MADE EASY

India's Best Institute for IES, GATE & PSUs

ESE 2019

Main Exam

Exam held on 30.06.2019

Electronics and Telecom. Engineering

Paper-II

Source of Questions from MADE EASY References

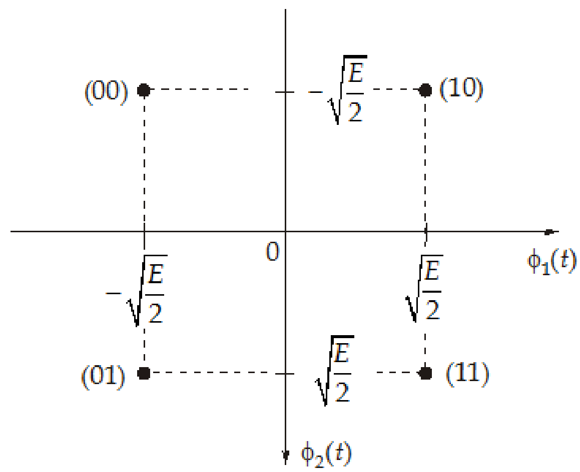
(Classroom/Books/Test Series)

1.(a) In a narrow band digital communication system the symbol error probability for the in-phase channel is P_{eI} and for quadrature phase channel is P_{eQ}. Prove that the probability of symbol error for the overall system is given by (P_e): 10

$$P_e = P_{eI} + P_{eQ} - P_{eI}P_{eQ}$$

Source: MADE EASY ESE Mains Test Series-2019 Þ Q.2 (c) of Test Number 3

(c) Consider the signal-space diagram of a coherent QPSK system as shown in the figure below:



$\phi_1(t)$ and $\phi_2(t)$ are two orthonormal basis functions, which are represented as,

$$\phi_1(t) = \sqrt{\frac{2}{T}}\cos(2\pi f_c t)\,;\; 0 \le t \le T$$

$$\phi_2(t) = \sqrt{\frac{2}{T}}\sin(2\pi f_c t)\,;\; 0 \le t \le T$$

All the four message symbols are occurring with equal probability and they are transmitted through an AWGN channel with two-sided noise power spectral density of $\frac{N_0}{2}$. Suggest a receiver model to reproduce the symbols at channel output and derive an expression for the probability of symbol error.

[25 marks]

1.(b) Consider a discrete time system with impulse response $h[n] = \left(\frac{1}{5}\right)^{2n} U[n]$. Find the value of constant A such that $h[n] - Ah[n-1] = \delta[n]$ and $\delta[n]$ is a unit impulse signal. 10

Source: MADE EASY Regular Classroom Workbook of Signals and Systems (Page Number 13)

Q.26 A discrete-time system S with impulse response $h[n] = \left(\frac{1}{2}\right)^n u[n]$. If system difference equation is $h[n] - c \cdot h[n-1] = \delta[n]$, then the value of c is ________ .

1.(c) A digital computer has a memory unit with 32 bits per word. The instruction set consists of 240 different operations. All instructions have an operation code part (opcode) and an address part (allowed for only one address). Each instruction is stored in one word of memory.

(i) How many bits are needed for the opcode ?

(ii) How many bits are left for the address part of the instruction ?

(iii) What is the maximum allowable size of the memory ? 10

Source: Similar Question From MADE EASY Classnotes

Q. Consider a hypothetical CPU which supports Instruction with two Register operands and 1 memory operates. Processor supports 200 Instructions, 24-Registers & 256 KB memory space. How many bits are required to encode the Instruction [Instruction size].

Soln Instruction design

Opcode	Reg	Reg	Mem
$\log_2 200$	$\log_2 24$	$\log_2 24$	$\log 256K$
$\log_2 2^8$	$\log_2 2^5$	$\log_2 2^5$	$\log_2 2^{18}$
8	5	5	18

(8 + 5 + 5 + 18) 36 bits.

1.(d) The Radiation intensity of an antenna is

$$U(\theta, \phi) = \begin{cases} 2 \sin\theta \sin^3\phi & 0 \leq \theta \leq \pi,\ 0 \leq \phi \leq \pi \\ 0 & \text{elsewhere} \end{cases}$$

Determine the directivity of the antenna. 10

Source: MADE EASY ESE Mains Test Series-2018 Þ Q.4 (b) of Test Number 6

Q.4 (b) An antenna is fed with 100 W power. The efficiency of the antenna is 80%. The power radiation pattern of the antenna is given by,

$$p(\theta, \phi) = \begin{cases} \sin^2\theta \sin^2\phi; & 0 \leq \theta \leq \pi,\ 0 \leq \phi \leq \pi \\ 0; & \text{otherwise} \end{cases}$$

Find the radiation intensity in the direction of maximum radiation. Also find the power density at a distance of 10 km in the direction of the maximum radiation.

