B.E.
Sixth Semester Examination, 2010
Telemetry Data Processing & Recording (IC-304-E)

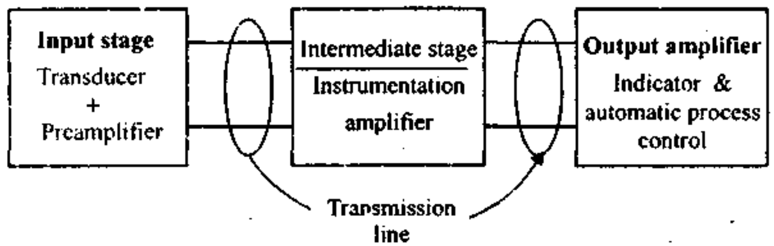
Note : Attempt any five questions. All questions carry equal marks.

Q. 1. Explain the block diagram and applications of a typical instrumentation system.

Ans. Instrumentation is a technology of measurement which serves not only science but all branches of engineering, medicine and almost every human endeavour.

The knowledge of any parameters largely depends on the measurement or its a device or mechanism used to determine the present value of quantity under measurement.

Instrumentation System :



The measurement and control of physical conditions is very important in many industrial and consumer application. For example, the operator may make necessary adjustments in the measurement of temperature or humidity inside a necessary adjustments in the measurement of temperature or humidity inside a dairy or meat plant to maintain the product quality, or to produce a particular type of plastic, precise temperature control of the plastic furnace is needed.

For example, when a strain gauge is subjected to pressure or force, the resistance of the strain gauge changes i.e., it convert mechanical energy into electrical energy. Actually an instrumentation system is used to measure the output signal produced by the transducer and most used to control the physical condition producing the output signal. The instrumentation system consists of a type of transducer as the input stage, depending upon the physical quality to be measured. The transducer output is fed to the pre-amplifier. The instrumentation amplifier is the intermediate stage. The output of the instrumentation amplifier can be connected to various device such as oscilloscope, charts or magnetic recorder.

The output of the transducer is the input signal source of the instrumentation amplifier. A transducer which produces sufficient strength can be used to drive the output device directly. Most do not produce sufficient output. Hence, to amplify these low level output signal of the transducer instrumentation amplifiers are used which drive the indicator or display unit.

The instrumentation amplifier is required for precise low level signal amplification. In brief, they are used, where the low noise, low thermal and time drift, high input resistance and accurate closed loop gain are required.

Applications of Instrumentation System :

(i) Temperature indicator using thermistor

(ii) Light intensity meter

(iii) Analog weight scale

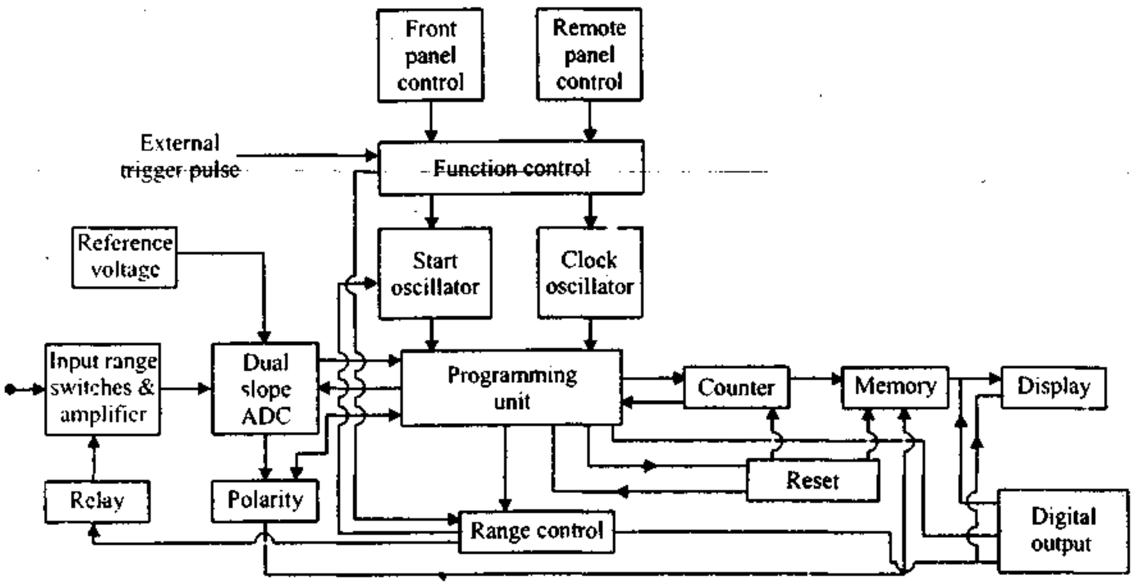
Types of instrumentation system :

(i) Digital controlled system

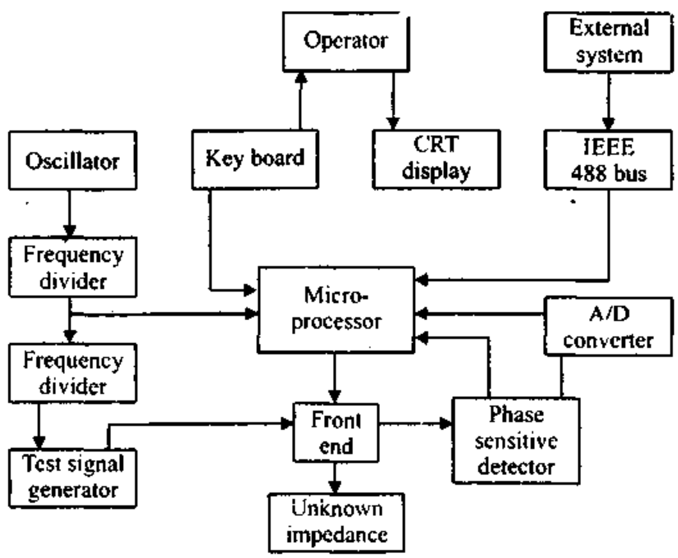
(ii) Microprocessor based system

(i) Digital Controlled or Fully Automatic Digital :

Instrumentation System :

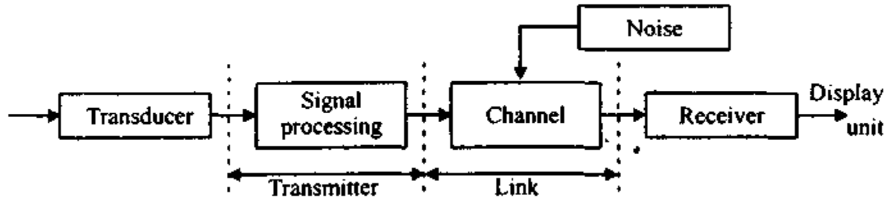


(ii) Microprocessor Based Instrumentation System :



Q. 2. (a) Draw and explain the block diagram of typical telemetry system.

Ans. Telemetry System :



Signal from a single transducer or signals from a number of transducers may be grouped together for transmission over the channel, each transducer has its signal covering a range of frequencies known as baseband. For grouping of signals, the range of frequencies of the different transducer is important. If they do not overlap they may be grouped by mixing so that all these signals from a single baseband of wide range. However it is then known as the bandwidth of the baseband signal.

Narrow low-frequencies signal bandwidths are often utilized in modulating a high frequency carrier and this process shifts the frequency spectrum to a higher value around the carrier for convenience of transmission.

Classification : The telemetry system for long medium distance can be broadly classified into factor to be considered.

Its capacity to carry information power level, band-factor to be considered. Its capacity to carry information, power levels, bandwidth, signal to noise ratio and reliability are some of the important aspects.

Telemetering equipment at the transmitting and receiving stations are however no less important.

