MOBILE COMPUTING (CS-417)

UNIT-1: Introduction to Wireless Communication

Wireless communication is the transmission of information over a distance without the use of wires, cables or any other forms of electrical conductors. It is a broad term that incorporates all procedures and forms of connecting and communicating between two or more devices using a wireless signal through wireless communication technologies and devices.

A communication device can thus exhibit one of the following characteristics:
● **Fixed and wired**: This configuration describes the typical desktop computer in an office. Neither weight nor power consumption of the devices allow for mobile usage. The devices use fixed networks for performance reasons.
● **Mobile and wired**: Many of today's laptops fall into this category; users carry the laptop from one hotel to the next, reconnecting to the company's network via the telephone network and a modem.
● **Fixed and wireless**: This mode is used for installing networks, e.g., in historical buildings to avoid damage by installing wires, or at trade shows to ensure fast network setup. Another example is bridging the last mile to a customer by a new operator that has no wired infrastructure and does not want to lease lines from a competitor.
● **Mobile and wireless**: This is the most interesting case. No cable restricts the user, who can roam between different wireless networks. Most technologies discussed in this book deal with this type of device and the networks supporting them. Today's most successful example for this category is GSM with more than 800 million users.

The basic components of a wireless communication system are:

- **Transmitter:** The transmitter converts the information to be transmitted into a form that can be propagated through a wireless medium.
- **Medium:** The medium is the physical path through which the signal travels. It can be air, space, or a guided medium such as a fiber optic cable.
- **Receiver:** The receiver converts the signal back into its original form so that it can be interpreted by the user.

The most common wireless communication technologies are:

- **Radio:** Radio waves are used for a wide variety of applications, including cellular networks, Wi-Fi, and Bluetooth.
- **Microwave:** Microwaves are used for long-distance communication, such as satellite communications and microwave links.
- **Infrared:** Infrared waves are used for short-range communication, such as remote controls and some medical devices.
- **Light:** Light is used for communication in optical fiber networks.

Wireless communication has many advantages over wired communication, including:

- **Mobility:** Wireless devices are not tied to a physical location, so they can be moved around more easily.
- **Flexibility:** Wireless networks can be easily deployed and expanded.
- **Cost:** Wireless networks can be less expensive to install and maintain than wired networks.

However, wireless communication also has some disadvantages, including:

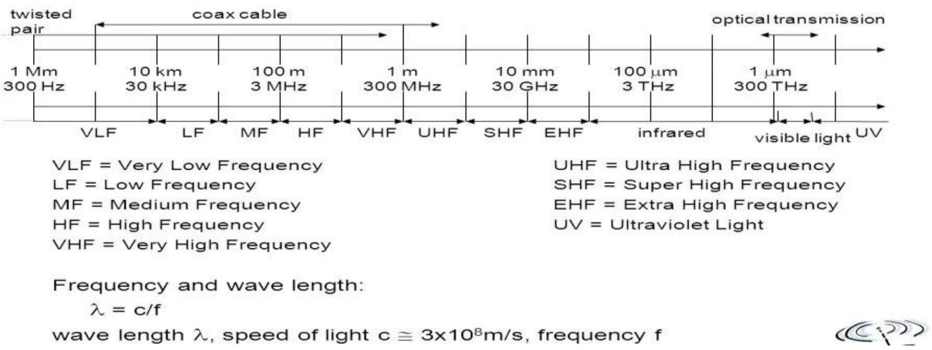
- **Security:** Wireless signals can be easily intercepted, so it is important to use encryption to protect sensitive data.
- **Interference:** Wireless signals can be affected by noise and interference from other devices.
- **Range:** The range of a wireless signal is limited by the power of the transmitter and the properties of the medium.

Applications of wireless communication:

- **Cellular networks:** Cellular networks are used for mobile phone communication.
- **Wi-Fi:** Wi-Fi is used for wireless internet access.
- **Bluetooth:** Bluetooth is used for short-range data transfer, such as between a smartphone and a headset.
- **Satellite communication:** Satellite communication is used for long-distance communication, such as television broadcasting and internet access in remote areas.
- **Microwave links:** Microwave links are used for high-speed communication between two points, such as between a city and a remote office.
- **Infrared communication:** Infrared communication is used for short-range communication, such as between a remote control and a TV.
- **Optical fiber networks:** Optical fiber networks are used for high-speed communication over long distances.

Frequencies for radio transmission: -

Radio transmission can take place using many different frequency bands. The figure shows frequencies starting at 300 Hz and going up to over 300 THz.



For traditional wired networks, frequencies of up to several hundred kHz are used for distances up to some km with twisted pair copper wires,

Frequencies of several hundred MHz are used with coaxial cable (new coding schemes work with several hundred MHz even with twisted pair copper wires over distances of some (100m).

Fiber optics are used for frequency ranges of several hundred THz, but here one typically refers to the wavelength which is, e.g., 1500 nm, 1350 nm etc. (infrared)
Very Low Frequency (VLF): 3 kHz to 30 kHz. Used submarine communication due to their ability to penetrate water.
Low Frequency (LF): 30 kHz to 300 kHz. Used for AM radio broadcasting.
Medium Frequency (MF): 300 kHz to 3 MHz. Used for AM radio broadcasting and aviation communication.
High Frequency (HF): 3 MHz to 30 MHz. Used for international shortwave broadcasting, aviation, marine communication, and amateur radio.
Very High Frequency (VHF): 30 MHz to 300 MHz. Used for FM radio broadcasting, television broadcasting, aviation communication, and some land mobile radio services.
Ultra-High Frequency (UHF): 300 MHz to 3 GHz. Used for TV broadcasting, cellular phones, satellite communication, and public safety radio systems.
Super High Frequency (SHF): 3 GHz to 30 GHz. Used for satellite communication, radar, and microwave links.
Extremely High Frequency (EHF): 30 GHz to 300 GHz. Used for advanced wireless communication technologies like 5G and some satellite communication.

