* Transmition

↳ **Base band :-** is the transmission of a message as generated is transmitted and the band of the frequency occupied by the messege.

↳ **Band pass :-** a wave form has a spectral magnitude that is non-zero for frequencies in som band concentrated about a frequency $f = +/- f_c$

f_c → is much greater than zero. → high frequencies.

* Band pass is transmission band.

Amplitude modulation (AM)

is a modulation technique where the Amplitude of a high-frequency sin wave is varied linearly with a time-varying message signal (m(t)). the modulating signal m(t) containes the intended message or information.

← * Carrier is modulated by combining it with the modulating signal.

pure carrier

it's pure wave of higher constant frequency and it requires the modulation of the message on to a carrier signal to transmit it. / and carrier signal ~~isn't contain~~ doesn't contain information.

* the need of Hilbert transform at communication system.

- helps us relate the I and Q component. → phase shift ($\mp \frac{\pi}{2}$) degree.
  → so only effect the phase of the signal
  it has no effect on the Amplitude at all.
- represent band pass signal as complex signal.

* Modlation. → deffinition تعريف
  ↳ what is need

is the process of inpanting the source information on to bandpass signal with a carrier frequency f_c by the introduction of Amplitude or phase perturbations or both.

why Modulation.

to transfer signals wee need to transfer the frequency to higher level

← what is need of filters in communication system.

are used to extract the base band signal in Low pass filter.

(OR) to extract a specific frequency in band pass filter.

← meaning of Narrow band signal. if $B << 1$, and $BW = 2 f_m$

is a type of approximations for FM

NBFM meaning $f_c >>$ band width of $m(t)$

← the need of frequency domain transform, in communication system.

- simplify the Mathematical analysis
- Convolution of two signals is simply in multiplication form.
- dealing the signal in frequency domain is more easier

the diffrance between SSB and USB

← موجود بالملف.

→

the difference between direct method and indirect Method.

- in direct Method a NBFM signal is first generated an then frequency Multiplier is used to increas both carrier frequency & Modulation index.

- in direct Method we use reasonant circuit to ~~make~~ tuning at certain frequency apply, make

and then I get a linear relation ship between $m(t)$ & $f_i(t)$ through a specific Approximation. but ~~this is requ~~ that requires the use of a varactor diod

to change capacitance $c(t)$ by changing the voltage ($m(t)$). (this depends on the main diod response).

and therefore (any change in $m(t)$ voltage ~~Causing~~ Causes ~~Changing~~ Change in a capacitance value. changing

and hence change in $f_i(t)$.

→

the diff between AM & FM → بالملف

→

Band width for each type of modulation

FM → NBFM → $2 f_m$
→ WBFM → ∞

AM → DSB + C → $2 f_m$
→ DSB - SC → $2 f_m$
→ SSB → f_m
→ USB → f_m +

* Amplitude modulation.

:- The amplitude of a carrier signal is varied linearly with a time-varying $m(t)$.

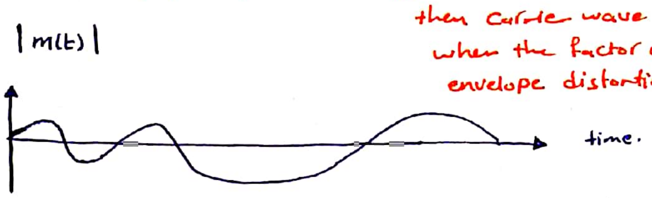
$$C(t) = A_c \cdot \cos 2\pi f_c t$$

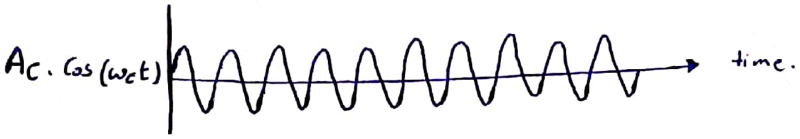
* $C(t)$ at AM only Amplitude A_c allowed to vary

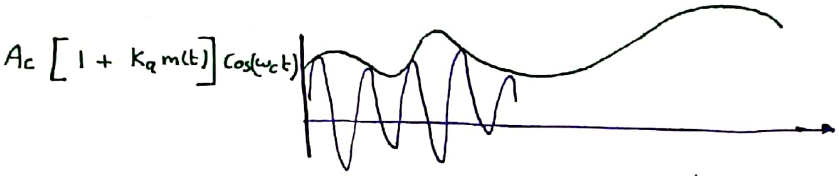
$$S(t) = A_c \underline{(1 + K_a m(t))} \cdot \cos 2\pi f_c t$$

* f_c, θ are fixed.

