ESE Main Examination

Electronics & Telecom. Engineering : Paper-II

(Previous Years Solved Paper 1999)

Contents

MADE EASY PUBLICATIONS

1 Analog and Digital Communication Systems

Revised Syllabus of ESE: *Random signals, noise, probability theory, information theory; Analog versus digital communication & applications: Systems- AM, FM, transmitters/receivers, theory/practice/ standards, SNR comparison; Digital communication basics: Sampling, quantizing, coding, PCM, DPCM, multiplexing-audio/ video; Digital modulation: ASK, FSK, PSK; Multiple access: TDMA, FDMA, CDMA.*

1. Analog Communication Systems

1.1 (i) In FM radio broadcasting, the modulation index is 40%. What is the value of frequency deviation?

(ii) In an FM modulation system, the modulation index is doubled. By what percentage does the total transmitted power increase?

(iii) For the following microwave coaxial connectors write the full form and the frequency upto which these can be used satisfactorily.

1. APC 3.5 2. BNC 3. TNC 4. SMC

[2 + 2 + 4 marks : 1999]

Solution:

(i) Frequency deviation, $\delta = m_f f_m$

where $m_f \rightarrow$ modulation index

$f_m \rightarrow$ modulating frequency

So, $\delta = 0.4\, f_m$

(ii) In FM, the total transmitted power remains constant. So on doubling the modulation index, there will be 0% change in the total transmitted power. Because in FM, we are concerned about the frequency not on the amplitude.

(iii)

Microwave coaxial connectors	Full form	Maximum Frequency
APC 3.5	Amphenol Precision Connector - 3.5 mm	34 GHz
BNC	Bayonet Navy Connector	4 GHz
TNC	Threaded Navy Connector	1 GHz
SMC	Sub-miniature Connector	7 GHz

3. Digital Communication Systems

3.1 Define equalization. Explain with relevant mathematical equations, the principles of operation of a zero forcing transversal equalizer.

[15 marks : 1999]

Solution:

Equalization:

- A pulse train is attenuated and distorted by the transmission medium. The distortion is in the form of dispersion, which is caused by on attenuation of high-frequency components of the pulse train.
- Equalization is the correction of the distortion in the pulse train.
- Theoretically, an equalizer should have a frequency characteristic that is the inverse of that of the transmission medium. This will restore higher frequency components and eliminate pulse dispersion.

Zero-forcing transversal equalizer:

- Zero-forcing transversal equalizer forces the equalizer output pulse to have zero values at the sampling instants.

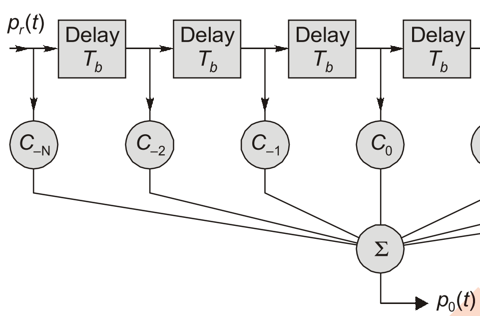


Figure (a)

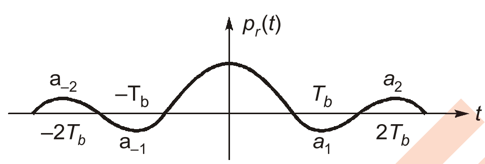


Figure (b)

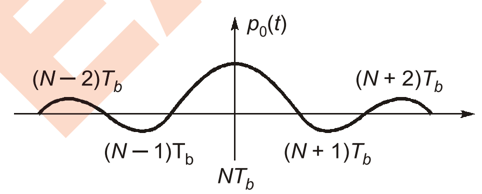


Figure (c)

⇒ **Zero-forcing equalizer analysis:** The output $p_0(t)$ is the sum of pulses of the form $c_k p_r(t-kT_b)$.

Thus,

$$p_0(t) = \sum_{n=-N}^{N} C_n p_r(t-nT_b)$$

The samples of $p_0(t)$ at $t = kT_b$ are

$$p_0(kT_b) = \sum_{n=-N}^{N} C_n p_r[(k-n)T_b];\ k = 0, \pm 1, \pm 2, \pm 3, \ldots$$

The Nyquist criterion requires the samples $p_0(kT_b) = 0$ for $k \neq 0$ and $p_0(kT_b) = 1$ for $k = 0$. Substituting these values into the above equation, we obtain a set of infinite simultaneous equations in terms of $2N+1$ variables. If we specify the values of $p_0(kT_b)$ only at $2N+1$ points as:

$$p_0(kT_b) = \begin{cases} 1 & k = 0 \\ 0 & k = \pm 1, \ \pm 2, \ldots, \pm N \end{cases}$$

Then a unique solution exists. This assures that a pulse will have zero interference at the sampling instants of N preceding and N succeeding pulses.

3.2 A signal $x(t) = \cos(3\pi t) + 0.125\cos(10\pi t)$ is periodically sampled every T_s seconds. Given a sampling signal, $s(t) = 4\sum_{n=-\infty}^{\infty} \delta(t-0.1n)$. Determine

(i) the maximum value of the sampling time

(ii) I_0, I_1, I_2, I_{n+4}, where I_n is the strength of each impulse.

