Communication Fundamentals

Modulation Process

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Introduction

Electronic communication systems can be categorized by the types of information signals transmitted by the system.

- **There are two types of signal "Analog and Digital".**
- **An analog signal is a continuously varying signal, such as a sine wave tone. Voice and video signals are analog signals.**
- **A digital has only two distinct levels, high and low, digital TV signal or ON/OFF.**

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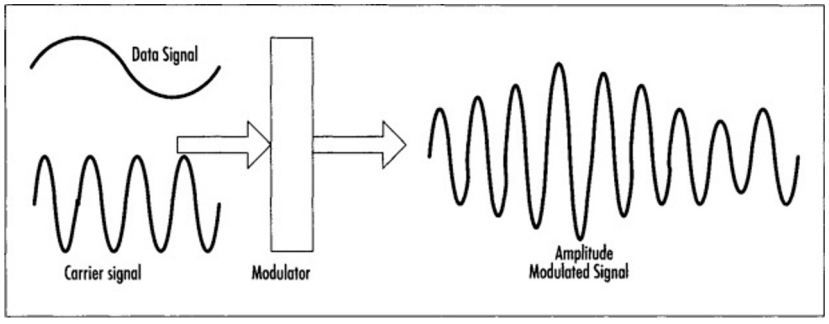
Introduction Modulation



Modulation of AM and FM radio

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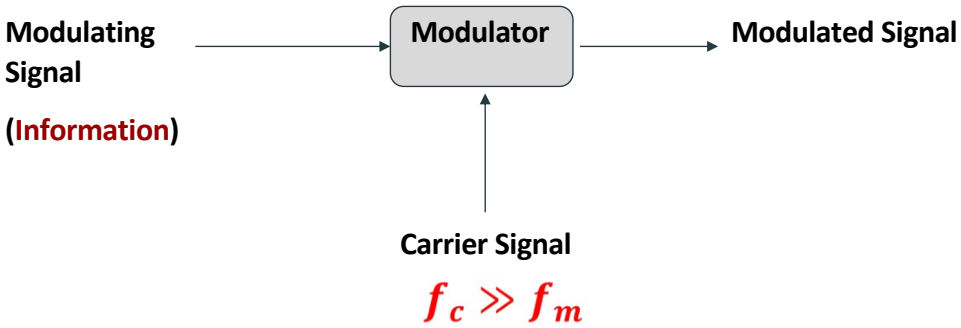
Modulation



$$f_c \gg f_m$$

MODEM: Stands for [Modulator+Demodulator].

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Why do we need to do Modulation?

1. Reduce the height of antenna
2. Avoids mixing of signals
3. Increases the range of communication
4. Allows multiplexing of signals
5. Allows adjustments in the bandwidth
6. Improves quality of reception

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Baseband Signals and Baseband Transmission

- The original information signals (baseband signals) may be transmitted over the medium.
- Putting the original signal directly into the medium is referred to as (baseband transmission).

- Although digital transmission can be made up of signal that originated in digital form, such as computer data; analog signals can be converted into digital form and then transmitted. Regardless of whether the original information signals are analog or digital, they are all referred to as "baseband signals".

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Modulation Techniques

- In the modulation process, the baseband voice, video, or digital signal modifies another, higher-frequency signal called the carrier, which is usually a sine wave.
- A sine wave carrier can be modified by the intelligence signal through
  1) Amplitude Modulation (AM)
  2) Frequency Modulation (FM)
  3) Phase Modulation (PM)

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What are the Types of the Continuous Modulation?

1. **Amplitude Modulation: The amplitude of the carrier is varied according to the baseband signal its frequency and phase constant.**

1. **Frequency Modulation: the frequency of the carrier is varied according to the baseband signal.**

1. **Phase Modulation: the phase of the carrier is varied according to the baseband signal.**

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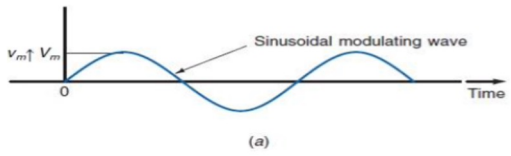
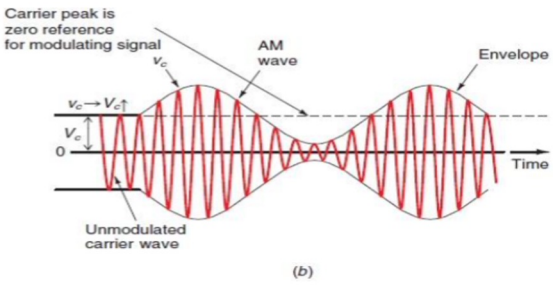
Amplitude Modulation



(a) In Amplitude modulation, The modulating or information signal.