Another classification can on the basic of (i) wired and (ii) wireless forms.

While the latter is essentially for long distance service the former is usually for short to medium-distance operation. If the signal is not available in electrical quantity but in terms of air pressure requiring to cover a short distance before display, pneumatic channels may be used.

Radio link for short distance are finding increasing use because in many situations the erection-commissioning costs of non *rf* land lines are more expensive and require more time than RF links. It is now almost a forgone conclusion that for data transmission separate landlines are rarely used. Instead telephone link and power line are used besides RF links.

Q. 2. (b) Explain the voltage and position telemetry system.

Ans. Voltage & Position Telemetry System : Electrical system are used for short distance telemetering the distance is around a few hundred meters (300 m) only.

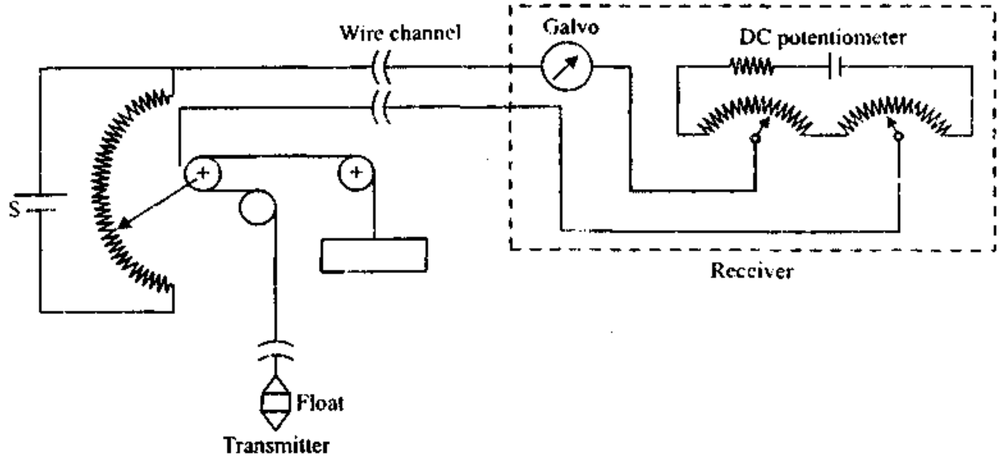
Such system can be classified as :

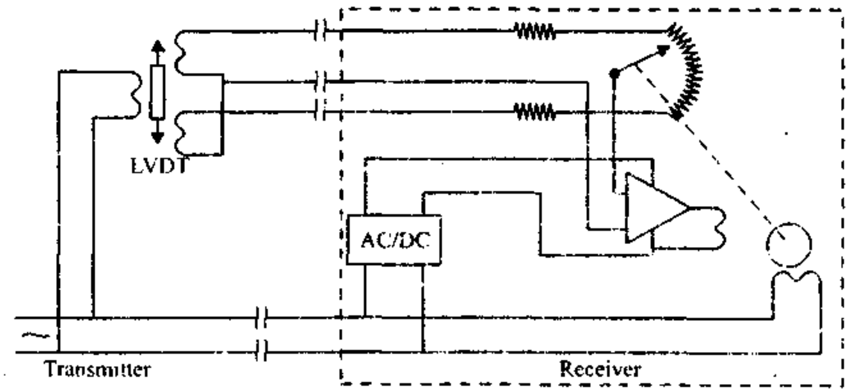
(i) Voltage telemetering

(ii) Position telemetering

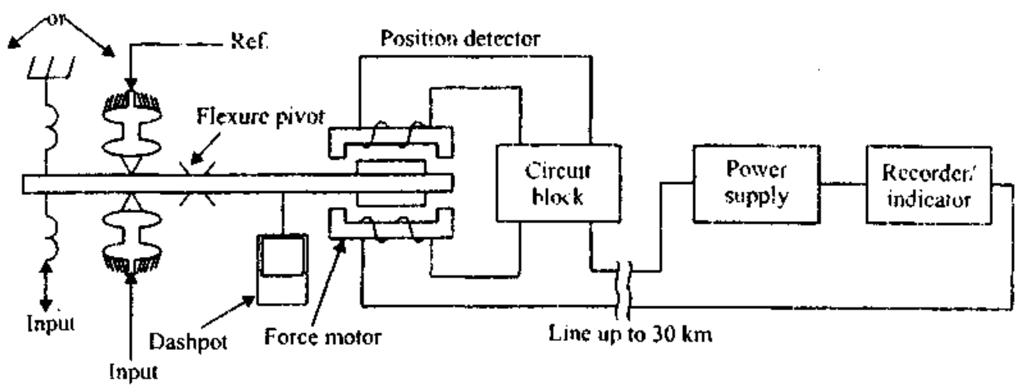
A typical voltage telemetry scheme shown in figure.

An important aspect of telemetering system is the SNR. Signal is generally referred to as the power of the transmitted message and noise in the interference that occurs during the transmission.

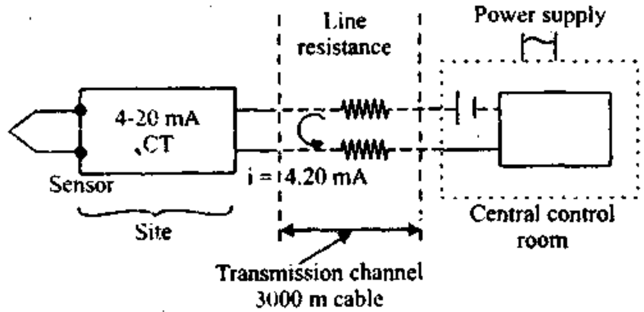




Position Telemetry System :

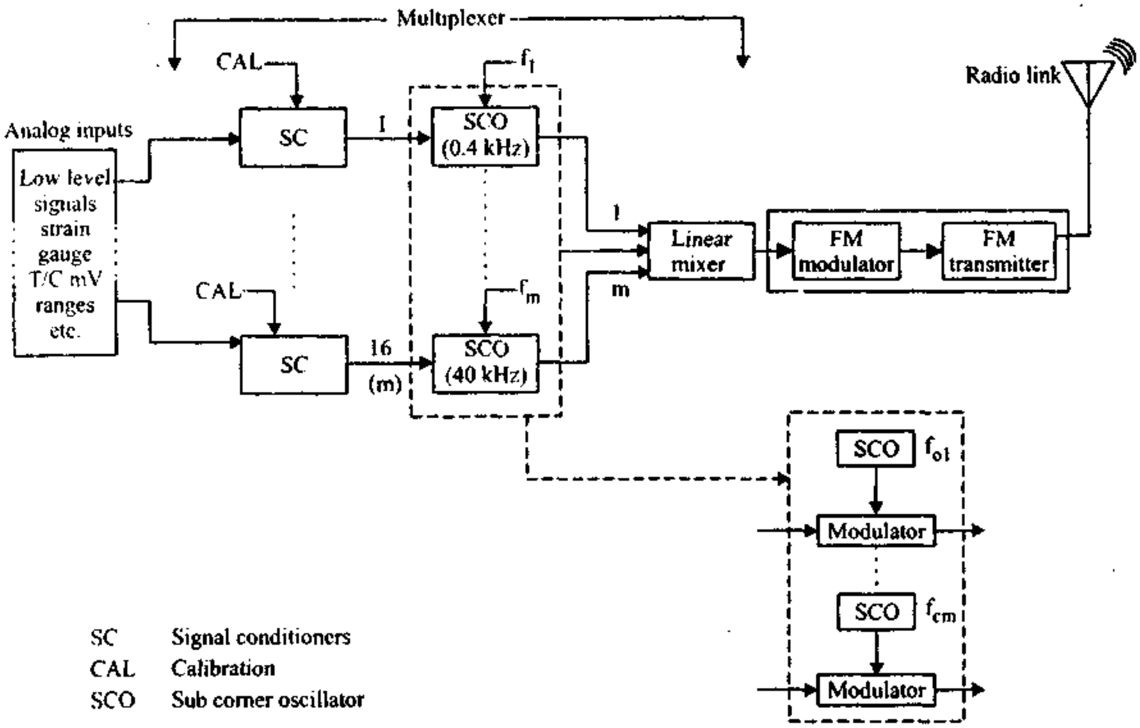


Up to about 3km the current loop transmission is very popular in the industries. It is actually a hardware cable data transmission technique, for a current ranging 4 to 20mA. Readymade transmitter that produce output of 4 to 20mA with input of *m* volt from thermocouples resistance from RTD, frequency of oscillator, output from sidewire potentiometer and bridge circuit are available commercially.



