Sections 8.1 – 8.4 Amplitude Modulation

We will start from basic discussion of AM to some practical considerations

Amplitude Modulation (AM)

$y(t) = x(t)\, c(t)$

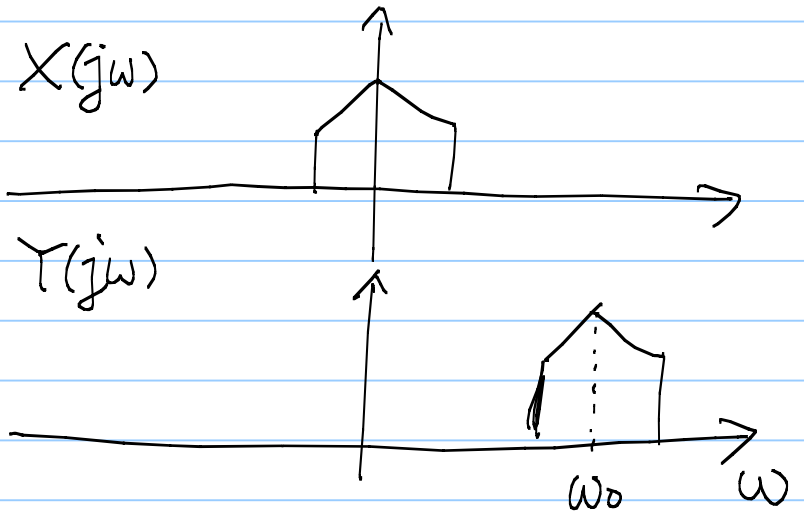
- $y(t)$: modulated signal
- $x(t)$: Modulating signal
- $c(t)$: carrier signal

Type 1: $c(t) = e^{j\omega_c t}$

$$y(t) = x(t)\, e^{j\omega_c t}$$

multiplication in time $\equiv$ shift in freq

$Y(j\omega)$ is the shifted version of $X(j\omega)$



Note: any real-valued signal $x(t)$, its $X(j\omega)$ is always (conjugate) symmetric.

$Y(jw)$ is no longer symmetric

$\equiv$ $y(t)$ is no longer real

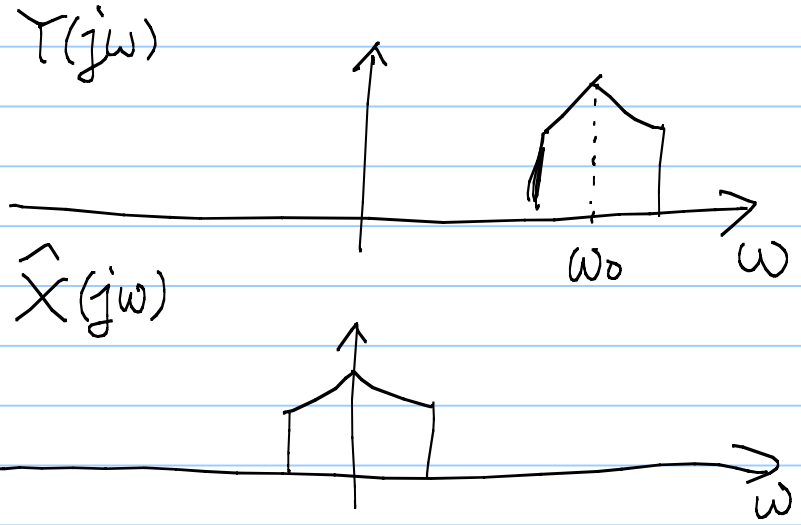
(since we multiply $x(t)$ by $e^{jw_c t}$)

Drawback: We cannot send imaginary-valued signals $y(t)$.

