POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

Electrical Engineering Department

AMPLITUDE MODULATION DEMYSTIFIED

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PREFACE

Welcome to the world of modulation and, in particular, the fascinating realm of amplitude modulation (AM). This eBook is designed to be your guiding light in understanding the fundamental principles of modulation and how AM works. Whether you are a student, a hobbyist, an aspiring engineer, or just someone curious about the technology behind broadcasting and telecommunications, this book is here to demystify the subject and provide you with a comprehensive introduction.

Modulation is a pivotal concept in the field of electronics and communication. It is the process of altering a carrier signal to transmit information effectively. AM, a widely used modulation technique, has been instrumental in shaping the world of radio broadcasting and has applications in various communication systems. As we embark on this journey, you'll discover the elegant simplicity of AM and its significance in our modern interconnected world.

Modulation, at its core, is the process of impressing a low-frequency signal (information signal) onto a high-frequency carrier signal. This allows us to transmit information over long distances, through various mediums, and even in the presence of interference. One of the most iconic modulation techniques is Amplitude Modulation, or AM. It's the technique that brought voices and music into our homes through radio. In this chapter, we'll get to know AM intimately.

This eBook is structured to make your journey through modulation and AM as smooth as possible. Each chapter is carefully crafted to build upon the knowledge from the previous one. So, get ready to embark on a captivating journey into the world of modulation and amplitude modulation. By the end of this eBook, you'll not only understand the fundamentals but also appreciate the pivotal role AM has played in shaping our interconnected world.

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Meet YOUR Author

The future depends what you do today

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Don't stop until you're proud

It always seems impossible until it's done

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Amplitude Modulation *Demystified*

CHAPTER 1

INTRODUCTION TO COMMUNICATION SYSTEM

""Electronic communication is the magic wand of the digital age, making the world a smaller place and our connections stronger."

INTRODUCTION TO COMMUNICATION SYSTEM

Communication is the basic process of exchanging information.

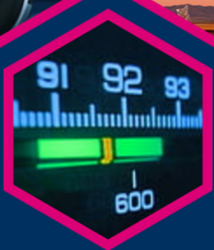
Source ⋯⋯ Flow of Information ⋯⋯> **Destination**

Electronic Communication System

The complete process of electronically transmitting, receiving, and processing information from its origin to a specific destination.

Examples : Telephone, radio and television, radar and satellite systems.

***The original source could be in analog form (human voice, music) or digital form (binary-coded numbers)**



Analog signals consist of continuously changing time-varying voltages or currents, often represented as sine or cosine waves. In contrast, **digital signals** are characterized by time-varying voltages or currents that change in discrete steps or levels, typically following a binary pattern.

*Before transmission through an electronic communication system, all types of information need to be transformed into electromagnetic energy.

Elements of a Communication Systems

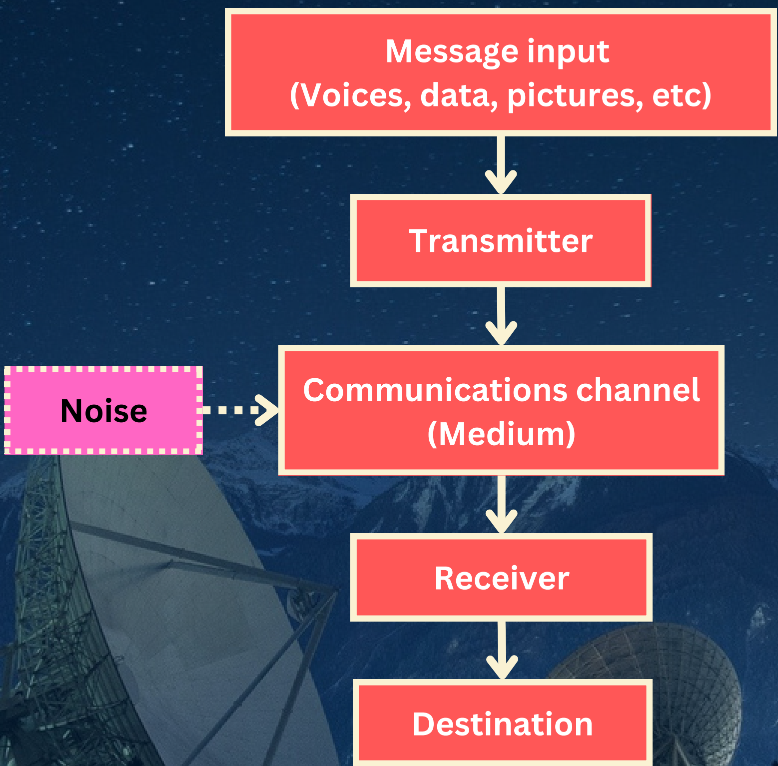
Basic Elements

01 *Transmitter*

02 *Communications channel*

03 *Receiver*

Basic Block Diagram of a Communication System



01 Transmitter

An assembly of electronic components and circuits specifically crafted to transform information into a signal that is appropriate for transmission across a designated communication medium. It may be as simple as a microphone or as complex as a microwave radio transmitter.

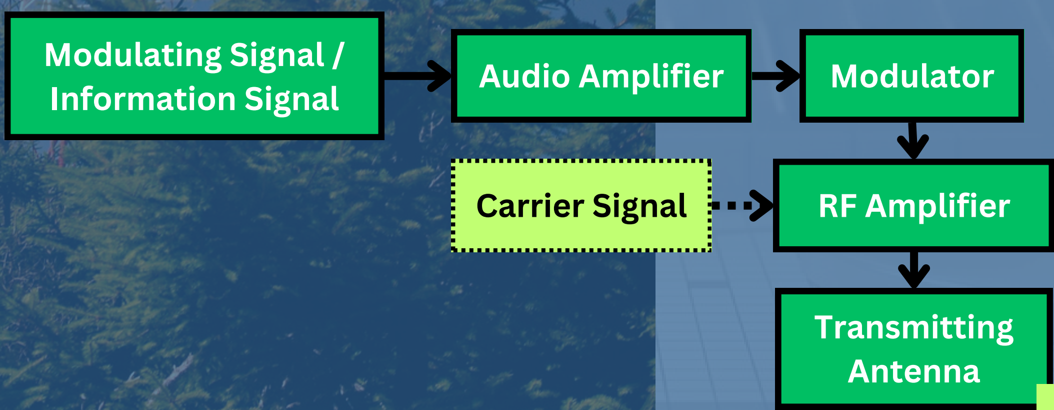
Primary Function

The process involves transforming the input message or information into electrical signals (voltage or current) or converting it into electromagnetic waves (such as radio waves, microwaves, or light waves) to make it suitable for transmission and in harmony with the chosen communication channel.

Main Process

- Modulation
- Encoding

Basic Block Diagram of a Transmitter

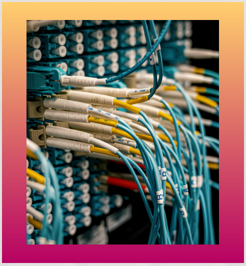


02

Communications Channel or Transmission Medium

The medium through which electronic signals are transmitted from one location to another can be achieved either via a physical connection, such as a conductive medium or a line, or through free space, like radio waves.

Examples : A collection of cables designed to transmit an audio signal from a microphone to either a headset or through fiber-optic cables.



- Free space or radio is the general term of wireless communication which makes use of the electromagnetic spectrum where signals are communicated from one point to another by converting them into electric and magnetic fields that propagate readily over long distances.
- There is normally no signal processing in the transmission medium, it is just the medium where the transmitter is connected to the receiver.
- Noise is random, undesirable electrical energy that enters the communications system via the communication medium and interferes with the transmitted message. Noise may be produced internally or externally.

03 Receiver

The receiver comprises an assortment of electronic elements and circuitry that receive the transmitted message from the channel and transform it into a format comprehensible to humans. Receiver normally compensates for the attenuation and distortion and reduces noise caused by the transmission medium. An example of the receiver is earphone or a complex electronic receiver.