Signals: -

Signals are the physical representation of data. Users of a communication system can only exchange data through the transmission of signals. Layer 1 of the ISO/OSI basic reference model is responsible for the conversion of data, i.e., bits, into signals and vice versa (Halsall, 1996), (Stallings, 1997 and 2002).
Signals are functions of time and location. Signal parameters represent the data values. The most interesting types of signals for radio transmission are **periodic signals**, especially **sine waves** as carriers.
The general function of a sine wave is:

$$g(t) = A_t \sin(2 \pi f_t t + \varphi_t)$$

Signal parameters are the **amplitude** A, the **frequency** f, and the **phase shift** φ. The amplitude as a factor of the function g may also change over time, thus A_t.

The frequency f expresses the periodicity of the signal with the period $T = 1/f$. The frequency f may also change over time, thus f_t.

Finally, the phase shift determines the shift of the signal relative to the same signal without a shift. An example for shifting a function is shown in Figure below. This shows a sine function without a phase shift and the same function, i.e., same amplitude and frequency, with a phase shift φ.

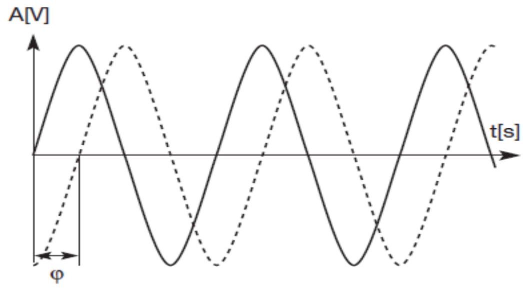


Fig. Time Domain Representation of a signal

Representations in the time domain are problematic if a signal consists of many different frequencies. In this case, a better representation of a signal is the **frequency domain.** Here the amplitude of a certain frequency part of the signal is shown versus the frequency. Figure only shows one peak and the signal consists only of a single frequency part (i.e., it is a single sine function).

A third way to represent signals is the **phase domain** shown in Figure below. This representation, also called phase state or signal constellation diagram, shows the amplitude M of a signal and its phase φ in polar coordinates. (The length of the vector represents the amplitude, the angle the phase shift.) The x-axis represents a phase of 0 and is also called **In-Phase (I)**. A phase shift of 90° or $\pi/2$ would be a point on the y-axis, called **Quadrature (Q)**.

Fig. Frequency domain representation of a signal

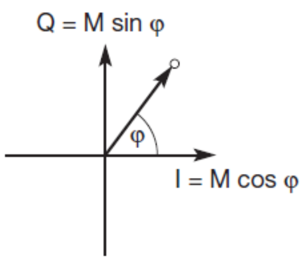


Fig. Phase domain representation of a signal

Antennas: - Antennas are essential components of wireless communication systems. They are used to transmit and receive electromagnetic waves. Antennas come in a variety of shapes and sizes, and each type of antenna has its own unique characteristics.

- **Dipole antennas** are simple to construct and can be used to transmit and receive radio waves in all directions. However, dipole antennas have relatively low gain, which means that they do not transmit or receive signals as well as some other types of antennas.
- **Directional antennas** focus the transmitted or received signal in a specific direction. This can be useful for applications where it is important to maximize the range or signal quality in a particular direction.
- **Polarization** is the direction of the electric field of the electromagnetic wave. There are two main types of polarization: linear polarization and circular polarization.
  Linearly polarized antennas transmit and receive signals with an electric field that is oriented in a specific direction.

Circularly polarized antennas transmit and receive signals with an electric field that rotates in a circle. Circularly polarized antennas are less susceptible to interference from multipath propagation than linearly polarized antennas.

Antennas are also characterized by their gain and directivity.

- **Gain:** The gain of an antenna is a measure of how much it concentrates the signal beam in a particular direction. Gain is measured in decibels (dB).
- **Directivity:** The directivity of an antenna is a measure of how well it focuses the signal beam in a particular direction. Directivity is measured in decibels per steradian (dBi).

Signal Propagation: -

In wireless networks, the signal has no wire to determine the direction of propagation, whereas signals in wired networks only travel along the wire. As long as the wire is not interrupted or damaged, it typically exhibits the same characteristics at each point. One can precisely determine the behavior of a signal travelling along this wire, e.g., received power depending on the length. For wireless transmission, this predictable behavior is only valid in a vacuum, i.e., without matter between the sender and the receiver. The situation would be as follows:

- **Transmission range**: Within a certain radius of the sender transmission is possible, i.e., a receiver receives the signals with an error rate low enough to be able to communicate and can also act as sender.
- **Detection range**: Within a second radius, detection of the transmission is possible, i.e., the transmitted power is large enough to differ from background noise. However, the error rate is too high to establish communication.
- **Interference range**: Within a third even larger radius, the sender may interfere with other transmission by adding to the background noise. A receiver will not be able to detect the signals, but the signals may disturb other signals.

There are three main types of signal propagation:

- **Ground wave propagation:** Ground wave propagation occurs when the signal travels along the surface of the Earth. This type of propagation is most effective at lower frequencies, such as AM radio broadcasting.
- **Sky wave propagation:** Sky wave propagation occurs when the signal is reflected off the ionosphere and back to the Earth. This type of propagation is most effective at shortwave radio broadcasting.
- **Space wave propagation:** Space wave propagation occurs when the signal travels directly from the transmitter to the receiver without being reflected or scattered. This type of propagation is most effective at higher frequencies, such as cellular networks and Wi-Fi.

