Signal

A signal is an electromagnetic current that is used for carrying data from one system or network to another. The signal is a function that conveys information about an occurrence. A signal can also be defined as an observable change in quality and quantity.

Digital and Analog Signal

An analog signal is a continuous signal i.e., it uses continuous values to represent information ans is denoted by sine waves. Analog signals are suited for audio and video transmission. Photocopiers, Audio tapes, Resistive touch screen, FM Radio signal are examples of analog signals. Processing can be done in real time and consumes lesser bandwidth compared to a digital signal.

A digital signal is non-continuous signal i.e., it uses 0 and 1 to represent any information and is denoted by square waves. Digital signals are suited for Computing and digital electronics. Computers, CDs, DVDs are the examples of digital signal. It never gives a guarantee that digital signal processing can be performed in real time.

Antennas

An Antenna (or sometimes called as an Aerial), is an electrical device that converts electric power into electromagnetic waves (or radio waves) and vice-versa.A signal from a transmission line or the guiding device like a co-axial cable, is given to an antenna, which then converts the signal into electromagnetic energy to be transmitted through space.

Types of Antennas

1. **Wire Antennas -** One of the most commonly used antennas are wire antennas. They can be found in vehicles (automobiles), ships, aircrafts, buildings etc. Wire Antennas come in different shapes and sizes like straight wire (Dipole), Loop and Helix.
2. **Short Dipole Antenna -** Short dipole antenna is an open circuit wire with the signal being fed at the centre. The term “short” here is for the size of the wire relative to the wavelength of the signal.
3. **Dipole Antenna -** A dipole antenna is made up of two conductors in the same axis and the length of the wire is kept small as compared to the wavelength.
4. **Loop Antenna -** A loop antenna is formed by a single or multiple turn of wire forming a loop. The radiation produced by a loop antenna is comparable to the short dipole antenna.
5. **Monopole Antenna -** It is half of the dipole antenna.

6. **Slot Antenna -** A type of aperture antenna which contains one or more slots cut on the surface of a waveguide. They are usually used in microwave frequencies and have an omni-directional radiation pattern.
7. **Horn Antenna -** One of the most popular antennas is the Horn Antenna, which effects the transition between transmission line and wave propagating in free space. It acts as a natural extension to a waveguide.

Multiple Access

Multiple Access techniques are used to allow many users to access a given frequency allocation. The sharing of spectrum is required to achieve high capacity simultaneously allocating the available bandwidth to multiple users.

- **Frequency Division Multiple Access -**

FDMA is the division of the frequency bands allocated for wireless cellular telephone communication into channels. Each channel can be assigned to one user at a time. All users transmit and receive the information at different frequencies because every user receives an individual frequency slot.

Working -

FDMA allows multiple users to send data through a single communication channel, such as coaxial cable by dividing the bandwidth of the channel into separate non-overlapping frequency sub-channels. Then allocating each sub-channel to a separate user. Users can send data through a sub-channel by modulating it on a carrier wave at the sub-channel's frequency.

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FDMA is implemented at the media access control (MAC) layer of the data-link layer in the OSI model.

Application -

It is used in the satellite communication system and telephone lines.

- **Time Division Multiple Access -**

TDMA is a digital cellular telephone communication technology. It facilitates many users to share the same frequency without interference. It's the technology that divides a signal into different time slots.

Working -

TDMA takes the cellular communication channel (frequency band) and slices it to a series of time segments. Each cellular user is assigned the time slices with a given number. Each user transmit information only for the duration of their time segments using TDMA scheme. By small time segments and high slicing frequency, user perceives a continuous communication channel.

FDMA is implemented at the media access control (MAC) layer of the data-link layer in the OSI model.

Application -

TDMA is used in the digital 2G cellular systems such as Global System for Mobile Communications (GSM), IS-136, Personal Digital Cellular (PDC) and iDEN, and in the Digital Enhanced Cordless **Telecommunications** (DECT) standard for portable phones.

- **Code Division Multiple Access -**

Code-division multiple access (**CDMA**) is a channel access method used by various radio communication technologies. **CDMA** is an **example** of multiple access, where several transmitters can send information simultaneously over a single communication channel.