1.(f) A mobile network transmits data having bandwidth of 200 Hz using a carrier frequency of 800 MHz. If the maximum speed of a vehicle is 120 km/hr, calculate the bandwidth and the cut-off frequencies of the filter at the receiver input. 10

Source: MADE EASY ESE Mains Test Series-2018 Þ Q.6 (b) of Test Number 15

Q.6 (b) (i) Determine the maximum speed of a vehicle in a mobile communication system experiencing a maximum Doppler frequency shift of 70 Hz. Assume that the frequency of transmission is 900 MHz and the angle between vehicle moving direction and signal arriving direction is zero.

(ii) A mobile receiver is tuned to a transmission at 800 MHz and receives signals with Doppler frequencies ranging from 10 Hz to 50 Hz when moving at a uniform speed of 80 kmph. What is the beamwidth of the mobile antenna?

2.(a) Two speech signals $m_1(t)$ and $m_2(t)$ are used to generate a composite signal as :

$$s(t) = m_1(t)\cos\omega_c t + m_2(t)\sin\omega_c t$$

Assume both the messages are low pass in nature and have W Hz bandwidth.

(i) Draw the block diagram and show the generation scheme of $s(t)$. 8

(ii) Propose a demodulation scheme in the form of block diagram and show the recovery of the two signals $m_1(t)$ and $m_2(t)$. Assume $\omega_c >> 2\pi W$. 12

Source: MADE EASY Theory Book of Communication Systems (Page Number 142)

4.9.1 Quadrature-Carrier Multiplexing

A quadrature-carrier multiplexing scheme enables two DSBSC modulated waves (resulting from the application of two independent message signals) to occupy the same transmission bandwidth, and yet it allows for the separation of the two message signals at the receiver output. It is therefore a bandwidth-conservation scheme.

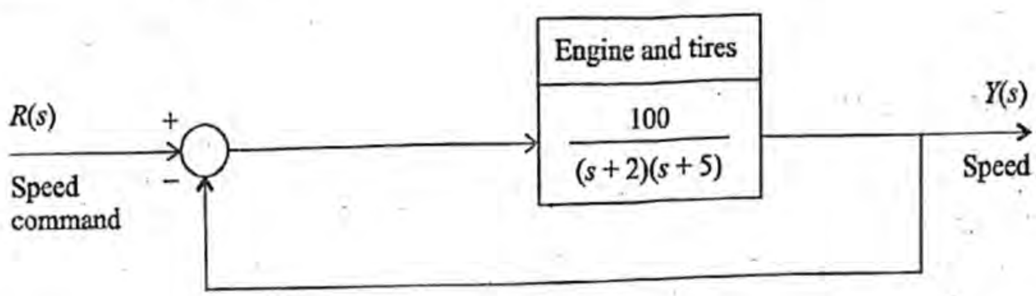
The transmitter of the system, involves the use of two separate product modulators that are supplied with two carrier waves of the same frequency but differing in phase by –90°. The multiplexed signal $s(t)$ consists of the sum of these two product modulator outputs, as shown by

$$s(t) = A_c m_1(t)\cos(2\pi f_c t) + A_c m_2(t)\sin(2\pi f_c t)$$

where $m_1(t)$ and $m_2(t)$ denote the two different message signals applied to the product modulators. Thus, the multiplexed signal $s(t)$ occupies a transmission bandwidth of 2W, centered at the carrier frequency f_c, where W is the message bandwidth of $m_1(t)$ or $m_2(t)$, whichever is largest.

The multiplexed signal $s(t)$ is applied simultaneously to two separate coherent detectors that are supplied with two local carriers of the same frequency, but differing in phase by –90°. The output of the first detector is $\frac{1}{2}A_c m_1(t)$, whereas the output of the second detector is $\frac{1}{2}A_c m_2(t)$.

2.(b) The engine, body, and tires of a racing vehicle affect the acceleration and speed attainable. The speed control of the car is represented by the model as shown in the following figure.



(i) Calculate the steady state error of the car to a step command in speed. 5

(ii) Calculate the overshoot of the speed to a step command. 15

Source: MADE EASY GATE Test Series-2019 Þ Q.16 of Test Number 26

Q.16 The steady state response of a unity negative feedback control system for a step input whose transfer function is given by $T(s) = \dfrac{10(s+2)}{(s^2+4s+8)}$ will be ________.