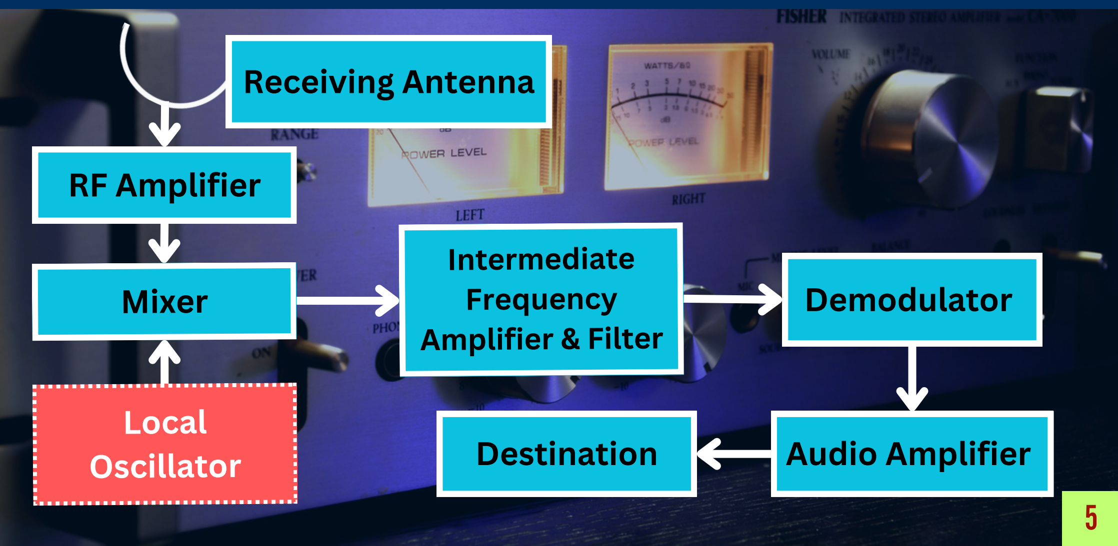
Primary Function

The receiver comprises an assemble of electronic elements and circuits designed to receive the transmitted message from the communication channel and convert it into a human-readable format.

Main Process

- Demodulation

Basic Block Diagram of a Receiver



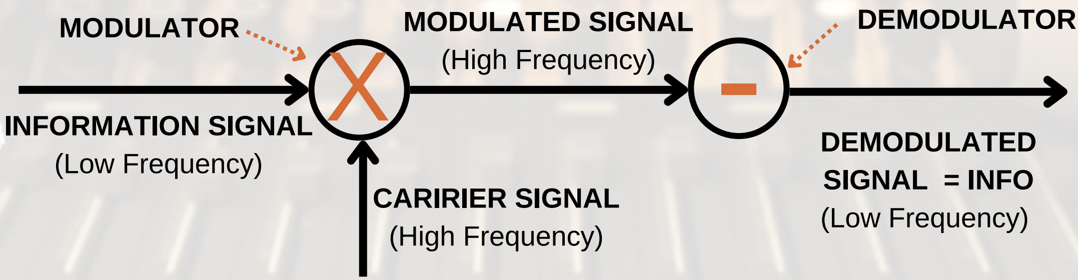
MODULATION AND DEMODULATION

Baseband Signal

The baseband signal represents the initial information signal, which can exist in either a digital or analog format. Putting the original signal directly into the medium is referred to as baseband transmission. However, there are many instances when the baseband signals are incompatible with the media and cannot be transmitted directly. This is when the modulation techniques must be used.

Modulation

Modulation refers to the procedure of altering one or more characteristics of the analog carrier wave through the use of the modulating signal, which can be the baseband signal or information signal. Typically, the carrier wave is a sine wave with a frequency that exceeds that of the modulating signal. The modification of one or more attributes of the analog carrier wave is directly linked to the features of the information signal. The fundamental characteristics of the carrier that can be adjusted include amplitude, frequency, or phase. A modulator is a circuit which performs modulation in a transmitter.



Modulation Process

MODULATION

Modulation is an essential element in every communication system, and the necessity for modulation arises from the following reasons:

- **To generate a modulated signal that is appropriate for transmission and harmonious with the communication channel.**
- **To enable effective transmission.**

By using a high frequency carrier signal, the information signal e.g. voice can travel and propagate through the air at greater distances, and shorter transmission time. Also, high frequency signal is less prone to noise and interference. Certain types of modulation have the useful property of suppressing both noise and interference.

For example, FM systems use limiter to reduce noise and keep the signal amplitude constant. PCM systems use repeaters to regenerate the signal along the transmission path.

- **To overcome hardware limitations**

The physical sizes of some electronic components depend on the range of frequencies that are used in the circuit. The higher the frequencies, the physical size of the components may be reduced.

MODULATION

- **To overcome hardware limitations**

Example 1:

Calculate the length of the antenna for a baseband signal of frequency 300Hz.

Solution:
Minimum antenna length, $L = \frac{1}{10}\lambda$ and $\lambda = \frac{c}{f}$

Therefore,

$$L = \frac{1}{10}\ x\ \frac{C}{f} = \frac{1}{10}\ x\ \frac{3x10^8}{300} = 100\ km$$

Example 2:

Based on example 1, the antenna length required is 100km. After modulation process, if assuming the carrier frequency is 100MHz, then the antenna length becomes:

New antenna length,

$$L = \frac{1}{10}\ x\ \frac{3\ x\ 10^8}{100\ x\ 10^6} = 0.3\ m$$

What you can conclude from example 1 & 2

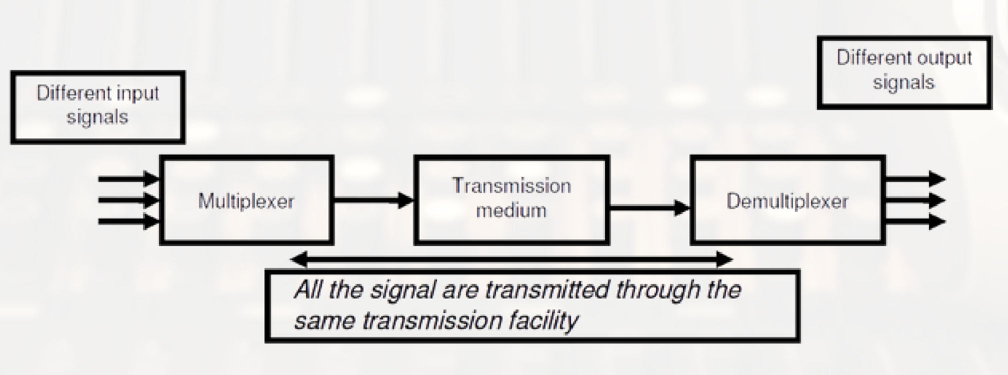
MODULATION

- **To allow frequency assignment**

Frequency assignment is where, several channels which carry different messages are assigned with different carrier frequencies to be transmitted simultaneously using a common communication medium.

- **Multiplexing**

Multiplexing is a process of sending multiple signals simultaneously through the same channel facility. By choosing appropriate carrier frequencies, all the signals can be multiplexed together and the channel can be shared,



