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- **Modulation**
- **Need of Modulation**

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Need of Modulation

- Distance
- Over Clouding Of same Frequency
- Antenna Size

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Modulation (Cont..)

- Examples
  - broadcasting of both audio and video signals.
  - Mobile radio communications, such as cell phone.
- Types
  - AM
  - FM
  - PM

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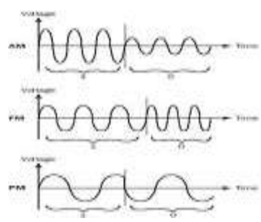
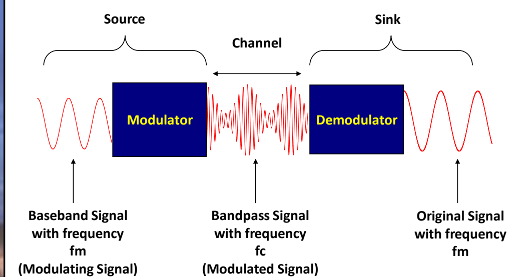
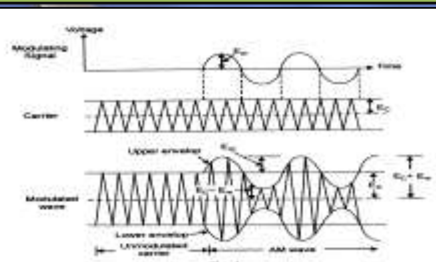
EXAMPLE



AM MODULATION/DEMODULATION



AM MODULATED WAVE



Modulation (Cont..)

- In amplitude modulation, the message signal $m(t)$ is impressed on the amplitude of the carrier signal $c(t) = A_c cos(2\pi f_c t)$
  - There are several different ways of amplitude modulating the carrier signal by $m(t)$
  - Each results in different spectral characteristics for the transmitted signal
  - We will describe these methods, which are called
    - (a) Double sideband,
    - (b) Double Side Band suppressed-carrier AM (DSB-SC AM)
    - (c) Single-sideband AM (SSB AM)

AMP MATHS

- Mathematical expression for AM: time domain

$$S_{AM}(t) = (1 + k\cos\omega_m t)\cos\omega_c t$$

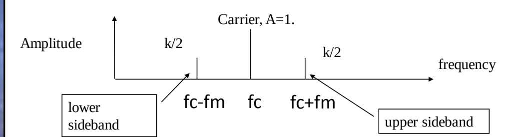
- expanding this produces:

$$S_{AM}(t) = \cos\omega_c t + k\cos\omega_m t\cos\omega_c t$$

$$\text{using:}\quad \cos A\cos B = \tfrac{1}{2}\left[\cos(A-B) + \cos(A+B)\right]$$

$$S_{AM}(t) = \cos\omega_c t + \tfrac{k}{2}\cos(\omega_c - \omega_m)t + \tfrac{k}{2}\cos(\omega_c + \omega_m)t$$

FREQUENCY REPRESENTATION



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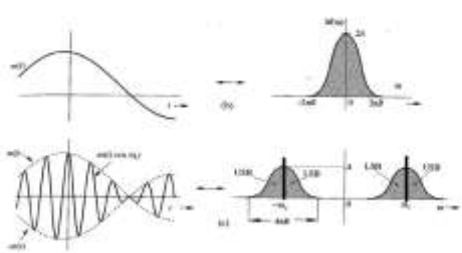
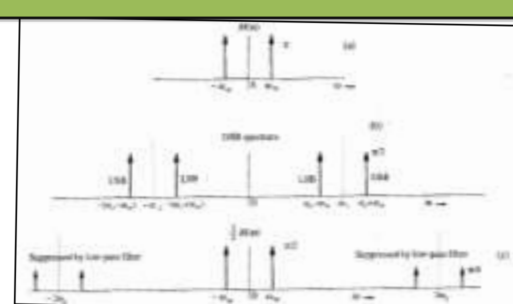
FREQUENCY REPRESENTATION