Q. 3. (a) Explain the frequency division multiplexing alongwith block diagram.

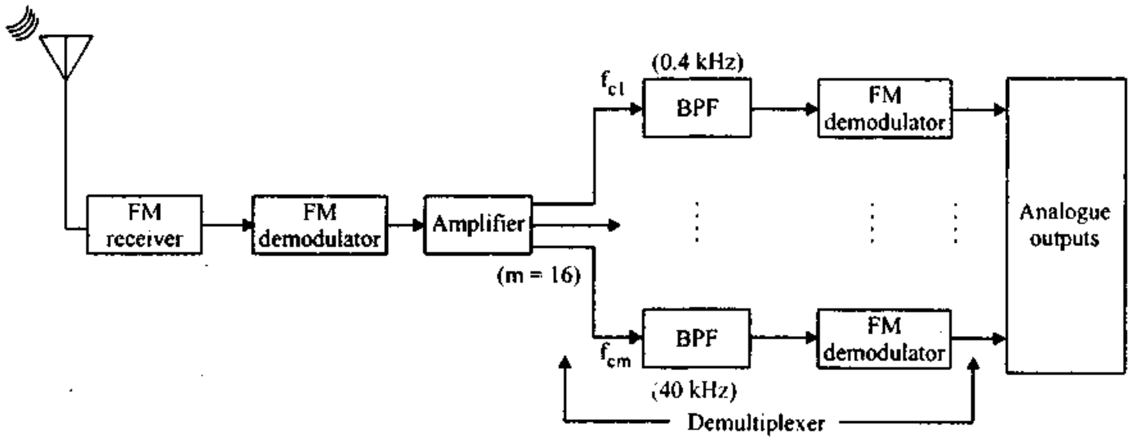
Ans. Transmitter for FDM :



Receiver FDM : The FDM type comprise a number of data channels, each of which modulates a separate sub-carrier oscillators. FDM is more of an analog type system and he conventional frequency modulation in association with other analogue modulation methods is used in transmission of information.

The output from all the above sub-carrier oscillators are mixed/summed to form a composite signal which modulates a high frequency carrier and the resultant wave is transmitted by an appropriate FM transmitter system through a radio link. At the receiver end, this wave is received by an FM receiver which is then FM-demodulated and amplified. The amplified output is passed through the same number of channels as the transmitting side data channels consisting of band-pass filter of frequencies of the sub-carrier. Output of each such channel is further demodulated or detected to obtain analog output that has originally been transmitted. This is then stored or displayed or monitored as necessary.

FDM actually means separ tion of individual carrier channels in the frequency domain. These separate carrier are termed as sub-carrier frequencies which in turn modulate a high carrier frequency in the RF range.



Q. 3. (b) Explain the block diagram of a basic frequency modulation telemetry system.

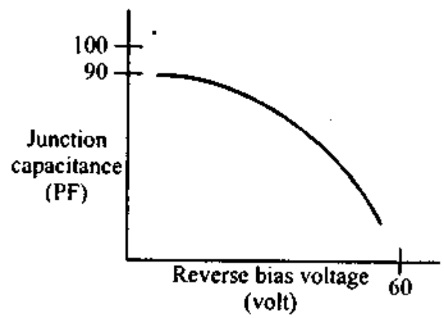
Ans. Frequency Modulation Telemetry System : FM circuits commercially available some are direct while others produce FM via phase modulation. The direct type vary the frequency of a carrier by the modulating signal.

A varactor diode basically a voltage variable capacitor can be used for such a purpose. It is a semiconductor junction diode operated in a reverse-biased condition. It is the width of the depletion layer that the capacitance and the width is controlled by reverse-bias

$$C_{v-d} = \frac{K\alpha}{\omega_d}$$

$$C_{v-d} = \frac{C_o}{(1-V_r/\phi)^n}$$

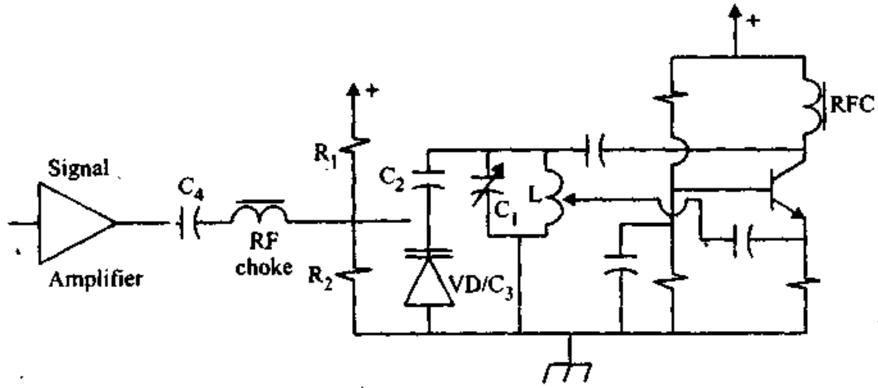
The tuned circuit is formed by L-C combination for producing carrier frequency. A very large capacitance C_2 is connected show as, so that at the operating frequency $1/\omega_{c2}$ approach to zero.



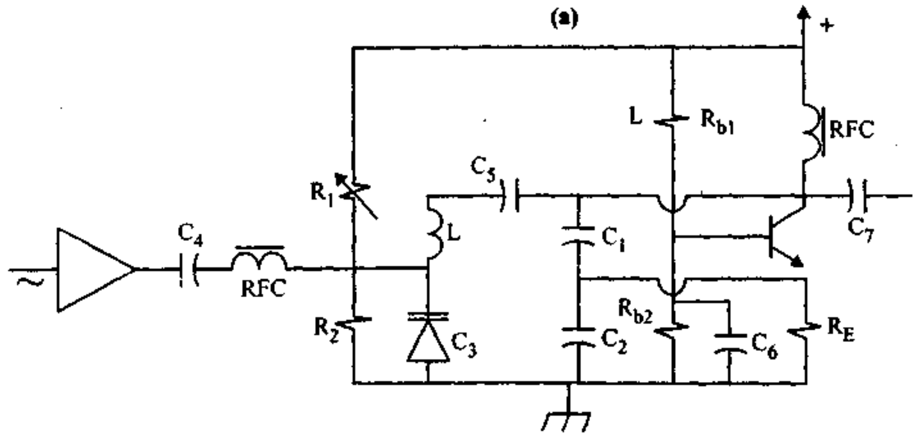
$$f_c = \frac{1}{2\pi\sqrt{L(C+C_3)}}$$

The effective inductance with the varactor diode capacitance C_3

$$L_{CFF} = L - \frac{1}{\omega^2 C_3}$$

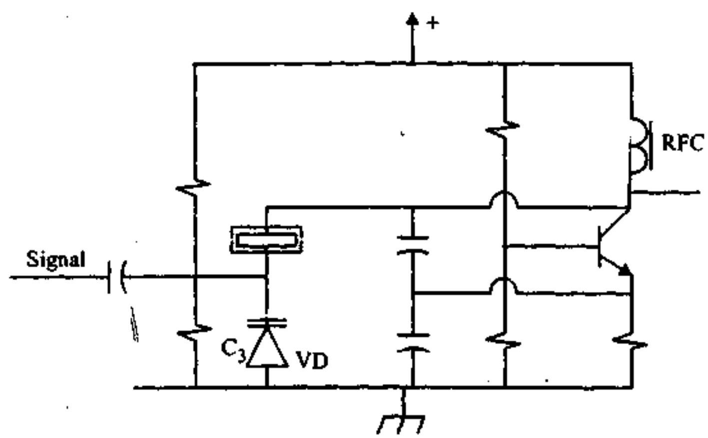


(a)



(b)

Crystal-varactor diode oscillator.