Demodulation $\quad \hat{x}(t) = y(t)\, e^{-jw_c t}$

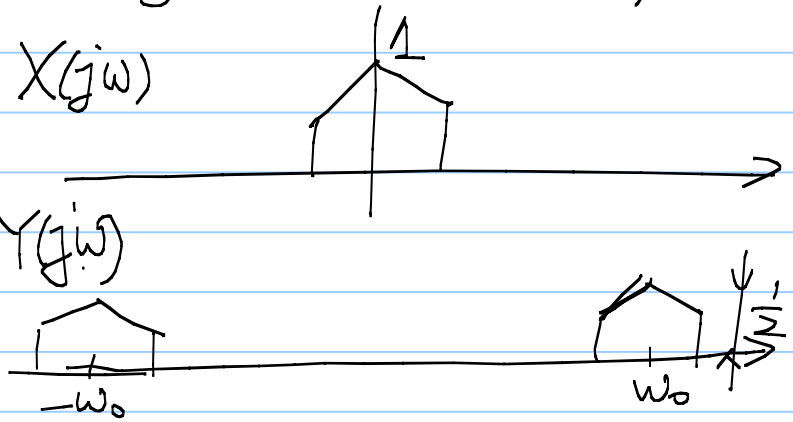
multiply $e^{-jw_c t}$ in time

$\equiv$ shift it back in freq



Type 2

$y(t) = x(t)\cos(w_c t)$



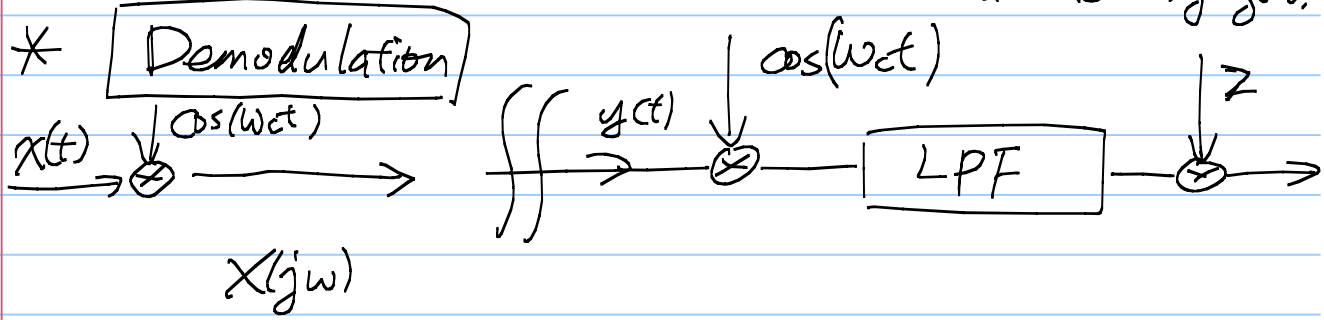
* How to demodulate (from $y(t)$ back to $x(t)$)?

Try 1: by division $x(t) = \frac{y(t)}{\cos(w_c t)}$ drawbacks: ① division is hard ② divided by zero.