$|K_a m(t)| < 1$ → if K_a is large to make $|K_a m(t)| > 1$ then carrier wave becomes over modulated when the factor crosses zero this creates envelope distortion in the modulated signal.





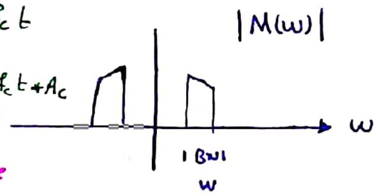


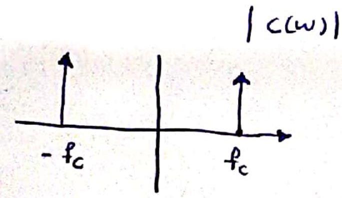
* Double - Sideband AM with Carrier.

$$S(t) = A_c (1 + K_a m(t)) \cdot \cos 2\pi f_c t$$

$$S(t) = A_c \cos 2\pi f_c t + k_a m(t) \cos 2\pi f_c t \cdot A_c$$

Carrier. message

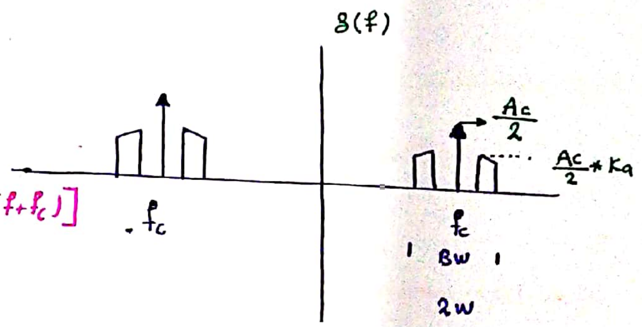




→ $\frac{A_c}{2} [\delta(f - f_c) + \delta(f + f_c)]$

message.

→ $\frac{K_a}{2} A_c [M(f - f_c) + M(f + f_c)]$



Tapp

we have two requirment to have base band signal shape over the envelope of the modulated signal.

$$S(t) = \underline{A_c (1 + K_a m(t))} \cdot \cos 2\pi f_c t$$

envelop for modulated signal $s(t)$

① ↳ $|K_a m(t)| < 1$ for all t → stays positive.

② ↳ Carrier frequency is much greater than highest frequency in base band signal. $f_c >> W$

* Single tone.

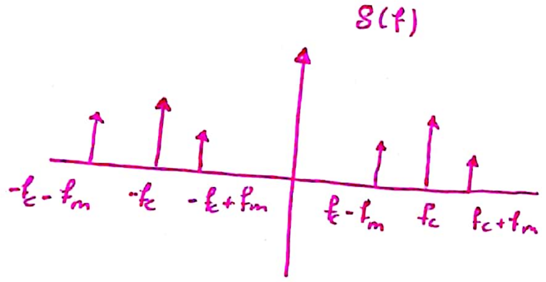
→ any point in frequency domain it represented a single tone in continuous wave.

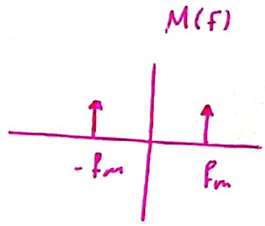
$m(t) = A_m \cdot \cos 2\pi f_c t$

$s(t) = A_c [1 + K_a A_m \cos 2\pi f_m t] \cdot \cos 2\pi f_c t.$

$s(t) = A_c \cos 2\pi f_c t + \frac{A_c}{2} \mu [\cos 2\pi (f_c - f_m) t + \cos 2\pi (f_c + f_m) t]$

$$S(f) = \frac{A_c}{2} [\delta(f - f_c) + \delta(f + f_c)] + \frac{A_c \mu}{4} [\delta(f - f_c + f_m) + \delta(f + f_c - f_m) + \delta(f - f_c - f_m) + \delta(f + f_c + f_m)].$$





* the Cause of uses single tone is :-

$\mu = \frac{A_m}{A_c}$

P_m is complicated and not known priecisely

So, we can find efficiency by using tone modulation.

