $\lambda = 1550\ nm$

$\alpha_{att} = 0.5\ dB/km$

$\alpha_{splice} = 1\ dB$ each.

$\alpha_{coupler} = 0.6\ dB$ each.

Total Length = 10 km

$P_{received} = 0.4\ \mu W$

Total No of splices = Total Distance − 1

10 − 1 = 9

Losses due to splices = 1 dB × 9 = 9 dB

Total No. of coupler = 2

Losses due to coupler = 2 × 0.6 = 1.2 dB.

Losses due to attenuation $= \alpha_{dB} \times L$

$= 0.5 \times 10 = 5\ dB$.

overall Loss $= \alpha_{splice} + \alpha_{coupler} + \alpha_{att}$

$9 + 1.2 + 5 = 15.2\ dB$.

$P_{Tx} = P_{received} + P_{loss}$.

$P_{Tx} = 0.4\ \mu W + 15.2\ dB$

$= (-63.98 + 15.2)\ dB$

$P_{TX} = -48.78\ dB$

$P_{rec} = 10 \log_{10}(P_{rec})$

$P_{rec} = -63.98\ dB$

Question Paper Solution

Submitted by: Richa Sharma

Branch : ECE Semester: VI Subject : OFC Mid Term : I/II/Extra/Imp.

2. (i) Critical angle ϕ_c at core-cladding interface:-

$$\phi_c = \sin^{-1}\frac{n_2}{n_1}$$

$n_1 = 1.50$ $n_2 = 1.47$

$$\phi_c = \sin^{-1}\frac{1.47}{1.50} = 78.5^\circ$$

(ii) Numerical aperture for fiber :

$$NA = (n_1^2 - n_2^2)^{1/2} = ((1.50)^2 - (1.47)^2)^{1/2}$$

$$= (2.25 - 2.16)^{1/2}$$

$$= (0.09)^{1/2} = 0.30$$

(iii) The acceptance angle in air for fiber θ_a :-

$$\theta_a = \sin^{-1} NA = \sin^{-1} 0.30$$

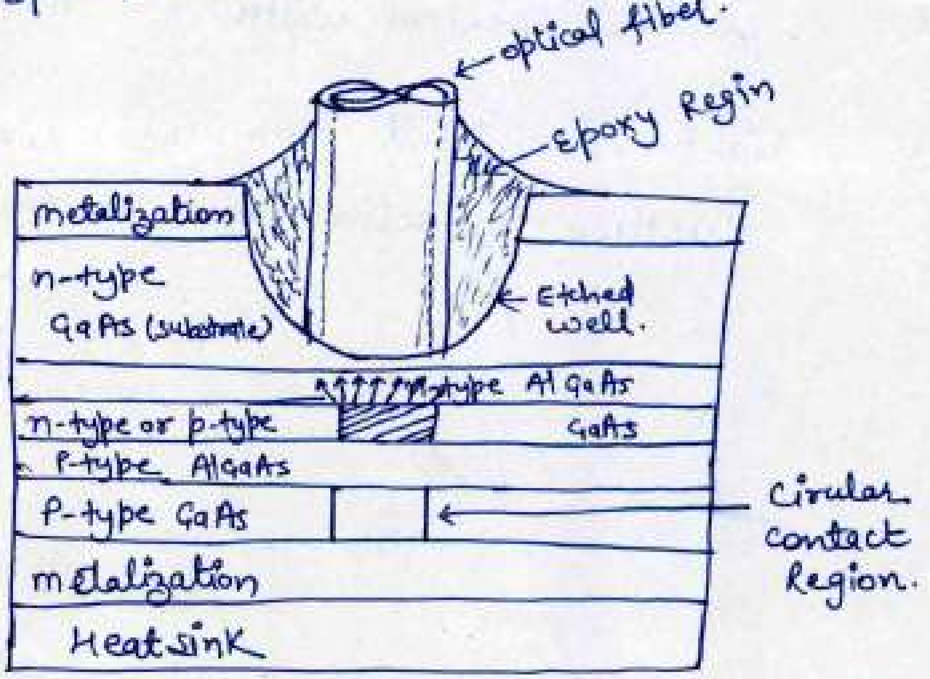
$$= 17.4^\circ$$

Question Paper Solution Submitted by: Ankit Agarwal

Branch : ECE Semester: VI Subject : OFC Mid Term : I/II/Extra/Imp.

