LECTURE # 03 – Topic 2

[2] Spectral Analysis of Signals.

(Reference: Network Analysis by Van Valkenburg. Refer Last few chapters on Fourier Series & Analysis.

[2.1] Introduction:

The purpose of studying Spectral Analysis of signals is to understand two major aspects of signals being transmitted from Tx to Rx over the Communication link. i.e to understand:-

→ Time domain representation of the:-
(i) Signal / Baseband signal to be transmitted
(ii) Carrier Signal to be modulated
(iii) Modulated carrier over Comm. Channel & at Rx.
[See Fig 2.1.a]

$m(t)$ → Baseband Signal
$V_c(t)$ → Carrier to be modulated
Carrier freq $f_c \gg f_m$.

→ Frequency domain representation of the :—
(i) Signal / Baseband signal to be transmitted
(ii) Carrier signal to be modulated.
(iii) Modulated Carrier over Comm. Channel.
[See Fig 2.1.b]

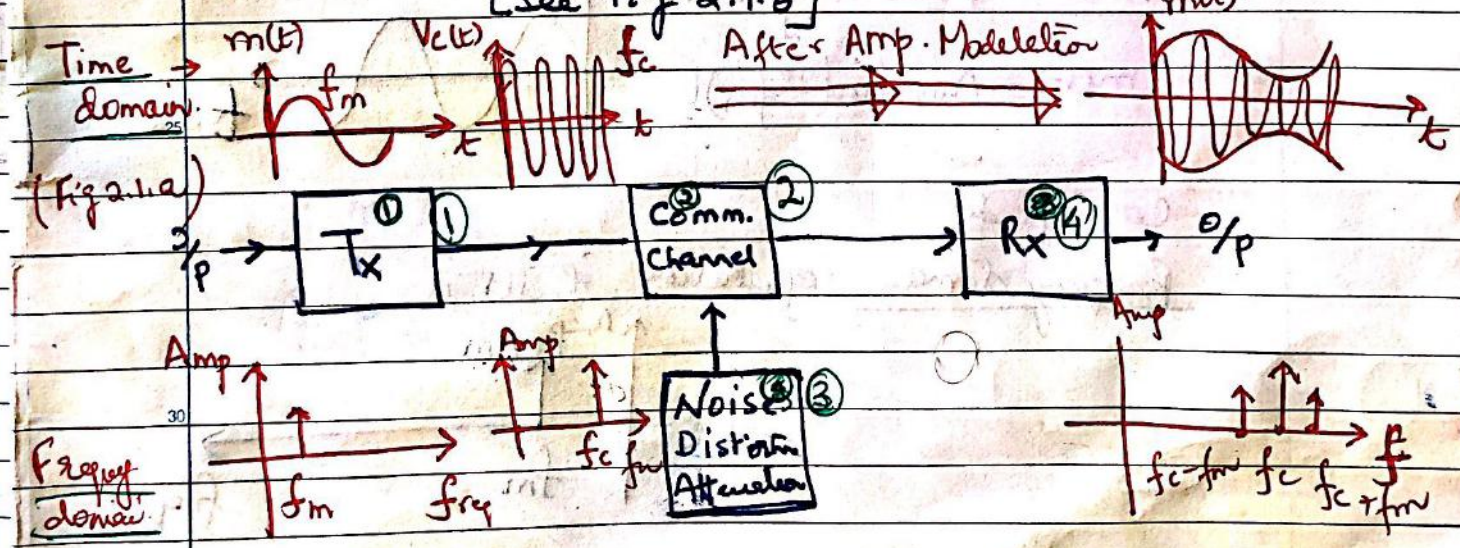


Fig 2.1.a & 2.1.b

Referring to the block digram (Simplified) on the previous page it is clear that the signal to be transmitted undergoes changes both in time domain as well as in frequency domain.

Again referring to Fig 2.1.a & 2.1.b we can understand these changes block by block starting with :-

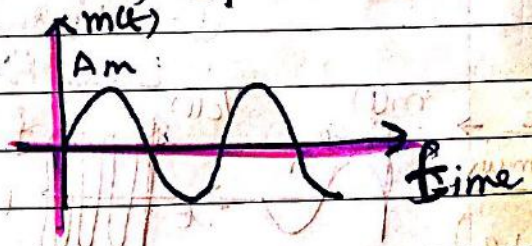
(1): Block # 01 → Transmitter (Tx).

Baseband electrical signal m(t) has freq fm and it is sinusoidal in nature. It can however be of any arbitrary shape but for simplicity we start to study the baseband signal in its simple form of a Sine Signal or Cosine Signal etc (or Clar etc).