$P_c = \frac{A_c^2}{2}$ → power in Carrier

$P_m = \frac{A_m^2}{2} = \frac{(\mu A_c)^2}{2}$ → Power in tone modulation $(m(t))$

$P_s = \frac{1}{2} P_m = \frac{(\mu A_c)^2}{4}$ → power in side band.

$\left[\eta = \frac{\mu^2}{2 + \mu^2} \right]$ ⇒ power efficiency.

→ when $\mu = 1$

$\eta = 0.33$

(efficiency is very low)

{In AM the power in the message is the power in sidebands.}

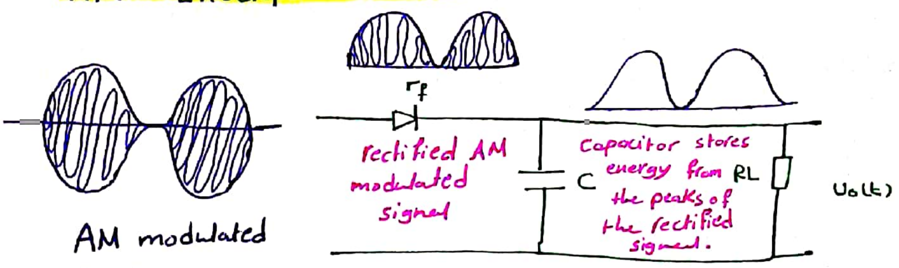
$[\eta_c = 0.66]$ → high

Maximum efficiency is that mean 66.66 % power is spent on Carrier.

Scanned with CamScanner

* AM Demodulation *

AM Envelope Detector circuit.



AM modulated signal.

[Key Idea: capacitor captures the voltage peaks of rectified wave form]

← Two condition must be met for an envelope detector to work:-

(1) → Narrow band [meaning $f_c >> $ bandwidth of $m(t)$].

(2) ⇒ $A_c + m(t) \geq 0$, Modulation Index < 1 .

(3) → time constant $\tau = RC$ too short.

(4) → Design criteria is $2\pi B < \frac{1}{RC} << 2\pi f_c$

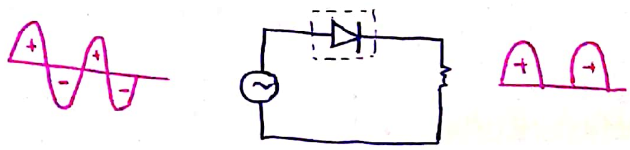
← on positive half-cycle of RF input signal (st) the diod is forward biased and the capacitor G charges up rapidly to the peak value of RF input signal.

← when RF input falls below the output voltage the the diod becomes reverse-biased and capacitor dis charge slowly
$\tau = RC$ too short.

* if (RC is too large) the voltage or the signal at the output doesn't follow the envelop
distortion. ☺

* Switching Amplitude Modulator.

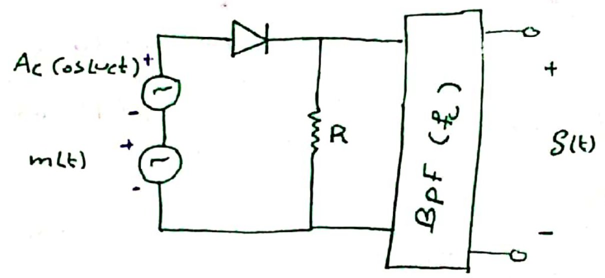
* half wave rectifier. → non-linear circuit component.



[nonlinearity generates new frequencies]

* Switching Modulator.

- diod is Ideal $V_D = 0$, $r_D = 0$ ~ forward bias.
- $c(t)$ is Larg an Amplitude.
- $m(t)$ is weak compared with $c(t)$.



شو الفكرة ؟!