Q3 :- SLED :- Surface Emitted LED.

* Primary Active region is a narrow strip that lies beneath the substrate.
* It is a small circular area located below the surface of the semiconductor substrate, 20-50 μm diameter and upto 2.5 μm thick.
* Emission is isotropic Pattern.
* A well is etched in the substrate to allow the direct coupling of emitted light to the optical fiber.
* Emission Area of substrate is perpendicular to axis of optical fiber.



Question Paper Solution

Submitted by: Ankit Agarwal

Branch : ECE Semester: VI Subject : OFC Mid Term : I/II/Extra/Imp.

S.No	SLED	ELED
1.	Easy to fabricate	Difficult to fabricate
2.	Easy to mount and Handle	Difficult
3.	Required less critical Tolerances	Need critical tolerance
4.	Less Reliable	Highly Reliable
5.	Low system performance	High System performance
6.	Less modulation Bandwidth	Better modulation Bandwidth.
7.	Couple less optical power into low NA fiber	couple more optical power.
8.	wider spectral width	Narrow spectral width.
9.	Light is emitted from the surface of active layer	Light is emitter from edge of Active layer.

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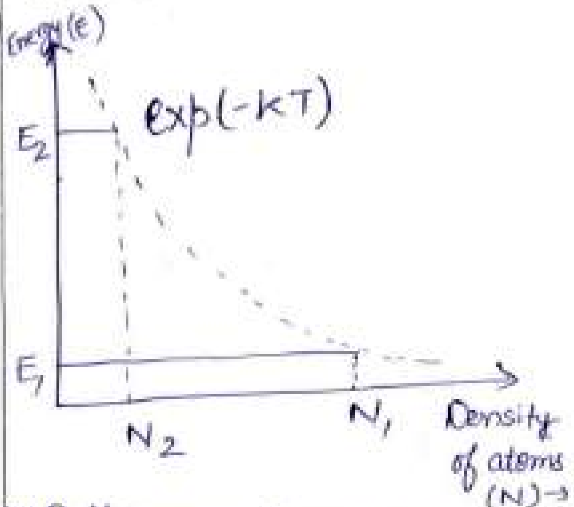
Question Paper Solution

Submitted by: Richa Sharma

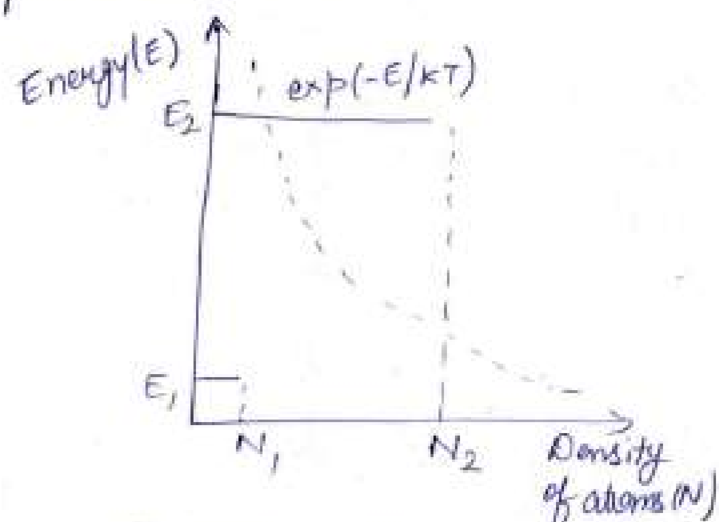
Branch : ECE Semester: VI Subject : OFC Mid Term : I/II/Extra/Imp.