Factors influence how signals propagate: -

1. **Path Loss:** Path loss is the reduction in signal strength as the wave travels through space. It is primarily determined by the distance between the transmitter and

receiver. As the distance increases, the signal strength decreases due to spreading and divergence of the wavefront.

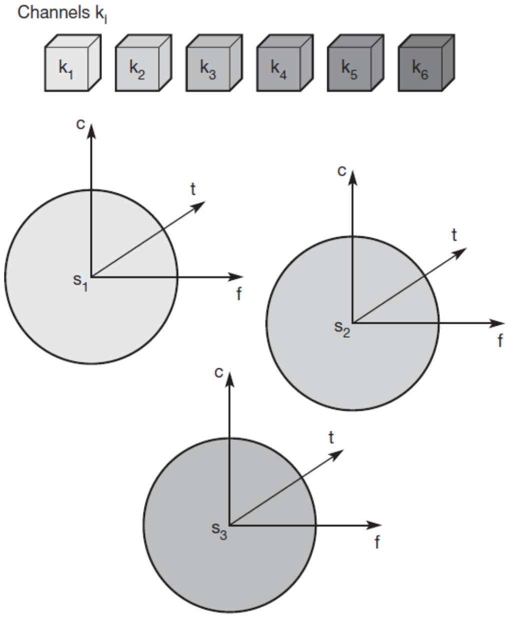
2. **Free Space Path Loss (FSPL):** In free space, where there are no obstacles or objects to cause reflection, refraction, or diffraction, the signal experiences free space path loss. The FSPL is directly proportional to the square of the distance between the transmitter and receiver and inversely proportional to the square of the signal wavelength.
3. **Absorption:** Absorption occurs when materials or objects in the signal's path absorb some or all of the electromagnetic energy. Different materials absorb different frequencies of electromagnetic waves to varying degrees. For example, water absorbs microwaves, which is why microwave ovens use this property to heat food.
4. **Reflection:** When a signal encounters a boundary or surface between two different media, such as air and a wall, part of the signal can be reflected back. Reflection can either reinforce or cancel out signals, depending on the phase relationship between the incident and reflected waves.
5. **Refraction:** Refraction occurs when a signal crosses a boundary between two media with different refractive indices, causing the wavefront to change direction. This bending of the wavefront can lead to changes in the signal path and coverage.
6. **Diffraction:** Diffraction is the bending of waves around obstacles or through openings. It allows signals to spread into the shadow region behind an obstruction, which is why you can receive radio signals even when the transmitter is not in direct line of sight.
7. **Scattering:** Scattering happens when small objects or irregularities in the medium cause signals to be redirected in various directions. This effect can lead to multipath propagation, where multiple signal paths reach the receiver with different delays and phases.
8. **Multipath Propagation:** In environments with reflections, diffractions, and scattering, a receiver can receive multiple delayed copies of the same signal due to different propagation paths. These copies can interfere constructively or destructively, affecting signal quality and leading to phenomena like fading.
9. **Fading:** Fading refers to the rapid variation in signal strength or quality over short periods. It can be caused by multipath propagation, interference, or other atmospheric conditions. Fading can be detrimental to wireless communication systems, so techniques like diversity reception and equalization are used to mitigate its effects.
10. **Atmospheric Effects:** Factors like atmospheric absorption, rain, fog, and atmospheric turbulence can also affect signal propagation. For example, rain can attenuate microwave signals.

Multiplexing: - Multiplexing is a method that can be used to combine multiple analog or digital signals into one signal over a shared medium. Multiplexing describes how several users can share a medium with minimum or no interference. One example, is highways with several lanes. Many users (car drivers) use the same medium (the highways) with hopefully no interference (i.e., accidents). This is possible due to the provision of several lanes (space division multiplexing) separating the traffic. In addition, different cars use the same medium (i.e., the same lane) at different points in time (time division multiplexing).

We can see a real-life example of Multiplexing in the telecommunication field where several telephone calls may be carried using one wire.

Types of Multiplexing: -

Space Division Multiplexing (SDM): - Figure shows six channels k_i and introduces a three dimensional coordinate system. This system shows the dimensions of code c, time t and frequency f. For this first type of multiplexing, the (three dimensional) space s_i is also shown. Here space is represented via circles indicating the interference range as introduced in Figure. The channels k_1 to k_3 can be mapped onto the three 'spaces' s_1 to s_3 which clearly separate the channels and prevent the interference ranges from overlapping. The space between the interference ranges is sometimes called **guard space**.



For the remaining channels (k_4 to k_6) three additional spaces would be needed.

Advantages of SDM

- In SDM, the data transmission rate is high.
- It uses Time and Frequency bands at its maximum potential.

Disadvantages of SDM

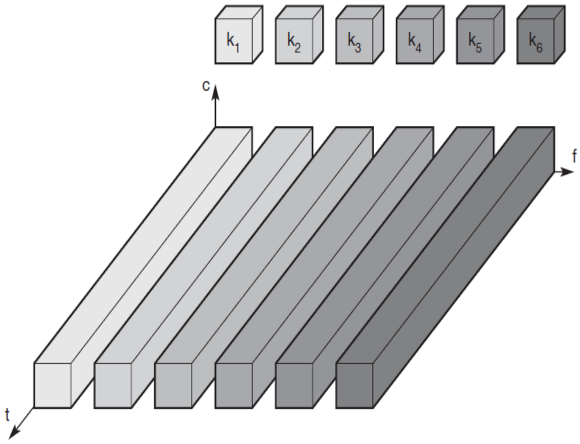
- An inference may occur.
- It faces high inference losses.