Q. 4. (a) The output voltage of a transmitter is given by $400(1 + 0.4 \sin 6280t) \sin 3.14 \times 10^7 t$. The voltage is fed to a load of 600Ω resistance.

Determine :

(i) Carrier frequency

(ii) Modulating frequency

(iii) Total power output

Ans.

$$v_o = 400(1 + 0.4\sin 6280t)\sin 3.14\times 10^7 t$$

$$R_L = 600\Omega$$

(i) Carrier Frequency :

$$\omega_c = 3.14\times 10^7$$

$$2\pi f_c = 3.14\times 10^7$$

$$f_c = \frac{10\times 10^6}{2\times 3.14}$$

$$= 5\times 10^6 \text{ Hz}$$

$$= 5\,\text{MHz}$$

(ii) Modulating Frequency :

$$f_m \text{ (modulating frequency)} = \frac{6280}{2\pi}$$

$$= 1000\,\text{Hz}$$

$$f_m = 1\text{kHz}$$

(iii) Total Power Output :

$$= \frac{(v_m)^2}{R_L}$$

$$= \frac{(400)^2}{600} = 266.6 \text{ watt}$$

Q. 4. (b) Give the comparison between FM and PM system.

Ans. FM System & PM System :

$$f(t) = A\cos\theta(t)$$

θ is angle of the sinusoidal signal and is a function of time (t).

For an ordinary fixed frequency sinusoidal signal

$$f(t) = A\cos(\omega_c t + \theta_o)$$

$$\theta(t) = \omega_c t + \theta_o$$

&

$$\omega_c = \frac{d\theta}{dt}$$

The radian frequency ω_c here is a constant given by the derivative of the angle $\theta(t)$. In general this derivative may not be constant. We now define $\frac{d\theta}{dt}$ as the instantaneous frequency ω_i, which may very with time.

$$\omega_i = \frac{d\theta}{dt}$$

$$\theta = \int \omega_i \, dt$$

It is now easy to appreciate the possibility of transmission of information in $f(t)$ by varying the angle θ of a carrier. Such techniques of modulation where the angle of the carrier is varied in some manner with a modulating signal $f(t)$ are known as angle modulation.

Two methods are commonly used in the angle modulation.

(i) Phase modulation (PM) and (ii) Frequency modulation (FM)

If the angle $\theta(t)$ is varied linearly with $f(t)$ then

$$\theta(t) = \omega_c t + \theta_o + k_p f(t)$$

Where K_p is a constant and the resulting form is called phase modulation (PM).

Thus, a signal $A\cos[\omega_c t + \theta_o + K_p f(t)]$ represents a phase modulated carrier

$$\omega_i = \frac{d\theta}{dt} = \omega_c + k_p \frac{df(t)}{dt}$$

FM : We vary the instantaneous frequency directly with the modulating signal, we have a frequency modulation.

Thus, for a FM carrier the instantaneous frequency ω_i is given by

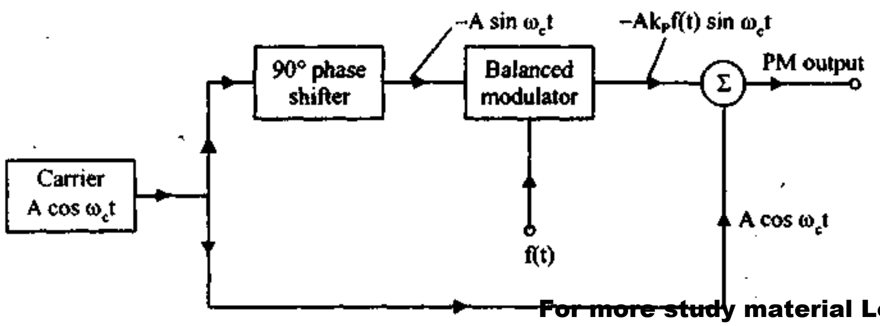
$$\omega_i = \omega_c + k_P f(t)$$

$$\theta(t) = \int \omega_i \, dt$$

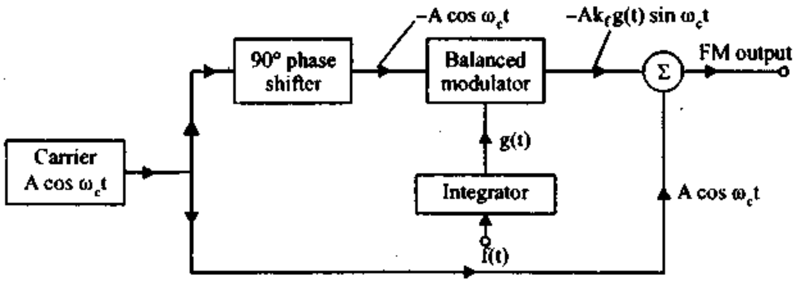
$$= \omega_c t + k_f \int f(t) + \theta_o$$

$$\phi_{PM} = A\cos[\omega_c t + k_P f(t)]$$

$$\phi_{FM} = A\cos\left[\omega_c t + k_f \int f(t) dt\right]$$



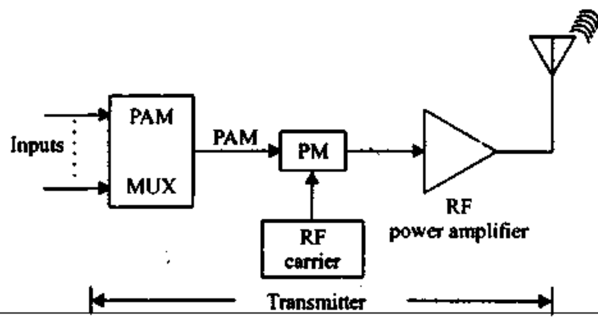
(a)



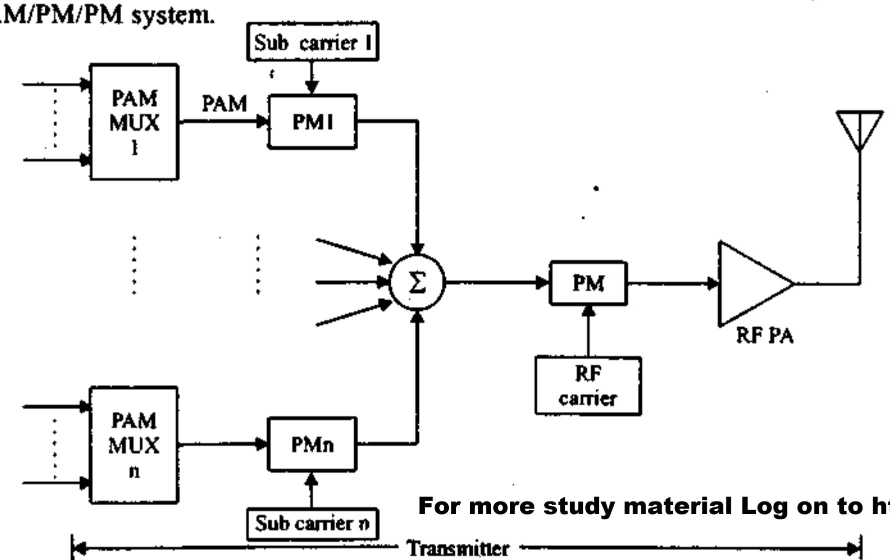
(b)

Q. 5. (a) Explain the concept of pulse telemetry system.

Ans. Pulse Telemetry System : For transmission purpose, the varying PAM signal are used to modulate a carrier which is then transmitted over an RF link. Usually, phase modulation is done and then system is known as PAM/PM system.