3.(a) A digital communication system uses five symbols $\{S_0, S_1, S_2, S_3, S_4\}$ with their following probabilities of occurrence

S_0	S_1	S_2	S_3
0·55	0·20	0·10	0·10

(i) Compute Huffman code for these symbols by moving the combined symbol as low as possible. 15

(ii) Calculate the average code word length. 5

Source: MADE EASY ESE Mains Test Series-2018 Þ Q.3 (a) of Test Number 15
MADE EASY ESE Mains Test Series-2019 Þ Q.5 (c) of Test Number 5

Q.3 (a) A discrete memoryless source is producing 5 symbols with probabilities as shown below:

s_i	s_0	s_1	s_2	s_3	s_4
$P(s_i)$	0.55	0.15	0.15	0.10	0.05

Compute two different Huffman codes for this source. In one case, move a combined symbol in the coding procedure as high as possible, and in the second case, move it as low as possible. Hence, for each of the two codes, find the average code-word length, coding efficiency and the variance of the code-word length.

Source: MADE EASY ESE Mains Test Series-2019 ⇒ Q.5 (c) of Test Number 5

Q.5 (c) A source emits seven symbols with probabilities 0.35, 0.3, 0.2, 0.1, 0.04, 0.005, 0.005. Give Huffman coding for these symbols and calculate average bits of information and average binary digits of information per symbol.

3.(b) A unity feedback control system has $KG(s) = \dfrac{K(s+2)}{s(s+1)}$

(i) Find the breakaway and entry points on the real axis. 10

(ii) Find the gain and the roots when the real part of the complex roots are located at −2. 10

Source: MADE EASY Theory Book of Control Systems (Page Numbers 252, 256)
MADE EASY ESE Mains Test Series-2018 Þ Q.7 (c) of Test Number 2

9.2 Angle and Magnitude Conditions

The angle condition is used for checking whether any point lie on the root locus or not and also the validity of root locus shape. Consider the characteristic equation (in case of negative feedback system),

$$1 + G(s)\,H(s) = 0$$

$$\Rightarrow \quad G(s)\,H(s) = -1$$

Hence, $|G(s)\,H(s)| = 1$ .... Magnitude condition

and $\angle G(s)\,H(s) = \pm 180^\circ$ or $\pm[2q+1]\,180^\circ$ .... Angle condition

where, $q = 0, 1, 2, 3$ .... Integers

Angle condition may be stated as, for a point to lie on root locus the angle evaluated at that point must be an odd multiple of $\pm 180^\circ$. We can also say that a locus of all the points in the complex plane satisfying the angle condition alone is the root locus. Once the root loci is drawn, the magnitude condition $[|G(s)\,H(s)| = 1]$ is used for finding the value of system gain (K) at any point on the root locus. It can also be used for finding the roots of the characteristic equation (or the close loop poles) corresponding to a given value of the gain.

However, angle condition and magnitude condition are not independent and one implies the other. The values of 's' that fulfill both of these conditions are the roots of the characteristic equation, or the close loop poles.

Rule-VI

The breakaway points (points at which the root locus gets break) of the root locus are the solutions of

$$\frac{dK}{ds} = 0.$$

Actually, breakaway points are the points at which multiple roots of the characteristic equation occur. These can be determined by rewriting the characteristic equation and solving for the value of s at which

$$\frac{dK}{ds} = 0.$$

To test valid breakaway (B.A.) points, put the solution of $\frac{dK}{ds} = 0$ in the expression of K (originally derived from the characteristic equation), if K comes out to be positive, the B.A. point is valid otherwise not.

General Predictions about Break-away Points

(i) The branches of root locus either approach or leave the B.A. point at an angle of $\pm 180^\circ/n$ where n is number of branches approaching or leaving the B.A. point.

(ii) The complex conjugate path for the branches of root locus approaching or leaving a B.A. point is a circle in certain cases only.

(iii) Whenever there are two adjacently placed poles or zeros lie on real axis (with a section of real axis between them as a part root locus) then there exists a B.A. point between them.

(iv) Whenever there is a zero on real axis and left side of that zero if these is no pole or zero on real axis with the entire section of real axis to the left side of that zero as a part of root locus then these exist a B.A. point to the left side of that zero.

Q.7 (c) The open-loop transfer function of a system with unity negative feedback is given by,

$$G(s) = \frac{K(s+2)}{(s+1)^2}$$

(i) Draw the root locus diagram (for $0 < K < \infty$) and give all the salient points in the diagram.

(ii) By using the root locus diagram obtained in part (i), determine the minimum value of the damping ratio (ζ) of the system.