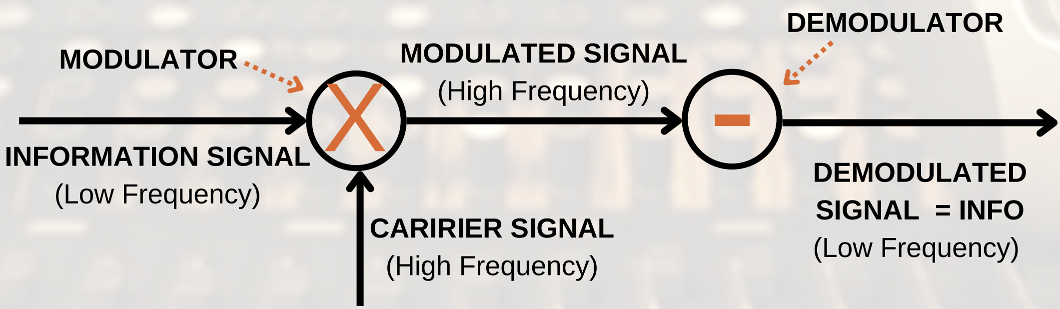
Multiplexing in a communication system

By modulation techniques, transmission speed and distance can be increased

MODULATION AND DEMODULATION

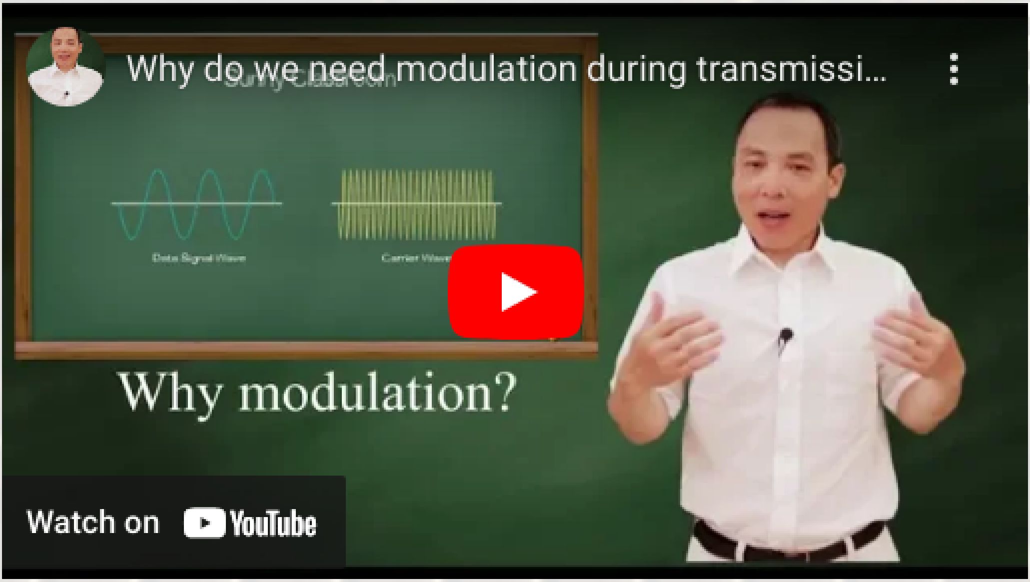
Demodulation

- Demodulation is the inverse procedure of modulation.
- It involves the retrieval of the original baseband information signal and the transmitted message.
- The demodulation process is responsible for converting the modulated carrier wave back to its original information state, essentially detecting the information from the carrier.
- A demodulator, found in a receiver, is a circuit designed for this demodulation task



Demodulation Process

Take a break with Mr Sunny



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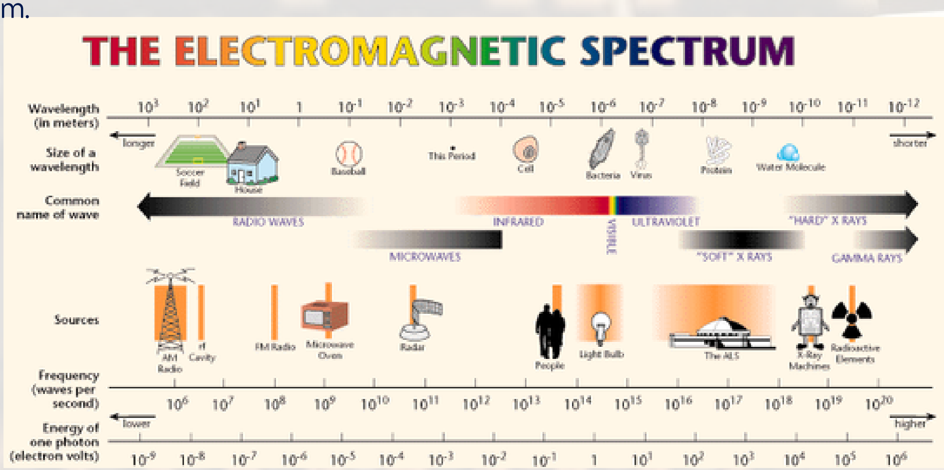
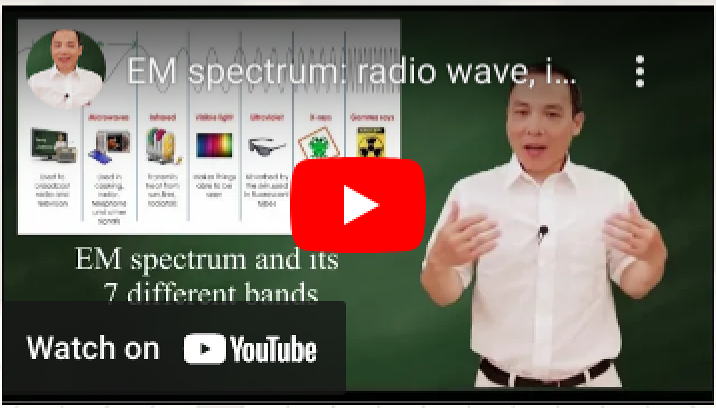
Thank you Mr Sunny

ELECTROMAGNETIC SPECTRUM AND TRANSMISSION FREQUENCIES

Electromagnetic signals are also referred to as radio-frequency (RF) waves. Electromagnetic waves are waves that propagate at the speed of light and exhibit oscillations characterized by the presence of electric and magnetic fields, with both fields oriented perpendicular to each other and to the direction of wave propagation. These oscillations can take place at either very low frequencies or extremely high frequencies. This entire span of frequencies is denoted as the electromagnetic spectrum. Figure below shows the entire electromagnetic spectrum.



Electromagnetic spectrum used in electronic communications



Do you want to know more?

https://youtu.be/1JpwDaOHppA?si=bLuIFdBzUdEy4FEf

TRANSMISSION FREQUENCIES AND WAVELENGTH

- **Frequency** represents how often a specific event or occurrence happens within a defined time frame. It is quantified in hertz (Hz).
- **Wavelength** denotes the spatial span covered by an electromagnetic wave during a single cycle, while the period signifies the interval between two corresponding points in successive cycles of a periodic wave.

For the electromagnetic waves, the **relationship between wavelength and frequency** is given by the equation,

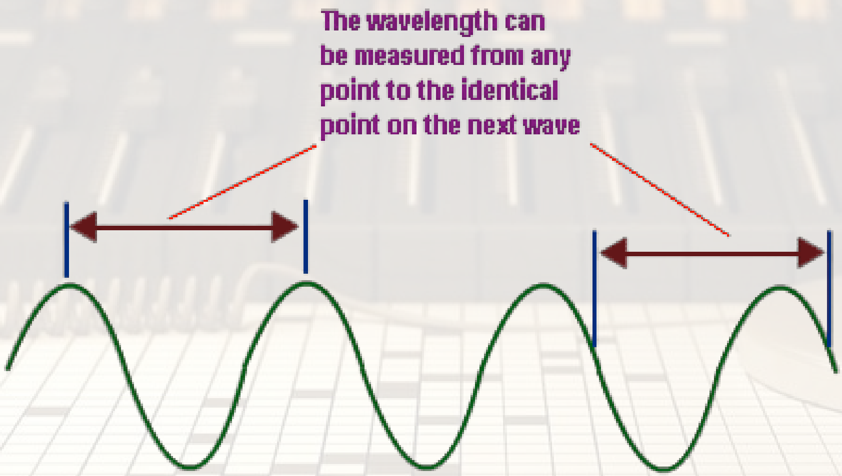
$$c = \frac{\lambda}{f}$$

where :

c – the speed of light

f – the frequency of the signal (Hz)

l – the wavelength of the signal (meters)



TRANSMISSION FREQUENCIES AND WAVELENGTH

Examples

01

If given f = 21 MHz, find the wavelength.

Solution:

$$\lambda = \frac{c}{f} = \frac{3.0x10^{8}}{21M} = 14.29m$$

02

If given the wavelength, l = 2.4m, find the frequency.

Solution:

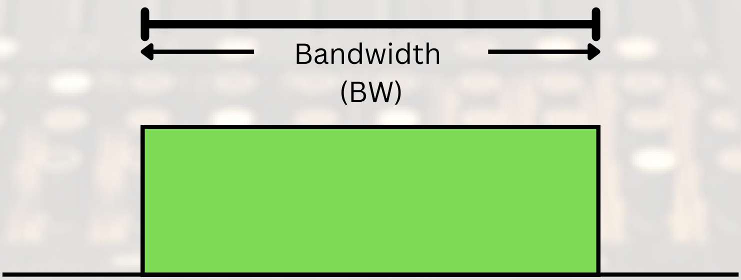
$$f = \frac{c}{\lambda} = \frac{3.0x10^{8}}{2.4} = 125MHz$$

BANDWIDTH

In a **modulated signal**, bandwidth is the range of frequencies that contain the information. For higher frequency operations, there is more spectrum space for information signals. It also permits wider bandwidth signals to be used.

***Since the electromagnetic spectrum is one of the most precious natural resources, techniques must be developed to minimize the bandwidth required to transmit given information.**

For example:



$f_1 = 300\ Hz$ $\qquad$ $f_2 = 3000\ Hz$

The bandwidth is then, $BW = f_2 - f_1$

$$= 3000 - 300$$

$$= 2700\ Hz$$

TRANSMISSION MEDIUM

GUIDED TRANSMISSION MEDIUM

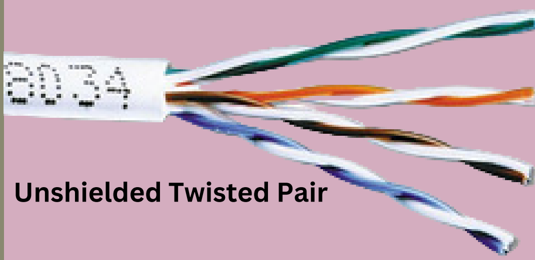
Guided transmission media is a type of conductor that serves as a channel for confining electromagnetic signals. These signals can only be received by devices that are directly linked to the medium.

