Sri SAI RAM ENGINEERING COLLEGE
INSTITUTE OF TECHNOLOGY
West Tambaram, Chennai - 44

SAIRAM DIGITAL RESOURCES

YEAR II

SEM III

EC8394

ANALOG AND DIGITAL COMMUNICATION

UNIT NO 1 ANALOG MODULATION

1.2.1 THEORY OF AMPLITUDE MODULATION

ELECTRONICS & COMMUNICATION ENGINEERING

4 QUALITY EDUCATION

MODULATION

- Defined as

  " The process by which some characteristics of a signal called carrier varied in accordance with the instantaneous value of another signal called modulating signal "

- The information bearing signal is called modulating signal
- The signal resulting from process of modulation is known as modulated signal

TYPES OF MODULATION

- Sine wave (carrier) described by 3 parameters: amplitude, frequency and phase.
- Let carrier signal be:

$$v(t) = A \sin(\omega t + \varphi)$$

So can have

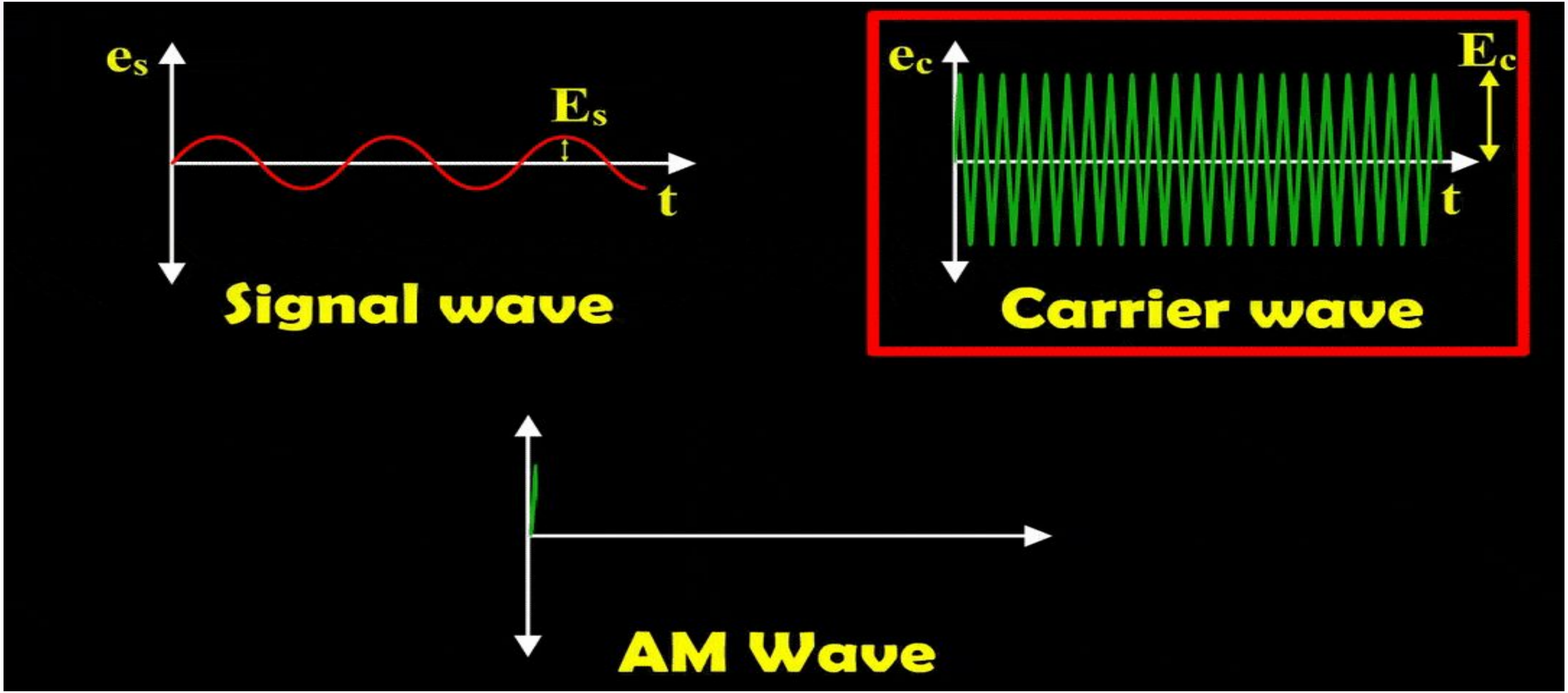
- – **Amplitude modulation (AM)**
- – **Frequency modulation (FM)**
- – **Phase modulation (PM)**