3.(c) What is virtual memory ? How it is different from main memory ? Suppose CPU generates 32 bit virtual addresses and the page size is 16 KB. The processor has a translation look-aside buffer (TLB) which can hold a total of 512 page table entries and is 4-way associative. Calculate the size of TLB tag. 20

Source: MADE EASY Theory Book of Microprocessors and Computer Organization (Page Numbers 254, 261)

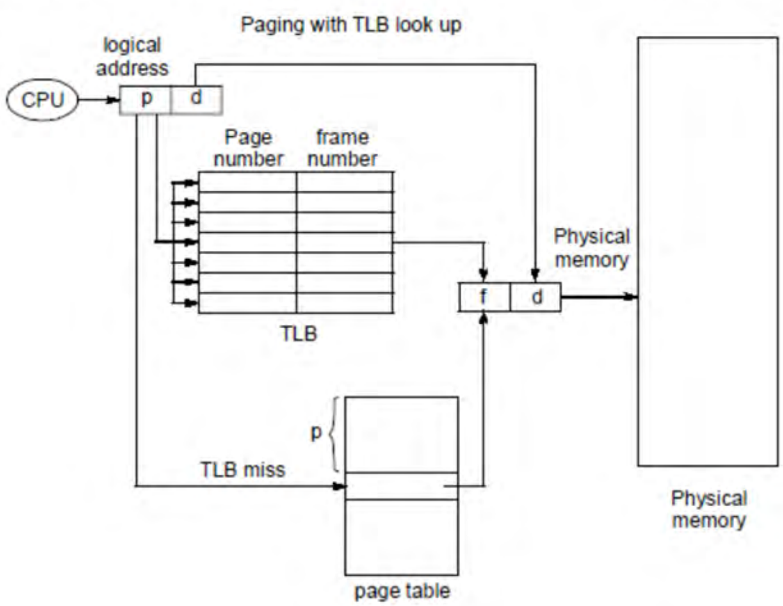
9.5 Virtual Memory

Virtual memory is the separation of user logical memory from physical memory. This technique provides larger memory to the user by creating virtual memory space. It facilitates the user to create a process which is larger than the physical memory space. We can have more processes executing in memory at a time.

It increases degree of multiprogramming. With the virtual memory technique, we can execute a process which is only partially loaded in memory.

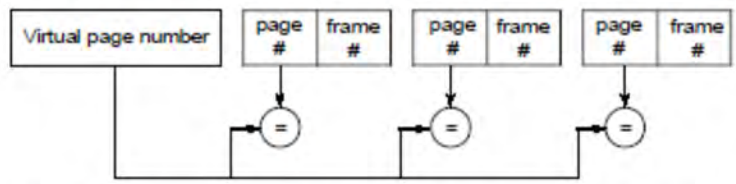
Paging with TLB (Translation Look-aside Buffer)

A TLB is on-chip hardware special cache which is part of memory-management unit. TLB is used in virtual-to-physical address translations so it is also called as address-translation cache. It is a cache that holds recently accessed page table entries. If address translation uses a TLB entry, access to the page table is avoided. TLB can cache only a few of page table entries. TLB is fully associative memory, so page numbers of all TLB entries are checked simultaneously for a match. TLB lookup is much faster than a memory access.



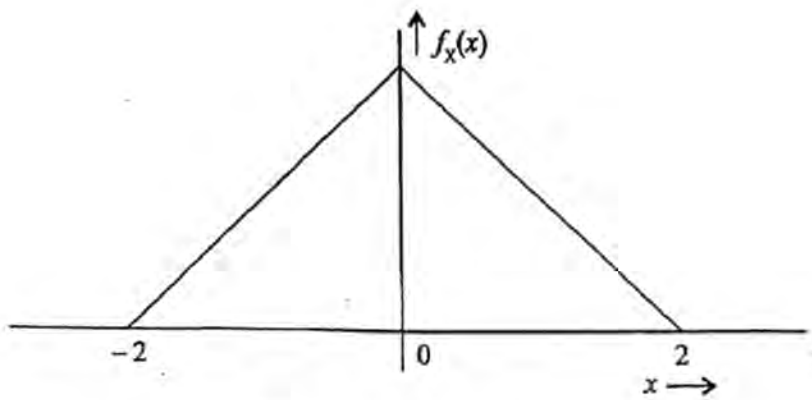
How TLB lookup helps in paging?

- When a logical address is generated by CPU, its page number searched in fully associative TLB.
- If page number is found in the TLB (hit), its frame number is accessed from TLB (without memory reference for address translation) to get physical address of actual frame.
- If page number is not found in the TLB(miss), one extra memory reference is needed to access the frame number (address translation needed) from page table to get the physical address of actual frame, and add the resulting translation to the TLB, replacing an existing entry if necessary.



Each entry in the TLB contains a (page number, frame number) pair, plus copies of some or all of the page's protection bits, use bit, and dirty bit.

4.(a)



A low pass stationary process $X(t)$ has probability density function (at any given point of time) as shown in the figure. This process has a bandwidth of 5 kHz and is to be transmitted by using a PCM system.

