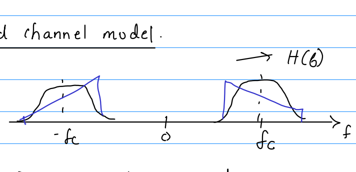
Lecture 10 14/08/2019

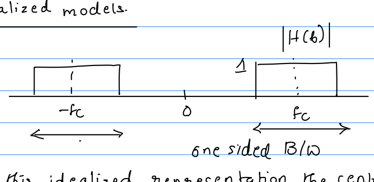
Review

Passband channel model.



1) $H(f)$ is symmetric around 0.
2) centre freq fc but an actual channel response need not be symmetric around fc.

Idealized models.



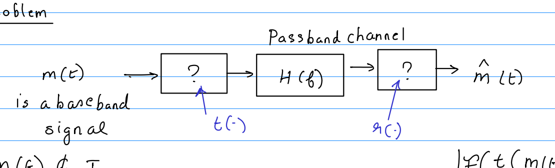
phase response is linear.

e.g. 100 MHz

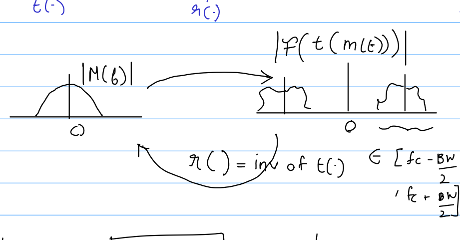
one sided B/W = 2 MHz

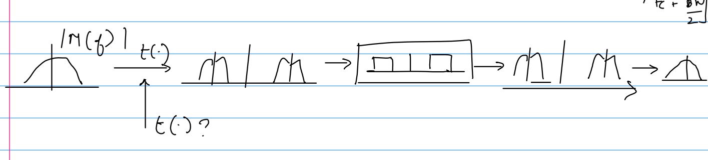
for this idealized representation the centre frequency is a point of symmetry for $|H(f)|$.

Our problem



1) $m(t) \notin I$
2) $t(m(t)) \in I$





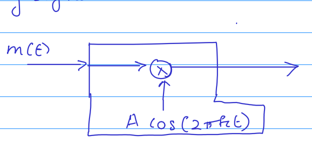
1) multiplication of $m(t)$ with a sinusoid.
2) changing freq/phase of a sinusoid as a function of $m(t)$.

$$\text{Sinusoid} = A\cos(2\pi f t + \phi)$$

one or more properties are changed/modulated.
1) and 2) are modulation techniques.

$\underbrace{A\,m(t)}_{\text{modulating signal}}\underbrace{\cos(2\pi f_c t)}_{\text{carrier signal}}$ → amplitude modulation

→ modulated signal



$i(t)$ which is channel input.

Is this LTI? Not LTI ⇒ cannot use $X(f)H(f) = Y(f)$!

$I(f)$?

$$i(t) = A\,m(t)\cos(2\pi f_c t)$$

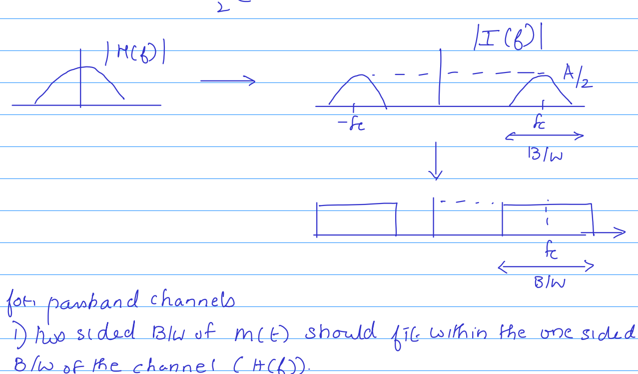
we use: $m(t) \xrightarrow{\mathcal{F}} M(f)$