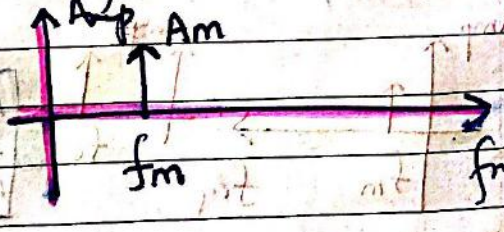
Let m(t) be Sinusoidal of amplitude Am.

Time domain representation

$m(t) = A_m \sin(2\pi f_m)t$



Corresponding frequency domain representation of m(t) is



Similarly figure also shows a f_c high frequency carrier to be modulated

Let Carrier be $V_c(t) = A_c \sin(2\pi f_c)t$

A_c is amplitude of Carrier

$f_c >> f_m$ is the Carrier frequency.

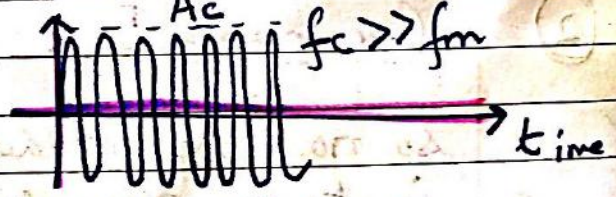
Since Carrier is propagated over Comm. Channel and is to be radiated by Tx thus its frequency is preferred to be much higher than f_m so that the Antenna Size ($\approx \frac{\lambda}{10}$) required is smaller & practical.

Carrier can be represented in time domain as well as frequency domain before modulation / frequency translation as well as after modulation / frequency translation

Hence:

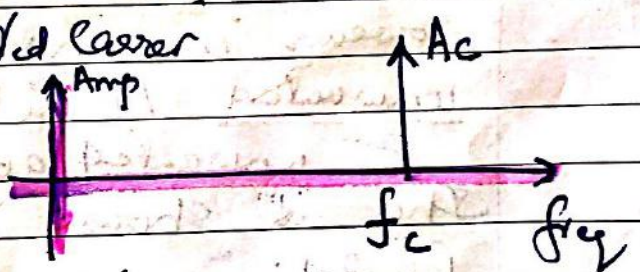
Unmodulated Carrier $= V_c(t) = A_c \sin(2\pi f_c)t$

Time domain Unmodulated Carrier



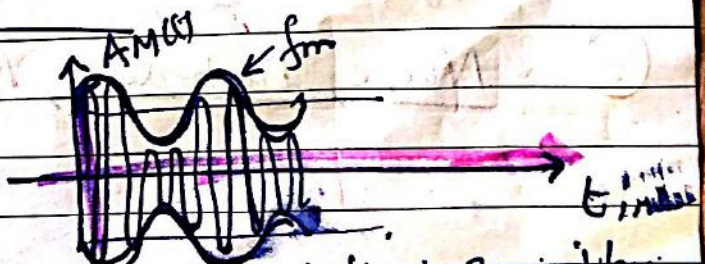
Corresponding

Frequency domain Unmodulated Carrier



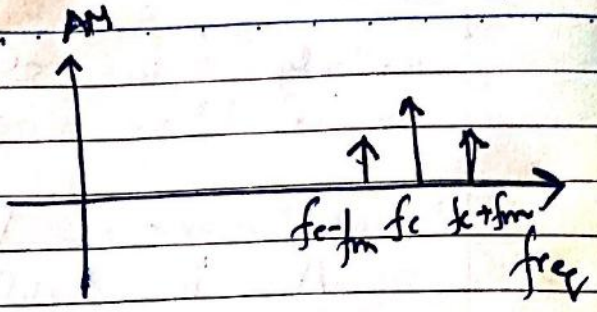
Amplitude Modulated Carrier

Time domain



Picture above illustration as mtg of fm freq being carried by carrier

Amplitude Modulated Carrier
Frequency domain



It is worthwhile to be noted that Baseband Signal / Information Signal can be of any shape. It can be monotone (single freq) or multi-tone. It can be arbitrary.

However the Carrier that serves the purpose to carry the baseband information signal is Single-tone / mono-tone (single frequency) and its freq f_c is high to allow small size Antenna for efficient radiation of the modulated Signal.