Here are some common guided transmission media:

- **Twisted Pair Cable:** Twisted pair cables consist of pairs of insulated copper wires twisted together. They are commonly used for telephone lines and Ethernet networks. Twisted pair cables can be shielded (STP) or unshielded (UTP).

- **Coaxial Cable:** Coaxial cables consist of a central conductor, an insulating layer, a metallic shield, and an outer insulating layer. They are utilized in applications such as cable television and high-speed internet connections.

Shielded Twisted Pair



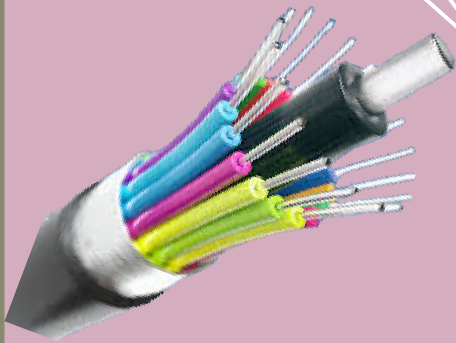
Unshielded Twisted Pair

Coaxial Cable

TRANSMISSION MEDIUM

Here are some common guided transmission media:

- **Fiber-Optic Cable:** Fiber-optic cables employ light signals for data transmission. They are made of thin strands of glass or plastic, which allows for extremely high data transfer rates. Fiber-optic cables are used in long-distance telecommunications and high-speed internet connections.



Fiber-Optic Cable

UNGUIDED TRANSMISSION MEDIUM (WIRELESS)

Wireless transmission mediums are used for data communication without the need for physical cables or wires. These mediums use electromagnetic waves to transmit data over the air, making them versatile for various applications. Here are some key types of wireless transmission mediums:

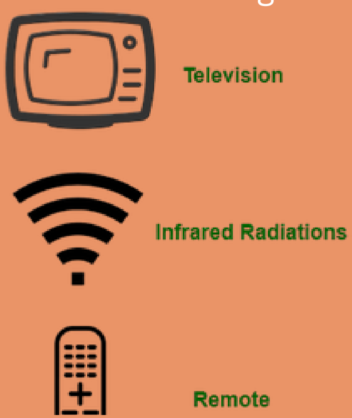
TRANSMISSION MEDIUM

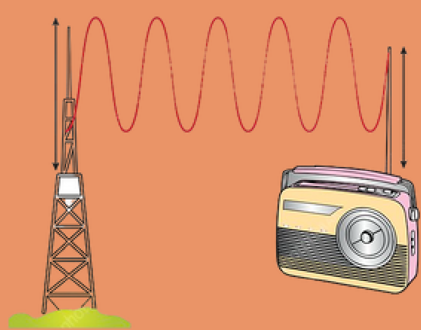
Here are some common unguided transmission medium:

- **Radio Waves:** Radio waves are commonly used for wireless communication. They have relatively long wavelengths and are employed in various radio and wireless network technologies, including AM/FM radio, Wi-Fi, and Bluetooth.

- **Microwave:** Microwaves are a higher-frequency form of radio waves and are often used for point-to-point communication, such as in microwave relay systems and satellite communication. They offer higher bandwidth and are suitable for long-distance links.

- **Infrared (IR):** Infrared transmission uses infrared light, typically for short-range communications. Infrared is often used in devices like TV remote controls and some short-range data transfer applications. It doesn't penetrate walls, making it secure for short-range data transfer.





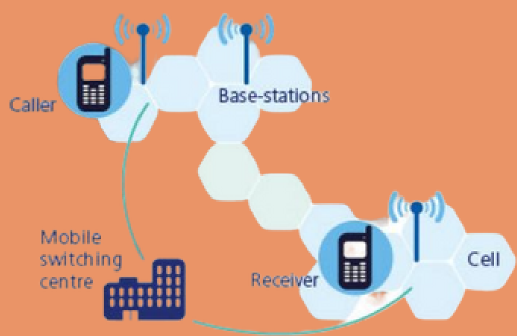
TRANSMISSION MEDIUM

Here are some common unguided transmission medium:

- **Wi-Fi:** Wi-Fi, which stands for Wireless Fidelity, uses radio waves in the 2.4 GHz and 5 GHz bands to provide wireless local area network (LAN) connections. It's widely used for wireless internet access in homes, offices, and public places.

- **Cellular Networks:** Cellular networks, such as 3G, 4G, and 5G, use radio waves to provide mobile voice and data services. They are designed for mobile devices like smartphones and tablets, providing wide-area wireless coverage.

- **Bluetooth:** Bluetooth technology uses short-range radio waves in the 2.4 GHz band for connecting devices like smartphones, headphones, and IoT devices. It's designed for low-power, short-range communication.



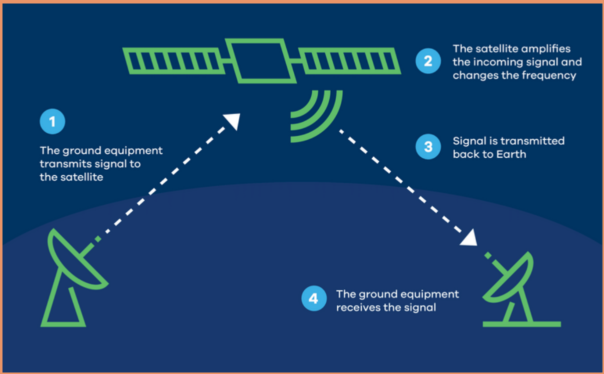
TRANSMISSION MEDIUM

Here are some common unguided transmission medium:

- **Zigbee:** Zigbee is a wireless communication standard used in IoT applications and home automation. It operates in the 2.4 GHz and sub-GHz bands and is known for its low power consumption and mesh networking capabilities.

- **Near-Field Communication (NFC):** NFC technology is used for very short-range communication (within a few centimeters). It's commonly found in contactless payment systems, access cards, and data transfer between devices.

- **Satellite Communication:** Satellites in space use various frequency bands, including microwave and radio waves, to relay data over long distances. Satellite communication is used for broadcasting, global communication, and remote areas.



TRANSMISSION MEDIUM

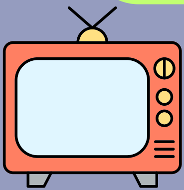
Wireless transmission mediums

have the advantage of mobility, flexibility, and the absence of physical cabling, which makes them suitable for various applications, from personal devices to large-scale telecommunications networks. However, they also come with challenges like signal interference, limited range, and security concerns, which need to be addressed in their design and implementation.

Transmission mode

Electronic communication systems can be designed to handle transmission in two transmission modes. They are:

1 Simplex



- In simplex communications, data flows in just one direction. These simplex systems are occasionally referred to as a systems designed exclusively for receiving or transmitting.
- Examples include radio and television (TV) broadcasting, satellite telemetry systems transmitting data from space to Earth, and pager services.

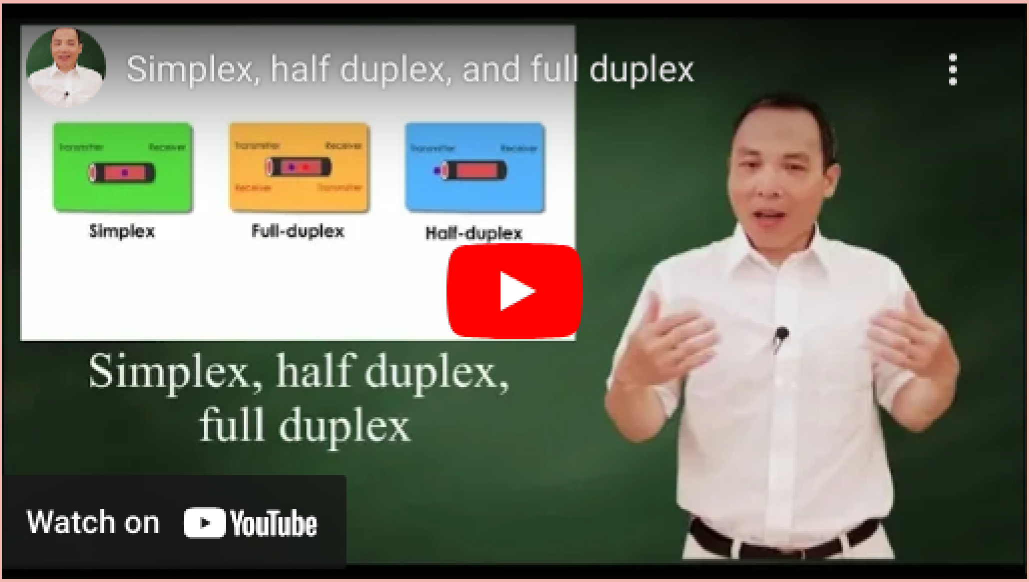
2 Half Duplex

- Half-duplex operation can be described as a mode where communication can occur in either transmitting or receiving but not simultaneously in both directions. In a half duplex system, the direction of communication alternates, allowing transmission to occur in simultaneous communication in both directions but not concurrently.
- An example of this is the telephone.