Frequency and phase combined are known as Angle Modulation

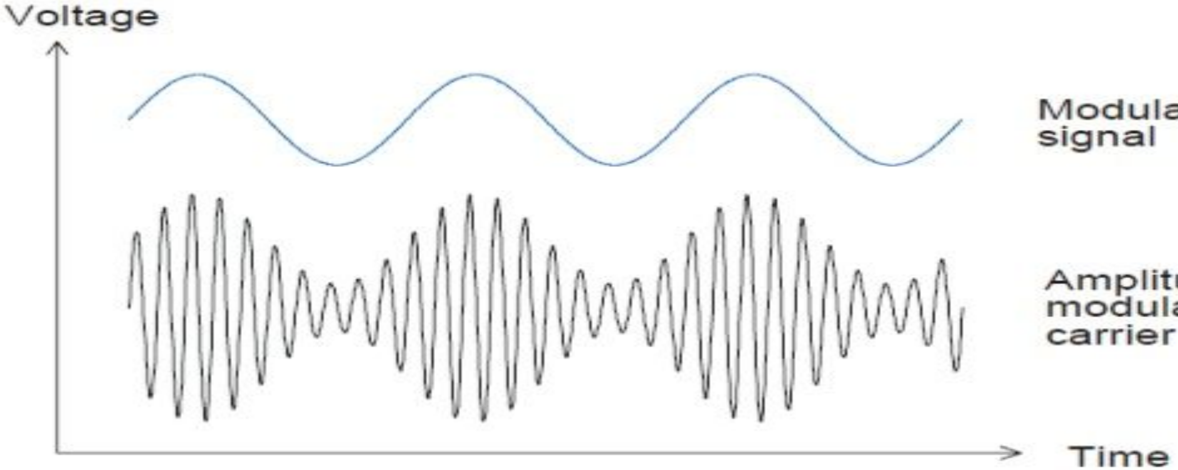
AMPLITUDE MODULATION

- The amplitude of the carrier is changed in accordance with the instantaneous value of modulating signal
- Carrier : $c(t) = \mathbf{V_c} \cos(2\pi f_c t + \varphi)$

  modulating signal $v(t) = V_m \cos(2\pi f_m t)$
- Information is contained in the envelop


e_s
E_s
t
Signal wave
e_c
E_c
t
Carrier wave
AM Wave

AMPLITUDE MODULATION



Frequency representation of AM wave:
(Double sideband – full carrier)

Upper sideband:
- The band of the frequency range between fc and fc+fm is called as upper sideband(USB).

Lower sideband:
- The band of the frequency range between fc and fc-fm is called as lower sideband(LSB).

Upper sideband frequency:
- Any of the frequency that lies between fc and fc+fm is called an upper sideband frequency.

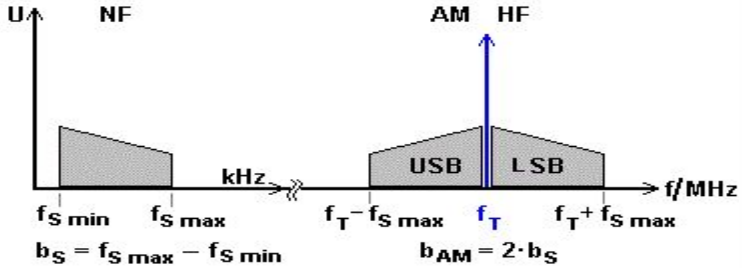
Lower sideband frequency:
- Any of the frequency that lies between fc and fc-fm is called a lower sideband frequency.

Bandwidth:

- It is the difference between upper sideband frequency to the lower sideband frequency.
- Upper side band frequency = fc+fc
- Lower side band frequency = fc-fc

BW= (fc+fm) – (fc-fm)