Usage

- Old analog telephone system: each subscriber is given a separate pair of copper wires to the local exchange.

Frequency Division Multiplexing (FDM): - Frequency division multiplexing (FDM) describes schemes to subdivide the frequency dimension into several non-overlapping frequency bands. Each channel ki is now allotted its own frequency band as indicated. Senders using a certain frequency band can use this band continuously. Again, **guard spaces**

are needed to avoid frequency band overlapping (also called **adjacent channel interference**). This scheme is used for radio stations within the same region, where each radio station has its own frequency.



Advantages of FDM

- The concept of frequency division multiplexing (FDM) applies to both analog signals and digital signals.
- It facilitates you to send multiple signals simultaneously within a single connection.

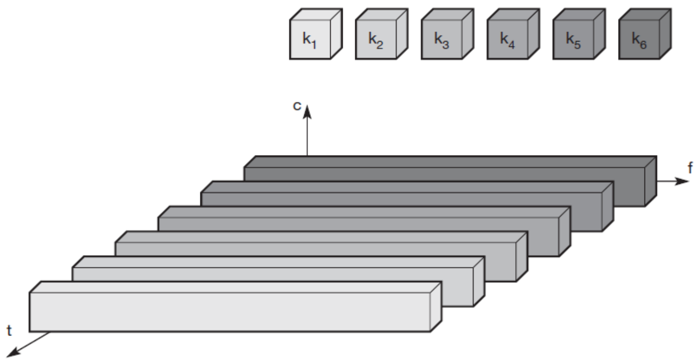
Disadvantages of FDM

- It is less flexible.
- In FDM, the bandwidth wastage may be high.

Usage

- It is used in Radio and television broadcasting stations, Cable TV etc.

Time Division Multiplexing (TDM): - A more flexible multiplexing scheme for typical mobile communications is **time division multiplexing (TDM)**. Here a channel ki is given the whole bandwidth for a certain amount of time, i.e., all senders use the same frequency but at different points in time. Again, **guard spaces**, which now represent time gaps, have to separate the different periods when the senders use the medium.



Advantages of TDM: -

- It facilitates a single user at a time.
- It is less complicated and has a more flexible architecture.

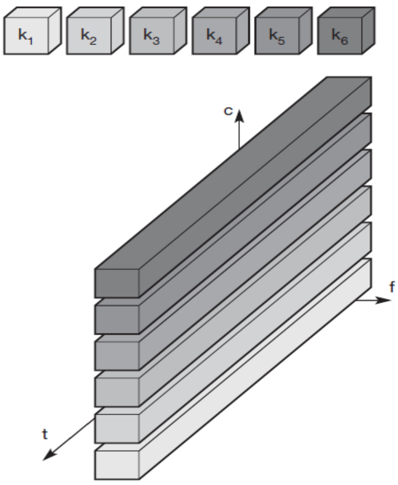
Disadvantages of TDM

- High Implementation cost.
- Inefficient use of Bandwidth.

Usage

- It is mainly used in telephonic services.

Code Division Multiplexing (CDM): - First used in military applications due to its inherent security features**,** it now features in many civil wireless transmission scenarios thanks to the availability of cheap processing power. Figure shows how all channels ki use the same frequency at the same time for transmission. Separation is now achieved by assigning each channel its own 'code', **guard spaces** are realized by using codes with the necessary 'distance' in code space, e.g., **orthogonal codes**.
In other words, CDM allots a unique code to every channel so that each of these channels can use the same spectrum simultaneously at the same time.



Advantages of CDM

- It is highly efficient.
- It faces fewer Inferences.

Disadvantages of CDM

- The data transmission rate is low.
- It is complex.

Usage

- It is mainly used in Cell Phone Spectrum Technology (2G, 3G etc.).

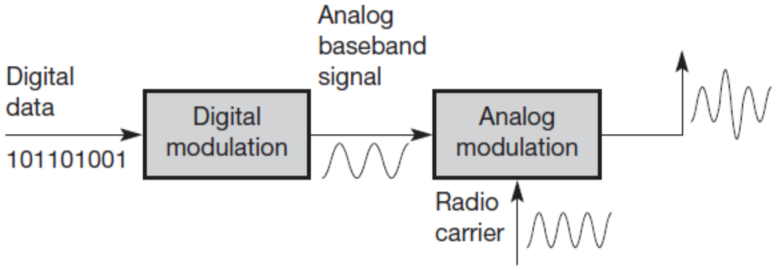
Modulation: - For **Digital Modulation**, digital data (0 and 1) is translated into an analog signal (baseband signal). Digital modulation is required if digital data has to be transmitted over a medium that only allows for analog transmission. One example for wired networks is to connect a computer to this system a modem is needed. The modem then performs the translation of digital data into analog signals and vice versa. In wireless networks, however, digital transmission cannot be used. Here, the binary bit-stream has to be translated into an analog signal first. The three basic methods for this translation are **amplitude shift keying (ASK)**, **frequency shift keying (FSK)**, and **phase shift keying (PSK)**.