اني استخدم ال rectified square wave.

ورح أوصل لنفس النتيجة

خاصة اني بقدر أعبر عن ال square wave.

ب { Fourier Series }

السؤال ؟! why ليش أنا بعمل هيك ؟!

Because the Cos wave is even function, symmetric around x-axis [has double-side band]

So Just we wanted transmite +ve or -ve half cycle.

condition
~ period for square wave = +ve cycle for carri

← Analysis fo circuit

$$V_o(t) \begin{cases} v_1(t) & , c(t) > 0 \\ 0 & , c(t) < 0 \end{cases}$$

rectification for $v_1(t)$

Diod → short circut..

→ لأن $m(t)$ negligible.

$$v_o(t) = [A_c \cdot \cos 2\pi f_c t + m(t)] \cdot g_{T_0}(t).$$

→ infinite summation of cos so, BW = ∞

Square wave BW = ∞ ↳ non-Causal. ↔

$$g_{T_0}(t) = \frac{1}{2} + \frac{2}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{(2n-1)} \cdot \cos[2\pi f_c t (2n-1)]$$

$g_{T_0}(t)$

infinite summition أنا بعطيني سـ

نقط ①

هو اللي بعطيني

وهو عند لـ $n=1$ $\{f = f_c\}$ → يسمى wanted component → $\left[V_o(t) = \frac{A_c}{2}\left[1 + \left\{\frac{4}{\pi A_c}\right\} m(t)\right] \cdot \cos(2\pi f_c t) \right]$

$\frac{4}{\pi A_c}$ → K_a

* $s(t) = A_c[1 + K_a m(t)] \cdot \cos 2\pi f_c t$.

كيف بقدر أفصل wanted component عن باقي الـ component

[Band pass filter ← بستخدم
$\{f = f_c\}$

un wanted component.

- delta's (Carrier) at even frequencies
- version of the message signal. at odd frequencies. يعني infinit number of summition وبالتالي رح يكون عندي infinite number of version of the message signal.

* وبالتالي نستنتج أنه switching circuit Modulator

هي اللي أجبرتني أنو أرسل الـ (carrier)

فعلاً موجود term الـ carrier في معادلة $V_o(t)$

وبالتالي شو سبب أنو بـ full منزل carrier وبالتالي الـ AM power أقل side pand

كثير صار total power ؟!

(السبب) أنه AM modulation قديم وأول نوع منه كان $s(t) = A_c(1 + K_a m(t)) \cdot \cos(2\pi f_c t)$

{ switching Modulator ← [diod circuit] بسبب استخدام }

* at Full AM Limitations, AM wave has two main concern.

① → Amplitude modulation has wasteful of power → why ?!
the carrier wave $c(t)$ is completely independent of the information-bearing signal $m(t)$. therefor, the transmission of the carrier wave is waste of power. (66.66% of the carrier)

② → Amplitude modulation has wastefull of bandwidth → why ?!
the upper and lower sideband of an AM wave are uniquely related each other by virtue of semmetry about the carrier frequency.
Hence, given Magnitude and phase spectra of either sid band, we can determine the other.

Double - Sideband suppressed Carrie.

* Conventional AM transmits both ($m(t)$, $c(t)$), the it's power efficiency is Low.

$$S(t) = A_c (1 + K_a m(t)) \cos(2\pi f_c t)$$

when this term cancelled Just remaine.

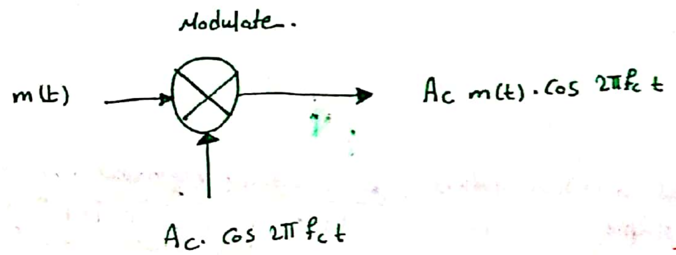
$$\left[S(t) = A_c \, m(t) \cdot \cos 2\pi f_c t\right] \Rightarrow \text{double - sideband supressed Carrie.}$$

then power efficiency becomes $\eta = 100\%$ Because $(A_c)^2$ approaches zero.

