EIE312 COMMUNICATIONS PRINCIPLES

Outline:

Principles of communications:

1. An elementary account of the types of transmission (Analogue signal transmission and digital signal transmission). Block diagram of a communication system.
2. Brief Historical development on communications:
    a. Telegraph
    b. Telephony
    c. Radio
    d. Satellite
    e. Data
    f. Optical and mobile communications
    g. Facsimile
3. The frequency Spectrum
4. Signals and vectors, orthogonal functions.
5. Fourier series, Fourier integral, signal spectrum, convolution, power and energy correlation.
6. Modulation, reasons for modulation, types of modulation.
7. Amplitude modulation systems:
    a. Comparison of amplitude modulation systems.
    b. Methods of generating and detecting AM, DBS and SSB signals.
    c. Vestigial sideband
    d. Frequency mixing and multiplexing, frequency division multiplexing
    e. Applications of AM systems.
8. Frequency modulation systems:

   a. Instantaneous frequency, frequency deviation, modulation index, Bessel coefficients, significant sideband criteria

   b. Bandwidth of a sinusoidally modulated FM signal, power of an FM signal, direct and indirect FM generation,

   c. Various methods of FM demodulation, discriminator, phase-lock loop, limiter, pre-emphasis and de-emphasis, Stereophonic FM broadcasting

9. Noise waveforms and characteristics. Thermal noise, shot noise, noise figure and noise temperature. Cascade network, experimental determination of noise figure. Effects of noise on AM and FM systems.

10. Block diagram of a superheterodyne AM radio receiver, AM broadcast mixer, local oscillator design, intermodulation interference, adjacent channel interference, ganging, tracking error, intermediate frequency, automatic gain control (AGC), delay AGC, diode detector, volume control.

11. FM broadcast band and specification, Image frequency, block diagram of a FM radio receiver, limiter and ratio detectors, automatic frequency control, squelch circuit, FM mono and FM stereo receivers.

12. AM broadcast band and specification.

13. TV broadcast band and specification. Signal format, transmitter and receiver block diagrams of black and white TV and colour TV.

ELECTROMAGNETIC SPECTRUM

The entire range of electromagnetic radiation frequencies is called the electromagnetic spectrum. The frequency range suitable for radio transmission (the radio spectrum) extends from 10 kilo Hertz to 300,000 mega Hertz. The electromagnetic spectrum is divided into a number of bands, as shown in Table 1.

Below the radio spectrum, but overlapping it, is the audio frequency band, extending from 20 to 20,000 hertz. Above the radio spectrum are heat and infrared, the visible spectrum (light in its various colours), ultraviolet, Xrays, gamma rays, and cosmic rays. Waves shorter than 30 centimeters are usually called microwaves.

Table1. Electromagnetic spectrum.

Band	**Abbreviation**	**Range of frequency**	**Range of wavelength**	**Area of Use**
Audio frequency	AF	20 to 20,000 Hz	15,000,000 to 15,000 m	
Radio frequency	RF	10 kHz to 300,000 MHz	30,000m to 0.1 cm	Used for transmission of data, via modulation as in Television, Mobile phones, wireless networking, Amateur radio broadcasting etc.
Very low frequency	VLF	10kHz to 30 kHz	30,000 to 10,000 m	Used for digital radio communication. Efficient during magnetic storm and for transmission of signals below surface of the sea
Low frequency	LF	30kHz to 300 kHz	10,000 to 1,000 m	Most suitable within groundwave distance of the transmitter and useful for radio direction finding and time dissemination.
Medium frequency	MF	300kHz to 3,000 kHz	1,000 to 100 m	Good for skywave reception, used in standard broadcast band for commercial stations
High frequency	HF	3MHz to 30 MHz	100 to 10 m	Used for ship to ship and ship to shore communication
Very high	VHF	30MHz to 300 MHz	10 to 1 m	Used for direct wave plus

frequency				ground reflected wave. This band is used much for communication
Ultra high frequency	UHF	300MHz to 3,000 MHz	100 to 10 cm	Can be used for ground waves and ground reflected waves. Also Used for ship to ship and ship to shore communication with sharp directive antennas
Super high frequency	SHF	3,000MHz to 30,000 MHz	10 to 1 cm	Used for Marine Navigation Radar
Extremely high frequency	EHF	30,000MHz to 300,000 MHz	1 to 0.1 cm	Used for direct and ground reflected waves
Heat and infrared*		10^6 to $3.l9X10^8$ MHz	0.03 to $7.6X10^{-5}$ cm	
Visible spectrum*		$3.9X10^8$ to $7.9X10^8$ MHz	$7.6 X 10^{-5}$ to $3.8 X 10^{-5}$ cm	
Ultraviolet*		$7.9X10^8$ to $2.3X10^{10}$ MHz	$3.8X10^{-5}$ to $1.3X10^{-6}$ cm	
X-rays*		2..0X109 to $3.0X10^{13}$ MHz	$1.5X10^{-5}$ to $1.0X10^{-9}$ cm	
Gamma rays*		$2.3X10^{12}$ to $3.0X10^{14}$ MHz	$1.3X10^{-8}$ to $1.0X10^{-10}$ cm	
Cosmic rays*		>$4.8X10^{15}$ MHz	<$6.2X10^{-12}$ cm	

* Values approximate.