Why Digital Modulation is required? There are several reasons why this baseband signal cannot be directly transmitted in a wireless system:

- **Antennas**: an antenna must be the order of magnitude of the signal's wavelength in size to be effective. For the 1 MHz signal this would result in an antenna some hundred meters high, which is obviously not very practical for handheld devices and also increases the cost in implementing. With 1 GHz, antennas a few centimeters in length can be used.
- **Frequency division multiplexing**: Using only baseband transmission, FDM could not be applied. Analog modulation shifts the baseband signals to different carrier frequencies. The higher the carrier frequency, the more bandwidth that is available for many baseband signals.
- **Medium characteristics**: Path-loss, penetration of obstacles, reflection, scattering, and diffraction – all the effects depend heavily on the wavelength of the signal. Depending on the application, the right carrier frequency with the desired characteristics has to be chosen: long waves for submarines, short waves for handheld devices, very short waves for directed microwave transmission etc.

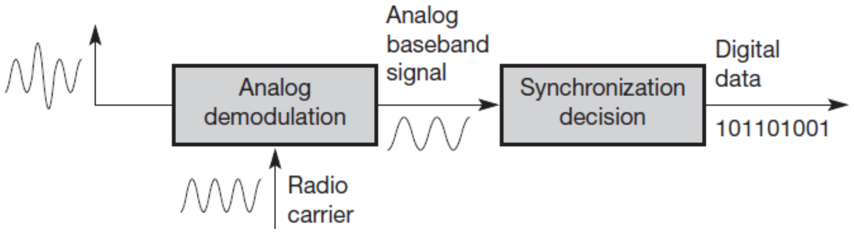
Working of Digital Modulation: - Figure shows a (simplified) block diagram of a radio transmitter for digital data.The first step is the digital modulation of data into the analog baseband signal according to one of the schemes. The analog modulation then shifts the center frequency of the analog signal up to the radio carrier. This signal is then transmitted via the antenna.

Figure 2.21
Modulation in a transmitter

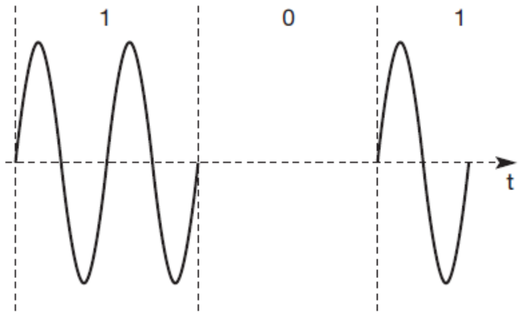


The receiver receives the analog radio signal via its antenna and demodulates the signal into the analog baseband signal with the help of the known carrier. This would be all that is needed for an analog radio tuned in to a radio station. (The analog baseband signal would constitute the music.) For digital data, another step is needed. Bits or frames have to be detected, i.e., the receiver must synchronize with the sender. How synchronization is achieved, depends on the digital modulation scheme. After synchronization, the receiver has to decide if the signal represents a digital 1 or a 0, reconstructing the original data.

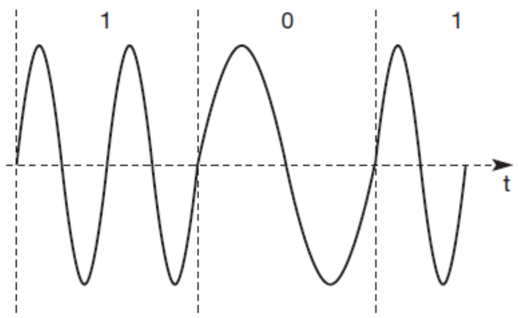
Figure 2.22
Demodulation and data reconstruction in a receiver



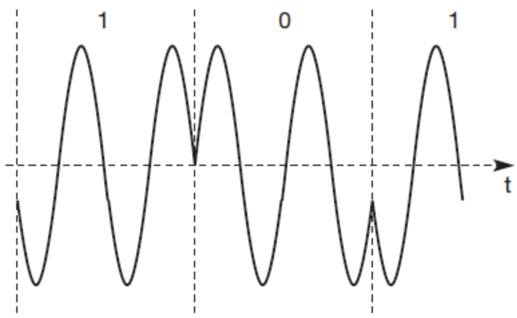
Amplitude Shift Keying (ASK): - As the name suggests, in Amplitude Shift Key or ASKS Modulation, the amplitude is represented by "1," and if the amplitude does not exist, it is represented by "0". Using Amplitude Shift Key Modulation is very simple, and it requires a very low bandwidth. Amplitude Shift Key Modulation is vulnerable to inference or deduction.



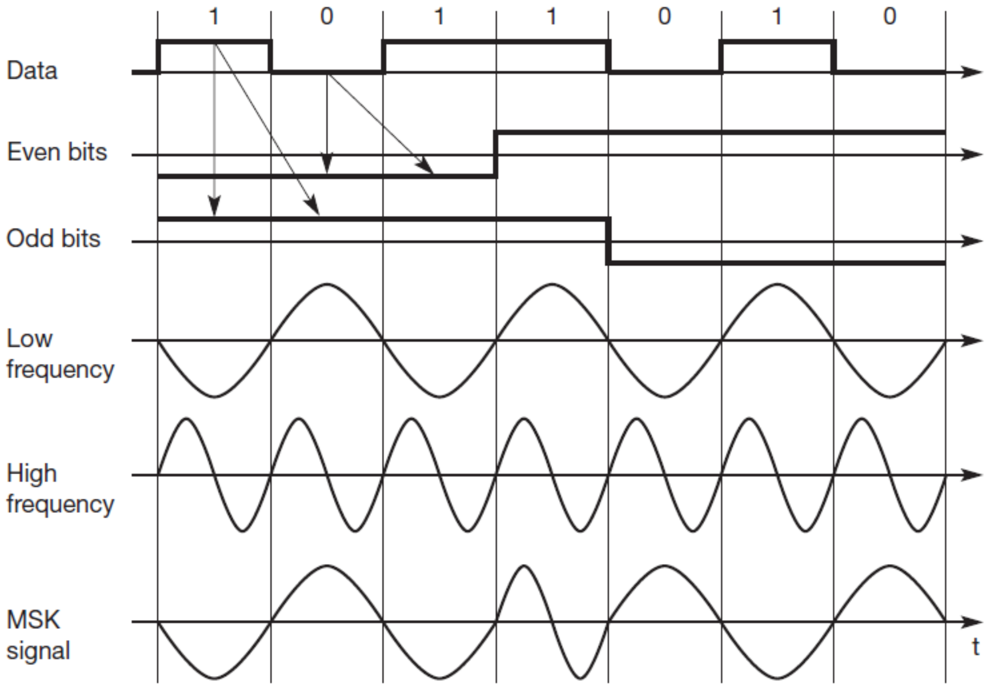
Frequency Shift keying (FSK): - The simplest form of FSK, also called **binary FSK (BFSK)**, assigns one frequency f_1 to the binary 1 and another frequency f_2 to the binary 0. A very simple way to implement FSK is to switch between two oscillators, one with the frequency f_1 and the other with f_2, depending on the input.