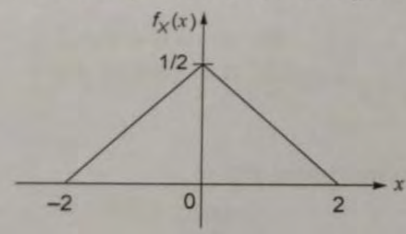
(i) Calculate the signal to quantization noise ratio (in dBs) if the sampling is done at the Nyquist rate and 5 bit uniform quantizer is used. 8

(ii) Calculate the bit rate generated. 4

(iii) If the maximum bit rate supported by the channel is 64 kbps, calculate the possible improvement in signal to quantization noise ratio if the uniform quantizer is redesigned. 8

Source: MADE EASY GATE Online Test Series 2018

Q.51 The probability density function of the amplitude of a message signal is shown in the figure below.



If the samples of this message signal are applied to a 32-level mid-rise uniform quantizer, then the resultant signal-to-quantization noise ratio will be

5.(a) In a system if data is transmitted to remote location using 8 bit PCM encoding, find

(i) Channel capacity if Bandwidth is 300 kHz and SNR = 15 dB. 4

(ii) the maximum number of channels that can be accommodated in this scheme if Time Division Multiplexing is used with each channel having 5 kHz fixed bandwidth allocation. 6

Source: MADE EASY ESE Mains Test Series-2019 Þ Q.4 (c) (ii) of Test Number 11

Q.4 (c) (ii) Five telemetry signals, each with a bandwidth of 10 kHz, are to be transmitted by binary PCM with TDM. The maximum tolerable quantization error is 0.50 percent of the peak signal amplitude. The signals are sampled at 20 percent above the Nyquist rate. Framing and synchronization require an additional 0.50 percent extra bits. Determine the minimum transmission data rate and the minimum required channel bandwidth to transmit the multiplexed signal.

5.(b) A system is described by the state equations

$$\dot{X} = \begin{bmatrix} 3 & 0 \\ -1 & 1 \end{bmatrix} X + \begin{bmatrix} -1 \\ 1 \end{bmatrix} U \text{ and } Y = \begin{bmatrix} 1 & 1 \end{bmatrix} X.$$

Determine whether the system is controllable and observable. 10

Source: MADE EASY GATE Previous Solved Papers, Q.7.5 of Control Systems

7.5 The system mode described by the state equations

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ 2 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u, \quad Y = \begin{bmatrix} 1 & 1 \end{bmatrix} x.$$

Determine whether the system is controllable and observable.

5.(c) An analog cellular system has a total of 33 MHz of bandwidth and uses two 25 kHz simplex channels to provide full duplex voice and control channels. What is the number of channels available per cell for a frequency reuse factor of 4 cells ? If 1 MHz is dedicated to a control channel then how many voice channels will be available for reuse factor of 4 cells. 10

Source: MADE EASY ESE Mains Test Series-2018 Þ Q.3 (b) of Test Number 9

Q.3 (b) A mobile communication system is allocated with an RF spectrum of 25 MHz and uses RF channel bandwidth of 25 kHz so that a total number of 1000 voice channels can be supported in the system.

(i) If the service area is divided into 20 cells with a frequency reuse factor of 4, compute the system capacity.

(ii) The cell size is reduced to the extent that the service area is now covered with 100 cells. Compute the system capacity while keeping the frequency reuse factor as 4.

(iii) Consider the cell size is further reduced so that the same service area is now covered with 700 cells with the frequency reuse factor of 7. Compute the system capacity.

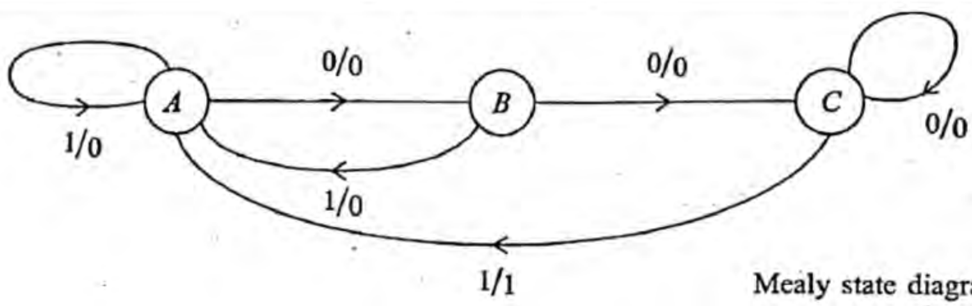
Comment on the results obtained.