Working -

TDMA takes the cellular communication channel (frequency band) and slices it to a series of time segments. Each cellular user is assigned the time slices with a given number. Each user transmit information only for the duration of their time segments using TDMA scheme. By small time segments and high slicing frequency, user perceives a continuous communication channel.

FDMA is implemented at the media access control (MAC) layer of the data-link layer in the OSI model.

Application -

It is used in military purposes, in RADAR and communication systems.

- **Frequency Hopping Spread Spectrum**

  Frequency-hopping spread spectrum is a method of transmitting radio signals by rapidly changing the carrier frequency among many distinct frequencies occupying a large spectral band. The changes are controlled by a code known to both transmitter and receiver.

  Application -

  FHSS modulation technique is used in military purposes. **FHSS** modulation is used in wireless LANs (WLAN).

- **Direct Sequence Spread Spectrum**

  Direct Sequence Spread Spectrum (**DSSS**) is a spread spectrum technique whereby the original data signal is multiplied with a pseudo random noise spreading code. This spreading code has a higher chip rate (this the bitrate of the code), which results in a wideband time continiuous scrambled signal.

  Application -

  Satellite based navigation systems use DSSS **as this gives a signal gain by spreading the signal out over a wide bandwidth.** It also enables different satellites to use the same channel without mutual interference.

Transmitters and Receivers

A transmitter is an electronic device which produces radio waves with an antenna. The transmitter itself generates a radio frequency alternating current, which is applied to the antenna. The antenna generates radio waves when excited by this alternating current. Transmitters are necessary component parts of all electronic devices that communicate by radio, such as radio and television broadcasting stations.

A receiver is an electronic device which receives radio waves and converts the information carried by them into a usable form. It is used with an antenna. The antenna intercepts radio waves (electromagnetic waves) and converts them to tiny alternating currents which are applied to the receiver, and the receiver extracts the desired information. The receiver uses electronic filters to separate the desired radio frequency signal from all the other signals picked up by the antenna, to

increase the power of the signal for further processing, and finally recovers the desired information through demodulation.

Cell

A cell is the geographic area that is covered by a single base station in a large number of base stations to efficiently use radio spectrum to cover the service area.

Signal Propagation

Wireless communications systems are composed of one or more “Antenna Sites”, “Tower Sites”, or “Cell Sites”. Antennas made on these structures generate wireless communications signals to the devices in the field through electromagnetic waves. User devices also transmit similar types of signals back to the sites. This establishes a two-way communication. This movement of these radio waves to and fro between aites and devices is called “Signal Propagation”.

Ground Wave and Sky Wave

A radio signal emitted from a certain place on the earth can be received at another location in two possible ways.

If wave travels directly along the earth from one point to another is called ground wave.
If the wave is directed towards the sky and after reflection from ionosphere of earth’s atmosphere reaches the desired location on earth is called sky wave.

Cellular System

In the cellular system, the service area is divided into cells. A transmitter is designed to serve an individual cell. The system seeks to make efficient use of available channels by using low-power transmitters to allow frequency reuse at much smaller distances.

Advantages of Small Cell -

1. Small cell base stations provide higher capacity than macro cells because of the deployment scenario. Because these base stations are mounted low above ground, they are less susceptible to interference. This translates directly into higher capacity.

2. They're connected with fiber so they are able to handle massive amounts of data at fast speeds, hence low user delay.

3. Small cells provide better outdoor-to-indoor coverage.

4. Macro base stations provide poor service at the cell edge which includes a large percentage of the cell area. Small cells provide better cell-edge performance, particularly for the uplink than large cells.

Disadvantages of Small Cell -

1. As these base stations are mounted low above ground, typical microwave systems are not technically effective because they require a clear line-of-sight between the two nodes of the microwave link – which is difficult to provide in urban areas where small cells are deployed below building rooflines.

2. Fiber is expensive to lay as it may not be available at the spot where the small cell is required.

3. Large monthly fees makes it less usable from the economic point of view.