4. Population Inversion:-

To achieve optical amplification, it is necessary to create a non-equilibrium distribution of atoms such that the population of upper energy level is greater than that of lower energy level ($N_2 > N_1$). This condition is known as Population Inversion.

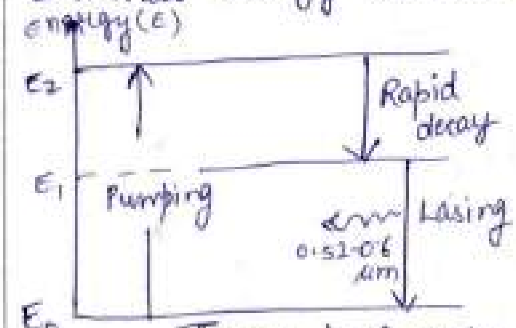


(a) Boltzmann distribution for a system in thermal equilibrium

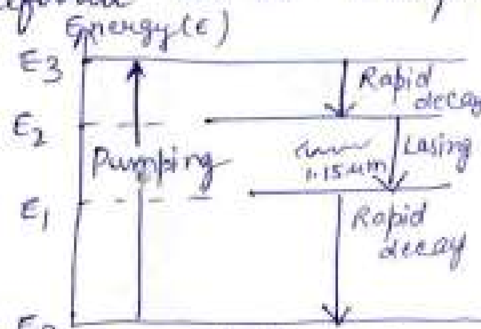


(b) Non equilibrium distribution showing population inversion

In order to achieve population inversion it is necessary to excite atoms into upper energy level E_2 and hence obtain a non equilibrium distribution. This process is achieved using an external energy source and is referred to as 'Pumping'.