5.(d) Find the potential at a point P which is 1 m radial distance from the midpoint of a 2 m straight line charge of uniform density 10 nC/m in air. If this line charge is bent to form an arc of a circle of radius 1 m, find the percentage change in potential at the same point P. Give reason for this change. 10

Source: MADE EASY ESE Previous Year Solved Convetional Paper Book (Page Number 212)

Q.18 40 nC of charge is uniformly distributed around a circular ring of radius 2m. Find the potential at a point on the axis at 5 m from the plane of the ring. What would be the voltage if all the charge at the origin like a point charge? [8 marks : 2014]

5.(e)

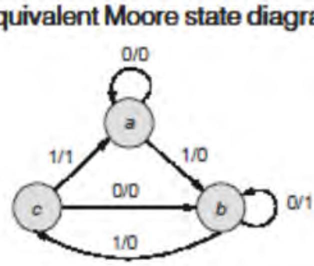


Mealy state diagram

Construct the state diagram for a Moore circuit from the given Mealy circuit. 10

Source: MADE EASY Theory Book of Advanced Electronics (Page Number 64)

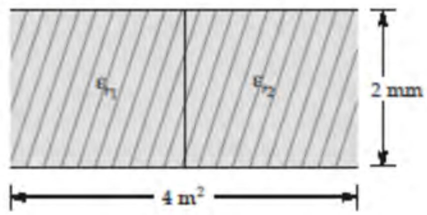
Example - 5.1 Draw the equivalent Moore state diagram for the following Mealy state diagram.



6.(a) The relative permittivity of a dielectric material between the plates of parallel plate capacitor varies uniformly from $\epsilon r_1 = 1$ at one plate to $\epsilon r_2 = 4$ at other plate. The area of each plate is 1 m^2. Find the capacitance per unit length of this capacitor if $d = 3$ mm. Derive the equation used. 20

Source: MADE EASY GATE Online Test Series-2019 Þ Q.16 of Test Number 22

Q.16 A parallel plate capacitor comprising two dielectrics $\varepsilon_{r_1} = 1.2$ and $\varepsilon_{r_2} = 4.8$. Each contains one half the volume as shown in figure below.



If the area $A = 4$ m^2 and $d = 2$ mm, the overall capacitance will be ________ nF.

6.(b) (i) Discuss the priority of interrupts of 8086. Draw a circuit that will terminate the INTR when interrupt request has been acknowledged. 15

(ii) Explain Direct Memory Access (DMA) mode of data transfer. 5

Source: MADE EASY Theory Book of Microprocessors (Page Number 73) ⇒ Q.6 (b) (ii)

DMA Data Transfer Scheme (DMA-DTS)

- In DMA-DTS, MPU doesn't participate because data is directly transferred from an I/O device to the memory or vice-versa.
- In DMA, the MPU releases the control of the buses to a device called "DMA Controller". The controller manages data transfer between memory and a peripheral under its control, thus by- passing the MPU.
- The MPU communicates with the controller by using the chip select line, Buses and Control signals. Examples of DMA controller chips are: Intel 8237A, 8257 etc.
- DMA-DTS is a faster scheme as compared to programmed DTS.
- It is used to transfer data from "mass storage devices" (hard disks, floppy disks etc). It is also used for high-speed printers.
- Once the controller has gained the control, it plays the role of a processor for data transfer as:
  1. The DMA controller chip puts the MPU in a HOLD state by means of the HOLD control signal. This is an active high input signal.
  2. The MPU then stops executing the program and disconnects the address, data and memory control lines from its bus by placing them on a high impedance state. The microprocessor is totally disabled during DMA.

7.(a) A lossless line with $L = 0{\cdot}5$ μH/m and $C = 150$ PF/m is operated at a frequency 10 MHz. Find the shortest length of line at which it acts as

(i) 150 PF Capacitor on an open circuit and short circuit.

(ii) 2 μH Inductor on an open circuit and short circuit. 20

Source: MADE EASY Theory Book of Electromagnetics (Page Number 170)

6.4 Special Cases

6.4.1 Shorted Line ($Z_L = 0$)

For this case, $$Z_{SC} = Z_{in}\big|_{Z_L=0} = jZ_0 \tan\beta l \quad \text{...(6.76 a)}$$

Also, $$\Gamma_l = -1,\ s = \infty \quad \text{...(6.76 b)}$$

We notice from equation (6.76 a) that Z_{in} is a pure reactance, which could be capacitance or inductive depending on the value of l. The variation of Z_{in} with l is shown in figure 6.8(a).

6.4.2 Open-Circuited Line ($Z_L = \infty$)

In this case,

$$Z_{OC} = \lim_{Z_L \to 0} Z_{in} = \frac{Z_0}{j\tan\beta l} = -jZ_0 \cot\beta l \quad \text{...(6.77 a)}$$

7.(b) (i) Implement the following Boolean functions using PLA :

$$\text{Sum } (A, B, C_{in}) = \Sigma m(1, 2, 4, 7)$$

$$\text{Cout } (A, B, C_{in}) = \Sigma m(3, 5, 6, 7)$$

10

Source: MADE EASY ESE Mains Test Series-2019 Þ Q.2 (c) of Test Number 4
MADE EASY ESE Mains Test Series-2019 Þ Q.6 (c) of Test Number 6
MADE EASY Theory Book of Advanced Electronics (Page Number 106)

Q.2 (c) Minimise the following Boolean functions using K-map and implement them using a (3 × 4 × 2) programmable logic array (PLA).