(iii) the minimum bandwidth for a low pass filter so that the recovered signal will be distortionless.

[15 marks : 1999]

Solution:

Given that, $x(t) = \cos(3\pi t) + 0.125\cos(10\pi t) = \cos(2\pi \times 1.5t) + 0.125\cos(2\pi \times 5t)$

$$s(t) = 4\sum_{n=-\infty}^{\infty} \delta(t - 0.1n)$$

(i) Maximum frequency, $f_m = \dfrac{10\pi}{2\pi} = 5$ Hz

Maximum value of sampling time

$$\Rightarrow \qquad T_{s_{max}} = \frac{1}{2f_m} = \frac{1}{2\times 5} = 0.1\text{sec}$$

(ii) Sampled signal $x_0(t) = x(t)\,s(t)$

$$x_0(t) = [\cos(3\pi t) + 0.125\cos(10\pi t)] \times 4\sum_{n=-\infty}^{\infty} \delta(t - 0.1n)$$

and
$$I_0 = [\cos(3\pi t) + 0.125\cos(10\pi t)] \times 4\sum_{n=-\infty}^{\infty} \delta(t)$$

$$\Rightarrow \qquad I_0 = 4[\cos(0) + 0.125\cos(0)] = 4[1 + 0.125] = 4.5$$

Now,
$$I_1 = [\cos(3\pi t) + 0.125\cos(10\pi t)] \times 4\sum_{n=-\infty}^{\infty} \delta(t - 0.1)$$

$$= 4[\cos(0.3\pi) + 0.125\cos(\pi)] \qquad \text{(in radian)}$$

$$\therefore \qquad I_1 = 1.85$$

also,
$$I_2 = [\cos(3\pi t) + 0.125\cos(10\pi t)] \times 4\sum_{n=-\infty}^{\infty} \delta(t - 0.2)$$

$$I_2 = 4[\cos(0.6\pi) + 0.125\cos(2\pi)] \qquad \text{(in radian)}$$

$$\therefore \qquad I_2 = -0.736$$

Now,
$$I_{n+4} = [\cos(3\pi t) + 0.125\cos(10\pi t) \times 4\sum_{n=-\infty}^{\infty} \delta[t - 0.1(n+4)]$$

$$= 4[\cos(3\pi\{0.1(n+4)\}] + 0.125\cos(10\pi\{0.1(n+4)\}]$$

$$= 4[\cos(0.3\pi n + 1.2\pi) + 0.125\cos(n\pi + 4\pi)$$

(iii) Minimum bandwidth for low pass filter so that the recovered signal will be distortionless is

$$\text{BW} = f_m = \frac{10\pi}{2\pi} = 5 \text{ Hz}$$

4. Information Theory

4.1 An information source produces 8 different symbols with probabilities 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, 1/256 respectively. These symbols are encoded as 000, 001, 010, 011, 100, 101, 110 and 111 respectively.

(i) What is the amount of information per symbol?
(ii) What are the probabilities of occurring for a 0 and a 1?
(iii) What is the efficiency of the code so obtained?
(iv) Give an efficient code with the help of the method of Shannon.
(v) What is the efficiency of the code so obtained in (iv) above?

15 marks : 1999]

Solution:

(i) Amount of information per symbol,

$$H(x) = -\sum_{i=1}^{m} P(i)\log_2 P(i) \text{ bits/symbol} = \sum_{i=1}^{m} P(i)\log_2 \frac{1}{P(i)} \text{ bits/symbol}$$

$$H(x) = \left[\frac{1}{2}\log_2 2 + \frac{1}{4}\log_2 4 + \frac{1}{8}\log_2 8 + \frac{1}{16}\log_2 16 + \frac{1}{32}\log_2 32 + \frac{1}{64}\log_2 64 + \frac{1}{128}\log_2 128 + \frac{1}{256}\log_2 256\right]$$

$$H(x) = \left[\frac{1}{2}\times 1 + \frac{1}{4}\times 2 + \frac{1}{8}\times 3 + \frac{1}{16}\times 4 + \frac{1}{32}\times 5 + \frac{1}{64}\times 6 + \frac{1}{128}\times 7 + \frac{1}{256}\times 8\right]$$

$$H(x) = \left[\frac{1}{2} + \frac{1}{2} + \frac{3}{8} + \frac{1}{4} + \frac{5}{32} + \frac{3}{32} + \frac{7}{128} + \frac{1}{32}\right]$$

$$H(x) = 1.96 \text{ bits/symbol}$$

(ii) Probability of occurring 0 is = $P(0)$

$$P(0) = \left[\frac{1}{2}\times 3 + \frac{1}{4}\times 2 + \frac{1}{8}\times 2 + \frac{1}{16}\times 1 + \frac{1}{32}\times 2 + \frac{1}{64}\times 1 + \frac{1}{128}\times 1 + \frac{1}{256}\times 0\right]\times\left(\frac{1}{3}\right)$$