Phase Shift Keying (PSK): - Phase shift keying (PSK) uses shifts in the phase of a signal to represent data. Figure shows a phase shift of 180° or π as the 0 follows the 1 (the same happens as the 1 follows the 0). This simple scheme, shifting the phase by 180° each time the value of data changes, is also called **binary PSK (BPSK)**.



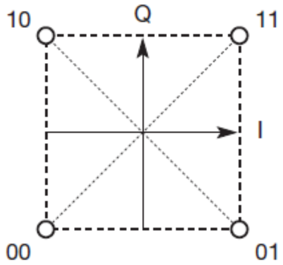
Advanced Frequency Shift keying (AFSK): - Also known as Minimum Shift Keying (MSK). Figure shows an example for the implementation of MSK.
In a first step, data bits are separated into even and odd bits, the duration of each bit being doubled. The scheme also uses two frequencies: f_1, the lower frequency, and f_2, the higher frequency, with $f_2 = 2f_1$.

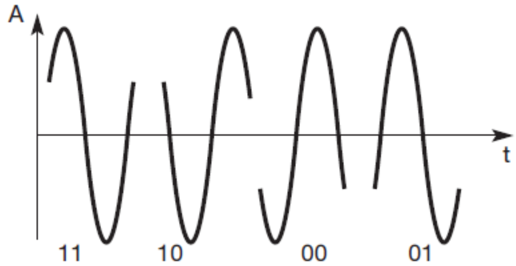


According to the following scheme, the lower or higher frequency is chosen (either inverted or non-inverted) to generate the MSK signal:
● if the even and the odd bit are both 0, then the higher frequency f_2 is inverted (i.e., f_2 is used with a phase shift of 180°);
● if the even bit is 1, the odd bit 0, then the lower frequency f_1 is inverted. This is the case, e.g., in the fifth to seventh columns of Figure.
● if the even bit is 0 and the odd bit is 1, as in columns 1 to 3, f_1 is taken without changing the phase,
● if both bits are 1 then the original f_2 is taken.

A high frequency is always chosen if even and odd bits are equal. The signal is inverted if the odd bit equals 0. This scheme avoids all phase shifts in the resulting MSK signal.

Advanced Phase Shift Keying (APSK): - The simple PSK scheme can be improved in many ways. The basic BPSK scheme only uses one possible phase shift of 180°. Quadrature Phase Shift Keying (QPSK) is a digital modulation technique that transmits two bits per symbol. It does this by shifting the phase of a carrier signal by one of four different values, each of which represents a unique combination of two bits.
The phase shift can always be relative to a **reference signal** (with the same frequency). If this scheme is used, a phase shift of 0 means that the signal is in phase with the reference signal. A QPSK signal will then exhibit a phase shift of 45° for the data 11, 135° for 10, 225° for 00, and 315° for 01 – with all phase shifts being relative to the reference signal.





Spread Spectrum: - "Spread Spectrum is a technique in which the transmitted signals of specific frequencies are varied slightly to obtain greater bandwidth as compared to initial bandwidth." Let's see an example to understand the concept of spread spectrum in wireless communication:
We know that a conventional wireless signal frequency is usually specified in megahertz **(MHz)** or gigahertz **(GHz).** It does not change with time (Sometimes it is exceptionally changed in the form of small, rapid fluctuations that generally occur due to modulation). Suppose you want to listen to FM stereo at frequency 104.8 MHz on your radio, and then once you set the frequency, the signal stays at 104.8 MHz. It does not go up to 105.1 MHz or down to 101.1 MHz. You see that your set digits on the radio's frequency dial stay the same at all times. The frequency of a conventional wireless signal is kept as constant to keep bandwidth within certain limits, and the signal can be easily located by someone who wants to retrieve the information.

In this conventional wireless communication model, you can face at least two problems:

1. A signal whose frequency is constant is subject to catastrophic interference. This interference occurs when another signal is transmitted on or near the frequency of a specified signal.
2. A constant-frequency signal can easily be intercepted. So, it is not suitable for the applications in which information must be kept confidential between the source (transmitting party) and the receiver.

The spread spectrum model is used to overcome with this conventional communication model. Here, the transmitted signal frequency is deliberately varied over a comparatively large segment of the electromagnetic radiation spectrum.

Characteristics of the Spread Spectrum are:

1. Higher channel capacity.

2. Ability to resist multipath propagation.
3. They cannot easily intercept any unauthorized person.
4. They are resistant to jamming.
5. The spread spectrum provides immunity to distortion due to multipath propagation.
6. The spread spectrum offers multiple access capabilities.