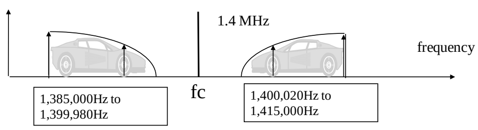


MODULATION AND DEMODULATION



Example – AM Signal

- **The information signal is usually not a single frequency but a range of frequencies (band). For example, frequencies from 20Hz to 15KHz. If we use a carrier of 1.4MHz, what will be the AM spectrum?**
- **In frequency domain the AM waveform are the lower-side frequency/band (f_c - f_m), the carrier frequency f_c, the upper-side frequency/band (f_c + f_m). Bandwidth: 2x(25K-20)Hz.**



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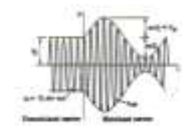
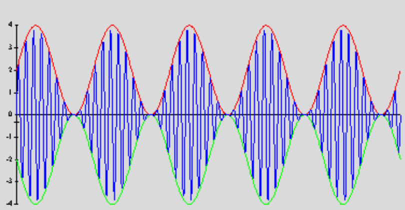
MODULATION INDEX

- Modulation index k is a measure of the extent to which a carrier voltage is varied by the modulating signal. When n=0 no modulation, when n=1 100% modulation, when n>1 over modulation.



Modulation Index of AM Signal

Modulation Index =1



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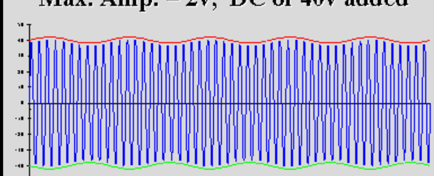
Modulation Index of AM Signal

Modulation Index =.05

Max. Amp. = 2v, DC of 40v added



Undermodulation

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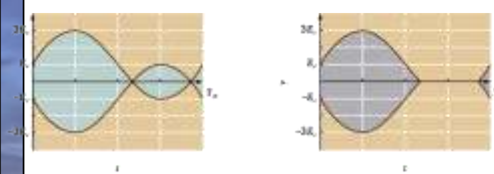
Modulation Index of AM Signal

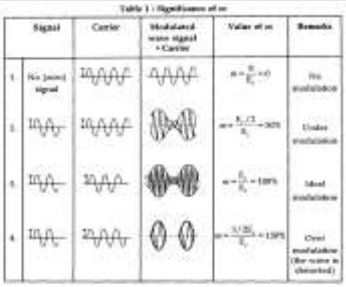
OVER MODULATION INDEX

- When the modulation index is greater than 1, **overmodulation** is present



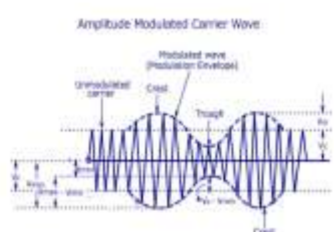
MODULATION INDEX

Table 1 : Significance of m



	Signal	Carrier	Modulated wave signal + Carrier	Value of m	Remarks
1.	No (zero) signal			$m = \frac{0}{E_c} = 0$	No modulation
2.				$m = \frac{E_c/2}{E_c} = 50\%$	Under modulation
3.				$m = \frac{E_c}{E_c} = 100\%$	Ideal modulation
4.				$m = \frac{3/2 E_c}{E_c} = 150\%$	Over modulation (the wave is distorted)

MODULATION INDEX



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

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

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

MODULATION INDEX

Suppose that on an 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.

a. What is the modulation index?

b. Calculate V_c, V_m, and m if the vertical scale is 2 V per division.