Therefore, BW = 2fm



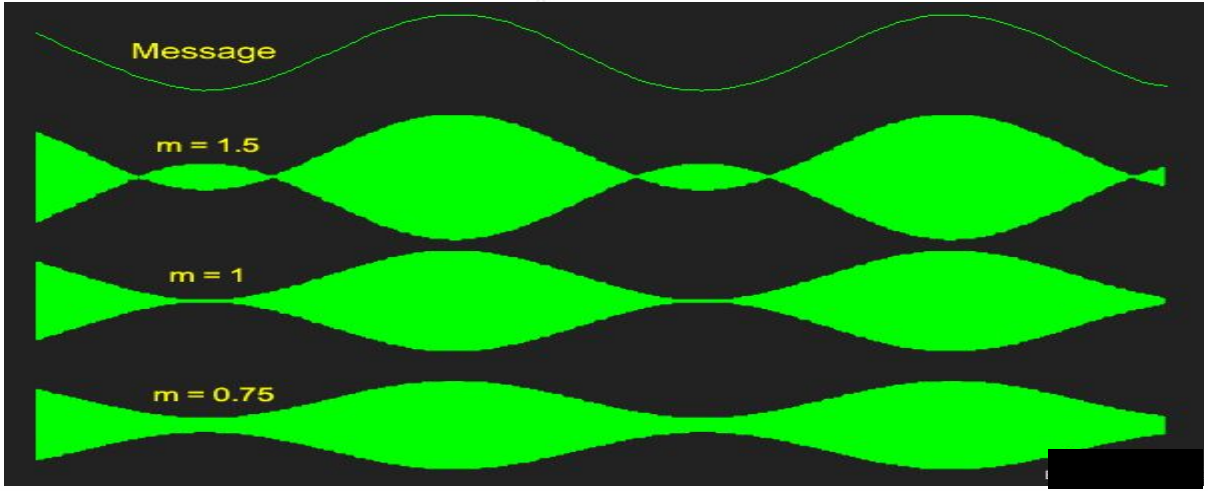
Coefficient of modulation or modulation index:

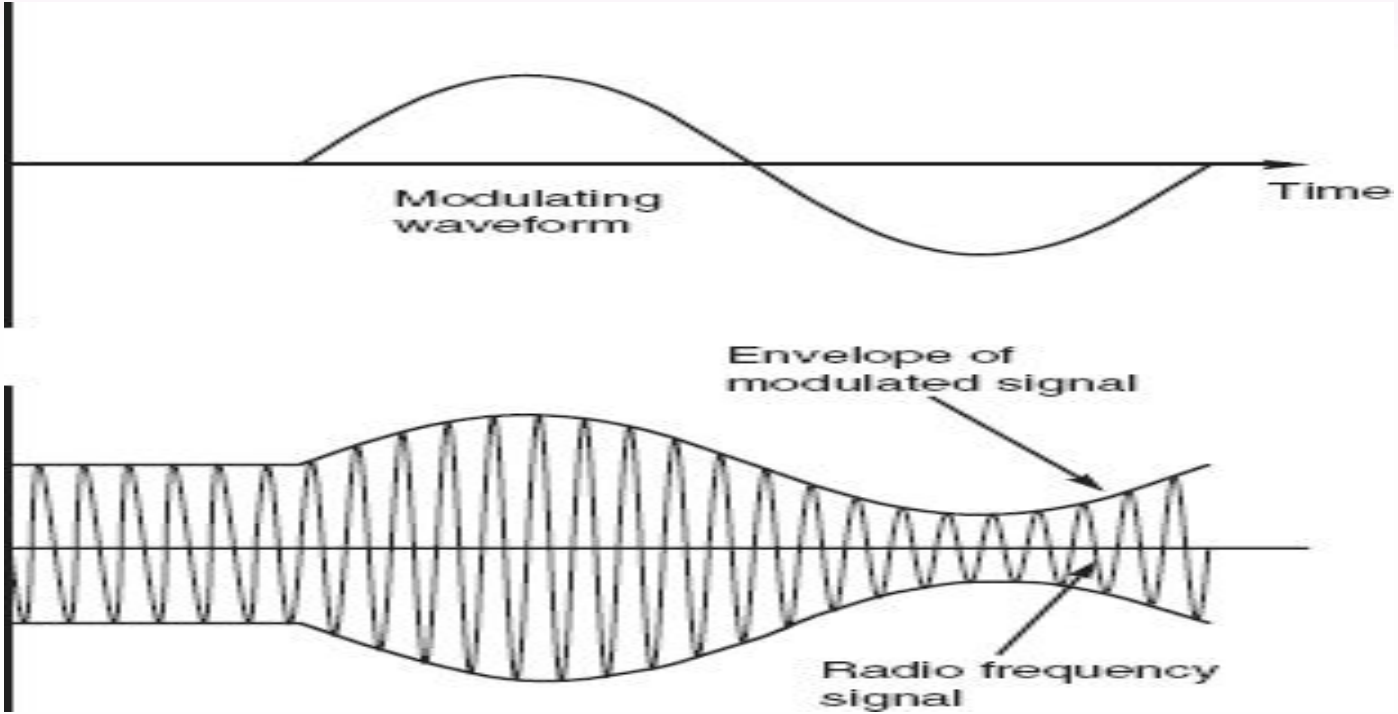
- The ratio between the maximum amplitude of the modulating signal to the maximum amplitude of the carrier signal is called a modulation index.
- Modulation index, m= Vm / Vc
- Where Vc be the maximum amplitude of the modulating signal.
- Value of Vm must be less than the value of Vc
- Hence the maximum value of the modulation index will be equal to 1 when Vm = Vc
- The minimum value will be zero.
- If the modulation index is higher than 1, then it is called overmodulation.

