EDO UNIVERSITY IYAMHO

Department of Computer Engineering
Communication Principles (Module I)

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Description: Module I is designed to introduce the course and specifically reach out to the students with foundational mathematics principles which are the basis for the understanding of this course.

Prerequisite: The required knowledge and skill is the knowledge gained in the courses offered in 100 and 200 level classes. The module will cover concepts in communications principles.

Learning Outcomes: The underlying objectives of the Communication Principles course taught at the EUI are as follows: At the end of this course, the students should be able:

1.) To identify and describe appropriately the basis of communication in engineering.
2.) To define modulation and differentiate between Analogue and Digital Modulation (AM and FM) in communication engineering.
3.) To calculate modulation index, transmitted power and efficiency of modulated signals.
4.) To differentiate between FDM and TDM.
5.) To identify transmission media, its types and antenna principles.

Course details: Lectures on module I will commence in the second (2nd) week of the semester. During this 2nd week, we are going to review some basic mathematical functions, introduce communication fundamentals, signals concepts, modulation components and amplitude modulation technique.

Assignments/Assessments: Various forms of assessments will be conducted. These shall include homework, which must be submitted before the next lecture day, term paper, which shall be given on group basis with submission deadline. The term paper shall be a report submission as mini project. One quiz will be conducted before the end of this module. All these assessments shall form parts the final assessment in this course.

Grading: The grading shall be in this format: tutorials 5% of total mark, attendance 5 marks, while all written test will constitute 10% of final score and all home works will constitute 10%.

Resources

Textbooks: The textbooks recommended for this module are

Title:	Communication Systems Engineering
Author(s):	John Proakis and Masoud Salehi
Publisher:	Pearson Education, London
ISBN:	0130617938 (ISBN13: 9780130617934)
Year:	2001

Title: Signalling in Telecommunication Networks
Author: John G. van Bosse, Fabrizio U. Devetak
Publisher: *John Wiley & Sons, Inc.*
ISBN: ISBN:13 978-0-471-66288-4
Year: 2007
Websites: Students can also check up the following websites for further details
https://www.tutorialspoint.com/principles_of_communication/

Lectures: The course details are presented as shown below:

Courseware: - CPE 312: COMMUNICATION PRINCIPLES
The following documents outline the courseware for the course CPE 312 - Communication Principles

Amplitude Modulation; Double Sideband, Single Sideband and Vestigial Sideband Modulation Schemes; Simple Modulators, Power and Bandwidth Performance. Angle Modulation; Frequency Modulation, Phase Modulation, Bandwidth requirements, Clippers and Limiters. Amplitude Modulated Signal reception; Discrimination, Frequency Tracking Loop, Phase Locke Loop and Noise Performance. Commercial Radio Systems. Transmission Media; Attenuation in Open space, air, cable and Fibre channels; construction of cables and Fibres, Sampling Theorem, Pulse Amplitude Modulation, Pulse Width Modulation, Multiplexing, Quantization Systems and Pulse Code Modulation, Delta Modulation, Causes and Correction of Errors in PCM and DM.

REVIEW OF MATHEMATICAL FUNCTIONS

1) Fourier series Fourier series and Fourier Transform
2) Cross and Auto cross Correlation
3) Signal Symmetry

FOURIER SERIES

Any periodic signal f(t) that satisfy Dirichlet condition can be expanded into a convergent series consisting of pure sinusoids of varying amplitudes with harmonically related frequencies, that is; *f*, 2*f*, 3*f*, 4*f*,…..,*nf*. This is written in the form;

$$f(t) = a_0 + a_1 Cos\ \omega t + a_2 Cos\ 2\omega t + a_3 Cos\ 3\omega t + \cdots . + a_n Cos\ n\omega t + \cdots + b_1 Sin\ \omega t + b_2 Sin\ 2\omega t + \cdots + b_n Sin\ n\omega t$$