$m(t)e^{j2\pi f_c t} \longrightarrow M(f-f_c)$ ✓

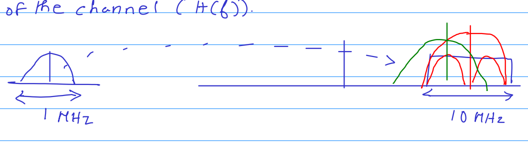
$$\int m(t)e^{-j2\pi(f-f_c)t}\,dt$$

$$i(t) = A\,m(t)\cdot\left(\frac{e^{j2\pi f_c t} + e^{-j2\pi f_c t}}{2}\right)$$

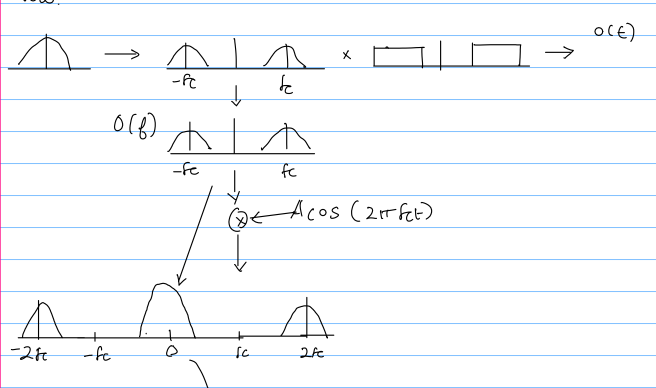
$$\Rightarrow I(f) = \frac{A}{2}\left[M(f-f_c) + M(f+f_c)\right]$$



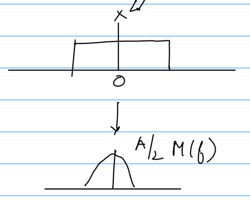
for passband channels
1) two sided B/W of $m(t)$ should fit within the one sided B/W of the channel ($H(f)$).

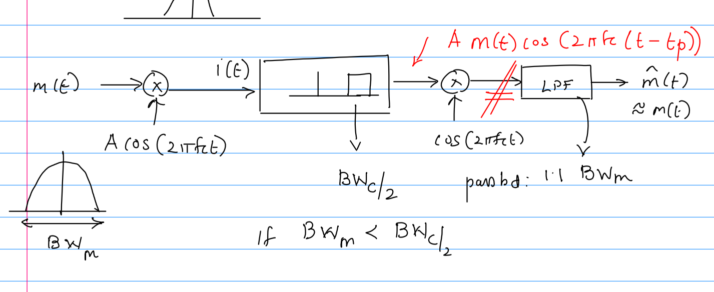


Now:



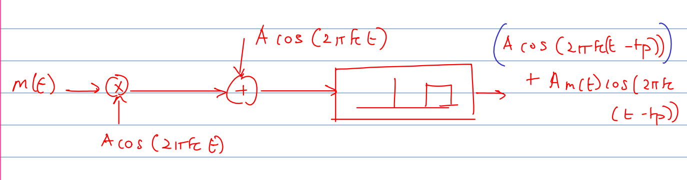
$$\frac{A}{2}\left[M(f-f_c) + M(f+f_c)\right] \rightarrow \frac{A}{4}M(f-2f_c) + \frac{A}{4}M(f+2f_c) + A/2\,M(f)$$



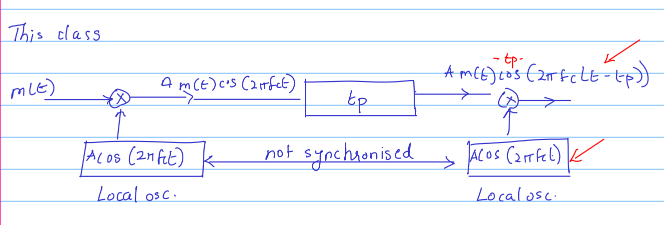


If $BW_m < BW_c/2$

where does one get $\cos(2\pi f_c t)$-s from?
generated by the transmitter and receiver separately
Local oscillators.