Sometimes, a number of PAM signals are used to phase-modulate, the sub carrier oscillator output which are then mixed or summed and composite signal is again used to phase modulation appropriate RF carrier. This modulated carrier is then amplified and transmitted through the RF channel. Such a system is called the PAM/PM/PM system.



The composite transmitted signal is received at the receiving side and then demodulated in one level for PAM/PM system and in two levels for PAM/PM/PM system and then demultiplexed and filtered by low pass filter for recovering the original signal. The demultiplexer through which the demodulated PAM signal passes through is a reverse multiplexer—a single-input, multi-output device, each output channel corresponding to the original signal channel. As a number of signals are to be obtained from a single input to the demultiplexer, synchronization has to be there on the receiving side with respect to the transmitting side. This involves :

(i) Identical clock frequency

(ii) Sequence in the demultiplexing which should be identical to that in multiplexing maintaining, also, the channelwise time identity.

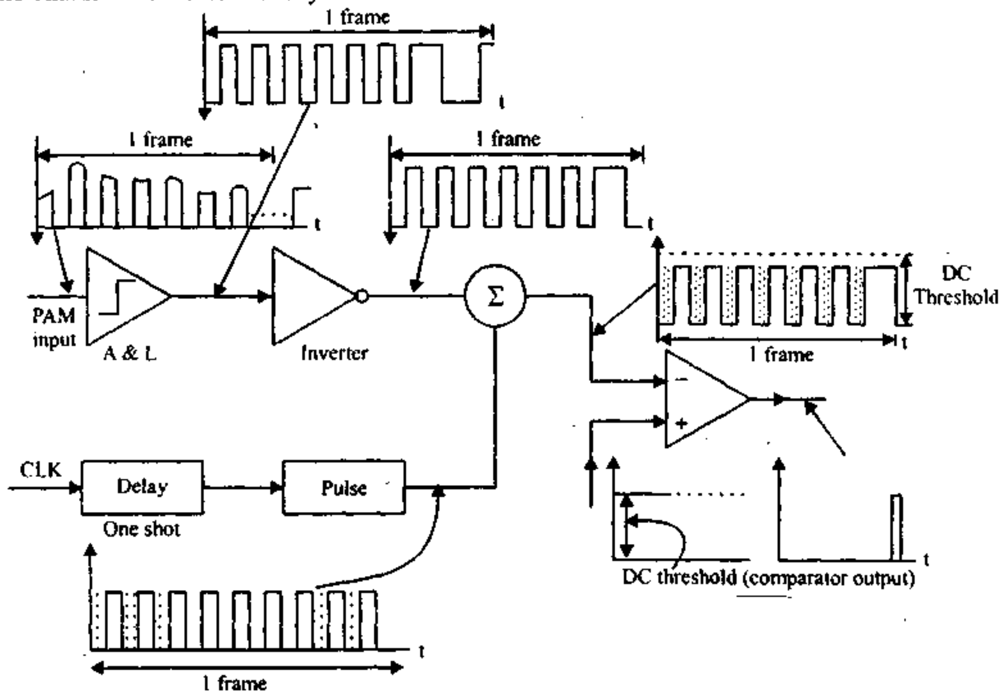
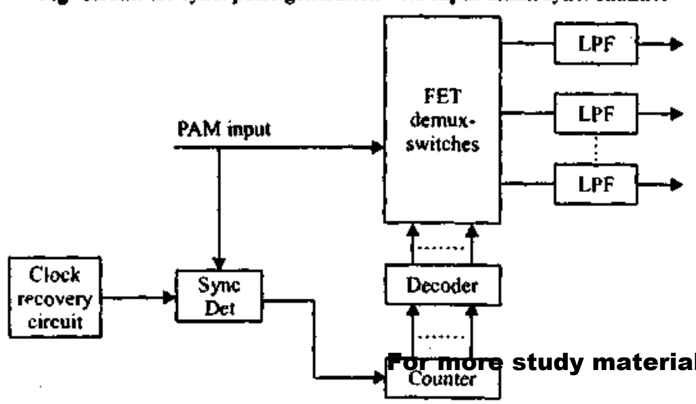
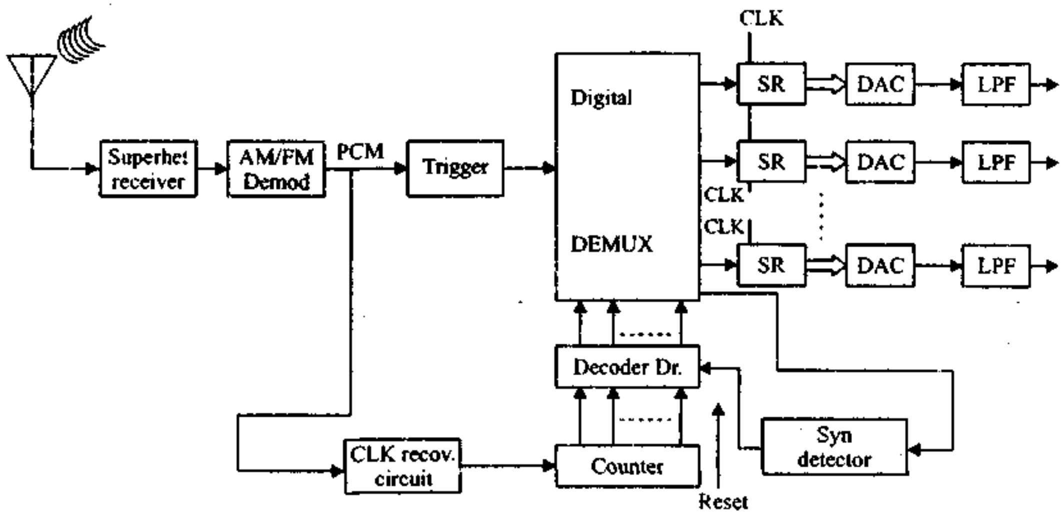


Fig. Circuit for sync. pulse generation with input blank sync. channel



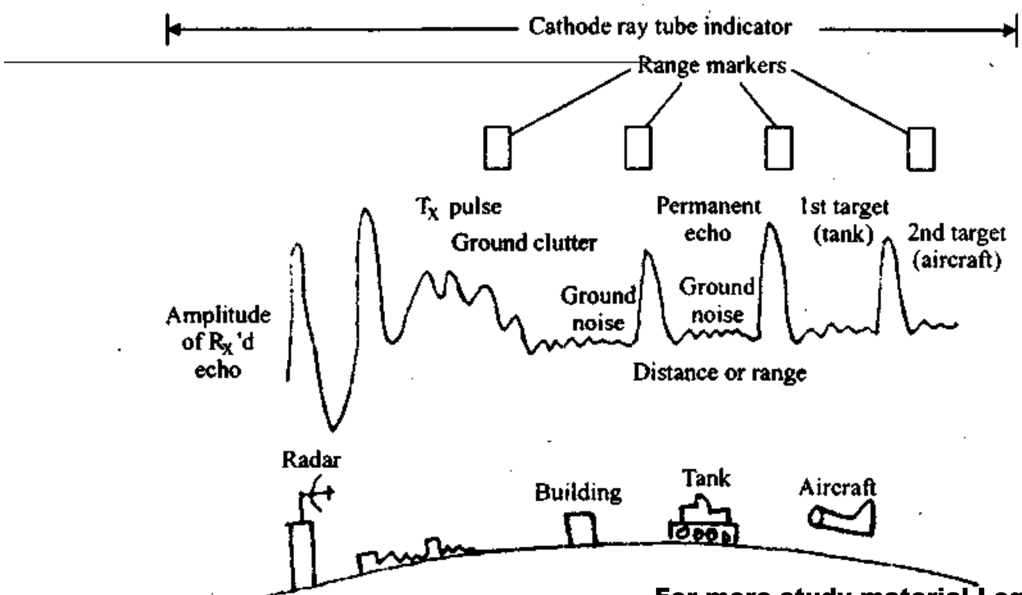


(b)