Direct Sequence Spread Spectrum (DSSS): - The Direct Sequence Spread Spectrum (DSSS) is a spread-spectrum modulation technique primarily used to reduce overall signal interference in telecommunication. The Direct Sequence Spread Spectrum modulation makes the transmitted signal wider in bandwidth than the information bandwidth. In DSSS, the message bits are modulated by a bit sequencing process known as a spreading sequence. This spreading-sequence bit is known as a chip. It has a much shorter duration (larger bandwidth) than the original message bits. Following are the features of Direct Sequence Spread Spectrum or DSSS.

- In Direct Sequence Spread Spectrum or DSSS technique, the data that needs to be transmitted is split into smaller blocks.
- After that, each data block is attached with a high data rate bit sequence and is transmitted from the sender end to the receiver end.
- Data blocks are recombined again to generate the original data at the receiver's end, which was sent by the sender, with the help of the data rate bit sequence.
- If somehow data is lost, then data blocks can also be recovered with those data rate bits.

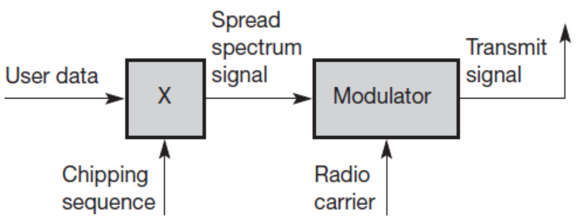
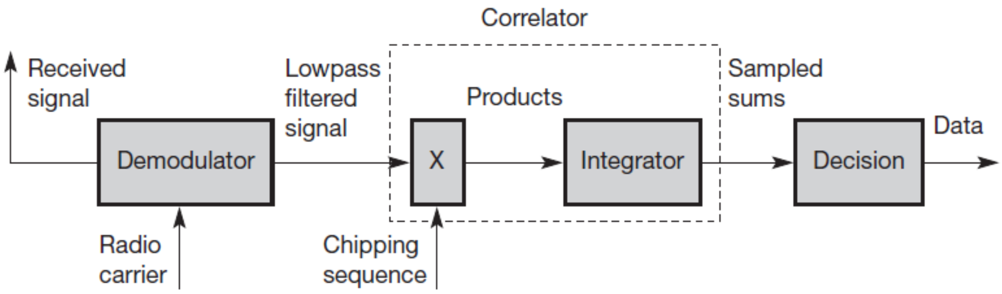


Figure 2.36
DSSS transmitter

Figure 2.37
DSSS receiver



The Direct Sequence Spread Spectrum or DSSS can also be classified into two types:

- Wide Band Spread Spectrum
- Narrow Band Spread Spectrum

The following are some advantages of Direct Sequence Spread Spectrum or DSSS:

- Direct Sequence Spread Spectrum or DSSS is less reluctant to noise; that's why the DSSS system's performance in the presence of noise is better than the FHSS system.
- In Direct Sequence Spread Spectrum or DSSS, signals are challenging to detect.
- It provides the best discrimination against multipath signals.
- In Direct Sequence Spread Spectrum, there are very few chances of jamming because it avoids intentional interference such as jamming effectively.

The following are some disadvantages of Direct Sequence Spread Spectrum or DSSS:

- The Direct Sequence Spread Spectrum or DSSS system takes large acquisition time; that's why its performance is slow.
- It requires wide-band channels with small phase distortion.
- In DSSS, the pseudo-noise generator generates a sequence at high rates.

Following is the list of most used applications of Direct Sequence Spread Spectrum or DSSS:

- LAN technology.
- Satellite communication technology.
- DSSS is used in the military and many other commercial applications.
- It is used in the low probability of the intercept signal.
- It supports Code division multiple access.

Frequency Hopping Spread Spectrum: -

The Frequency Hopping Spread Spectrum or FHSS allows us to utilize bandwidth properly and maximum. In this technique, the whole available bandwidth is divided into many channels and spread between channels, arranged continuously.

The frequency slots are selected randomly, and frequency signals are transmitted according to their occupancy. The transmitters and receivers keep on hopping on channels available for a particular amount of time in milliseconds.

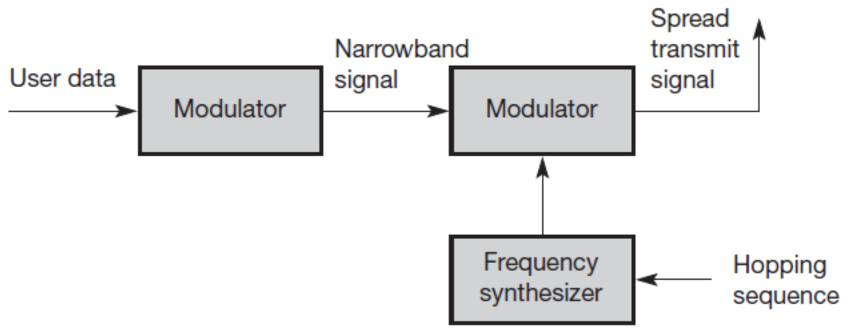


Figure 2.39
FHSS transmitter

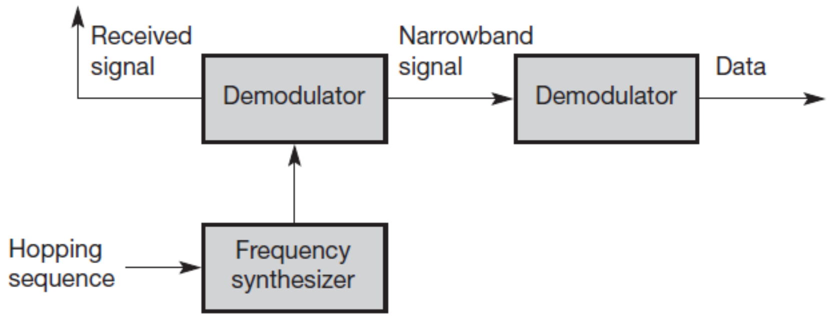


Figure 2.40
FHSS receiver

So, we can see that it implements the frequency division multiplexing and time-division multiplexing simultaneously in FHSS.

