Q.2 a. Draw and Explain block diagram of analog communication system.

Answer:

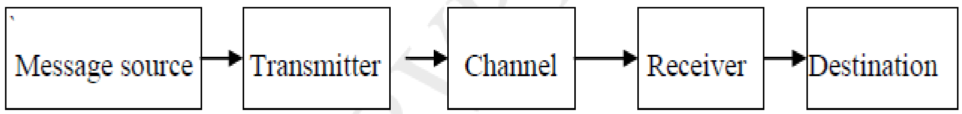


Fig. Block diagram of Communication system

The communication system consists of three basic components.

- Transmitter
- Channel
- Receiver

Transmitter is the equipment which converts physical message, such as sound, words, pictures etc., into corresponding electrical signal.
Receiver is equipment which converts electrical signal back to the physical message.

Channel may be either transmission line or free space, which provides transmission path between transmitter and receiver.

b. Define noise in communication system and explain shot noise in detail.

Answer:

Noise is often described as the limiting factor in communication systems: indeed if there as no noise there would be virtually no problem in communications. Noise is a general term which is used to describe an unwanted signal which affects a wanted signal. These unwanted signals arise from a variety of sources which may be considered in one of two main categories:-

a)Interference, usually from a human source (man made)
b) Naturally occurring random noise.

Shot Noise:
Shot noise was originally used to describe noise due to random fluctuations in electron emission from cathodes in vacuum tubes (called shot noise by analogy with lead shot). Shot noise also occurs in semiconductors due to the liberation of charge carriers, which have discrete amount of charge, in to potential barrier region such as occur in *pn* junctions. The discrete amounts of charge give rise to a current which is effectively a series of current pulses.
For *pn* junctions the mean square shot noise current is

$$I_n^2 = 2\left(I_{DC} + 2I_o\right)q_e B \quad (amps)^2$$

Where

I_{DC} is the direct current as the *pn* junction (amps)

I_0 is the reverse saturation current (amps)

q_e is the electron charge = 1.6 x 10^{-19} coulombs

B is the effective noise bandwidth (Hz)

Shot noise is found to have a uniform spectral density as for thermal noise.

Q.3 a. Explain amplitude modulation (AM) in detail and derive the expression for total power in a single tone AM signal.

Answer:

Amplitude Modulation is the process of changing the amplitude of a relatively high frequency carrier signal in proportion with the instantaneous value of the modulating signal.

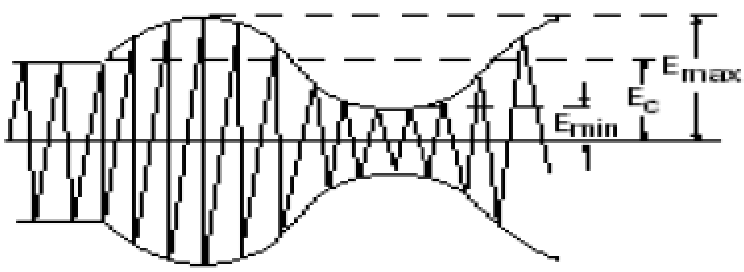
Consider a sinusoidal carrier signal C (t) is defined as

$$C(t) = A_c \mathrm{Cos}\,(2\pi f_c t + \phi)\, t$$

Where Ac= Amplitude of the carrier signal

f_c= frequency of the carrier signal

ϕ= Phase angle.



The standard time domain equation for single-tone AM signal is given by

$S(t) = A_c \cos(2\pi f_c t) + A_c\mu/2[\cos 2\pi(f_c+f_m)t] + A_c\mu/2[\cos 2\pi(f_c-f_m)t]$

Power of any signal is equal to the mean square value of the signal

Carrier power $P_c = A_c^2/2$

Upper Side Band power $P_{USB} = A_c^2\mu^2/8$

Lower Side Band power $P_{LSB} = A_c^2\mu^2/8$

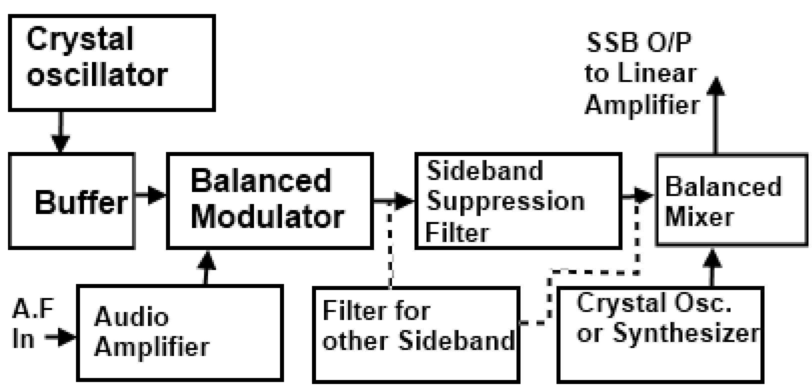
Total power $P_T = P_c + P_{LSB} + P_{USB}$