Therefore, *f*(*t*) can be expressed compactly as

$$f(t) = \sum_{n=0}^{\infty} [a_n Cos\ n\omega t + b_n Sin\ n\omega t]$$

The constants a_0 …. a_n and b_1 ….b_n are known as the Fourier coefficients and can be evaluated using the following integrals:

$$a_0 = \frac{1}{T}\int_{t_1}^{t_1+T} f(t)dt$$

$$a_n = \frac{2}{T}\int_{t_1}^{t_1+T} f(t)Cos\ n\omega t\ dt$$

$$b_n = \frac{2}{T}\int_{t_1}^{t_1+T} f(t)Sin\ n\omega t\ dt$$

Equation (i) can also be expressed in another useful form as:

$$f(t) = C_0 + \sum_{n=1}^{\infty} C_n Cos\ (n\omega t - \emptyset_0)$$

or

$$f(t) = \sum_{n=0}^{\infty} C_n Cos\ (n\omega t - \emptyset_0)$$

Where $C_0 = a_0$ known as direct current (d.c) amplitude component and $C_n = \sqrt{a_n^2 + b_n^2}$ is the amplitude of the nth harmonic component. And $\emptyset_0 = tan^{-1}\, {}^{b_n}/_{a_n}$ is the relative phase of the nth harmonic component.

SIGNAL SYMMETRY

The Fourier series of different functions contain sometimes odd harmonics, even harmonics and sometimes sine or cosine terms. These patterns of harmonics result in different types of symmetry. A knowledge of these symmetries help to reduce iterations in calculating and determining the series. These symmetries are as follows:

a) **Even Symmetry:** here, if the function is even, then all the terms of the series are cosine terms and possibly a constant term that is a_0. Here no need to evaluate the integral of b_n term. The following property is satisfied: *f(t) = f(- t)*
b) **Odd Symmetry:** Here if a signal has an odd symmetry, then it Fourier series consist of only sine terms. There will no need to evaluate a_n term. The following property is satisfied: *f(t) = - f(- t)*
c) **Half-wave Symmetry:** Here, if only the odd terms are presented in the series we need to examine a single period of the signal. If, when shifted by half the period, the signal is found to be the negative of the original signal, then the signal has half-wave symmetry. That is, the following property is satisfied:

$$f(t) = -f(t + \frac{T}{2})$$

d) **Quarter-Wave Symmetry:** Here, if a signal has the following properties, it is said to quarter-wave symmetric: It is half-wave symmetric and it has symmetry (odd or even) about the quarter-period point (i.e. at a distance of L/2 from an end or the centre). Any quarter-wave symmetric signal can be made even or odd by shifting it up or down the time axis. A signal does not have to be odd or even to be quarter-wave symmetric, but in order to find the quarter-period point, the signal will need to be shifted up or down to make it so.

INTRODUCTION TO COMMUNICATION

Definition: Communication in engineering is concerned with the sending and receiving of electrical or radio frequency (RF) signals especially by means of electrical or electroacoustic devices and electromagnetic waves. It is the conveyance of information from one place to another or between two or more individuals. Any system that provides communication consists of the three basic parts as shown in figure 1 below.

Figure 1: Basic Functional Block of Communication System

Transmission is defined as the electrical transfer of a signal, message, or other form of intelligence from one location to another. Usually, transmission has been one of the two major disciplines of communication. *Switching* is the other principal specialty. Switching establishes a connection from user source to some distant user destination.

The **Transmitter** could be a person or transmitting station from where the message (information) signal is sent. The **Channel** is the medium through which the message signals travel to reach the destination. The **Receiver** is the person or receiving station that receives the message. Conveying information by some means such as gestures, sounds, actions, etc., can be termed as **signalling**. Hence, a signal can be a **source of energy which transmits information**. This signal helps to establish communication between a sender and a receiver. An electrical impulse or an electromagnetic wave which travels a distance to convey a message can be termed as a **signal** in communication systems. Depending on their characteristics, signals are mainly classified into two types: Analogue and Digital. Analogue and Digital signals are further classified, as shown in the following figure 1.

Types of Signals

Analogue Signal

A continuous time varying signal, which represents a time varying quantity can be termed as an **Analogue Signal**. This signal keeps on varying with respect to time, according to the instantaneous values of the quantity, which represents it. The communication based on analogue signals and analogue values is called as **Analogue Communication**.

Digital Signal

A signal which is discrete in nature or which is non-continuous in form can be termed as a **Digital signal**. This signal has individual values, denoted separately, which are not based on the previous values, as if they are derived at that particular instant of time. These values can be considered individually and separately or discretely, hence they are called as **discrete values**.
The binary value which has only 1s and 0s combinations are mostly termed as **digital values**. Hence, the signals which represent 1s and 0s are also called as **digital signals**. The communication based on digital signals and digital values is called as **Digital Communication**.