MODULATION INDEX

Suppose that on an 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.

a. What is the modulation index?

$$m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} = \frac{5.9 - 1.2}{5.9 + 1.2} = \frac{4.7}{7.1} = 0.662$$

b. Calculate V_c, V_m, and m if the vertical scale is 2 V per division. (Hint: Sketch the signal.)

$$V_c = \frac{V_{max} + V_{min}}{2} = \frac{5.9 + 1.2}{2} = \frac{7.1}{2} = 3.55 @ \frac{2\text{ V}}{\text{div}}$$

$$V_c = 3.55 \times 2\text{ V} = 7.1\text{ V}$$

$$V_m = \frac{V_{max} - V_{min}}{2} = \frac{5.9 - 1.2}{2} = \frac{4.7}{2}$$

$$= 2.35 @ \frac{2\text{ V}}{\text{div}}$$

$$V_m = 2.35 \times 2\text{ V} = 4.7\text{ V}$$

$$m = \frac{V_m}{V_c} = \frac{4.7}{7.1} = 0.662$$

Sideband Calculations

A standard AM broadcast station is allowed to transmit modulating frequencies up to 5 kHz. If the AM station is transmitting on a frequency of 980 kHz, compute the maximum and minimum upper and lower sidebands and the total bandwidth occupied by the AM station.

AM POWER

- We know that our AM out put consist of PC and side bands

$$S_{AM}(t) = \cos\omega_c t + \tfrac{k}{2}\cos(\omega_c - \omega_m)t + \tfrac{k}{2}\cos(\omega_c + \omega_m)t$$

AM POWER

- The power can easily be calculated by taking average of square of Amplitude of the signal across the load/resistance , which is under consideration .
- So $PC = \frac{Ac^2}{2R}$

AM POWER

- Similarly for side band power can be calculated as
- $Psb = \frac{(mAc)^2}{2R}$
- This is the power for both Side band . What will be the power of single side band

AM POWER

- Psb (one side)= $\frac{(mAc/2)^2}{2R}$

  $= \frac{m^2Ac^2}{8R}$
- Finalizing Power Equation

AM POWER

- Total Power = Pc + Pusb + PLsb
- $= \frac{Ac^2}{2R} + \frac{m^2Ac^2}{8R} + \frac{m^2ACv}{8R}$
- $= Pc + \frac{m^2Pc}{4} + \frac{m^2Pc}{4}$
- Or $Pt = Pc(1 + m^2/2)$

AM POWER Example

An AM transmitter has a carrier power of 30 W. The percentage of modulation is 85 percent. Calculate (*a*) the total power and (*b*) the power in one sideband.

AM POWER Example

An AM transmitter has a carrier power of 30 W. The percentage of modulation is 85 percent. Calculate (*a*) the total power and (*b*) the power in one sideband.

a. $P_T = P_c\left(1 + \frac{m^2}{2}\right) = 30\left[1 + \frac{(0.85)^2}{2}\right] = 30\left(1 + \frac{0.7225}{2}\right)$

$P_T = 30(1.36125) = 40.8 \text{ W}$

b. $P_{SB}\text{(both)} = P_T - P_c = 40.8 - 30 = 10.8 \text{ W}$

$P_{SB}\text{(one)} = \frac{P_{SB}}{2} = \frac{10.8}{2} = 5.4 \text{ W}$

IMPORTANT NOTICE

- Reference Chapter for AM has been updated on website
- Assignment which was handed over yesterday has been cancelled, as I do believe that it was too lengthy ☺

Assignment

- Part A (To be submitted on 10th)
- Short Questions (at the end of reference Chapter)
  - 1 to 29 + All Examples
  - Quiz will be held in LAB C
- Part B (To be su
  - Numerical 1
  - Quiz on Tues

Remember : Examples and Numericals Related to PCM and PAM are not included

MID TERM PATTREN

- All question will be compulsory
- **Question1**
  - (MCQs + Short Questions)
  - Quantity – 12
  - Marks 6
- **Question 2**
  - Part A : Short Question / Formula expression
  - Marks 2
  - Part B – Numerical (Class practice Questions + example and Assignment from Chapter 1 and 2 BP lathi)
  - Marks 5
- **Question 3**
  - Part A :Short Question / Formula expression
  - Marks 2
  - Part B – Numerical/ Examples (Chapter 3 available on website)
  - Marks 5