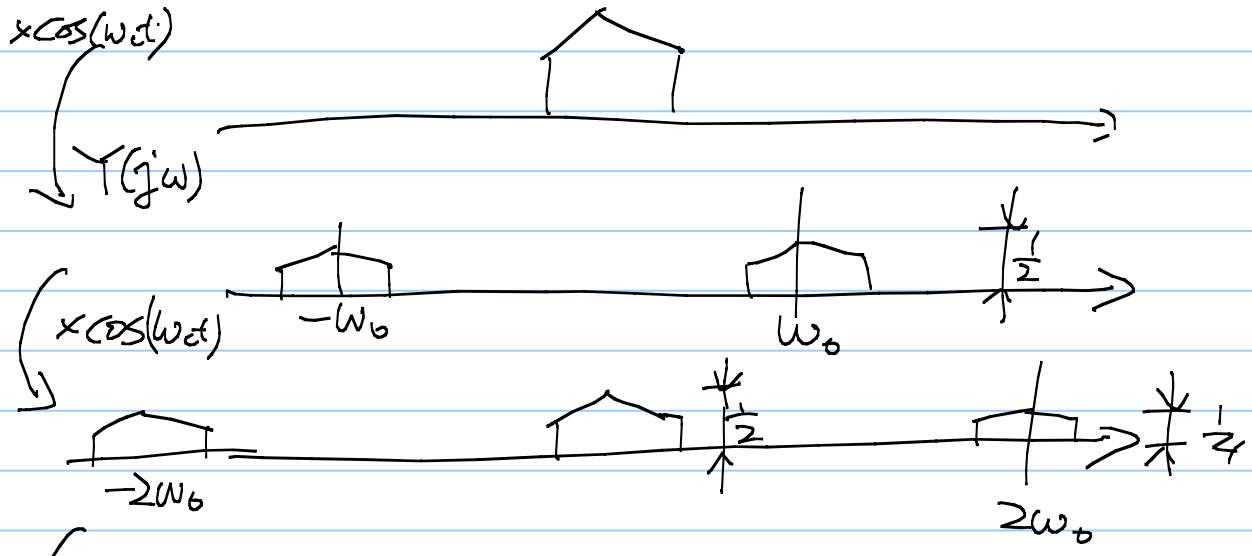
Note Title 10/28/2012

Try 2

* **Demodulation**



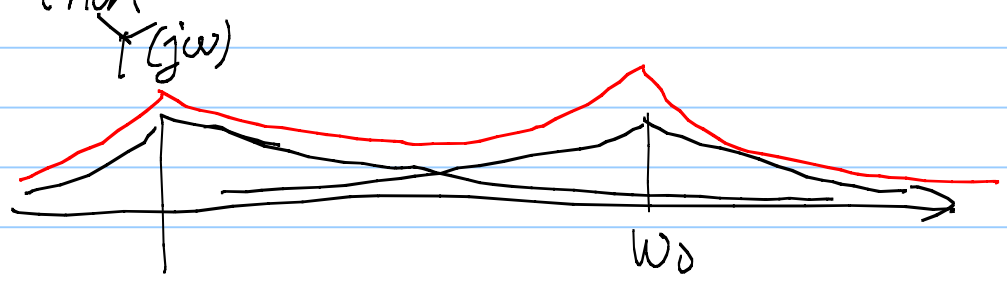
$X(jw)$



Apply LPF

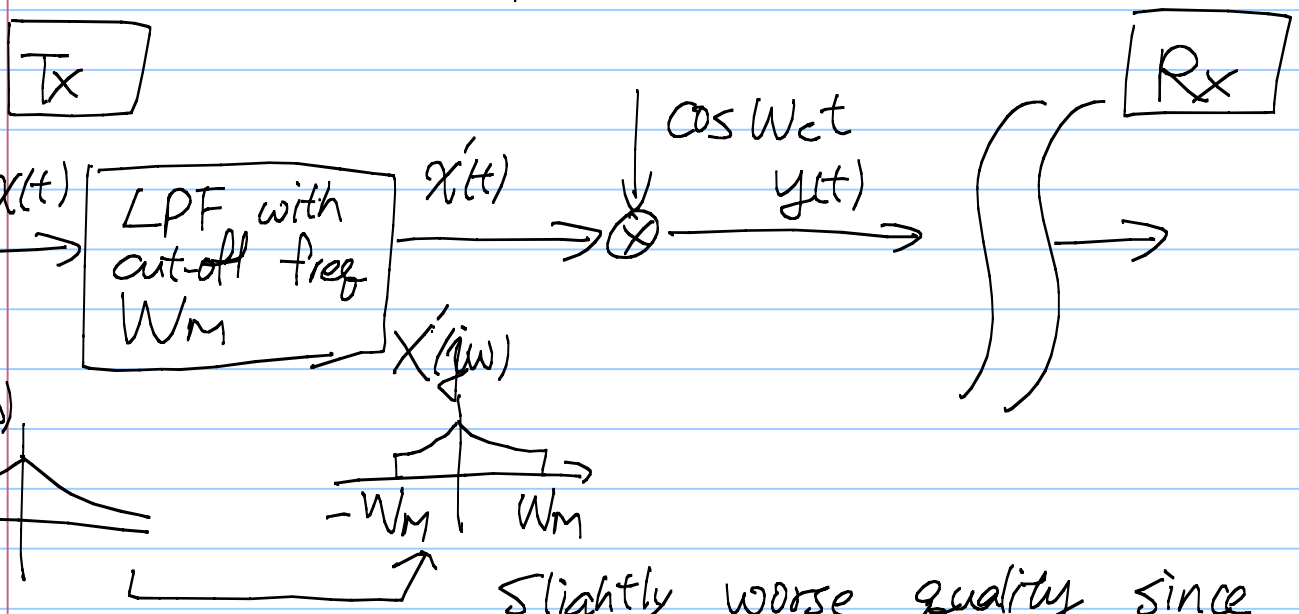
Drawback: ① What if $X(jw) = e^{-|w|}$

then



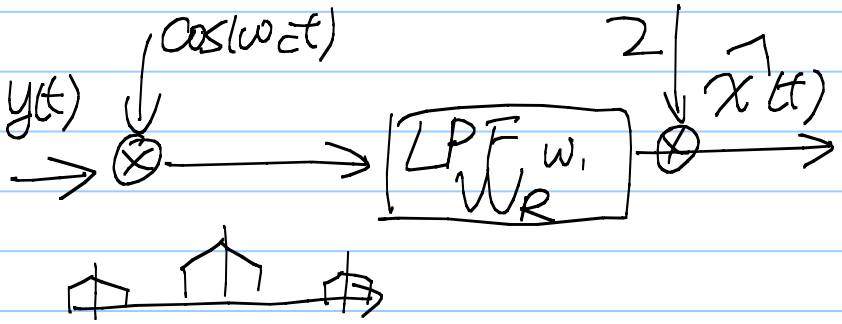
We do not have identical copies any more due to the undesired "frequency overlap" after multiplying $\cos(w_c t)$. The original signal is unrecoverable even before demodulation

Solution to drawback #1:
Make the input $x(t)$ band-limited



Slightly worse quality since we lose some high-freq components. However, we avoid the undesired freq overlay in the "center" of the freq band.

Cont'd



We have three frequency parameters to choose in this AM system.