3 Full Duplex

- Full duplex transmission happens when individuals can communicate with each other, and both can send and receive data at the same time. This full duplex system is occasionally known as two-way simultaneous, duplex, or both-way communication. Within a full duplex system, simultaneous transmission isn't limited to happening solely between the same two locations. As an example, one station can transmit to a second station and receive from a third station simultaneously.
- An example of full duplex communication is the telephone.

Take a break with Mr Sunny



https://youtu.be/kKCDLk9irkQ?si=XdgBTwLr7I8nPGyr

Self Assessment

Let's test your understanding for this chapter

The basic element of a communication system is:

A. Information source, communication channel, transmitter
B. Transmitter, communication channel, receiver
C. Information source, communication channel, receiver
D. Receiver, communication channel, destination

A signal has the highest frequency of 3 MHz. Calculate the wavelength

A. 100 m
B. 101 m
C. 90 m
D. 95 m

The characteristics of the guided medium are shown below:

- **Commonly used for telephone lines and Ethernet network.**
- **Use a very high bandwidth**

The points above describe.

A. Twisted Pair Cable
B. Coaxial Cable
C. Fiber Optic Cable
D. Waveguide

In a multipoint communication, which transmission mode allows multiple devices to transmit and receive data simultaneously?

A. Simplex
B. Half-duplex
C. Full-duplex
D. Multiplex

Verify your answer

Your paragraph text

CHAPTER 2

AMPLITUDE MODULATION (AM)

"Amplitude modulation is the technique that allowed voices to travel through the airwaves, connecting people from distant places in real time."

AMPLITUDE MODULATION (AM)

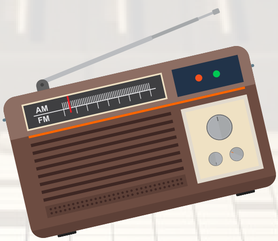
INTRODUCTION TO AMPLITUDE MODULATION

Definition: The process of modifying the amplitude of the radio frequency (RF) carrier wave based on the amplitude fluctuations of a modulating signal or the information signal.

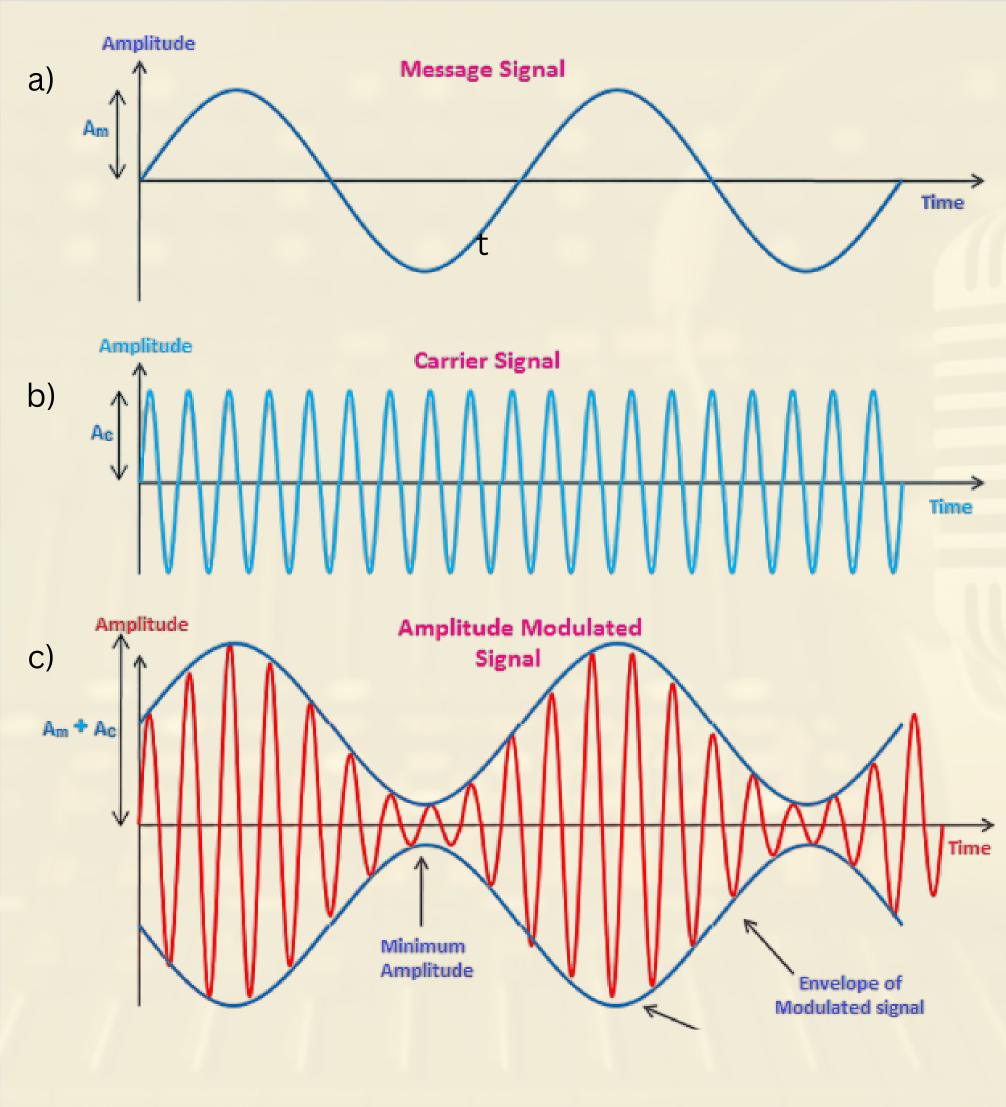
***The carrier amplitude's instantaneous value adjusts in response to the amplitude and frequency changes of the modulating signal.**

Characteristics

- **Applications:** Radio broadcasting, TV pictures (video), Facsimile transmission.
- **Frequency Range:** 535 kHz – 1600 kHz
- **Bandwidth:** 10 kHz



AMPLITUDE MODULATION SIGNAL



(a) Modulating signal (b) Carrier signal (c) Modulated signa1

AM SIGNAL NOTES

i) A single frequency sine wave or modulating signal modulates a higher frequency carrier signal.

ii) Without a modulating signal, the output waveform consists solely of the carrier signal.

iii) Applying a modulating signal causes the output's amplitude to vary accordingly. An increase in the modulating signal's amplitude results in a corresponding increase in the modulated signal's amplitude, and conversely.

iv) If we interconnect the positive and negative peaks of the carrier waveform with a line, we recreate the exact shape of the modulating signal which is called as the envelope.

v) The envelope represents the modulating signal, with the carrier frequency remaining consistent throughout the modulation procedure.

AM SIGNAL ANALYSIS

Let the instantaneous wave of sinusoidal carrier and modulating signal are:

- **Carrier signal :** $v_c(t) = V_c \sin 2\pi f_c\, t$ (2.1)
- **Modulating signal :** $v_m(t) = V_m \sin 2\pi f_m\, t$ (2.2)

Where: $f_c \gg f_m$ and $V_c \gg V_m$

f_c = frequency of carrier signal

f_m = frequency of modulating signal

V_c = peak value of the carrier signal

V_m = peak value of the modulating signal

AM SIGNAL ANALYSIS

- Referring to Figure 1.4 (c) the modulating signal references the peak value of the carrier signal instead of zero.

- The modulating signal's envelope fluctuates both above and below the peak carrier amplitude.