Frequency is an important consideration in radio wave propagation. The following summary indicates the principal effects associated with the various frequency bands, starting with the lowest and progressing to the highest usable radio frequency.

Very Low Frequency (VLF, 10 to 30 kHz) (λ=30,000 to 10,000 m):

The VLF signals propagate between the bounds of the ionosphere and the earth and are thus guided around the curvature of the earth to great distances with low attenuation and excellent stability. Diffraction is maximum in this band. Because of the long wavelength, large antennas are needed, and even these are inefficient, permitting radiation of relatively small amounts of power. Magnetic storms have little effect upon transmission because of the efficiency of the "earth-ionosphere waveguide." During such storms, VLF signals may constitute the only source of radio communication over great distances. However, interference from atmospheric noise may be troublesome. Signals may be received from below the surface of the sea.

Low Frequency (LF, 30 to 300 kHz)(λ=10,000 to 1,000 m):

As frequency is increased to the LF band and diffraction decreases, there is greater attenuation with distance, and range for a given power output falls off rapidly. However, this is partly offset by more efficient transmitting antennas. LF signals are most stable within groundwave distance of the transmitter. A wider bandwidth permits pulsed signals at 100 kHz. This allows separation of the stable groundwave pulse from the variable skywave pulse up to 1,500 km, and up to 2,000 km for overwater paths. This band is also useful for radio direction finding and time dissemination.

Medium Frequency (MF, 300 to 3,000 kHz)(λ= 1,000 to 100 m):

Groundwaves provide dependable service, but the range for a given power is reduced greatly. This range varies from about 643.737Km at the lower portion of the band to about 24.1401Km at the upper end for a transmitted signal of 1kilowatt. These values are influenced, however, by the power of the transmitter, the directivity and efficiency of the antenna, and the nature of the terrain over which signals travel. Elevating the antenna to obtain direct waves may improve the transmission. At the lower frequencies of the band, skywaves are available both day and night. As the frequency is increased, ionospheric absorption increases to a maximum at about 1,400 kHz. At higher frequencies the absorption decreases, permitting increased use of skywaves. Since the ionosphere changes with the hour, season, and sunspot cycle, the reliability of skywave signals is variable. By careful selection of frequency, ranges of as much as 12874.752Km with 1 kilowatt of transmitted power are possible, using multihop signals. However, the frequency selection is critical. If it is too high, the signals penetrate the ionosphere and are lost in space. If it is too low, signals are too weak. In general, skywave reception is equally good by day or night, but lower frequencies are needed at night. The standard broadcast band for commercial stations (535 to 1,605 kHz) is in the MF band.

High Frequency (HF, 3 to 30 MHz)(λ= 100 to 10 m):

As with higher medium frequencies, the groundwave range of HF signals is limited to a few miles, but the elevation of the antenna may increase the direct-wave distance of transmission. Also, the height of the antenna does have an important effect upon skywave transmission because the antenna has an "image" within the conducting earth. The distance between antenna and image is related to the height of the antenna, and this distance is as critical as the distance between elements of an antenna system. Maximum usable frequencies fall generally within the HF band. By day this may be 10 to 30 MHz, but during the night it may drop to 8 to 10 MHz. The HF band is widely used for ship-to-ship and ship-to-shore communication.

Very High Frequency (VHF, 30 to 300 MHz)(λ=10 to 1 m):

Communication is limited primarily to the direct wave, or the direct wave plus a ground-reflected wave. Elevating the antenna to increase the distance at which direct waves can be used results in increased distance of reception, even though some wave interference between direct and ground-reflected waves is present. Diffraction is much less than with lower frequencies, but it is most evident when signals cross sharp mountain peaks or ridges. Under suitable conditions, reflections from the ionosphere are sufficiently strong to be useful, but generally they are unavailable. There is relatively little interference from atmospheric noise in this band. Reasonably efficient directional antennas are possible with VHF. The VHF band is much used for communication.

Ultra High Frequency (UHF, 300 to 3,000 MHz)(λ=100 to 10 cm):

Skywaves are not used in the UHF band because the ionosphere is not sufficiently dense to reflect the waves, which pass through it into space. Groundwaves and ground-reflected waves are used, although there is some wave interference. Diffraction is negligible, but the radio horizon extends about 15% beyond the visible horizon, due principally to refraction. Reception of UHF signals is virtually free from fading and interference by atmospheric noise.

Sharply directive antennas can be produced for transmission in this band, which is widely used for ship-to-ship and ship-to-shore communication.

Super High Frequency (SHF, 3,000 to 30,000 MHz)(λ=10 to 1 cm):

In the SHF band, also known as the microwave or as the centimeter wave band, there are no skywaves, transmission being entirely by direct and ground-reflected waves. Diffraction and interference by atmospheric noise are virtually non-existent. Highly efficient, sharply directive antennas can be produced. Thus, transmission in this band is similar to that of UHF, but with the effects of shorter waves being greater. Reflection by clouds, water droplets, dust particles, etc., increases, causing greater scattering, increased wave interference, and fading. The SHF band is used for marine navigational radar.

Extremely High Frequency (EHF, 30,000 to 300,000MHz)(λ=1 to 0.1 cm):

The effects of shorter waves are more pronounced in the EHF band, transmission being free from wave interference, diffraction, fading, and interference by atmospheric noise. Only direct and ground-reflected waves are available. Scattering and absorption in the atmosphere are pronounced and may produce an upper limit to the frequency useful in radio communication.