Periodic Signal

Any analogue or digital signal, that repeats its pattern over a period of time, is called as a **Periodic Signal**. This signal has its pattern continued repeatedly and is easy to be assumed or to be calculated.

Aperiodic Signal

Any analogue or digital signal, that doesn't repeat its pattern over a period of time, is called as **Aperiodic Signal**. This signal has its pattern continued but the pattern is not repeated and is not so easy to be assumed or to be calculated.
In general, the signals which are used in communication systems are analogue in nature, which are transmitted in analogue or converted to digital and then transmitted, depending upon the requirement. But for a signal to get transmitted to a distance, without the effect of any external interferences or noise addition and without getting faded away, it has to undergo a process called as **Modulation**, this will be discussed next.

Modulation

At the transmitting side of a communication link a radio carrier is generated which is characterized by a frequency value. This single radio frequency carries no useful information such as voice, data or image for the user. *Modulation* is the process of impinging that useful information on the carrier, and *demodulation* is the recovery of that information from the carrier at the distant end of the destination user.

The IEEE defines *modulation* as "a process whereby certain characteristics of a wave, often called the carrier, are varied or selected in accordance with a modulating function. "The *modulating function* is the information baseband. There are three broad forms of modulation:
1. Amplitude modulation (AM)
2. Frequency modulation (FM)
3. Phase modulation (PM).

Need For Modulation

1.) *Overcoming Equipment limitat*ion: The design of frequency devices such as filters and amplifiers commonly used in communication systems depend on the signal location in the frequency domain region and on the ratio of the highest to lowest signal frequencies.

Modulation can be used to translate the signal to a location in the frequency domain where design requirements are easily met.

2.) *Frequency assignment*: This enables several Radio stations to broadcast simultaneously without experiencing frequency jamming.

3.) *Multiplexing*: This enables translating different signals to different spectral locations thus enabling receivers to select desired signal frequency.

4.) *Ease of radiation*: For open space antenna to effectively receive the transmitted radiated signals, it is required that the dimension of the antenna should be of the same order of magnitude as the wavelength of the signal being radiated. Most signals including audio have frequencies down to 100 Hz or lower. From the relationship $v = f\lambda$, antennas of height 3000 km could be necessary if signals are to be radiated directly. If 100 Mhz signal is used to modulate the signal, however, the antenna need not be more than 3 m of there about.

5.) *Noise and interference*: Modulation saves us from noise and interference in communication networks.

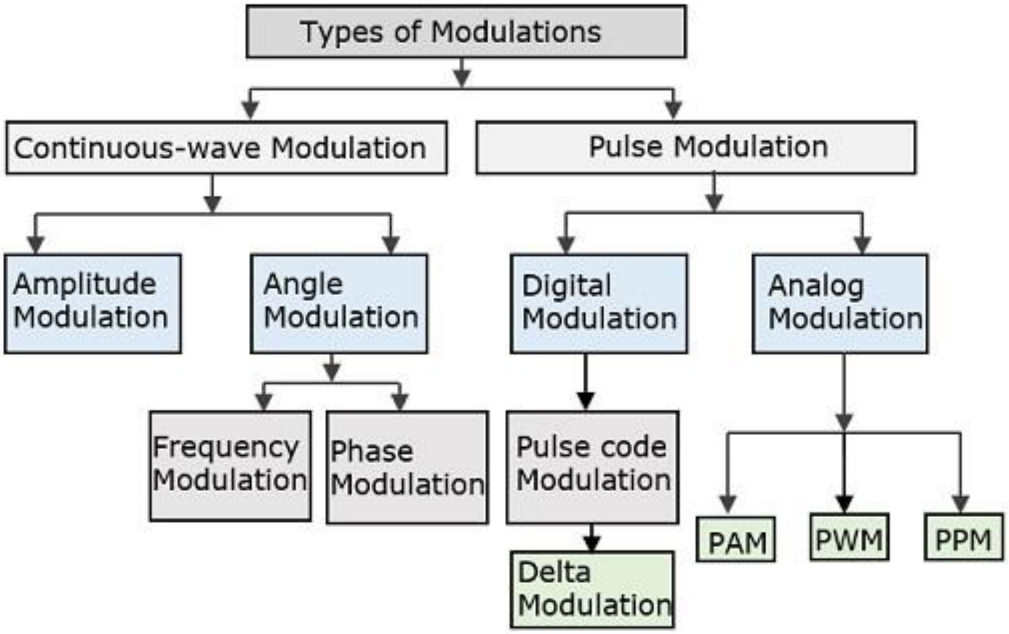
Advantages of Modulation

Following are some of the advantages for implementing modulation in the communication systems.