ـــ هذا هو الفرق بين DSB-SC, full AM → with Carrie.

التشابه ← $2W = BW$

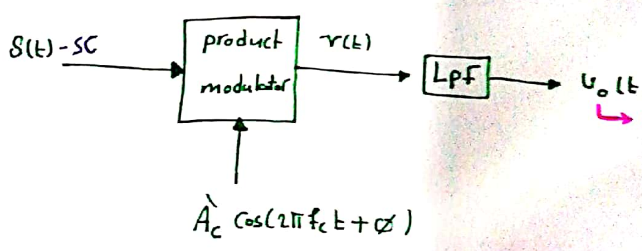
Modulation



$$\boxed{S(t) = A_c \, m(t) \cdot \cos 2\pi f_c t}$$ AM. DSB-SC

$$S(f) = \frac{A_c}{2}\left[M(f - f_c) + M(f + f_c)\right]$$

De Modulation



→ version of m(t).

$$\leftarrow V(t) = S(t) \, A_c' \cos(2\pi f_c t + \phi)$$

$$= A_c' \cos(2\pi f_c t + \phi) \, \underbrace{(A_c \, m(t) \cdot \cos 2\pi f_c t)}_{S(t)}$$

$$= \frac{A_c \cdot A_c'}{2} m(t) \cos(4\pi f_c t + \phi) + \frac{A_c A_c'}{2} m(t) \cos\phi$$

تلغى بعد (LPF) ←

$$\leftarrow V_o(t) = \frac{A_c A_c'}{2} m(t) \cos(\phi)$$

AT D-Modulation in DSB-SC we needed **Coherent detection (synchronous)**

Coherent demodulation or detection is a method to recover the message signal from the recieved modulated signal that requires a carrier at the reciever.

→ this carrier signal **must match** in frequency and phase to the recieved signal.

$$v_o(t) = \left[\frac{A_c A_c'}{2} \cos\phi \cdot m(t)\right]$$

→ recieved signal.

$v_o(t)$ → at reciever after demodulated

$\cos\phi$ → phase shift from carrier signal.

$m(t)$ → modulated signal.

* quadrature null effect

(when $\phi = \mp \frac{\pi}{2}$)

→ ϕ ⇒ يعني إذا كانت قليلة أنا بكي أزيد A_c عن طريق A وبالتالي بعوض بزيادة power.

بسبب بيخ أخلي سمعا؟!

Advantage of AM

→ AM not requiring coherent detection Method, Non-coherent Methods can be used which are much simpler to implement. like (Envelope Detector.)

→ Costas reciever

→ De modulation DSB-SC

الحل هو عن طريق modulated signal without phase discremenator الموجودة ب coherent detection.

zero ≈ حتى تغير (بعمل controlling عن phase discremeter)

* De-modulation

Full AM → Envelope detector

DSB-SC → Costas reciever

أي ملاحظة على الرسمة

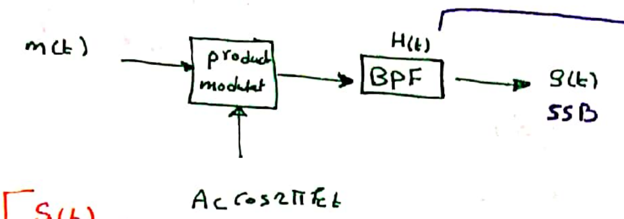
Single side band (SSB) AM

لـه تستخدم كل هتي أنا أقال من BW
مرسل ع m(t)

→ DSB - SC is spectrally inefficient because it uses twice the bandwidth of the message.

[SSB addresses that issue.]

Modulated :-

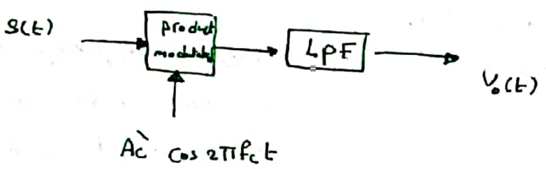


$$\left[S(t) = \frac{1}{2} A_c\, m(t) \cos 2\pi f_c t \mp \frac{1}{2} A_c\, \hat{m}(t) \sin 2\pi f_c t \right]$$

SSB عشان اعمل

For the designe of the band-pass filte to be practicaly feasible, there must be a certain speration between the two side bands that is wide enough to accommodate the transition band of the band-pass filte.