modulation index of an amplitude modulated signal is defined as the measure or extent of amplitude variation about an un-modulated carrier

Percentage of modulation:

- Whenever the coefficient of a modulation index is expressed in terms of percentage then it is called a percentage of modulation.
- M = (Vm / Vc) *100




Modulating
waveform
Time
Envelope of
modulated signal
Radio frequency
signal

- Consider the upper highest peak value as Vmax=Em+Ec
- Upper lowest peak value as Vmin=Em-Ec
- Downward highest peak value as -Vmax= -Em-Ec

Downward lowest peak value as -Vmin=-Em+Ec

Vmax +Vmin = Em + Ec + Em – Ec

Vmax +Vmin = 2 Em

Em = (Vmax +Vmin) / 2

Similarly,

Vmax -Vmin = Em + Ec – Em + Ec

Vmax -Vmin = 2 Ec

Ec = (Vmax -Vmin) / 2

Therefore,

m= Vm / Vc = Em / Ec

Therefore,

m= (Vmax +Vmin) /(Vmax -Vmin)

M =((Vmax +Vmin) /(Vmax -Vmin)) *100

Voltage representation of AM wave:
(Equation of double sideband- full carrier)

From the diagram we can observe the following:

$$v_m(t) = E_m \sin w_m t$$

where, $v_m(t)$ be the instantaneous value of the modulating signal.
E_m be the maximum amplitude of the modulating signal.
w_m be the angular frequency of the modulating signal.

$$v_c(t) = E_c \sin w_c t$$

where, $v_c(t)$ be the instantaneous value of the carrier signal.
E_c be the maximum amplitude of the carrier signal.
w_c be the angular frequency of the carrier signal.

Therefore for amplitude modulated signal,

VAM (t) = (Ec + Em Sin wmt) Sin wct

VAM (t) = Ec Sin wct + Em Sin wmt Sin wct

VAM (t) = EcSin wct +mEc Sin wmt Sin wct [since m=Em / Ec]

VAM (t) = Ec {Sin wct +m Sin wmt Sin wct}

VAM (t) = Ec {Sin wct +m/2{Cos (wc-wm)t – Cos (wc+wm)t }}

[since SinASinB=1/2(Cos (A-B) – (Cos (A+B))]

VAM (t) = Ec {Sin 2∏fct +m/2{Cos 2∏(fc-fm)t – Cos 2∏(fc+fm)t }}

VAM (t) = Ec Sin 2∏fct – mEc /2{Cos 2∏(fc+fm)t – Cos 2∏(fc-fm)t }}

- Ec be the amplitude of the carrier signal.
- mEc/2 be the amplitude of the USB signal.
- mEc /2 be the amplitude of the LSB signal.
- fc be the frequency of the carrier signal.
- fc+fm be the frequency of the USB signal.
- fc-fm be the frequency of the LSB signal

Power distribution of AM wave: Pc = Vrms2/ load resistor

i.e,. Pc = Vrms2/R

where, Vrms be the root mean square voltage.

Pc be the power of the carrier signal.

Vrms = Vm / √2 = Ec / √2

Pc = (Ec / √2)2 /R

Pc = Ec2 / 2R

PLSB = PUSB = (mEc /2)2 / 2R

PLSB = PUSB = m2Ec2 / 8R

PLSB = PUSB = (m2/4) * (Ec2 / 2R)

PLSB = PUSB = (m2/4) * Pc

Total power PT = Pc +PLSB +PUSB

PT =Pc+(m2/4) * Pc +(m2/4) * Pc

PT =Pc+2(m2/4) * Pc

PT = Pc+(m2/2) * Pc

PT =Pc(1+m2/2)

Where, m is the modulation index.

PT is the total power.

Pc is the power of the carrier signal.

MULTIPLE CHOICE QUESTIONS

https://forms.gle/vWCyETgxrySpcjAW7

VIDEO LINK OF AMPLITUDE MODULATION

https://www.youtube.com/watch?v=fGf_ng7qljI&list=RDCMUCXvKiwWVq5mvrfICSfzmyug&index=1