$P(0) = 0.799 \approx 0.8$

Probability of occurring 1 is

$$P(1) = 1 - P(0) = 1 - 0.8 \Rightarrow P(1) = 0.2$$

(iii) $$H(x)_{max} = \log_2 8 = 3$$

$$\text{Efficiency of the code} = \frac{H(x)}{H(x)_{max}} \times 100 = \frac{1.961}{3} \times 100 = 65.367\%$$

(iv) Shannon coding:

Symbol	Probability	Code
A	1/2	0
B	1/4	10
C	1/8	110
D	1/16	1110
E	1/32	11110
F	1/64	111110
G	1/128	1111110
H	1/256	1111111

(v) $$H(x)_{new} = \left[1\times\frac{1}{2} + 2\times\frac{1}{4} + 3\times\frac{1}{8} + 4\times\frac{1}{16} + 5\times\frac{1}{32} + 6\times\frac{1}{64} + 7\times\frac{1}{128} + 7\times\frac{1}{256}\right]$$

$H(x)_{new} = 1.96$ bits/symbol

$$\text{New efficiency } \eta_{new} = \frac{H(x)}{H(x)_{new}} \times 100 = \frac{1.96}{1.96} \times 100 = 100\%$$

■■■■

2 Control Systems

Revised Syllabus of ESE: *Signal flow graphs, Routh-Hurwitz criteria, root loci, Nyquist/Bode plots; Feedback systems-open &close loop types, stability analysis, steady state, transient and frequency response analysis; Design of control systems, compensators, elements of lead/lag compensation, PID and industrial controllers.*

1. Basics, Block Diagrams and Signal Flow Graphs

1.1 A closed loop transfer function of a unity feedback control system is

$$\frac{C(s)}{R(s)} = \frac{20s^2}{(s+1)(s+3)(s+5)}$$

Determine the response of the system when the excitation applied to the input terminal is $\left[1 + 2t + \frac{3t^2}{2}\right]$.

[5 marks : 1999]

Solution:

Given that,

$$\frac{C(s)}{R(s)} = \frac{20s^2}{(s+1)(s+3)(s+5)} \quad \text{...(i)}$$

and

$$r(t) = 1 + 2t + \frac{3t^2}{2} \quad \text{...(ii)}$$

$$\therefore \quad R(s) = \frac{1}{s} + \frac{2}{s^2} + \frac{3}{2}\cdot\frac{2}{s^3} = \frac{s^2+2s+3}{s^3}$$

Response of system = $C(s) = T(s)\cdot R(s)$

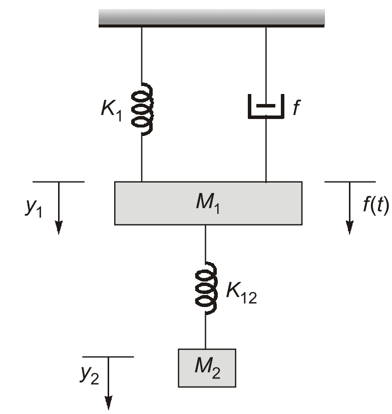
$$C(s) = \frac{20s^2}{(s+1)(s+3)(s+5)}\cdot\frac{(s^2+2s+3)}{s^3} = \frac{20(s^2+2s+3)}{s(s+1)(s+3)(s+5)}$$

$$C(s) = \frac{4}{s} - \frac{5}{s+1} + \frac{10}{s+3} - \frac{9}{s+5} \quad \text{...(iii)}$$

Taking inverse Laplace transform of equation (3) we have,

$$c(t) = (4 - 5e^{-t} + 10e^{-3t} - 9e^{-5t})\, u(t)$$

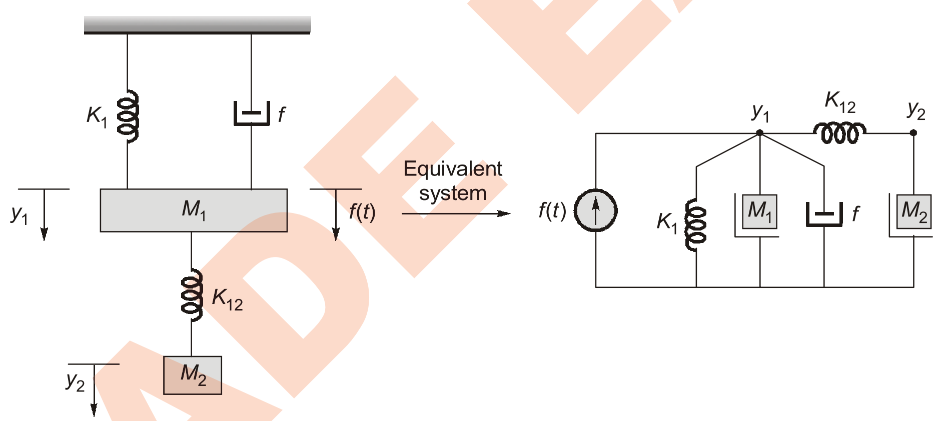
1.2 A dynamic vibration absorber is shown in the figure given below. The system is seen in many situations involving machines containing several unbalanced components. The parameters M_2 and K_{12} may be chosen such that the main Mass M_1 does not vibrate when $f(t) = a \sin \omega_0 t$.