Total power $P_T = A_c^2/2 + A_c^2\mu^2/8 + A_c^2\mu^2/8$

$P_T = P_c\,[1+\mu^2/2]$

b. Draw and explain the block diagram of the filter method for single side band (SSB) modulator.

Answer:



1. A crystal controlled master oscillator produces a stable carrier frequency fc (say 100 KHz)
2. This carrier frequency is then fed to the balanced modulator through a buffer amplifier which isolates these two stages.
3. The audio signal from the modulating amplifier modulates the carrier in the balanced modulator. Audio frequency range is 300 to 2800 Hz. The carrier is also suppressed in this stage but allows only to pass the both side bands. (USB & LSB).
4. A band pass filter (BPF) allows only a single band either USB or LSB to pass

through it. It depends on our requirements.
Let we want to pass the USB then LSB will be suppressed. In this case.
fc = 100 KHz
Audio range = 300 - 2800 Hz
USB frequency range = fc + 300 to fc + 2800
= 100000 + 300 to 100000 + 2800
= 100300 to 102800 Hz
So this band of frequency will be passed on through the USB filter section

5. This side band is then heterodyned in the balanced mixer stage with 12 MHz frequency produced by crystal oscillator or synthesizer depends upon the requirements of our transmission. So in mixer stage, the frequency of the crystal oscillator is added to SSB signal. The output frequency thus being raised to the value desired for transmission.
6. Then this band is amplified in driver and power amplifier stages and then fed to the aerial for the transmission.

Q.4 a. What are the advantages and disadvantages of FM over AM?

Answer:

Advantages:

- The amplitude of FM is constant. Hence transmitter power remains constant in FM where as it varies in AM.
- Since amplitude of FM is constant, the noise interference is minimum in FM. Any noise superimposing on modulated carrier can be removed with the help of amplitude limiter.
- The depth of modulation has limitation in AM. But in FM, the depth of modulation can be increased to any value.
- Since guard bands are provided in FM, there is less possibility of adjacent channel interference.
- Since space waves are used for FM, the radius of propagation is limited to line of sight(LOS) . Hence it is possible to operate several independent transmitters on same frequency with minimum interference.
- Since FM uses UHF and VHF ranges, the noise interference is minimum compared to AM which uses MF and HF ranges.

Disadvantage:

1. Require more Bandwidth
2. Use more complex circuits in both transmitter and receiver

b. A carrier is frequency modulated with a sinusoidal signal of 2 kHz resulting in a maximum frequency deviation of 5 kHz. Find the approximate band width of the modulated signal?

Answer:

Δf = frequency deviation in Hz = 5 KHz

$f_{m(max)}$ = highest modulating signal frequency in Hz = 2 KHz

Band Width = 2 [Δf + $f_{m(max)}$] Hz
= 2 [5 + 2] = 14 KHz

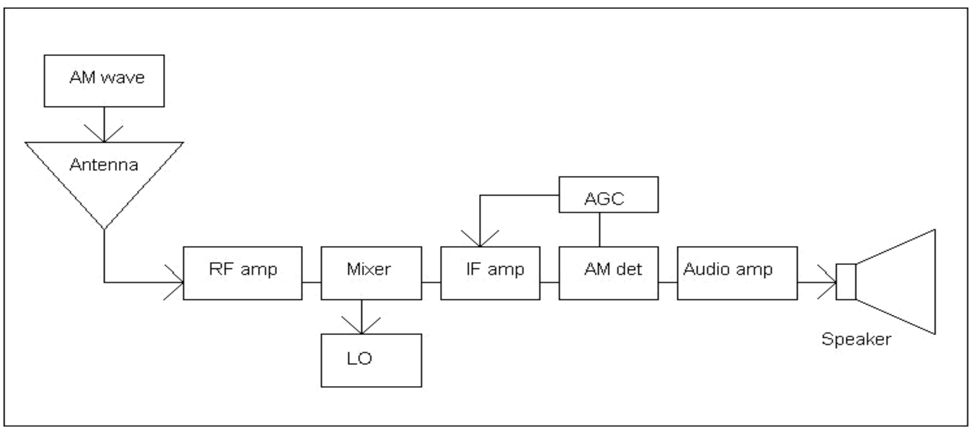
c. **Compare wideband and narrowband Frequency modulation (FM).**