- In AM, the amplitude of the carrier wave varies sinusoidally between the values of $V_c + V_m$ and $V_c - V_m$

- The instantaneous value of either the top or bottom voltage envelope V_1 can be computed by this expression :

$$V_1 = V_c + V_m(t) \qquad (2.3)$$

- By substituting the trigonometric expression for V_m(t)

$$v_1(\text{t}) = V_c + V_m \, sin2\pi f_m t \qquad (2.4)$$

- The instantaneous value of the modulated wave

$$v_{AM}(t) = V_1 \, sin2\pi f_c t \qquad (2.5)$$

AM SIGNAL ANALYSIS

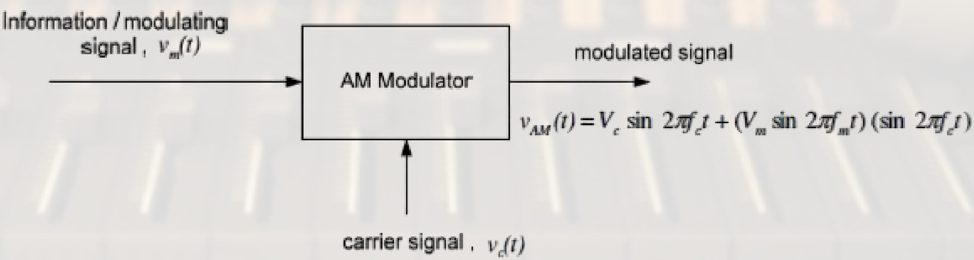
- Substituting (2.4) into (2.5) :

$$v_{AM}(t) = [V_c + V_m sin2\pi f_m t] sin2\pi f_c t$$

$$= \underbrace{V_c sin2\pi f_c t}_{\text{Carrier signal}} + (\underbrace{V_m sin2\pi f_m t}_{\text{Modulating signal}})(\underbrace{sin2\pi f_c t}_{\text{Carrier signal}}) \quad (2.6)$$

- Equation 2.6 shows that it consists of two parts :
  - The first part – carrier waveform
  - The second part – carrier waveform multiplied by the modulating signal

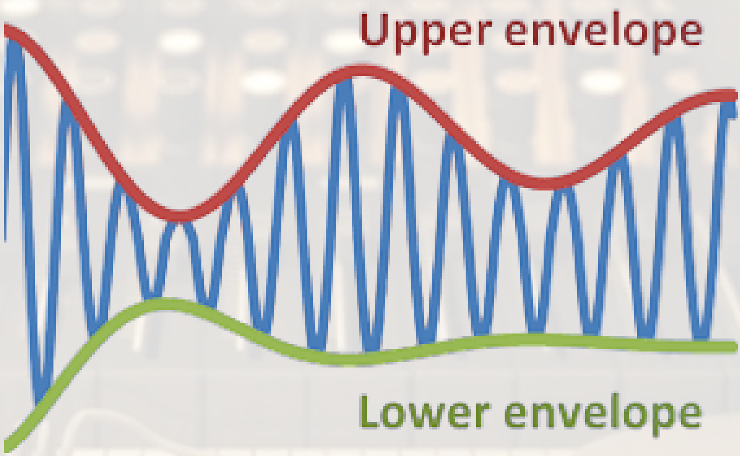
- The circuit employed for generating AM is known as a modulator.



2.3 AM SIGNAL CHARACTERISTICS AND PARAMETERS

2.3.1) AM Envelope

- The shape of the modulated wave : AM envelope.
- AM envelope is indicated in red and green line as in Figure 1.5.
- The repetition rate of envelope is equal to the frequency of the modulating signal and the shape of the envelope is identical to the shape of the modulating signal.



Modulated signa1 (AM envelope)

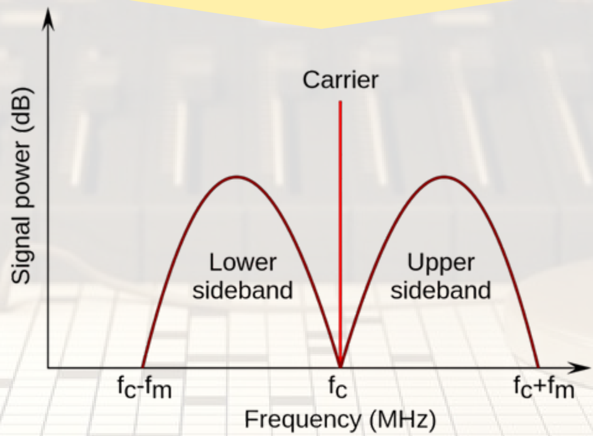
2.3.2) AM Frequency Spectrum

- Frequency spectrum : a plot of **amplitude versus frequency**.
- Frequency spectrum can be view using spectrum analyzer.
- When a carrier is modulated by an information signal, new signals at different frequencies are generated as part of the process => side frequencies or sidebands.
- Sidebands occur in the frequency spectrum directly above and below the carrier frequency.
- Assuming a carrier frequency, f_c and a modulating frequency, f_m :
- Lower sideband frequency (LSB) = frequency below the carrier frequency

$$f_{LSB} = f_c - f_m$$

- Upper sideband frequency = frequency above the carrier frequency

$$f_{USB} = f_c + f_m$$



AM frequency spectrum

2.3.2) AM Frequency Spectrum

- The side frequencies can be proven mathematically. Using Eq. 2.6:

$$V_{AM}(t) = V_c\, sin2\pi f_c + (V_m\, sin2\pi f_m t)(sin2\pi f_c t) \qquad (2.7)$$

- Using a trigonometric identity :

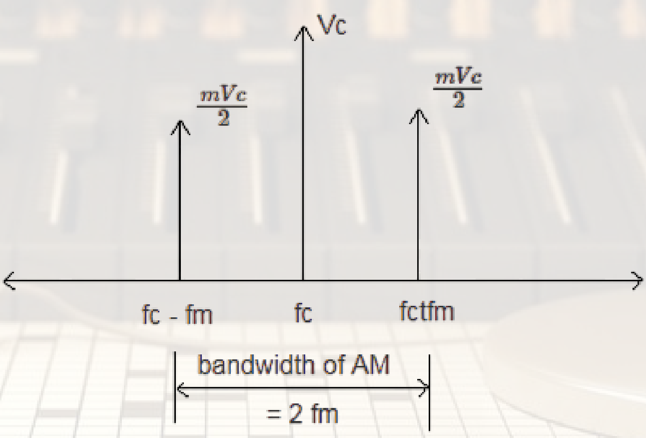
$$\sin A \sin B = \frac{\cos(A-B)}{2} - \frac{\cos(A+B)}{2}$$

- Eq.2.6 become :

$$V_{AM}(t) = V_c\, sin2\pi f_c + \frac{Vm}{2}\, cos2\pi(f_c - f_m)t - \frac{Vm}{2}\, cos2\pi(f_c - f_m)t \qquad (2.8)$$

Carrier **LSB** **USB**

- Eq. 2.7 proof that an AM wave contains not only the carrier but also the sideband frequencies.



AM spectrum when the modulating signal frequency is f_m

COEFFICIENT OF MODULATION & PERCENT OF MODULATION

1 Coefficient of Modulation

Ratio of the modulating signal voltage to the carrier voltage.

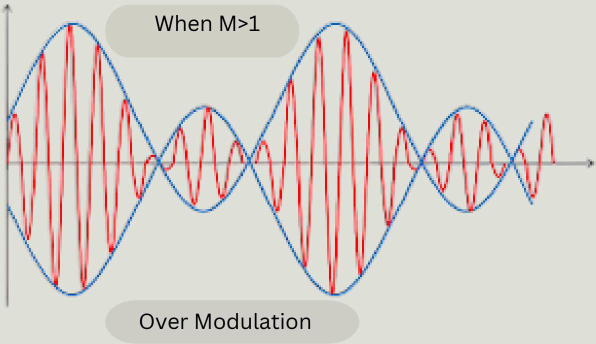
$$m = \frac{V_m}{V_c} \qquad (2.9)$$

2 Modulation Index

The modulation index must be a numerical value within the range of 0 to 1.

3 Overmodulation

Should the modulating voltage's amplitude, denoted as V, exceed that of the carrier voltage, it will result in a modulation index, represented as 'm,' greater than 1, leading to pronounced and substantial modulation.

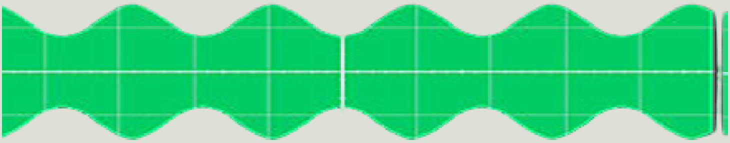


Distortion of the envelope caused by overmodulation

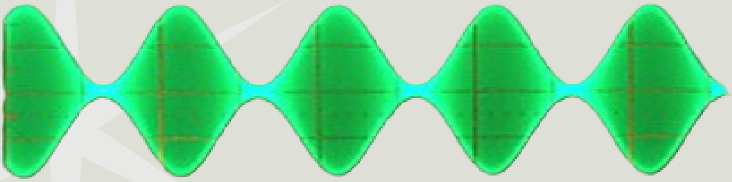
A sine wave information signal modulates a sine wave carrier, but the modulating voltage is much greater than the carrier voltage.