(a) Obtain the differential equation describing the system

(b) Draw the analogous electric circuit based on Force current analogy [15 + 15 marks : 1999]

Solution:



Differential equation

at node y_1

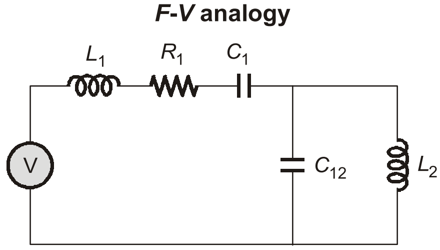
$$f(t) = M_1 \frac{d^2 y_1}{dt^2} + f \frac{dy_1}{dt} + K_1 y_1 + K_{12}(y_1 - y_2)$$

at node y_2

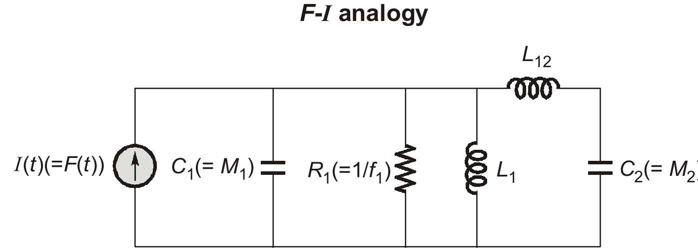
$$0 = M_2 \frac{d^2 y_2}{dt^2} + K_{12}(y_2 - y_1)$$

Equivalent electrical system

***F-V* analogy**

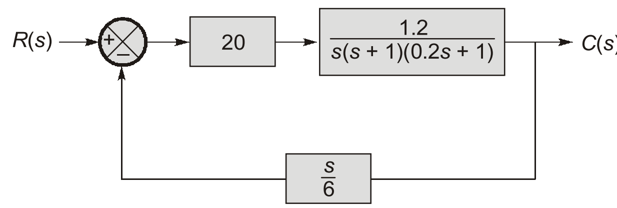


***F-I* analogy**



2. Time Domain Analysis

2.1 For the system shown below, determine the characteristic equation. Hence, find the following when the excitation is a unit step:



(i) Undamped natural frequency

(ii) Damped frequency of oscillation

(iii) Damping ratio and damping factor

(iv) Maximum overshoot

(v) Settling time

(vi) Number of cycles completed before the output is settled within 2%, 5% of its final value.

(vii) Time interval after which maximum and minimum will occur. [20 marks : 1999]

Solution:

The characteristic equation for the given system is,

$$\Rightarrow \quad 1+\frac{20\times 1.2}{s(s+1)(0.2s+1)}\cdot\frac{s}{6} = 0$$

$$\Rightarrow \quad 1+\frac{4\times 5}{(s+1)(s+5)} = 0$$

$$\Rightarrow \quad s^2+6s+5+20 = 0$$

$$\Rightarrow \quad s^2+6s+25 = 0 \quad \text{...(i)}$$

Comparing the characteristic equation $s^2 + 6s + 25 = 0$ with the standard second order characteristic equation, $s^2 + 2\xi\omega_n s + \omega_n^2 = 0$

where ω_n = undamped natural frequency

ξ = damping factor or damping ratio

$$\therefore \quad \omega_n = \sqrt{25} \Rightarrow \omega_n = 5 \text{ rad/s}$$

and

$$\xi = \frac{6}{2\times 5} \Rightarrow \xi = 0.6$$

(i) Undamped natural frequency,

$$\omega_n = 5 \text{ rad/sec}$$

(ii) Damped frequency of oscillation,

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

(iii) Damping ratio or Damping factor = ξ

$$\xi = 0.6$$

(iv) Maximum overshoot,

$$M_p = e^{-\xi\pi/\sqrt{1-\xi^2}} = e^{-\frac{0.6\pi}{\sqrt{1-(0.6)^2}}} = e^{-\frac{0.6\pi}{0.8}} = 0.09478 = 9.478\%$$

(v) Settling time,

$$T_s = \frac{4}{\xi\omega_n} = \frac{4}{0.6\times 5} = 1.33 \text{ sec}$$

(vi) Time period of damped oscillation,

$$T = \frac{2\pi}{\omega_d}$$

So, number of cycles completed before the output is settled within 2% of its final value

$$= \frac{4}{\xi\omega_n T} = \frac{4}{0.6\times 5\times 2\pi/4} = 0.8488 \text{ cycles}$$

Number of cycles completed before the output is settled within 5% of its final value

$$= \frac{3}{\xi\omega_n T} = \frac{3}{0.6\times 5\times 2\pi/4} = 0.6366 \text{ cycles}$$

(vii) Time interval after which maximum and minimum will occur (they occur alternately after this time gap)

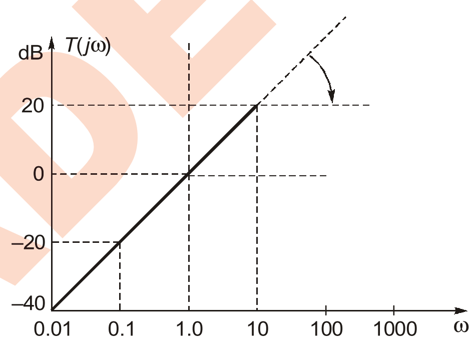
$$T_{max} = \frac{\pi}{\omega_d} = \frac{\pi}{4} = 0.785 \text{ sec}$$

also for minimum will occur (when $n = 2$)

$$T_{min} = \frac{2\pi}{4} = 1.57 \text{ sec}$$

5. Frequency Domain Analysis

5.1 The frequency response of a transfer function $T(j\omega)$ is given below. Determine



(i) the transfer function (ii) the step response assuming no initial energy storage.