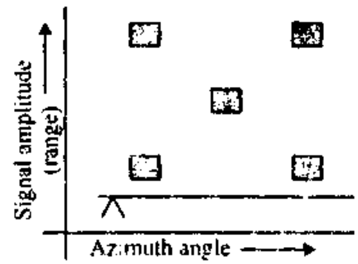
Q. 5. (b) Explain the types of various display methods.

Ans. A-Scope Display : The most popular of the detection modulation type display system which indicates the range of the target.

A beam is made to scan the CRT screen horizontally by applying a linear sawtooth voltage to horizontal deflection plates in synchronism with the transmitted pulses. The demodulation signal from the receiver applied to the vertical deflection plates so as to cause vertical deflections from the horizontal lines shown as

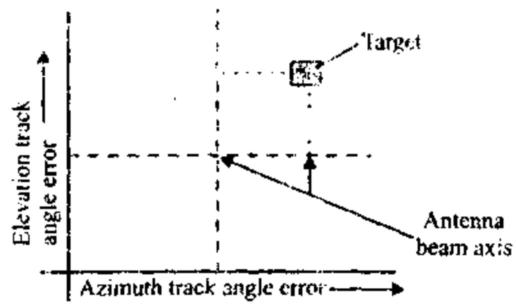


B-Scope, E-Scope & F-Scope Display : The B-scope display signal amplitude as a function of azimuth. The intensity modulated display has azimuth angle along the horizontal axis and range along the vertical axis shown.



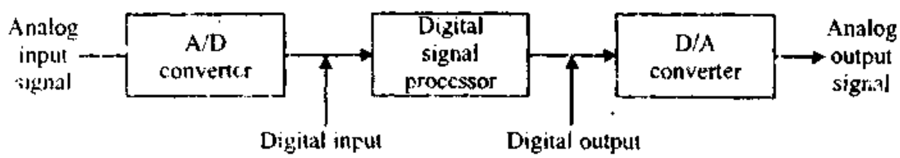
The E-scope display is similar to B-scope display and display signal amplitude as a function of range.

The F-scope display elevation track angle error (ETAE) as a function of azimuth track angle error (ATAE) with the centre of the display indicating antenna's beam axis location. The displacement of the blip from the centre is an indication of the position of target wrt the antenna beam axis shown as



Q. 6. Give the comparison of analog vs digital processing. Also explain the terms quantization and aperture time.

Ans. Analog Vs Digital Processing : There are many reason why digital signal processing of an analog signal may be preferable to processing the signal directly in the analog domain as mentioned briefly earlier, a digital programmable system allows flexibility in reconfiguring the digital signal processing operations simplify changing the program.



Reconfiguration of an analog system usually implies a redesign of the hardware followed by testing and verification to see that it operates properly :

(i) Accuracy consideration also play an important role in determining the form of the processor

(ii) Digital system provide much better control of accuracy requirements.

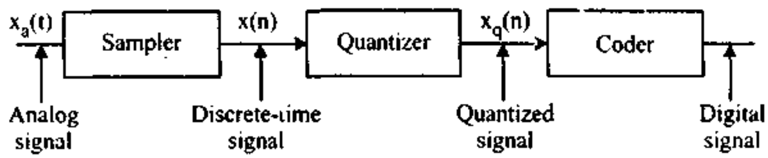
(iii) Digital signals are easily stored on magnetic media without deterioration or loss of signal fideling beyond that introduced in the A/D conversion.

(iv) Digital implementation of the signal processing system is cheaper than its analog counter part.

(v) Digital signal processing has been applied in practical system covering a broad range of disciplines.

Limitations of Digital Implementation : One practical limitation is the speed of operation of A/D converters and digital signal processor. We shall see that signals having extremely wide bandwidth require fast-sampling-rate A/D converters and fast digital signal processor. Hence there are analog signal with large bandwidth for which a digital processing approach is beyond the state of the art of digital hardware.

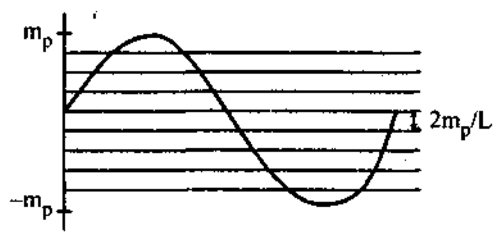
Analog-to-Digital and Digital-to-Analog Conversion :



Analog Signal	Digital Signal
$\Omega = 2\pi f$	$\omega = 2\pi f$
$\frac{\text{rad}}{\text{sec}}$ Hz	$\frac{\text{Radian}}{\text{Samples}}$
$-\infty < \Omega < \infty$	$-\pi/T < \Omega < \pi/T$
$-\infty < F < \infty$	$-F_s/2 \le F \le F_s/2$

Quantization : Some sources are analog but are converted into digital form by a variety of techniques such as PCM and delta modulation which will now be analyzed.

For quantization, we limit the amplitude of the message signal $m(t)$ to the range $(-m_p, m_p)$



m_p is not necessarily the peak amplitude of $m(t)$. The amplitudes of $m(t)$ beyond $\pm m_p$ are simply chopped off.

Thus, m_p is not a parameter of the signal $m(t)$ rather, it is the limit of the quantizer.

The amplitude range $(-m_p, m_p)$ is divided into L uniformly spaced interval each of width $\Delta V = \frac{2m_p}{L}$

If $m(kT_s)$ is the k^{th} sample of the signal $m(t)$ and if $\hat{m}(kT_s)$ is the corresponding quantized sample, then from the interpolation formula

$$m(t) = \sum_k m(kT_s) \sin c(2\pi Bt - k\pi)$$

$$\hat{m}(t) = \sum_k \hat{m}(kT_s) \sin c(2\pi Bt - k\pi)$$

$$q(t) = \hat{m}(t) - m(t)$$

$$= \sum_k [\hat{m}(kT_s) - m(kT_s)] \sin(2\pi Bt - k\pi)$$

$$= \sum_k q(kT_s) \sin c(2\pi Bt - k\pi)$$

Quantization Noise :

$$\tilde{q}^2(t) = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} q^2(t) dt$$

$$= \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} \left[\sum_k q(kT_s) \sin c(2\pi Bt - k\pi) \right]^2 dt$$