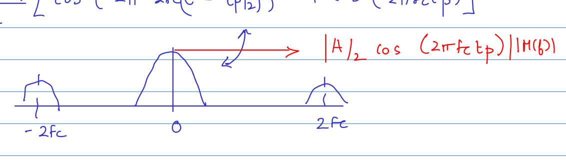


This class



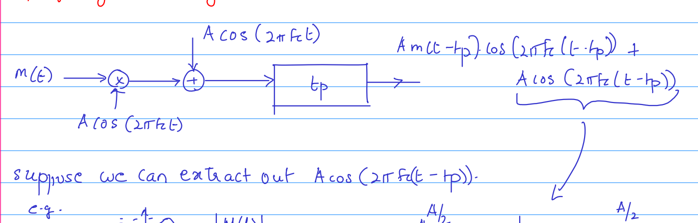
$$A\,m(t)\cos(2\pi f_c(t-t_p))\cdot\cos(2\pi f_c t)$$
$$= \frac{A\,m(t)}{2}\left[\cos\left(2\pi\, 2f_c(t - t_p/2)\right) + \cos(2\pi f_c t_p)\right]$$

$|A/2\,\cos(2\pi f_c t_p)|\,|M(f)|$



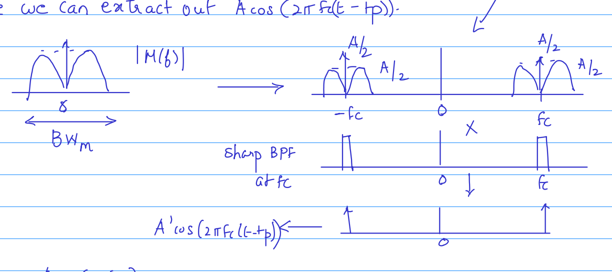
if $2\pi f_c t_p = m\pi/2$ or $t_p = (m/4f_c)$

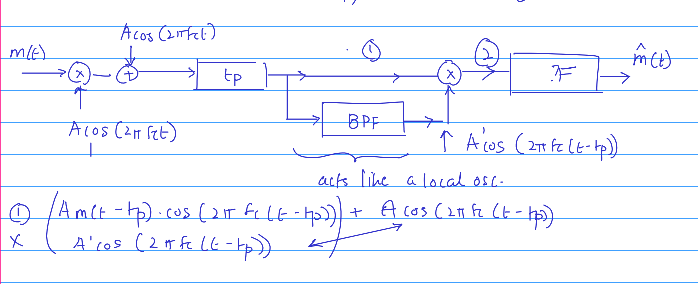
* The receiver's local oscillator's signal $A\cos(2\pi f_c t)$ is not in phase with the received carrier signal. (synchronization issue – more specifically, carrier synch. issue).



suppose we can extract out $A\cos(2\pi f_c(t-t_p))$.

e.g.





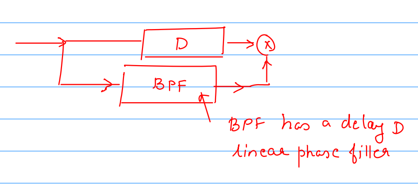
① × $\left(A\,m(t-t_p)\cdot\cos(2\pi f_c(t-t_p)) + A\cos(2\pi f_c(t-t_p))\right)$ $A'\cos(2\pi f_c(t-t_p))$

$$= \frac{AA'}{2}m(t-t_p)\cdot\left(1 + \cos(2\pi\, 2f_c(t-t_p))\right) + \frac{AA'}{2}\left(1 + \cos(2\pi\, 2f_c(t-t_p))\right) \quad ②$$

suppose we do LPF on ②

F: → LPF → DC block → $\hat{m}(t)$

a practical issue :-



BPF has a delay D
linear phase filter

Two schemes for passband commn.

1) Double sideband suppressed carrier modulation and demod.
2) Plain amplitude modulation or large carrier amplitude modulation