[8 marks : 1999]

Solution:

Since, $Y = MX + C$

$\Rightarrow$ $T(j\omega)$ (in dB) $= -20 \log \omega + 20 \log K$

(i) The transfer function is $T(s) = \dfrac{Ks}{\left(1+\dfrac{s}{10}\right)}$

at $\omega = 1.0$

$$20 \log_{10} K = 0$$

$\Rightarrow$ $\boxed{K = 1}$

So, $$T(s) = \frac{s}{1+\frac{s}{10}}$$

$$T(s) = \frac{10s}{s+10}$$

(ii) Given that the input is step signal.

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

Step response, $C(s) = T(s)\cdot R(s)$

$$C(s) = \frac{10s}{s+10} \times \frac{1}{s} = \frac{10}{s+10}$$

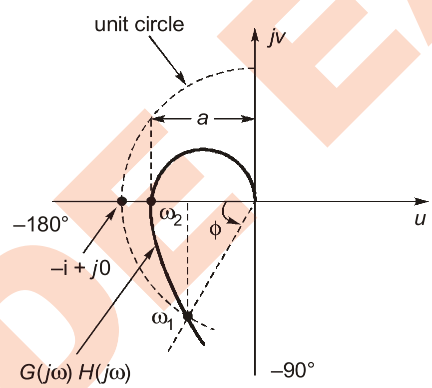
So, step response $c(t) = 10e^{-10t}$.

5.2 Explain Gain margin and Phase margin from Nyquist diagram. [5 marks : 1999]

Solution:

Gain margin from Nyquist diagram:

Consider a Nyquist plot as shown in the figure,



- Gain margin is the factor by which the system gain can be increased to drive it to the verge of instability.
- From the Nyquist diagram, the gain margin may be defined as the reciprocal of the gain at the frequency at which the phase angle becomes 180°. The frequency at which the phase angle is 180° is called the phase cross-over frequency (ω_2) represented as ω_{pc}.

In the diagram, we have,

$$GM = 1/a$$

Where $$a = |G(j\omega)\,H(j\omega)|_{\omega=\omega_2}$$

In decibels, $$\boxed{GM = 20\log\left(\frac{1}{a}\right) dB = -20\log a \text{ dB}}$$

- Phase margin from Nyquist diagram: Phase margin is defined as the amount of additional phase-lag at the gain cross-over frequency required to bring the system to the verge of instability.

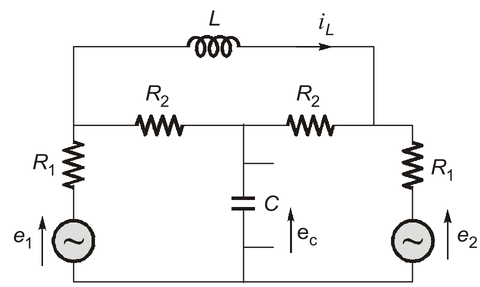
In the Nyquist diagram, ω_1 is the gain cross-over frequency at which $|G(j\omega)\ H(j\omega)| = 1$. The additional phase-lag ϕ driving the system to the verge of instability is called the phase margin.

Thus, $$PM = \angle G(j\omega)\,H(j\omega)|_{\omega=\omega_1} + 180°$$

where the angle at ω_1 is measured negatively.

7. State Space Analysis

7.1 A balanced bridge network is shown in the figure.



(i) Choose a set of state variables and write the state equations representing the network in the form $\dot{x} = AX + BU$. [15 marks : 1999]

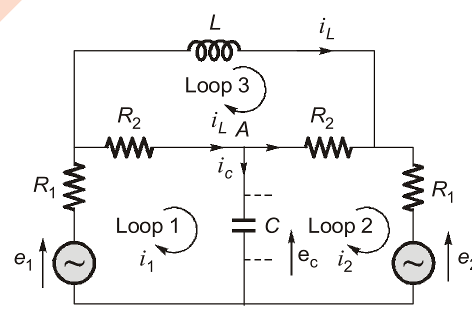
(ii) Draw the state model flow graph of the above system. [15 marks : 1999]

(iii) State the advantages of state space analysis over the conventional differential equation methods of solving system behaviour. [40 marks : 1999]

Solution:

(i) Let us choose i_L and e_C to be the state variables.