COEFFICIENT OF MODULATION
&
PERCENT OF MODULATION

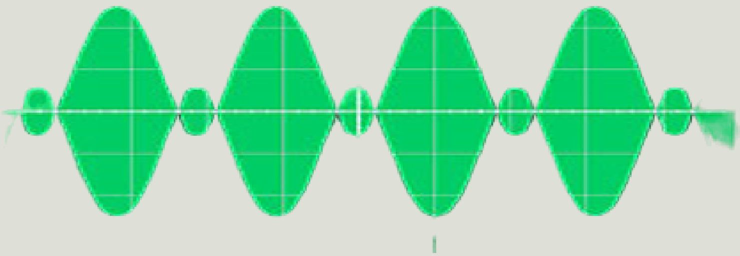
1 **Undermodulation**



2 **100% Modulation**

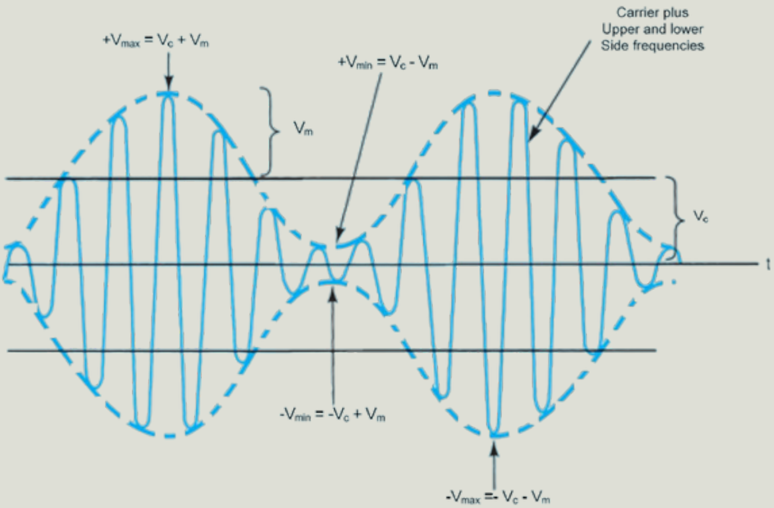


3 **Overmodulation**



COEFFICIENT OF MODULATION
&
PERCENT OF MODULATION

Modulation index also can be derived from measurements conducted on the composite modulated wave itself.



Amplitude Modulation Signal

- The peak value of the modulating signal, Vm is given by this expression :

$$Vm = \frac{V_{max} - V_{min}}{2} \quad (2.10)$$

- The peak value of the carrier signal, V_c is given by this expression :

$$V_c = \frac{V_{max} + V_{min}}{2} \quad (2.11)$$

Substituting these values into original formula for **modulation index** (Eq. 2.9) produces the result

$$m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} \qquad (2.12)$$

Percentage of Modulation : multiplying the modulation index by 100%

$$\%m = \frac{V_m}{V_c}\ x\ 100\% \qquad (2.13)$$

In practice, it is desirable to operate with as closed as to 100 percent modulation so that the maximum information signal can be transmitted

EXAMPLE:

From a displayed AM signal, the $V_{max\,(p-p)}$ value read from the graticule on the oscilloscope screen is 5.9 divisions and $V_{min\,(p-p)}$ is 1.2 divisions. One division represent 1V. Calculate:

i) Modulation index
ii) Amplitude of carrier signal, and amplitude of modulating signal.

Solution :
i) Modulation index, m :

$$m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$

$$= \frac{5.9 - 1.2}{5.9 + 1.2}$$

$$= \frac{4.7}{7.1}$$

$$= 0.662$$

ii) Amplitude of carrier signal and amplitude of modulating signal.

→ Amplitude of Carrier Signal,

$$V_c = \frac{V_{\max} + V_{\min}}{2}$$

$$= \frac{5.9 + 1.2}{2}$$

$$= \frac{7.1}{2}$$

$$= \mathbf{3.55V}$$

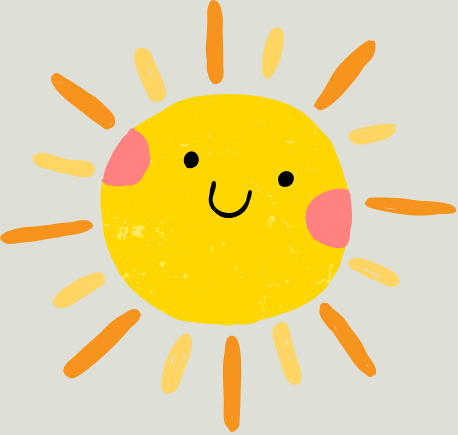
→ Amplitude of Modulating Signal,

$$V_m = \frac{V_{\max} - V_{\min}}{2}$$

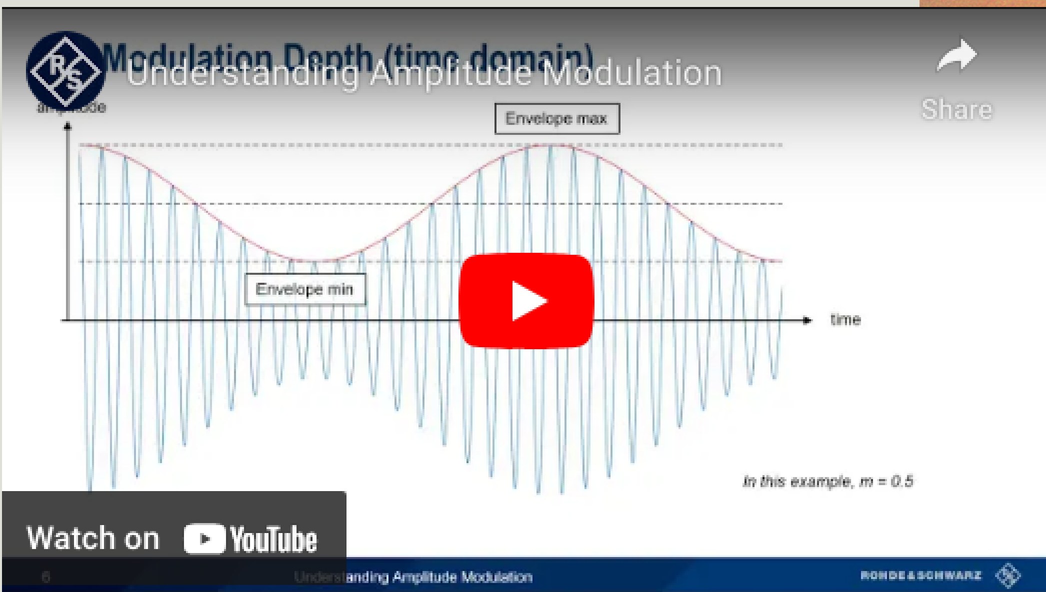
$$= \frac{5.9 - 1.2}{2}$$

$$= \frac{4.7}{2}$$

$$= \mathbf{2.35V}$$



Let's Jommmmm



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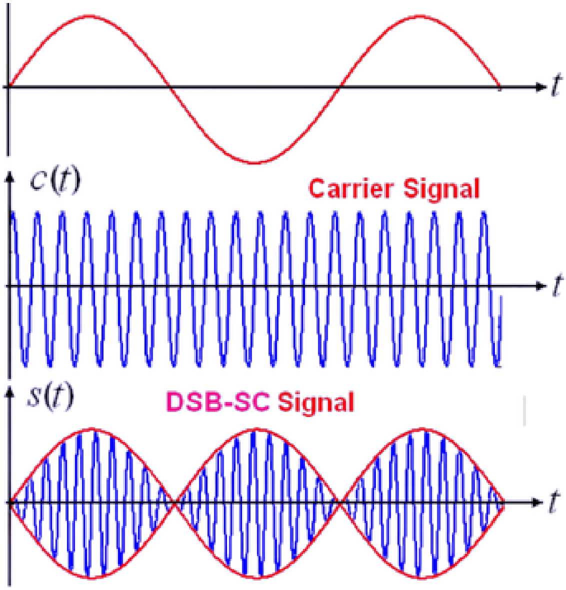
AM Transmission Techniques

1) Double Sideband Suppressed Carrier (DSBSC)



Double Sideband Suppress Carrier

From total power transmitted calculation, **two-thirds of the transmitted power appears in the carrier** which conveys no information. The real information is contained within the sidebands.