Answer:

Narrow band FM	**Wide band FM**
Frequency deviation in carrier frequency is very small	Frequency deviation in carrier frequency is large
Band width is twice the highest modulating frequency	Band width is calculated as per Carson's rule

Q.5 a. Explain, with a neat block diagram, the working of a superheterodyne radio receiver.

Answer:



The incoming signal is picked up on the antenna and fed to an RF amplifier. The RF amplifier provides some initial gain and selectivity and minimises radiation of the Local Oscillator (LO) signal through the receiving antenna by isolating the Mixer from the antenna. However, the most important function of the RF amplifier is to eliminate what is known as the image signal. The frequency of this signal is greater than the LO and will mix to give a mixer output at the IF frequency. This will cause problems as after down conversion to IF it will appear at the same frequency as the desired signal and cause interference.

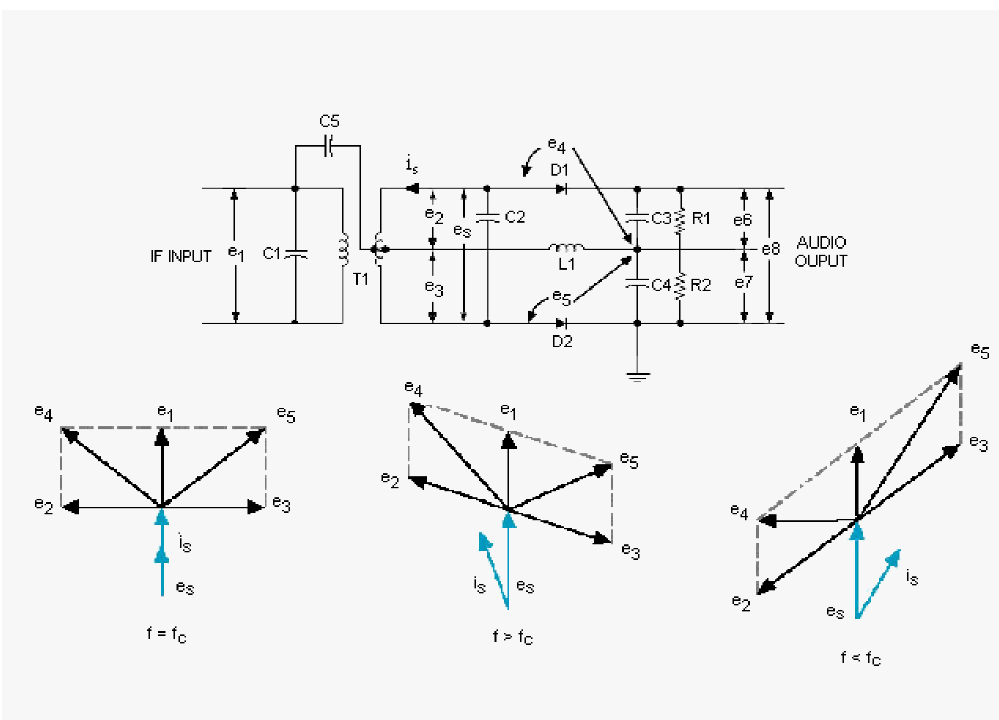
The output of the RF amplifier is then applied to the input of the Mixer. It also has an input from the LO. The Mixer (or Frequency Converter) is a non-linear device, which results in the creation of sum and difference frequencies. The output from the Mixer is a combination of the received signal and the LO signal as well as their sum and difference frequencies. This process is called Heterodyning. The non-linearity is necessary to provide the mathematical equivalent of time multiplication between the LO voltage and the RF signal voltage. A tuned circuit at the Mixer output selects the Difference frequency (i.e. the IF or Intermediate frequency). The LO frequency is tuneable over a wide range and therefore the Mixer can translate a wide range of input frequencies to the IF.

$$f_{LO} = f_{RF} + f_{IF}$$

Therefore the difference or intermediate frequency (IF) is $f_{IF} = f_{LO} - f_{RF}$. This frequency is selected while the other signals are rejected . The output of the mixer is amplified by one or more IF amplifier stages. Most of the receiver sensitivity and selectivity is to be found in these stages. All IF stages are fixed and tuned to only f_{IF} (this standard is fixed at 455kHz). Hence, high selectivity can be obtained. The highly amplified IF signal is now applied to the detector or demodulator where the original modulating signal is recovered. The detector output is then amplified to drive a Loudspeaker.

b. Explain, with a neat block diagram, foster seeley discriminator for FM detector.