KCL at node '*A*',



$$-i_1 + i_C + i_2 = 0$$

$$\Rightarrow \quad i_C = i_1 - i_2$$

Applying KVL in Loop 1,

$$R_1 i_1 + R_2(i_1 - i_L) = e_1 - e_C$$

or
$$(R_1 + R_2)i_1 - R_2 i_L = e_1 - e_C \quad \text{...(i)}$$

Applying KVL in Loop 2,

$$R_2(i_2 - i_L) + R_1 i_2 = e_C - e_2$$

or
$$i_2(R_1 + R_2) - R_2 i_L = e_C - e_2 \quad \text{...(ii)}$$

On solving equation (i) and (ii) we get,

$$i_1 = \frac{e_1 - e_c + R_2 i_L}{R_1 + R_2}$$

and
$$i_2 = \frac{e_c - e_2 + R_2 i_L}{R_1 + R_2}$$

Now applying KVL in Loop 3,

$$L\frac{di_L}{dt} + R_2(i_L - i_2) + R_2(i_L - i_1) = 0$$

or
$$R_2 i_1 + R_2 i_2 = L\frac{di_L}{dt} + 2R_2 i_L \quad \text{...(iii)}$$

Putting value of i_1 and i_2 in the equation (iii),

$$\Rightarrow \quad R_2\left\{\frac{e_1 - e_c + R_2 i_L}{R_1 + R_2}\right\} + R_2\left\{\frac{e_C - e_2 + R_2 i_L}{R_1 + R_2}\right\} = L\frac{di_L}{dt} + 2R_2 i_L$$

$$\Rightarrow \quad \frac{R_2}{R_1 + R_2}\{e_1 - e_2 + 2R_2 i_L\} = L\dot{i}_L + 2R_2 i_L \quad \left[\because \frac{di_L}{dt} = \dot{i}_L\right]$$

$$\Rightarrow \quad L\dot{i}_L = -2R_2 i_L\left(1-\frac{R_2}{R_1+R_2}\right)+\frac{R_2}{R_1+R_2}(e_1-e_2)$$

$$\Rightarrow \quad L\dot{i}_L = \left(\frac{-2R_1R_2}{R_1+R_2}\right)i_L+\frac{R_2}{R_1+R_2}(e_1-e_2)$$

$$\Rightarrow \quad \dot{i}_L = \frac{-2R_1R_2}{(R_1+R_2)L}i_L+\frac{R_2}{(R_1+R_2)L}(e_1-e_2) \qquad \text{...(iv)}$$

Since, $$i_C = C\frac{de_c}{dt} = C\dot{e}_c = i_1 - i_2$$

$$\therefore \quad C\dot{e}_c = -i_2 + i_1 \qquad \text{...(v)}$$

Now, putting values of i_1 and i_2 in equation (v), we get,

$$\Rightarrow \quad C\dot{e}_c = -\left(\frac{e_C-e_2+R_2i_L}{R_1+R_2}\right)+\left(\frac{e_1-e_C+R_2i_L}{R_1+R_2}\right)$$

$$\Rightarrow \quad C\dot{e}_c = \left(\frac{e_2+e_1-2e_C}{R_1+R_2}\right)$$

$$\therefore \quad \dot{e}_c = \frac{2}{(R_1+R_2)C}e_c+\frac{1}{(R_1+R_2)C}(e_1+e_2) \qquad \text{... (vi)}$$

Writing the equation (iv) and (vi) in the required state variable form as,

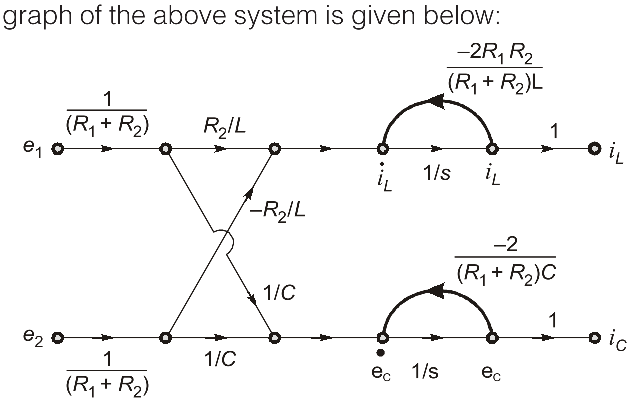
$$\begin{bmatrix}\dot{i}_L\\ \dot{e}_c\end{bmatrix} = \begin{bmatrix}\frac{-2R_1R_2}{(R_1+R_2)L} & 0\\ 0 & \frac{-2}{(R_1+R_2)C}\end{bmatrix}\begin{bmatrix}i_L\\ e_c\end{bmatrix}+\begin{bmatrix}\frac{R_2}{(R_1+R_2)L} & -\frac{R_2}{(R_1+R_2)L}\\ \frac{+1}{(R_1+R_2)C} & \frac{+1}{(R_1+R_2)C}\end{bmatrix}\begin{bmatrix}e_1\\ e_2\end{bmatrix}$$

Comparing with $\dot{X} = AX + BU$ we have,

$$A = \begin{bmatrix}\frac{-2R_1R_2}{(R_1+R_2)L} & 0\\ 0 & \frac{-2}{(R_1+R_2)C}\end{bmatrix}$$

and $$B = \begin{bmatrix}\frac{R_2}{(R_1+R_2)L} & \frac{-R_2}{(R_1+R_2)L}\\ \frac{1}{(R_1+R_2)C} & \frac{1}{(R_1+R_2)C}\end{bmatrix}$$

(ii) State model flow graph of the above system is given below:



(iii) Advantages of state space analysis over the conventional differential equation methods:

1. The state variable analysis gives the complete information about the internal states of the system at any given point of time.
2. It takes initial conditions into consideration.
3. It is applicable for multiple-input-multiple-output system.
4. It is applicable for both LTI and time-varying systems.
5. The controllability and observability can be determined easily.
6. It employs the use of vector matrix notation.
7. Representation of higher order system thus become very simple through this technique.