$\Rightarrow$

$$\int_{-\infty}^{\infty} \sin c(2\pi Bt - m\pi) \sin c(2\pi Bt - n\pi) dt = \begin{cases} 0 & m \neq n \\ 1/2B & m = n \end{cases}$$

$$\tilde{q}^2(t) = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} \sum q^2(kT_s) \sin c^2(2\pi Bt - k\pi) dt$$

$$= \lim_{T \to \infty} \frac{1}{T} \sum_k q^2(kT_s) \int_{-T/2}^{T/2} \sin c^2(2\pi Bt - k\pi) dt$$

$$\tilde{q}^2(t) = \lim_{T \to \infty} \frac{1}{2BT} \sum_k q^2(kT_s)$$

The quantization error lies in the range $\left(-\frac{\Delta V}{2} \text{ to } \frac{\Delta V}{2} \right)$

$$\Delta V = \frac{2m_p}{L}$$

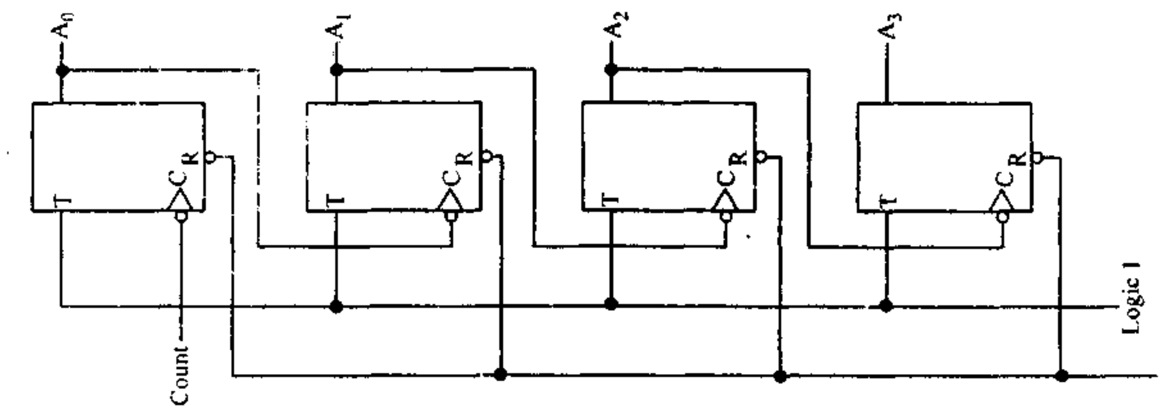
$$\tilde{q}^2 = \frac{1}{\Delta V} \int_{-\Delta V/2}^{\Delta V/2} q^2 dq$$

$$= \frac{(\Delta V)^2}{12}$$

$$= \frac{mp^2}{3L^2} \qquad \left(\Delta V = \frac{2m_p}{L} \right)$$

Q. 7. Design a decade counter using T flip-flop.

Ans. Decade Counter :



Operation : To understand the operation of 4-bit decade counter used table

Binary Count Sequence

A_3	A_2	A_1	A_0
0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
0	1	0	0
0	1	0	1
0	1	1	0
0	1	1	1
1	0	0	0

The count start with binary 0 and increments by 1 with each count pulse input. After the count of 15, the counter goes back to 0 to repeat the count. The least significant bit A_0 is complementary with each count pulse input. Every time that A_0 goes from 1 to 0 it complements A_1. Every time that A_1 goes from 1 to 0. It complements A_2 every time that A_2 goes from 1 to 0 it complements A_3 and so on for any other higher order bit of decade counter.

Q. 8. Discuss the following :

(a) BCD decoder

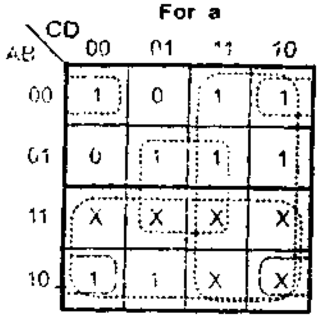
(b) BCD to dot matrix converter

(c) Wire line and microwave channels

Ans. (a) BCD Decoder :

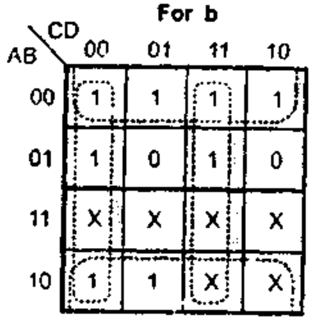
Digit	*A*	*B*	*C*	*D*	*a*	*b*	*c*	*d*	*e*	*f*	*g*
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	1	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	1	1	0	1	1

For a



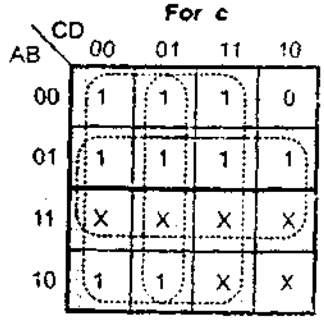
$a = A + C + BD + \bar{B}\bar{D}$

For b



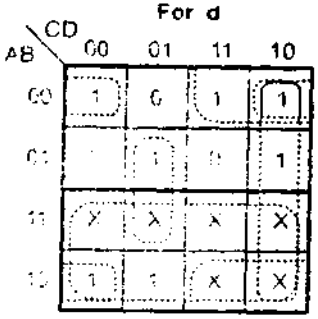
$b = \bar{B} + \bar{C}\bar{D} + CD$

For c



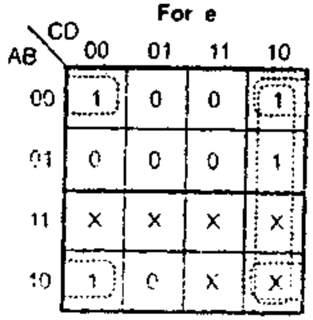
$c = B + \bar{C} + D$

For d



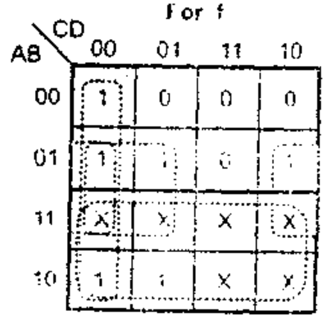
$d = \bar{B}\bar{D} + C\bar{D} + B\bar{C}D + \bar{B}C + A$

For e

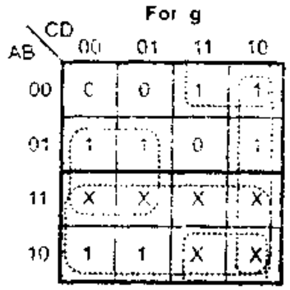


$e = \bar{B}\bar{D} + C\bar{D}$

For f



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

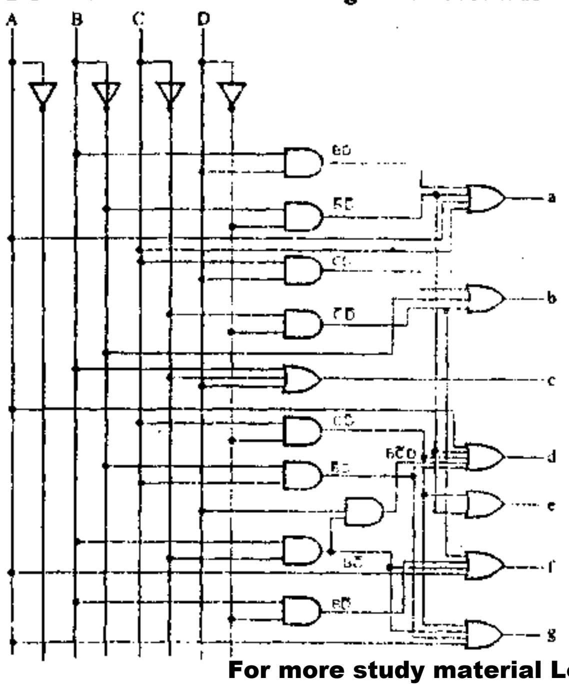


$$g = A + B\bar{C} + \bar{B}C + C\bar{D}$$

Digit	*A*	*B*	*C*	*D*	*a*	*b*	*c*	*d*	*e*	*f*	*g*
0	0	0	0	0	0	0	0	0	0	0	1
1	0	0	0	1	1	0	0	1	1	1	1
2	0	0	1	0	0	0	1	0	0	1	0
3	0	0	1	1	0	0	0	0	1	1	0
4	0	1	0	0	1	0	0	1	1	0	0
5	0	1	0	1	0	1	0	0	1	0	0
6	0	1	1	0	0	1	0	0	0	0	0
7	0	1	1	1	0	0	0	1	1	1	1
8	1	0	0	0	0	0	0	0	0	0	0
9	1	0	0	1	0	0	0	0	1	0	0