Answer:



The Foster-Seely Discriminator is a widely used FM detector. The detector consists of a special center-tapped IF transformer feeding two diodes. The schematic looks very much like a full wave DC rectifier circuit. Because the input transformer is tuned to the IF frequency, the output of the discriminator is zero when there is no deviation of the carrier; both halves of the center tapped transformer are balanced. As the FM signal swings in frequency above and below the carrier frequency, the balance between the two halves of the center-tapped secondary are destroyed and there is an output voltage proportional to the frequency deviation.

The discriminator has excellent linearity and is a good detector for WFM and NBFM signals. Its major drawback is that it also responds to AM signals. A good limiter must precede a discriminator to prevent AM noise from appearing in the output.

Q.6 a. Determine the length of the antenna operating at frequency of 500 kHz (consider velocity factor 0.95).

Answer: The length of the antenna is given by

$$L = c/f \text{ X } 0.95$$

$$\text{Here } C = 3 \text{ X } 10^8$$

$$f = 500 \text{ KHz}$$

$$L = 3/5 \text{ X } 10^3 \text{ X } 0.95 \text{ m} = 570 \text{ m}$$

b. Explain the following terms with respect to antenna
(i) Directive gain
(ii) Radiation resistance
(iii) Beam width.

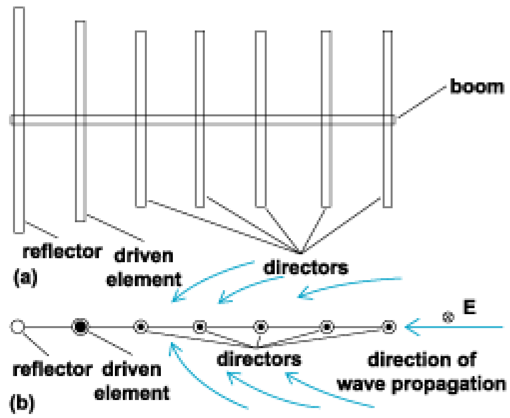
Answer:

(i) Directive gain: It is defined as the ratio of power density in a particular direction of one antenna to the power density radiated by isotropic antenna.
(ii) Radiation resistance: It is ratio of power radiated by antenna to the square of current at the feed point.
(iii)Beam width: Angle created by comparing half power point on the main radiation lobe to its maximum power point.

c. Explain the construction and working of Yagi Uda antenna.

Answer:

Yagi-Uda antenna: An antenna in which the gain of a single dipole element is enhanced by placing a reflector element behind the dipole (the driver) and one or more director elements in front of it (see illustration). It was invented in 1926 by H. Yagi and S. Uda in Japan. The gain is slightly increased by the reflector and further enhanced by the first director element. Additional director elements further increase the gain and improve the front-to-back ratio, up to a point of diminishing returns. This type of antenna has traditionally been used for local television reception. Its variants have found applications in the more modern communication systems at higher frequencies and smaller sizes, and have even been adapted to printed-circuit techniques in some applications. The same electromagnetic induction principle used in such linear elements can be applied to loop and disk elements as well with similar results



Since these antennas can be made highly directive with good radiation efficiency, they have found new applications and new manufacturing techniques with miniaturization. They can be printed on microwave circuit substrates with high dielectric constants, which reduces their size even further. The parasitic electromagnetic coupling demonstrated in the Yagi-Uda antenna has been adapted to many new types of miniaturized antennas applicable to mobile communication devices in wide use, and will be used in future wireless Internet devices

Q.7 a. Explain the various types of propagation modes in rectangular waveguide.

Answer:

In a waveguide a signal will propagate as an electromagnetic wave. Even in a transmission line the signal propagates as a wave because the current in motion down the line gives rise to the electric and magnetic fields that behaves as an electromagnetic field. The transverse electromagnetic (TEM) field is the specific type of field found in transmission lines. We also know that the term “transverse” implies to things at right angles to each other, so the electric and magnetic fields are perpendicular to the direction of travel. These right angle waves are said to be “normal” or “orthogonal “to the direction of travel.