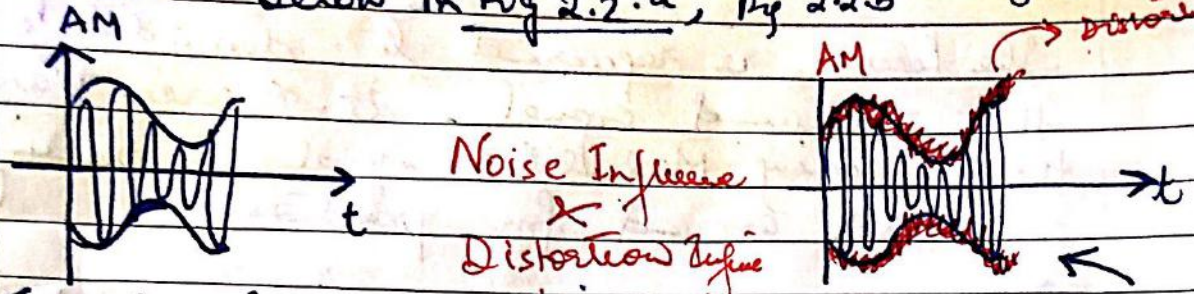
(2) Communication Channel. = Block #2 in Fig 2.1

So now the modulated signal (in this case AM signal) is to be trasmitted over the Comm. channel. However it undergoes changes such as unwanted Noise influence, unwanted distortion & unwanted attenuation.
This is shown contributed by Block #3 in Fig 2.1.

(3) Noise, Distortion, Attenuation = Block # 3 in Fig 2.1.

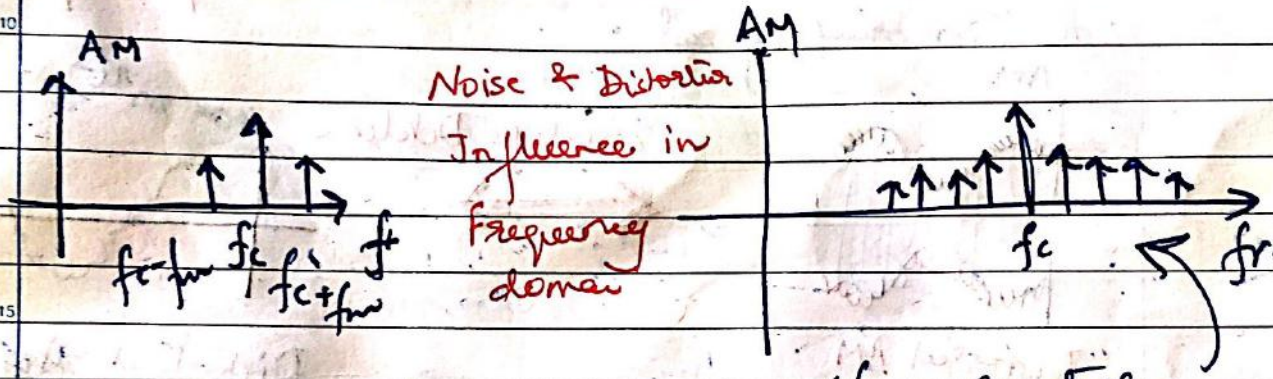
Examples of these unwanted influences roughly are shown below in Fig 2.2.a, Fig 2.2.b