- Antenna size gets reduced.
- No signal mixing occurs.
- Communication range increases.
- Multiplexing of signals occur.
- Adjustments in the bandwidth are allowed.
- Reception quality improves.

TYPES OF MODULATION

There are many types of modulations depending on the modulation techniques used in equipment design. Here are the classifications as shown in the following figure.



Source:https://www.tutorialspoint.com/principles_of_communication/principles_of_communication_modulation.htm

AMPLITUDE MODULATION

In amplitude modulation, the amplitude is caused to vary in direct proportion with the modulating signal (i.e. information signal). The general sinusoidal carrier signal can be written as:

$$V_c(t) = a(t)cos\theta \text{ -------(1)}$$

Where a (t) is time varying amplitude and θ (t) is time varying angle

It is usually more convenient to write θ (t) as:

$$\theta(t) = \omega_c + \gamma(t) \text{ -------(2)}$$

So that $V_c(t) = a(t)Cos[\omega_c(t) + \gamma(t)]$

Where ω_c is the frequency of carrier signal and γ (t) is the phase angle.

In A.M, the phase γ (t) is usually zero or a constant and a (t) is made to vary in direct proportion with the information (message) signal. Thus,

$$V(t) = V_m(t)Cos\ \omega_c t \text{ -------(3)}$$

Equation (3) is valid for unity constant of proportionality where V (t) is the modulating signal. Recalling the modulation property of the Fourier Transform of equation (3), then the spectral density of the signal in equation (3) is given by:

$$V(\omega) = \frac{1}{2}f(\omega + \omega_c) + \frac{1}{2}f(\omega - \omega_c) \text{ -------(4)}$$

Thus, the spectrum of the modulated signal is translated by $\pm w_c$ rad/sec with the spectrum of the modulated signal left unaltered. In Pictorial view, the sequence of events is shown in figure 2 below.

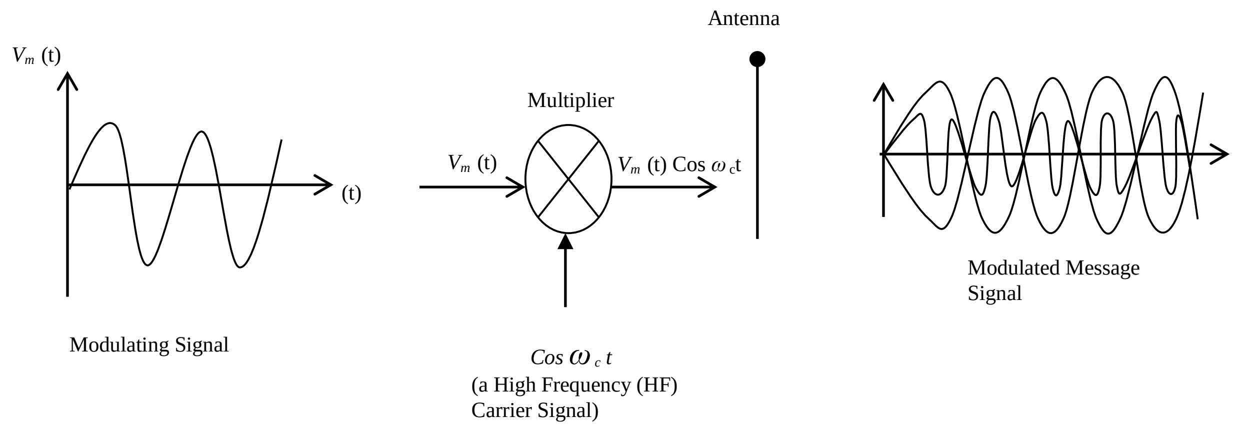


Figure 2: Amplitude Modulation

From equation (4), the frequency spectrum modulated signal gives the figure 3 below:

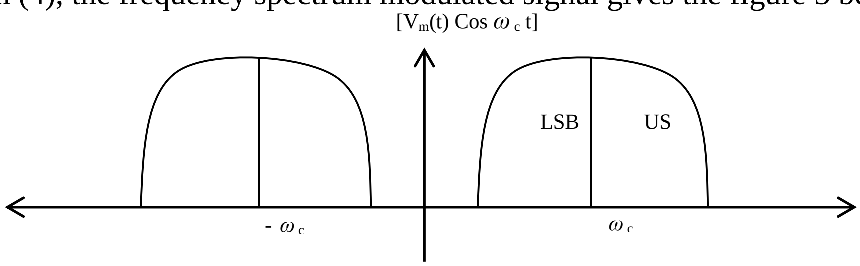


Figure 3: Frequency Spectrum Modulated signal

Looking at equation (40, there is no identifiable carrier and this makes it possible for this type of modulation to be referred to as *Suppressed Carrier Amplitude Modulation*.

The USB is the Upper Side Band which is the positive frequencies bandwidth in the modulated signal spectrum and the LSB is the Lower Side Band being the negative frequencies bandwidth in the modulated signal spectrum. Actually, the bandwidth of the modulating signal is doubled when signal amplitude is modulated. It must be note that as a result of the doubling of the bandwidth and the absence of an identifiable carrier signal in the resulting modulated signal makes it possible to have a designation called **Double Side Band Suppressed Carrier** (DSB-SC) signal.

GENERATION OF DSB-SC SIGNALS

It can easily be demonstrated that the information signal $V_m(t)$ can be translated by ω_c rad/sec when it is multiplied by any periodic signal. We know that any periodic signal $P_T(t)$ can be represented by the Fourier series

$$P_T(t) = \sum_{-\infty}^{\infty} P_n e^{j\omega_o t} \text{--(1)}$$

Where $\omega_o = \frac{2\pi}{T}$. If we chose $\omega_o = \omega_c$ where ω_c is frequency of carrier signal. Multiplying equation (1) by the information signal $V_m(t)$, then we will obtain

$$V_m(t) \cdot P_T(t) = \sum_{-\infty}^{\infty} P_n V_m(t) e^{jA\omega_c t} \text{-----(2)}$$

Applying the frequency translation properties of the Fourier transform, the frequency spectrum becomes

$$[V_m(t) \cdot P_T(t) = \sum_{-\infty}^{\infty} P_n F(\omega - n\omega_c)$$

Thus, the spectrum of the signal Vm(t).PT(t) contains F(ω) and F(ω) is translated by $\pm\ \omega_c$, $2n\ \omega_c$, *……n* ω_c *each scaled by the constant* P_o, P_1, P_2, *……*P_n.

In Amplitude modulation, *interest is on the spectrum centre which is around* $\pm\ \omega_c$ and can be obtained by using a band pass filter with multiplicative variables.

AMPLITUDE MODULATION LARGE CARRIER (AM) (DSB-LC)

The modulated waveform of a DSB-LC signal can be described mathematically by adding a carrier term (A Cos $\omega_c t$) to a Double Side Band Suppressed Carrier (DSB-SC) signal, i.e.

$$DSB - LC = T_{AM}(t)Cos\omega_c t + ACos\omega_c t$$

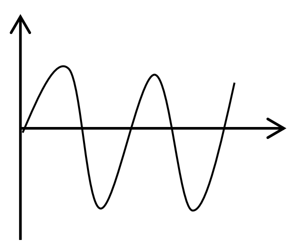
The spectral density of T_{AM} *(t)* is

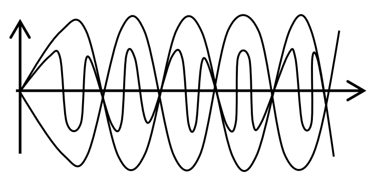
$$T_{AM}(\omega) = \frac{1}{2}F(\omega + \omega_c) + \frac{1}{2}F(\omega - \omega_c) + \pi A\delta(\omega + \omega_c) + \pi A\delta(\omega - \omega_c)$$

The amplitude modulated signal can now be written in the form

$$T_{AM}(t) = (V_m(t) + A)Cos\omega_c t$$

Being a carrier with amplitude ($V_m(t)$ + A). This means that if A is large enough, the envelope or magnitude of the modulated waveform will be proportional to $V_m(t)$. And demodulation in this case simply reduces to the detection of the envelope of a sinusoid, with no dependence on the exact phase or frequency of the carrier.





If A is not large enough the T_{AM}(t) is not proportional to V_m(t), we thus require that at all time, then:

$$A \geq |Min\{V_m(t)\}|$$