Three level system



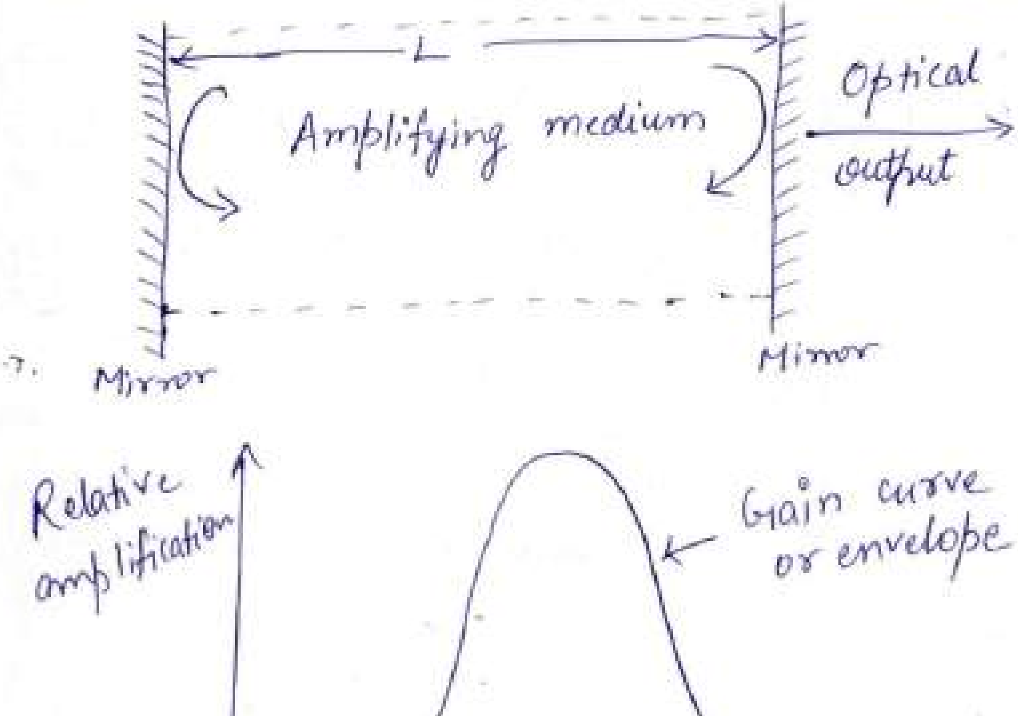
Four level system

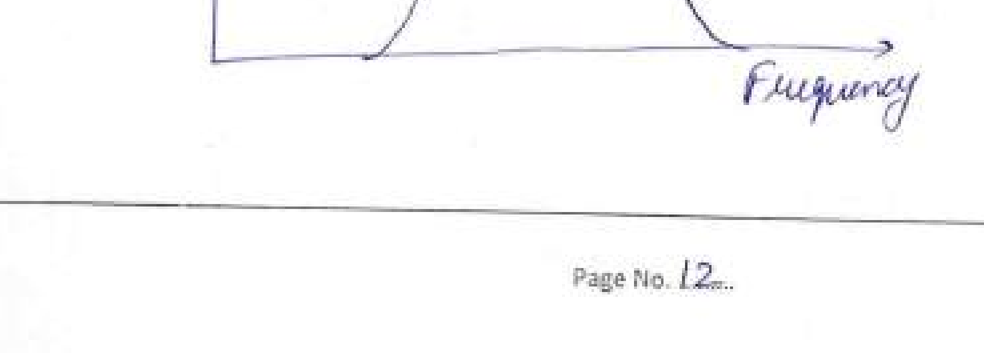
Question Paper Solution Submitted by: Richa Sharma

Branch: ECE Semester: VI Subject: OFC Mid Term: I/II/Extra/Imp.

Optical Feedback :-

Light amplification in laser occurs when a photon colliding with an atom in the excited energy state causes the stimulated emission of a second photon and then both these photons release two more. this continuation causes avalanche multiplication. This is achieved by placing mirrors at either end of amplifying medium. The optical cavity acts as an amplifier and provides positive feedback of photons by reflection at mirrors at either end of cavity. Hence optical signal is fed back many times while receiving amplification as it passes through medium. The structure therefore acts as a Fabry-Perot resonator.





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Question Paper Solution Submitted by: Richa Sharma

Branch : ECE Semester: VI Subject : OFC Mid Term : I/II/Extra/Imp.

Threshold condition for laser oscillation :-

Population inversion is necessary for oscillation but not sufficient for lasing to occur. In addition, a threshold gain within amplifying medium must be attained such that laser oscillations are initiated and sustained. This change is determined by considering change in energy of light beam as it passes through amplifying medium.

Assuming amplifying medium of length L, filling the region between two mirrors having reflectivities r_1 and r_2, fractional loss is given by

$$\text{Fractional loss} = r_1 r_2 \exp(-2\bar{\alpha}L)$$

$\bar{\alpha}$: all losses except transmission loss included in single loss coefficient per unit length.

$$\text{Fractional gain} = \exp(2\bar{g}L)$$

$$\text{Fractional loss} \times \text{Fractional gain} = 1$$

$$r_1 r_2 \exp(-2\bar{\alpha}L) \times \exp(2\bar{g}L) = 1$$

$$r_1 r_2 \exp 2(\bar{g}-\bar{\alpha})L = 1$$

Thus, threshold gain per unit length $\bar{g}_{th}$:

$$\exp 2(\bar{g}-\bar{\alpha})L = \frac{1}{r_1 r_2}, \quad 2(\bar{g}-\bar{\alpha})L = \ln\frac{1}{r_1 r_2}$$

$$(\bar{g}-\alpha) = \frac{1}{2L}\ln\frac{1}{r_1 r_2}$$

$$\boxed{\bar{g}_{th} = \bar{\alpha} + \frac{1}{2L}\ln\frac{1}{r_1 r_2}}, \quad \frac{1}{2L}\ln\frac{1}{r_1 r_2} \rightarrow \text{Transmission loss through mirrors}$$

For laser action, high threshold gain per unit length is required to balance losses from cavity.