Types of FHSS: -

- **Slow Hopping:** In slow hopping, multiple bits are transmitted on a specific frequency or same frequency.
- **Fast Hopping:** In fast hopping, individual bits are split and then transmitted on different frequencies.

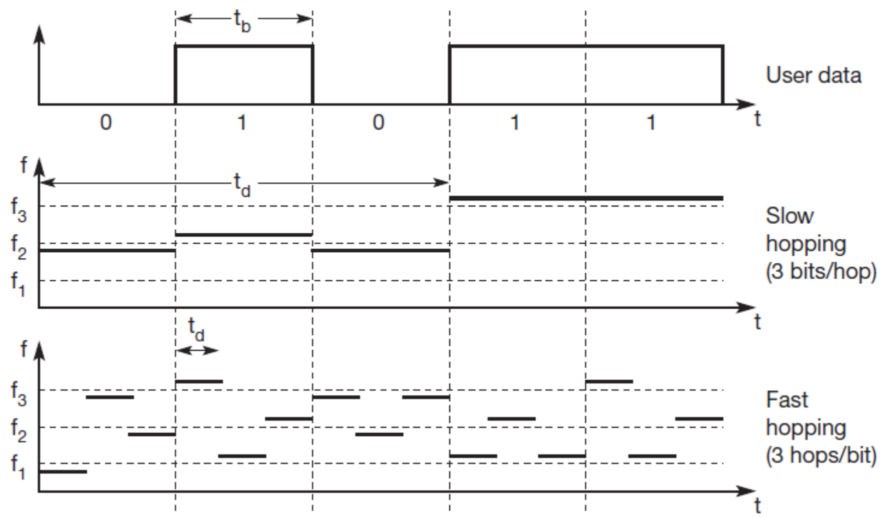


Figure 2.38
Slow and fast frequency hopping

Advantages of frequency hopping spread spectrum (FHSS):

- High efficiency.
- FHSS signals are highly resistant to narrowband interference because the signal hops to a different frequency band.
- It requires a shorter time for acquisition.
- It is highly secure. Its signals are very difficult to intercept if the frequency-hopping pattern is not known; that's why it is preferred to use in Military services.
- It provides a very large bandwidth.
- It can be simply implemented as compared to DSSS.

Disadvantages of Frequency Hopping Spread Spectrum (FHSS):

- FHSS is less Robust, so sometimes it requires error correction.
- FHSS needs complex frequency synthesizers.
- FHSS supports a lower data rate of 3 Mbps as compared to the 11 Mbps data rate supported by DSSS.
- It is not very useful for range and range rate measurements.

Applications of Frequency Hopping Spread Spectrum or FHSS:

- Used in wireless local area networks (WLAN) standard for Wi-Fi.
- It is also used in the wireless personal area networks (WPAN) standard for Bluetooth.

Cellular Systems: - A cellular system is a wireless communication network that divides its coverage area into small geographic regions called cells. Each cell has at least one base station, which is a fixed transceiver that provides coverage for the cell. Mobile devices communicate with the base station in the cell that they are currently in.

As a mobile device moves from one cell to another, the call is handed off to the base station in the new cell. This process is seamless to the user, and the call continues without interruption.

Here are some of the key components of a cellular system:

- **Mobile station (MS):** The MS is the mobile device that is used to communicate with the cellular system.
- **Base station (BS):** The BS is a fixed-location transceiver that provides service to the mobile devices in the cell.

- **Base station controller (BSC):** The base station controller controls the base stations in a group of cells.
- **Mobile switching center (MSC):** The MSC is a central switch that connects the BSs to the rest of the telephone network.
- **Home location register (HLR):** The HLR is a database that stores information about all of the mobile devices in the network.
- **Visitor location register (VLR):** The VLR is a database that stores information about all of the mobile devices that are currently visiting a particular cell.

Advantages of Cellular Systems: -

● **Higher capacity**: Implementing SDM allows frequency reuse. If one transmitter is far away from another, i.e., outside the interference range, it can reuse the same frequencies.
● **Less transmission power**: While power aspects are not a big problem for base stations, they are indeed problematic for mobile stations. A receiver far away from a base station would need much more transmit power than the current few Watts. But energy is a serious problem for mobile handheld devices.
● **Local interference only**: Having long distances between sender and receiver results in even more interference problems. With small cells, mobile stations and base stations only have to deal with 'local' interference.
● **Robustness**: Cellular systems are decentralized and so, more robust against the failure of single components. If one antenna fails, this only influences communication within a small area.

Disadvantages of Cellular Systems: -

● **Infrastructure needed**: Cellular systems need a complex infrastructure to connect all base stations. This includes many antennas, switches for call forwarding, location registers to find a mobile station etc, which makes the whole system quite expensive.
● **Handover needed**: The mobile station has to perform a handover when changing from one cell to another. Depending on the cell size and the speed of movement, this can happen quite often.
● **Frequency planning**: To avoid interference between transmitters using the same frequencies, frequencies have to be distributed carefully. On the one hand, interference should be avoided, on the other, only a limited number of frequencies is available.