The boundary conditions that apply to waveguides will not allow a TEM wave to propagate. However, the wave in the waveguide will propagate through air or inert gas dielectric in a manner similar to free space propagation, the phenomena is bounded by the walls of the waveguide and that implies certain conditions that must be met. The boundary conditions for waveguides are:

1. The electric field must be orthogonal to the conductor in order to exist at the

surface of that conductor.
2. The magnetic field must not be orthogonal to the surface of the waveguide.

The waveguide has two different types of propagation modes to satisfy these boundary conditions:
1. TE – transverse electric (Ez = 0)
2. TM – transverse magnetic (Hz = 0)

The transverse electric field requirement means that the E-field must be perpendicular to the conductor wall of the waveguide. This requirement can be met with proper coupling at the input end of the waveguide. A vertically polarized coupling radiator will provide the necessary transverse field.

One boundary condition will require the magnetic (H) field not to be orthogonal to the conductor surface. Since it is at right angles to the E-field, the requirement will be met. The planes that are formed by the H-field will be parallel to the direction of propagation and to the surface.

b. Explain the following terms with reference to sky wave propagation:
(i) Maximum Usable frequency
(ii) Critical frequency
(iii) Skip distance
(iv) Fading

Answer:

(i) Maximum Usable frequency : In this the sky waves with maximum frequencies are sent at some angles towards the ionosphere. Then these rays will again be reflected by the ionosphere to earth.

$$MUF = CF / \cos\theta = CF \sec\theta$$

This is the angle which is formed along the direction of the incident wave and the normal.

(ii) Critical frequency: Critical frequency of sky wave is that maximum frequency in which the sky wave after reflecting from the ionosphere return back to earth. If the frequency of the sky wave is increased then the critical frequency, it will not come back to earth after reflection.

(iii) Skip distance: When the sky wave is reflected back from the ionosphere having a constant frequency, but more than that of the critical frequency. Then the smallest distance from the transmitter to the earth's surface covered by the sky wave is known as skip distance.
The distance of the sky wave from the transmitter to earth will increase if the angle made by the sky wave during reflection from the ionosphere surface will increase. So, in other words we can say that with the increase in angle the skip distance will also increase.

(iv)Fading: Due to the disturbance created by the waves, some variations can be seen in the signal strength at the receiver end. This is known as fading effect.
If the frequencies of the sky waves will be high, then the fading effect will increase. Errors in data transmissions and data retrievals are also caused by fading. Fading basically varies with time.

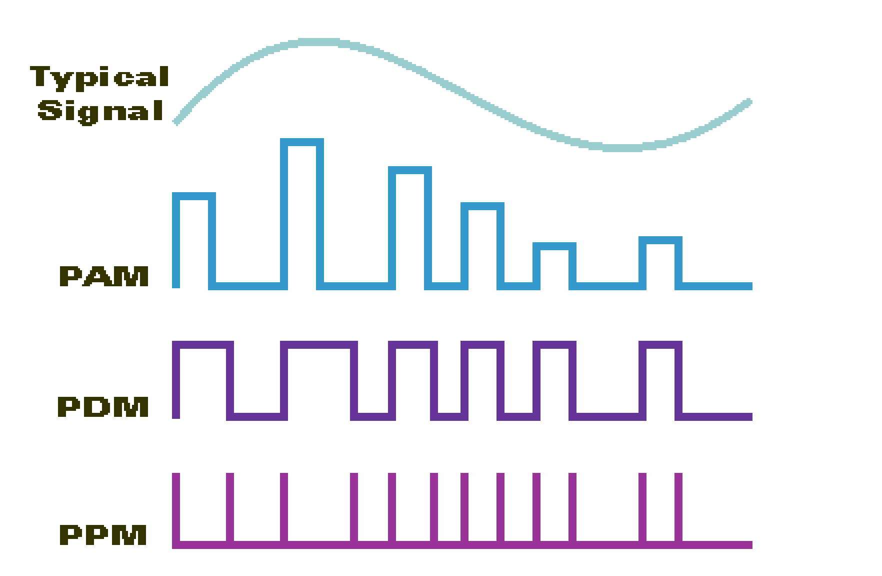
Q.8 a. Explain in detail with suitable waveform pulse amplitude modulation, pulse width modulation and pulse position modulation.

Answer:

1. **Pulse Amplitude Modulation (PAM):**
In pulse amplitude modulation system the amplitude of the pulse is varied in accordance with the instantaneous level of the modulating signal. Now days, the PAM system is not generally used, but it forms the first stage of the other types of pulse modulation.