$$F_1(A, B, C) = \Sigma m(0, 1, 2, 4)$$
$$F_2(A, B, C) = \Sigma m(0, 5, 6, 7)$$

Q.6 (c) Minimize the following Boolean expressions and implement them using a 4 × 8 × 4 programmable logic array (PLA).

$$F_1(A, B, C, D) = \Sigma m(0, 2, 5, 7, 8, 10, 12)$$
$$F_2(A, B, C, D) = \Sigma m(0, 2, 4, 6, 8, 9, 14, 15)$$
$$F_3(A, B, C, D) = \Sigma m(0, 1, 8, 9, 14, 15)$$
$$F_4(A, B, C, D) = \Sigma m(0, 1, 2, 4, 5, 8, 9, 10)$$

Example - 6.8 Realize a full-adder using a (3 × 8 × 2) PLA.

(ii) Explain photolithography process. Also, explain the importance of photoresists.

10

Source: MADE EASY ESE Mains Test Series-2019 Þ Q.3 (b) of Test Number 4
MADE EASY Theory Book of Advanced Electronics (Page Number 9)

Q.3 (b) Explain different steps involved in the photolithographic process with diagrams.

1.4 Masking and Photolithography

As already pointed out, for the fabrication of semiconductor devices, selective doping is often necessary. This means that certain regions of the wafer have to be protected against doping during diffusion or ion-implantation. In general, this is done by covering the entire sample by a protective (masking) layer and then removing this mask layer at some selected regions by a process called photolithography. Afterwards, diffusion or ion-implantation is carried out and doping takes place only in the regions not protected by the mask. The most commonly used mask material in silicon technology is silicon dioxide (SiO_2) and it can be easily grown on silicon by thermal oxidation as discussed in the previous section. For compound semiconductors, SiO_2 and/or Si_3N_4 deposited by chemical vapour deposition can be used as masks. Since ion-implantation is a relatively low temperature process, photoresist itself can be used as a mask against implantation.

Once the mask layer is grown or deposited on the semiconductor surface, it must be patterned. That is, the mask should be retained only over certain selected regions and removed from the rest of the surface. Patterning is a two-step process. In the first step, a photosensitive material (photoresist) is spin-coated on the entire sample surface. There are two types of photoresist, namely positive and negative. In optical photolithography, the photoresist-coated wafer is exposed to UV light through an appropriate mask plate (or photomask). Certain regions on the mask plate are transparent, and the rest is opaque. In case of positive photoresist, the photoresist exposed to UV light is softened and is therefore easily removed in a developer solution. In case of negative photoresist, only the exposed resist remains and the unexposed resist is removed by the developer solution. Thus, the mask pattern (or its negative) is transferred onto the resist-coated sample after the exposed (or unexposed) resist is removed in the developer solution. Figures 1.7(a), (b), and (c) illustrate the process schematically.

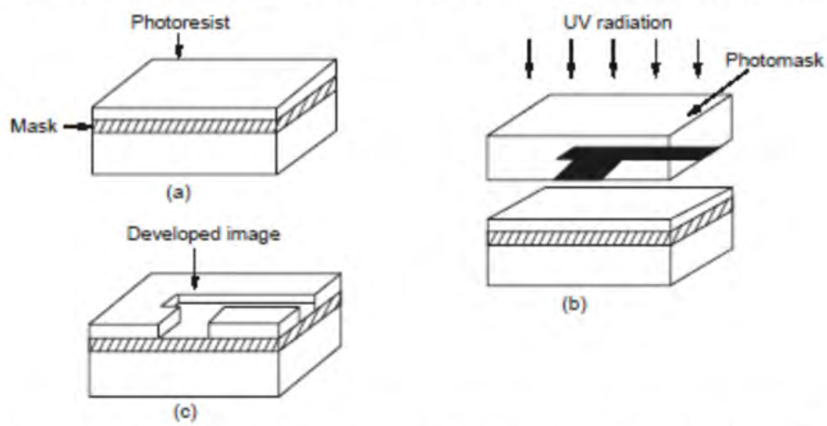


***Figure-1.7:** Different steps in photolithography process showing the transfer of patterns*

In the second step of patterning, the mask is removed (etched) from the regions no longer protected by photoresist (also called opening windows in the mask). If the masking layer is SiO_2, etching is usually done by dipping the sample in hydrofluoric acid (wet chemical etching), which etches SiO_2 in the regions which are not protected by the photoresist. After the selective removal of oxide, photoresist is removed from everywhere. The sample is then washed in de-ionized water, dried thoroughly, and is ready for diffusion/implantation. However, if photoresist itself is the mask used against ion-implantation, it is not necessary to grow and selectively etch the oxide.