De - Modulated :-



$$\left[V_o(t) = \frac{1}{4} A_c \grave{A}_c \left[M(t) \cdot \cos \phi + \hat{M}(t) \sin \phi \right] \right]$$

بس للأسف الموضوع مارح يكون سهل والسهولة رح تواجهنا مشكلات ب SSB

وهي عدم تحقيق الشرط اللي موجود عدم وجود gap بين upper & Lower.

Dis adv SSB

1) Designing and implementing the sharp Low / high (Ideal filte) Band pass filte is not easy for circuit designer.

2) SSB relies (تعتمد) on being able to filte out one side band, this make it not possible for all signal, that have strong component at low frequency.

- SSB Valid for audio signal
- SSB not valid for vedio signal.

طيب هون مش حالنا شو الحل !؟
لحل المشكلة

the solution is Vestigial sideband Modulation (VSB) معلومة مش حيمر. a small portion (trace) of the unneeded side band is used → this reduces DC distortion

adv VSB OR Comparision between [SSB & VSB]

1- Allow a small amount (trace) or vestige, of the unwanted sideband to appear at the output of an SSB.
2. the design of the side band filte is simplified since the need for sharp cutoff at the carrie frequency is eliminated.
3- VSB improve low - frequency response.

* بيوجد طريقة لـ Modulation أخرى بتستخدم الـ Helbet transform دون الحاجة إلى filter.

[phase shift Method to Generat SSB AM]

* ... Method
A. selective Filtering Method.
B. phase shift Method.

* De-modulation of SSB signals
A. coherent demodulation
B. Envelope Detection with a carrier (SSB + C)

*** distortion in SSB** →

demodulated ← distortion بيحصل

[phase distortion] دي بيحصلها

↳ Valid for audio signal, not for vedio signal (shift in time)

vedio signal frequency → 80 HZ to 6 KHZ

audio signal frequency → 20 HZ to 20 KHZ → higher frequency then vedio so any shift in time in audio signal will be very effictive.

Adv SSB

- transmit power efficiency
- Bandwidth efficiency
- impovement SNR
- Reduction in distortion

Dis adv SSB

- Difficulty in alignment and tuning
- complex

Adv VSB

- use simple filter design
- less bandwidth as compared to that DSB SC
- Also efficient as ~~compared to that~~ SSB
- possibility of transmission of low frequency components of modulating signals. like vedio signals [TV signal]

[* distortion in VSB happen in Demodulation. inside the invelope
Because m(t) is non-linear.]

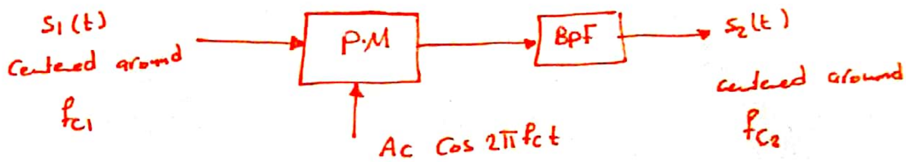
* the distortion can be reduced by
1) - reducing the percentage modulation to reduce ka.
2) - Increasing the width of vestigal side band to reduce m'(t).

Frequency Translation or Frequency Division Multiplexing : FDM

Multiplexing is a technique when a number of independent signals are combined and transmitted in a common channel.

* these signal are de - Multiplexed at the recieve.

← MoD :- shift message frequency range to mutually exclusive high frequency bands



→ FDM كم حيثي مهم شامل للمرضى .

← useful bandwidth of medium exceeds required bandwidth of channel.

← [Each signal Modulated to a different carrier frequency]

← Carrier frequencies separated so signals don't overlap (don't happen trace at near message signal).

سبب عدم وجود trace at near message signal.
على الأقل الغرض بنيم تحيث
يساوي BW
إذا كانت $m_n(t)$ متساوي للجميع .