2. **Pulse Width Modulation (PWM):**
In PWM system the width of the pulse is varied in accordance with the instantaneous level of the modulating signal.

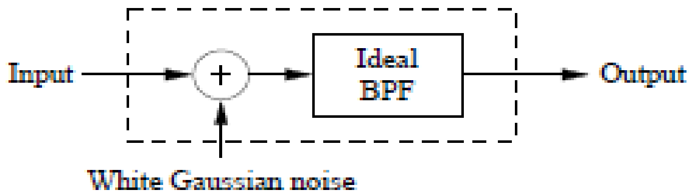
3. **Pulse Position Modulation (PPM):**
In PPM System, the position of the pulse relative to the zero reference level is varied in accordance with the instantaneous level of the modulating signal.



b. State Shannon-Hartley theorem. Calculate the capacity of the noisy channel having bandwidth of 3.1 kHz and signal to noise ratio of 32 dB.

Answer: Shannon-Harley Theorem:

Consider a bandlimited Gaussian channel operating in the presence of additive Gaussian noise:



The Shannon-Hartley theorem states that the channel capacity is given by

$$C = B\log_2(1 + S/N)$$

where C is the capacity in bits per second, B is the bandwidth of the channel in Hertz, and S/N is the signal-to-noise ratio.

$C = B \log_2 (1+S/N)$

$B = 3.1$ KHz

$S/N = \text{antilog}(32/10) = 1585$

$C = 3.1 \text{ K} \log_2 (1586)$

$= 32{,}953$ bits per second

Q.9 Write short note on the following:
(i) Time division multiplexing (TDM)
(ii) Advantages of fibre optics links over coaxial cable

Answer:

(i) **TDM: Time-Division Multiplexing**

Time-Division Multiplexing (TDM) is a type of digital or analog multiplexing in which two or more signals or bit streams are transferred apparently simultaneously as sub-channels in one communication channel, but are physically taking turns on the channel. The time domain is divided into several recurrent timeslots of fixed length, one for each sub-channel.

Time-division multiplexing (TDM) is a method of putting multiple data streams in a single signal by separating the signal into many segments, each having a very short duration. Each individual data stream is reassembled at the receiving end based on the timing.

Time division multiplexing (TDM) and has many applications, including wireline telephone systems and some cellular telephone systems. The main reason to use TDM is to take advantage of existing transmission lines.

TIME DIVISION MULTIPLEXING (TDM) allows multiple conversations to take place by the sharing of medium or channel in time. A channel is allocated a the whole of the line bandwidth for a specific period of time. This means that each subscriber is allocated a time slot.

(ii) **Fibre optics links over coaxial cable :**
The following characteristics distinguish optical fiber from twisted pair or coaxial cable:

• **Greater capacity:** The potential bandwidth, and hence data rate, of optical fiber is immense; data rates of hundreds of Gbps over tens of kilometers have been demonstrated. Compare this to the practical maximum of hundreds of Mbps over about 1 km for coaxial cable and just a few Mbps over 1 km or up to 100 Mbps to 10 Gbps over a few tens of meters for twisted pair.
• **Smaller size and lighter weight:** Optical fibers are considerably thinner than coaxial cable or bundled twisted-pair cable—at least an order of magnitude thinner for comparable information transmission capacity. For cramped conduits in buildings and underground along public rights-of-way, the advantage of small size is considerable. The corresponding reduction in weight reduces structural support requirements.
• **Lower attenuation:** Attenuation is significantly lower for optical fiber than for coaxial cable or twisted pair and is constant over a wide range.
• **Electromagnetic isolation:** Optical fiber systems are not affected by external electromagnetic fields. Thus the system is not vulnerable to interference, impulse noise, or crosstalk. By the same token, fibers do not radiate energy, so there is little interference with other equipment and there is a high degree of security from eavesdropping. In addition, fiber is inherently difficult to tap.
• **Greater repeater spacing:** Fewer repeaters mean lower cost and fewer sources of error. The performance of optical fiber systems from this point of view has been steadily improving. Repeater spacing in the tens of kilometers for optical fiber is common, and repeater spacings of hundreds of kilometers have been demonstrated. Coaxial and twisted-pair systems generally have repeaters every few kilometers.

TEXT BOOK

I. Systems Analysis and Design Methods, Jeffrey L Whitten, Lonnie D Bentley, Seventh Edition, TMH, 2007