(b) In Amplitude modulation, The modulated carrier.

This imaginary line on the carrier waveform is known as the Envelope.

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Amplitude Modulation

$$V_{max} = V_c + V_m$$

And

$$V_{min} = V_c - V_m$$

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

and

$$V_m = \frac{V_{max} - V_{min}}{2}$$ The Modulating Signal Voltage

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Amplitude Modulation - Carrier Signal

$$v_c = V_c \cos \omega_c t \quad \text{Or} \quad v_c = V_c \cos 2\pi f_c t$$

v_c The sine wave carrier signal.

V_c Represents the instantaneous value of the carrier sine wave voltage at some specific time in the cycle.

f_c Represents the peak value of the constant unmodulated carrier sine wave as measured between zero and the maximum amplitude of either the positive-going or the negative-going alterations.

t is the frequency of the carrier sine wave; and t is a particular point in time during the carrier cycle.

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Amplitude Modulation - Carrier Signal

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- V_c Represents the peak value of the constant unmodulated carrier sine wave as measured between zero and the maximum amplitude of either the positive-going or the negative-going alterations.
- f_c It represents the frequency of the carrier sine wave.
- t It represents a particular point in time during the carrier cycle.

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Amplitude Modulation - Modulating Signal

A modulating signal can be expressed with a similar formula.

$$v_m = V_m \cos \omega_m t \qquad \text{Or} \qquad v_m = V_m \cos 2\pi f_m t$$

- v_m instantaneous value of information signal
- V_m peak amplitude of information signal
- f_m frequency of modulating signal

$$f_c \gg f_m$$

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Modulation Index and Percentage of Modulation

Modulation Index : **it is the relationship between the amplitude of the modulating signal and the amplitude of the carrier signal.**

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

Multiplying the modulation index by 100 gives the percentage of modulation:

$$percentage\ of\ modulation = m * 100\%$$

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Example1: Suppose that Vmax value read from the graticule on an oscilloscope screen is 4.6 divisions and Vmin is 0.7 divisions. Calculate the modulation index and percentage of modulation.

Solution

The modulation index is defined as

$$m = \frac{V_m}{V_c} = \frac{\frac{V_{max} - V_{min}}{2}}{\frac{V_{max} + V_{min}}{2}} = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} = \frac{4.6 - 0.7}{4.6 + 0.7} = 0.736$$

The percentage of modulation is defined as

$$M_{\%} = M \cdot 100\% = 0.736 \cdot 100\% = 73.6\%$$

Answer

$M = 0.736,\ M_{\%} = 73.6\%.$

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Example1: Suppose that Vmax value read from the graticule on an oscilloscope screen is 5.9 divisions and Vmin is 1.2 divisions. Calculate the modulation index.

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Example1: Suppose that Vmax value read from the graticule on an oscilloscope screen is 5.9 divisions and Vmin is 1.2 divisions. Calculate the modulation index.

Solution:

$$m = \frac{V_m}{V_c} = \frac{\frac{V_{max} - V_{min}}{2}}{\frac{V_{max} + V_{min}}{2}} = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} = \frac{5.9 - 1.2}{5.9 + 1.2} = 0.662$$

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Homework…

1- Suppose that Vmax value read from the graticule on an oscilloscope screen is 2.8 divisions and Vmin is 0.4 divisions. Calculate the modulation index and percentage of modulation.

2- Suppose that Vmax value read from the graticule on an oscilloscope screen is 3.5 divisions and Vmin is 1.2 divisions. Calculate the modulation index and percentage of modulation.

3- Suppose that Vmax value read from the graticule on an oscilloscope screen is 5 divisions and Vmin is 2 divisions. Calculate the modulation index and percentage of modulation.

4- Suppose that Vmax value read from the graticule on an oscilloscope screen is 4 divisions and Vmin is 1.5 divisions. Calculate the modulation index and percentage of modulation.

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Thank you …

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