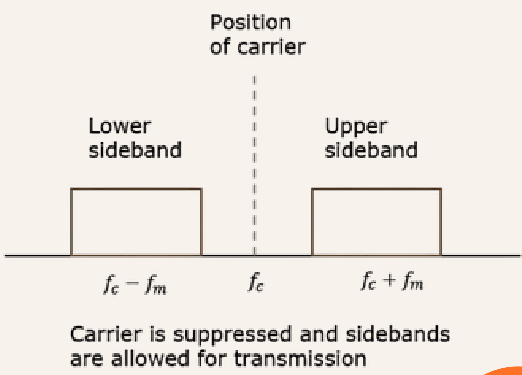
• To overcome this problem, carrier is suppressed. The resulting signal is simply the upper and lower sidebands.

DSBSC stands for **"Double-Sideband Suppressed Carrier."** It is a modulation technique used in communication systems to transmit information by **suppressing (removing) the carrier signal** while retaining both the upper and lower sidebands. DSBSC modulation is a type of amplitude modulation (AM), but it eliminates the carrier wave to reduce the power required for transmission and make more efficient use of the available bandwidth.

Here's how DSBSC modulation works:

Carrier Wave	The carrier wave is a high-frequency sine wave, just like in traditional AM modulation.
Information Signal	The information signal (usually an audio signal) is used to modulate the amplitude of the carrier wave. In DSBSC modulation, the carrier wave is multiplied by the information signal, resulting in the generation of both upper and lower sidebands.
Suppressed Carrier	In DSBSC modulation, the carrier component is completely suppressed or removed from the modulated signal. This means that the amplitude of the carrier is reduced to zero, resulting in a signal that only contains the upper and lower sidebands.
Frequency Spectrum	The resulting signal contains both sidebands, each carrying the same information. The upper sideband (USB) contains the same information as the lower sideband (LSB) but is a mirror image of it in terms of frequency.

DSBSC modulation is often used in applications where efficient use of power and bandwidth is critical. By removing the carrier, DSBSC reduces the transmitted power compared to traditional AM while still conveying the same information. This can be advantageous in situations like amplitude modulation of radio signals, where power efficiency and spectrum utilization are important.



Frequency spectrum of a DSBSC signal

DSBSC

From frequency spectrum of a DSBSC signal the spectral space occupied by a DSSC signal is identical to that of a traditional AM signal, with the only difference being the suppression of the carrier.

Benefits of Double Sideband Suppressed Carrier

Energy is conserved by eliminating the carrier, enabling the allocation of this saved power to strengthen the sidebands for more robust signals that can travel extended distances.

Disadvantages of Double Sideband Suppressed Carrier

Complex receivers are required due to the challenge of signal recovery at the receiver, even though generating the signal at the transmitter is relatively straightforward through the use of a balanced modulator.

DSB application

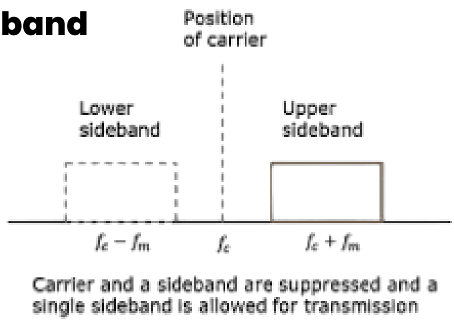
Employed in FM and TV broadcasting for the transmission of stereo signals in a two-channel format.

SINGLE SIDEBANDS (SSB)

Single Sideband (SSB) is a method of transmitting one of the sidebands from the conventional AM signal by suppressing both the carrier and the other sideband.

In a DSB signal, the basic information is transmitted twice, once in each sideband. The information is contained in both sidebands. In order to convey the information, transmitting one sideband is enough. One sideband may be suppressed. The remaining sideband is called a Single Sideband Suppressed Carrier (SSSC or SSB) signal.

Why is the suppression of a sideband allowed in SSB modulation?



Frequency spectrum of a SSB signal

Purpose

Single sideband modulation technique was adopted, as by suppression of one of the two sidebands along with the carrier causes no loss of information.

Reason

This is so because the two sidebands of the modulated signal are particularly related to each other. In other words, we can say the two sidebands carry similar information. **Thus, for the transmission of information, we need only one sideband. So, by suppressing one sideband along with the carrier, no any information is lost.**

Benefit

Hence, the bandwidth requirement also gets reduced to half and there are chances for an accommodation of twice number of channels using the SSB modulation technique.

Benefits of Single Sideband (SSB).

- The **bandwidth** requirement is just half that of AM and DSB signals, enabling a greater number of signals to be transmitted within the same frequency range. As a result, there is reduced interference among signals.
- All power that reserved to the carrier and other sidebands can be channeled into the single sideband, thereby **producing a stronger signal** that should carry farther and more reliable at greater distance. Alternately, SSB transmitters can be made smaller and lighter than an equivalent AM or DSB transmitter because less circuitry and power are used.
- Less noise on the signal. **The less bandwidth, the less noise**. Since SSB signal has less bandwidth than AM or DSB signal, there will be less noise on it. This is a major advantage for a long distance telecommunication.
- **Less selective fading**. Fading means that a signal alternately increases and decreases in strength as it is picked up by the receiver. It occurs because the carrier and sidebands may reach the receiver shifted in time and phase respect to one another. With SSB, there is only one sideband, so this kind of fading does not occur.

SSB application

- Utilized in systems that demand minimal bandwidth, like telephone multiplex systems, and is not employed in broadcasting.
- Point to point communications at frequency below 30 MHz: amateur radio, mobile communication, military and navigation radio, where power saving is needed

VESTIGIAL SIDEBAND (VSB)

Vestigial Sideband (VSB) is a modulation technique used in the transmission of analog television signals, particularly in the North American television broadcasting system, such as the NTSC (National Television System Committee) standard. It was developed to reduce the required bandwidth for transmitting television signals while still maintaining an acceptable level of signal quality.

In VSB modulation, one sideband of the signal is transmitted almost entirely (the "full" sideband), while the other sideband is transmitted partially (the "vestigial" sideband). The term "vestigial" refers to the fact that only a portion of the sideband is transmitted. This technique allows for more efficient use of the available frequency spectrum.

The key reasons for using VSB modulation in analog television broadcasting were:

Bandwidth Efficiency

VSB reduces the bandwidth requirements for each television channel, making it possible to fit more channels within the available frequency spectrum. This is essential for accommodating a larger number of TV stations without causing interference.

Coexistence with Other Channels

VSB modulation helps prevent interference between adjacent television channels. By transmitting one sideband nearly in full and the other sideband partially, it limits the impact on neighboring channels, allowing for clear reception.

VESTIGIAL SIDEBAND (VSB)

The key reasons for using VSB modulation in analog television broadcasting were:

Signal Quality

Despite the reduction in bandwidth, VSB modulation can maintain reasonable signal quality for analog television signals, ensuring that viewers receive clear and watchable broadcasts.

Backward Compatibility

VSB modulation was designed to be backward compatible with older black-and-white television sets, as it allowed for transmitting monochrome (black-and-white) signals using the full sideband while also transmitting color information in t

It's important to note that with the transition to digital television standards (such as ATSC in the United States), analog VSB modulation has become obsolete. Digital broadcasting offers superior picture and sound quality, more efficient use of spectrum, and additional features like high-definition (HD) television and interactive content. Digital television broadcasting uses entirely different modulation and encoding techniques compared to analog VSB modulation.

Let's Recap !

Sidebands

AM generates two sidebands on either side of the carrier frequency. These sidebands contain the information from the modulating signal.

Demodulation

At the receiver, the modulated signal is demodulated to extract the original information signal.

Usage

AM is commonly used in broadcast radio, where the amplitude of the carrier wave is modulated with audio signals, allowing for the transmission of voice and music.

In summary, AM involves varying the strength of a carrier signal in response to an information signal, creating sidebands that carry the information, and it is widely used in traditional broadcast radio.

5 Reflection Questions

Define Amplitude Modulation

State TWO (2) applications of Amplitude Modulation.

Calculate the percentage of amplitude modulation index if the modulating signal is 3Vpp and the carrier signal is 4Vpp.

Check your answer

A.... ha...

Recognize elements needed in modulation process

Can a modulation process be achieved if either one of above elements is do not exist? Why?

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