Example 1



Time domain

Distorted Signal over communication channel



Frequency domain

New spectral components get introduced by influence of Noise & Distortion

[Fig 2.2]: Noise & Distortion

Example 2

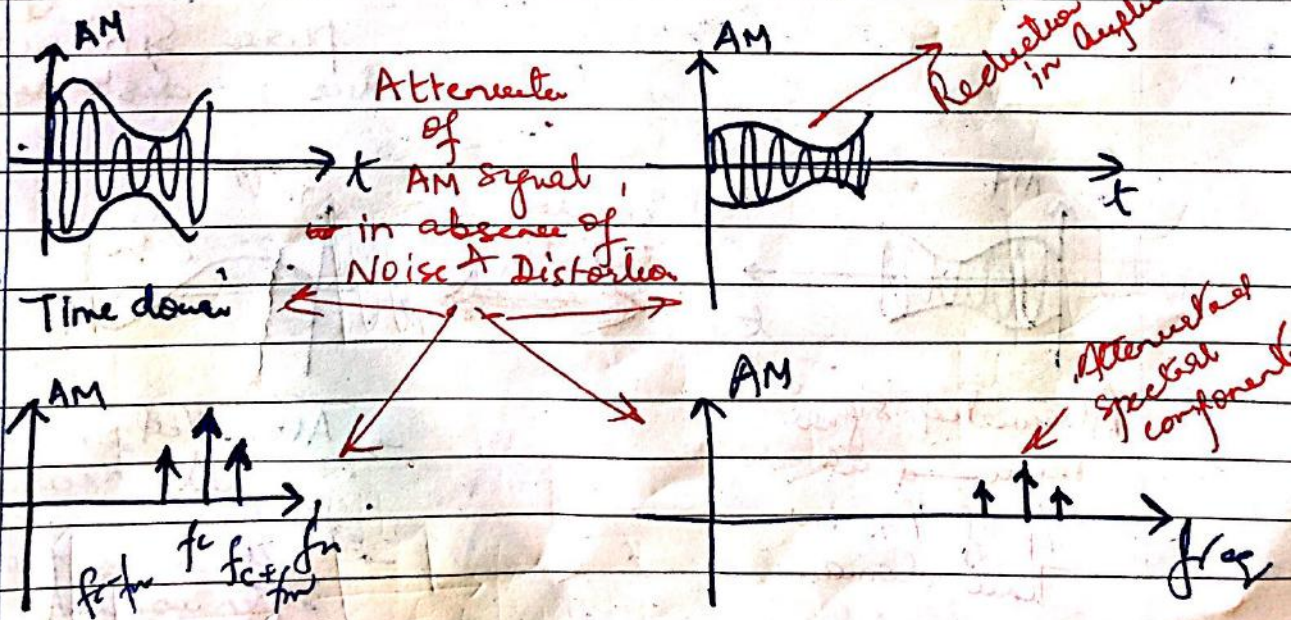


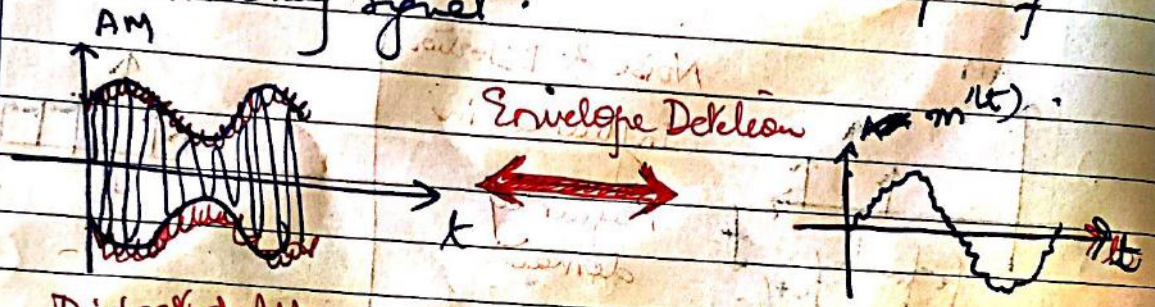
Fig 2.2.b :- Attenuation

(4)

Block # 04 → Receiver

The Receiver is required to demodulate the received signal. It receives translated the incoming Modulated signal by placing it back around fm position.

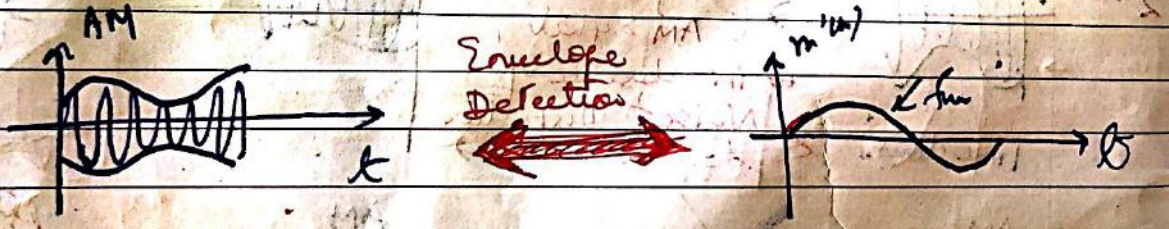
In Case of AM System an envelope detector is used that retrieves the envelope of the incoming signal.



Distorted AM Signal received at I/p of Rx in Time domain

→ Distorted message signal received.

→ It is no longer a pure Sinusoid due to distortion.



Attenuated Signal received at I/p of Rx in Time domain

→ Attenuated message signal received

→ It is a pure Sinusoid.

→ It can be Amplified.

Tutorial Sheet #02; Topic #02

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Q.1. Define with at least 4 examples (in time domain) periodic functions or signals. Draw these signals only in time domain.

Q.2 Define what are Aperodic or Non periodic functions or signals. Give an example & draw its illustration in time domain.

Q.3. Define what are Odd functions?. Give 4 examples with illustration in time domain.

Q.4 Define what are Even functions? Give 4 examples with illustration in time domain.

Q.5 Draw a Sinusoid in time domain & in frequency domain with Amplitude Am, frequency fm.

Q.6 Draw a Cosine in time domain & in frequency domain with Amplitude Ac, frequency fc. Assume Ac > Am & fc >> fm.

Q.7 What is Fourier Series Analysis?