① W_M : The cut-off freq to make x(t) band-limited

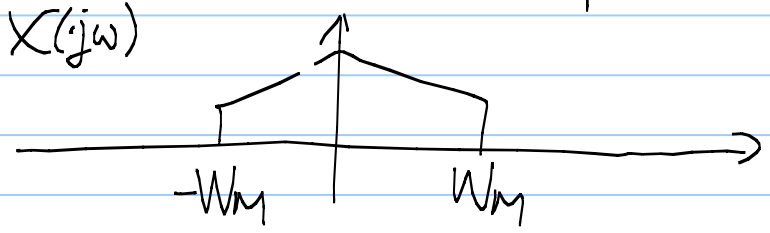
② w_c : The carrier freq

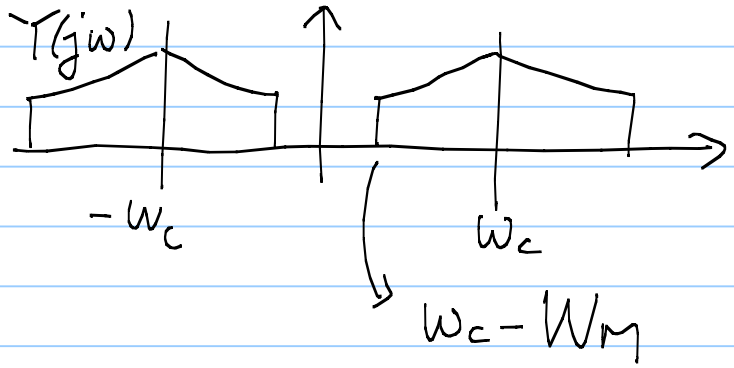
③ W_R : The cut-off freq at the receiver to recover the original signal.

How to choose them?

① W_C : Usually given by the government (FCC). Need to purchase "licence" to use certain frequency-band. Different frequency bands will have different price, depending on the transmission range, bandwidth, channel quality, etc.

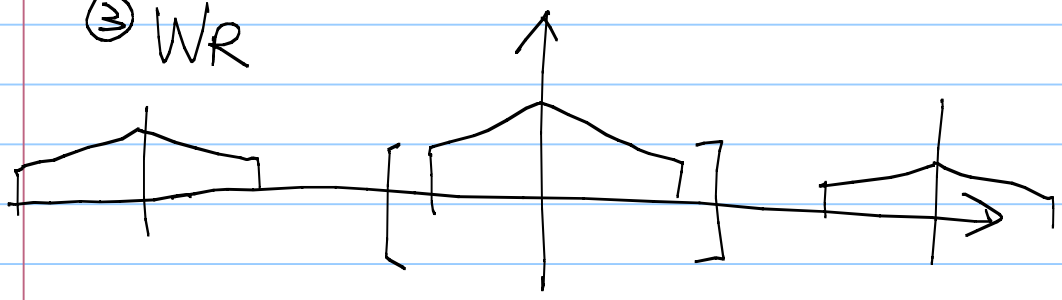
② W_M: To avoid overlap in freq





$\Rightarrow \quad w_c - W_M > 0 \Rightarrow \quad W_M < w_c.$

③ W_R



W_R : Choose it to be equal to or sightly larger than W_M