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3 Microprocessors and Microcontrollers

Revised Syllabus of ESE: *Microprocessors & microcontrollers, basics, interrupts, DMA, instruction sets, interfacing; Controllers & uses; Embedded systems.*

1. 8085 Microprocessor

1.1 Write an 8085 ALP to add a 16-bit number in Locations 5000 H (high byte) and 5001 H (Low byte) with another 16-bit number stored in 5002 H (high byte) and 5003 H (Low byte). Store the result in BC.

[10 marks : 1999]

Solution:

8085 ALP for the addition of two 16-bit numbers:

Labels	Mnemonics	Operands	Comments
	LHLD	5000 H	1st 16-bit number in H-L Pair.
	XCHG		Get 1st number in D-E Pair.
	LHLD	5002 H	2nd 16-bit number in H-L Pair.
	DAD	D	1st number + 2nd number.
	JNC	AHEAD	Is carry? No, go to the Label AHEAD
	MVID	00 H	
	INR	D	If yes, increment C.
	MOV	B,H	Store MSBs of the sum in register-B.
	MOV	C,L	Store LSBs of the sum in register-C
	HLT		Halt.
AHEAD:	MOV	B, H	
	MOV	C, L	
	HLT		

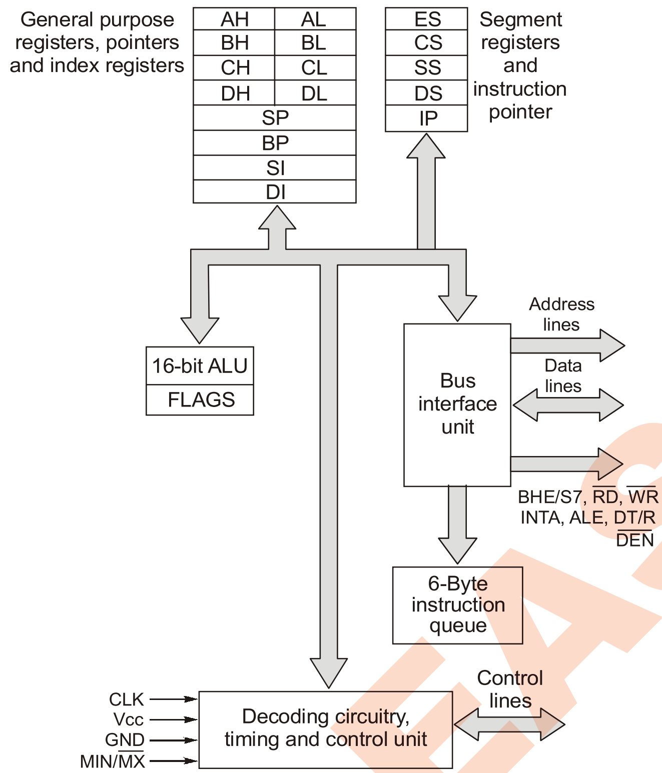
2. 8086 Microprocessor

2.1 Draw the architecture of intel 8086 and mention the special functions associated with its registers.

[8 marks : 1999]

Solution:

The 8086 is a 16-bit , N-channel, HMOS microprocessor (high speed MOS). Its clock frequencies for its different versions are : 5, 8 and 10 MHz. The intel 8086 microprocessor uses 20 address lines and 16 data lines. It can directly address up to 2^{20} = 1 Megabytes of memory



(Block diagram of Intel 8086 microprocessor)

⇒ The Intel 8086 µp contains the following types of registers:

(i) General Purpose registers (ii) Points and Index registers

(iii) Segment registers (iv) Instruction Pointer

(v) Status Flags

Accumulator	AX	AH	AL	General purpose registers
Base	BX	BH	BL	
Counter	CX	CH	CL	
Data	DX	DH	DL	
Stack pointer		SP		Pointer and index registers
Base pointer		BP		
Source index		SI		
Destination index		DI		
Code segment		CS		Segment registers
Data segment		DS		
Stack segment		SS		
Extra segment		ES		
Instruction pointer		IP		
Status register		FLAGS		

- Register AX serves as an accumulator. Registers BX, CX and DX are serving as general purpose registers and also serve as special purpose registers (SPR). As a SPR, BX serves as a base register for the computation of the memory address. Register CX is also used as a counter in case of multi – iteration instructions. When content of CX = O, then it terminate the execution. DX register is also used for memory addressing when data are transferred between I/O port and memory using certain I/O instructions.