Truth table for BCD-to-common-anode 7-segment decode/driver

Logic Diagram :

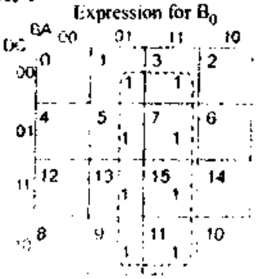


(b) BCD to Dot Matrix Converter :

Binary Code				*BCD Code*				
D	***C***	***B***	***A***	B_4	B_3	B_2	B_1	B_0
0	0	0	[illegible]	0	0	0	0	0
0	0	0	1	0	0	0	0	1
0	0	1	0	0	0	0	1	0
0	0	1	1	0	0	0	1	1
0	1	0	0	0	0	1	0	0
0	1	0	1	0	0	1	0	1
0	1	1	0	0	0	1	1	0
0	1	1	1	0	0	1	1	1
1	0	0	0	0	1	0	0	0
1	0	0	1	0	1	0	0	1
1	0	1	0	1	0	0	0	0
1	0	1	1	1	0	0	0	1
1	1	0	0	1	0	0	1	0
1	1	0	1	1	0	0	1	1
1	1	1	0	1	0	1	0	0
1	1	1	1	1	0	1	0	1

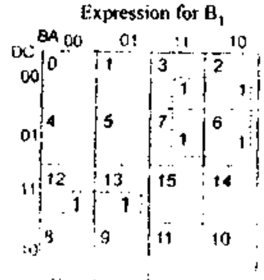
K-Map Simplification :

Expression for B_0



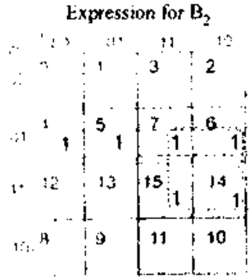
$B = A$

Expression for B_1



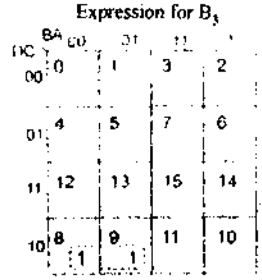
$B_1 = DCB + DB$

Expression for B_2



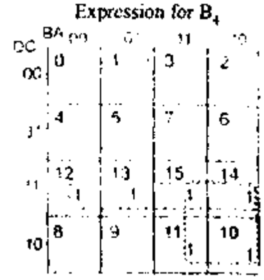
$B_2 = \bar{D}C + CB$

Expression for B_3



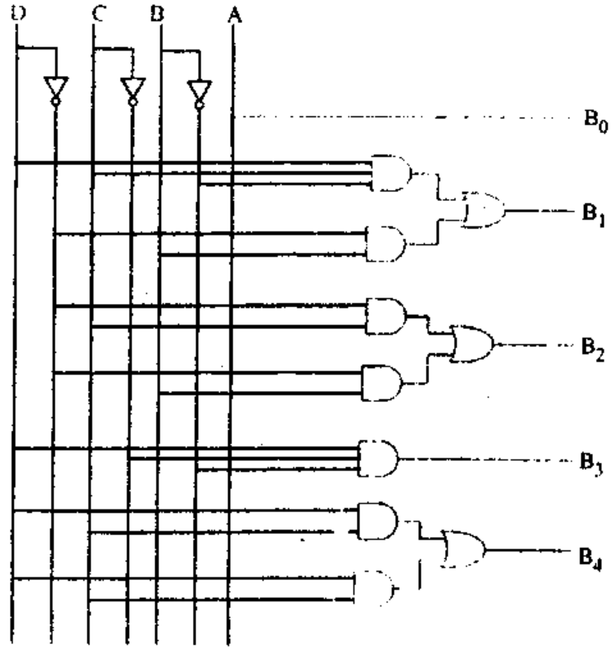
$B_3 = D\bar{C}\bar{B}$

Expression for B_4



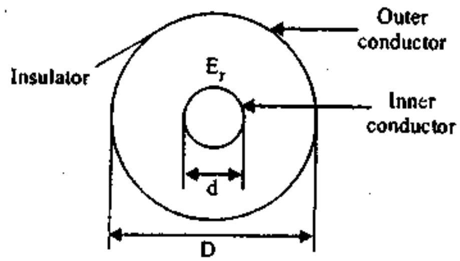
$B_4 = DC + DB$

Logic Diagram :

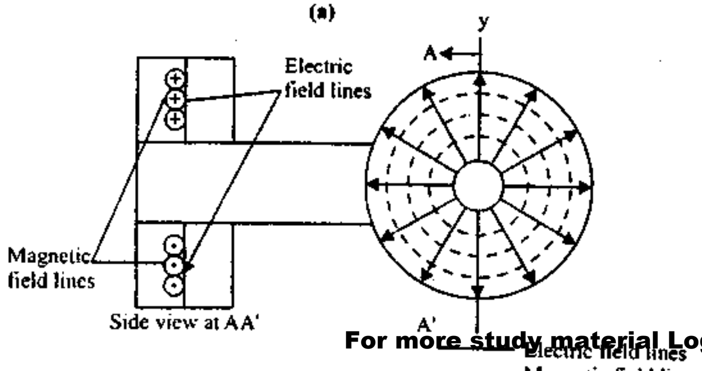


(c) Wire Line & Microwave Channels :

Wire Line (Co-axial Line) : The co-axial and microwave channels transmission line is the most widely used transmission line for high frequency application. A cross-section view of a typical co-axial cable shown below

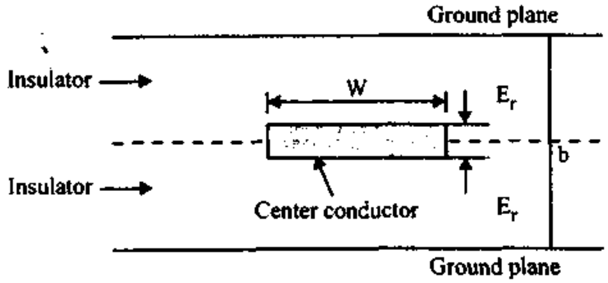


(a)



(b)

(ii) Strip Line : Strip line are essentially modifications of the two wire lines and co-axial line. These are basically planer transmission lines that are widely used at frequencies from 100 MHz to 100 GHz shown below.



(ii) Microstrip Line : Microstrip line is an unsymmetrical strip line that is nothing but a parallel transmission line having dielectric substrate, the one face of which is metallized ground and other face has a thin conducting strip of certain width '*W*' and thickness '*t*', shown below

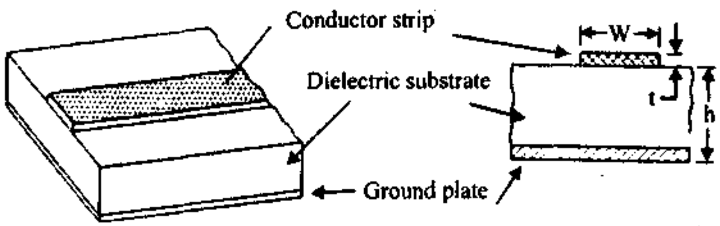


Fig. Microstrip line