Optical lithography using deep UV light is by far the most widely used lithography technique today. The minimum feature size which can be obtained by the photolithography process depends on the wavelength of the UV radiation, and lower wavelengths are used for better resolution. Electron beam lithography and X-ray lithography have also been used to reduce the minimum feature size. Electron beam lithography allows direct writing on the sample (no patterned mask plate is needed as the electron beam is directly raster-scanned on the photoresist). Due to the very small electron beam size, high resolution can be achieved. However, scanning the entire wafer is a very slow process and hence not suitable for large scale production. On the other hand, it is difficult to prepare a suitable mask plate for X-ray lithography. Thus, these techniques so far have found only limited application.

8.(a)	The inside dimensions of 9 GHz air filled waveguide are $2{\cdot}286$ cm $\times$ $1{\cdot}016$ cm. Find the maximum power that can be transmitted in the TE mode assuming that the breakdown electric field intensity is 3×10^{6} V/m.	20

Source: MADE EASY ESE Mains Test Series-2018 Þ Q.7 (b) of Test Number 8

Q.7 (b) An air-filled rectangular waveguide of dimensions a = 2 cm, b = 4 cm transports energy in the dominant mode at a rate of 2 mW. If the frequency of operation is 10 GHz, then determine the peak value of the magnetic field in the waveguide.

8.(b) (i) For given discrete time systems, where $y[n]$ and $x[n]$ are the output and the input sequences, respectively. Determine, whether or not the system is — linear, causal, stable and time-invariant. 10

(A) $y[n] = n^2x[n]$ (B) $y[n] = x[n-5]$

(ii) Develop two different cascade canonic realization of given causal IIR transfer function

$$H(z) = \frac{(0{\cdot}3 - 0{\cdot}5z^{-1})(2 + 3{\cdot}1z^{-1})}{(1 + 2{\cdot}1z^{-1} - 3z^{-2})(1 + 0{\cdot}67z^{-1})}$$ 10

Source: MADE EASY ESE Mains Test Series-2019 ⇒ Q.1 (d) of Test Number 15
MADE EASY ESE Mains Test Series-2019 ⇒ Q.2 (c) of Test Number 11

Q.1 (d) Consider a discrete-time system with the following input-output relationship,

$$y(n) = \begin{cases} x(n) & ; \quad n \geq 1 \\ 0 & ; \quad n = 0 \\ x(n+1) & ; \quad n \leq -1 \end{cases}$$

where $x(n)$ is the input and $y(n)$ is the output of the given system. Check whether the system is (i) Linear; (ii) Causal; (iii) Time-invariant; (iv) Stable

Q.2 (c) Consider the discrete-time linear causal system defined by the difference equation $y(n) - \frac{3}{4}y(n-1) + \frac{1}{8}y(n-2) = x(n) + \frac{1}{3}x(n-1)$. Draw a signal flow graph to implement this system in each of the following forms:

(i) Direct form I
(ii) Direct form II
(iii) Cascade form
(iv) Parallel form

8.(c) Describe the mechanism of intermodal dispersion in a multimode step index fiber. Show that the total broadening of a light pulse δT_s due to intermodal dispersion in a multimode step index fiber may be given as :

$$\delta T_s \approx \frac{L(NA)^2}{2n_1 C}$$

where L is the fiber length, NA is the numerical aperture of the fiber, n_1 is the core refractive index and C is the velocity of light is a vacuum. 5+15

Source: MADE EASY Theory Book of Advanced Communication (Page Number 71)
Numerical on this Topic is given in MADE EASY ESE Mains Test Series-2019 Þ Q.8 (a) of Test Number 13

3.13.1 Inter-Modal Dispersion

- This is caused because different rays take different path in a fibre.
- When a light pulse is launched in fibre, it is combination of different rays. If all rays are incident at same time at input of fibre, we find they will reach at different times.
- We can calculate time difference (ΔT) between the fastest ray (which come out first or axial ray) and the slowest ray (which come at last) and found.

For multimode step index fibre, $\Delta T = \frac{Ln_1}{C} \cdot \Delta$

where, L = length of fibre, Δ = relative refractive index difference and c = velocity of light in vacuum.

For multimode graded index fibre, $\Delta T = \frac{Ln_1\Delta^2}{8C}$

as we can see for graded index fibre ΔT is directly proportional to square of index difference (where $\Delta \sim 0.01\text{-}0.02$) so dispersion in multimode graded index fibre is less than that of multimode step index fibre.

Q.8 (a) A 6 km optical link consists of multimode step index fiber with a core refractive index of 1.5 and a relative index difference of 1%. Estimate:

(i) The delay difference between the slowest and fastest modes at the fiber output.

(ii) The rms pulse broadening due to intermodal dispersion on the link.

(iii) The maximum bit rate that may be obtained without substantial errors on the link, assuming only intermodal dispersion.

(iv) The bandwidth-length product corresponding to part (iii).