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4 Electromagnetics

Revised Syllabus of ESE: *Elements of vector calculus, Maxwell's equations-basic concepts; Gauss, Stokes theorems; Wave propagation through different media; Transmission Lines-different types, basics, Smith's chart, impedance matching/transformation, S-parameters, pulse excitation, uses; Waveguides-basics, rectangular types, modes, cut-off frequency, dispersion, dielectric types; Antennas-radiation pattern, monopoles/dipoles, gain, arrays-active/passive, theory, uses.*

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4. Waveguides

4.1 Why do we prefer hollow wave guides to open wire two conductors, or coaxial transmission lines for transmission of power? [10 marks : 1999]

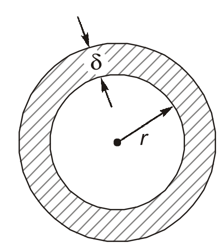
Solution:

We prefer hollow waveguide to open two wire or coaxial transmission line because.

(i) Lower I^2R Loss:

At high microwave frequencies,

the resistance of a thin conductor $R = \dfrac{l}{2\pi\delta r \sigma_c}$



Cross section of the cylindrical conductor

i.e. resistance varies inversely with radius.

l = length of cable

r = radius of cable's cross-section

δ = skin depth

σ_c = conductivity of cable material

Now, this resistance is direct result of skin effect specially, the inner conductor of coaxial cable and the thin two wire cable which have smaller radii as compared to outer conductor of coaxial cable or the only hollow conductor waveguide and hence much higher resistance.

As waveguide will have larger cross-section. So R will be very small as compared to thinner inner conductor.

⇒ The total resistance of coaxial cable is roughly ≈ resistance of inner conductor as outer conductor has a fairly low resistance in comparison to inner conductor.

(ii) Power Handling Capacity:

In order to avoid severe radiation losses it is mandatory to keep the

(a) separation in two wire (d)

(b) mean circumference = $\pi(a + b)$ in coaxial cable.

much smaller than the free space wavelength of the operating frequency for proper field cancellation. This limitation on size at high microwave frequencies limits the cross-section of the transmission line and consequently the power carrying capacity.

However in absence of inner conductor; the size limitation does not effect the power handling capacity of waveguide as it does to wire and coaxial cable.

(iii) Electromagnetic Interference (EMI)
Waveguide are not affected by EMI much but the two-wire cable, if not shielded, will be severely interfered by electromagnetic fields.

(iv) Due to uniform field distribution in the waveguide, the dielectric breakdown is highly unlikely which is observed more often in the coaxial and two-wire transmission line due to non-uniform field distribution.

4.2 What factors does the power carrying capacity of a wave guide depend upon? [10 marks : 1999]

Solution:

The power carrying capacity of a waveguide depends upon the following factors:

(i) Dielectric strength of the insulating material in the waveguide
(ii) Maximum frequency used in waveguide
(iii) Operating frequency in waveguide
(iv) Dimension of waveguide
(v) Conductivity of wall of waveguide

4.3 A waveguide has an internal breadth '*a*' of 3 cms and carries a dominant mode of a signal of unknown frequency. If the characteristic impedance of the mode is 500 ohms what is frequency of the signal? [20 marks : 1999]

Solution:

Given that, $a = 3$ cm

Cut-off frequency of dominant mode TE_{10} is

$$f_c = \frac{c}{2a} = \frac{3\times10^{10}}{2\times3} = 5\text{ GHz}$$

Characteristic impedance of TE mode is

$$\therefore \quad Z_{TE} = \frac{\eta}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} \Rightarrow 500 = \frac{120\pi}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$$

$$\Rightarrow \quad 1-\left(\frac{5}{f}\right)^2 = \left(\frac{120\pi}{500}\right)^2$$

$$\Rightarrow \quad \left(\frac{5}{f}\right)^2 = 1 - 0.568 = 0.432$$

$$\Rightarrow \quad \frac{5}{f} = 0.657$$

$$\therefore \quad f = 7.61\text{ GHz}$$

So, the frequency of signal is 7.61 GHz.

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5 Advanced Communication

Revised Syllabus of ESE: *Communication networks: Principles /practices /technologies /uses /OSI model/ security; Basic packet multiplexed streams/scheduling; Cellular networks, types, analysis, protocols (TCP/TCPIP); Microwave & satellite communication: Terrestrial/space type LOS systems, block schematics link calculations, system design; Communication satellites, orbits, characteristics, systems, uses; Fibre-optic communication systems: fibre optics, theory, practice/standards, block schematics, link calculations, system design.*

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3. Fibre Optic Communication Systems

3.1 A multimode graded index fibre has an acceptance angle in air of 9°. Calculate the relative refractive index difference between the core axis and the cladding when the refractive index at the core axis is 1.45. [10 marks : 1999]

Solution:

Numerical Aperture is *NA* and it is equal to,

$$NA = n_0 \sin \theta_a$$

where, $n_0 \rightarrow$ Refractive index of air ($\cong 1$) and $\theta_a \rightarrow$ Acceptance angle

$$\therefore \quad NA = \sin 9° = 0.1564$$

Also,

$$NA = n_1 (2\Delta)^{1/2}$$

where $n_1 \rightarrow$ Refractive index of core

$\Delta \rightarrow$ Relative refractive index difference

$$\Rightarrow \quad 0.1564 = 1.45(2\Delta)^{1/2}$$

$$\Rightarrow \quad 2\Delta = (0.10786)^2$$

$$\Rightarrow \quad \Delta = 5.817 \times 10^{-3}$$

$$\Rightarrow \quad \Delta \cong 0.582\%$$

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