Signal Analysis & Communication ECE 355

Ch. 8.2. NON-IDEAL DEMODULATION

Ch. 8.3. FREQUENCY DIVISION MULTIPLEXING

Lecture 33

30-11-2023

Ch. 8.2. NON-IDEAL DEMODULATION

- Two commonly used methods.

① Synchronous Demodulation

- Assume that the transmitter & receiver are synchronized in phase θ_c (using "Phase locked loop (PLL)")
  - method for maintaining phase synchronism
  - Another method is called "costas loop".

- We have modulated signal

$$y_{(t)} = x_{(t)} \cos(\omega_c t + \theta_c)$$

- The demodulated signal is given as

$$w_{(t)} = y_{(t)} \cos(\omega_c t + \theta_c)$$

synchronized (same θ_c)

$$= \underbrace{\frac{1}{2} x_{(t)}}_{\text{Get back the original signal.}} + \underbrace{\frac{1}{2} x_{(t)} \cos(2\omega_c t + 2\theta_c)}_{\text{Filter out}}$$

NOTES

I. If unsychronized with phase, i.e., transmitter & receiver oscillator freq. are out of phase ($\theta_c \neq \phi_c$)

θ_c: transmitter's osc

ϕ_c: receiver's osc

- Then the demodulated sig. is given as:

$$w_{(t)} = x_{(t)} \cos(\omega_c t + \theta_c) \cdot \cos(\omega_c t + \phi_c)$$

$$= \frac{1}{2} x_{(t)} \cos(\theta_c - \phi_c) + \frac{1}{2} x_{(t)} \cos(2\omega_c t + \theta_c + \phi_c)$$

(using $\cos\alpha \cos\beta = \frac{1}{2}\cos(\alpha+\beta) + \cos(\alpha-\beta)$)

- The output of LPF is then given as:

$$\underline{\cos(\theta_c - \phi_c)}\, x_{(t)}$$

- That's fine ① If $(\theta_c - \phi_c)$ doesnot change over time.

(simple amplification)

② If $(\theta_c - \phi_c) \neq \frac{\pi}{2} + k\pi$

(equality makes $\cos(\theta_c - \phi_c) = 0$)

II. If unsynchronized with freq., i.e., transmitter & receiver oscillator freq. are not the same ($\omega_c \neq \omega_d$ assuming $\theta_c = 0$), then.

transmitter's OSC freq. / receivers OSC freq.

$$y_{(t)} = x_{(t)} \cos \omega_c t$$

$$W_{(t)} = x_{(t)} \cos(\omega_c t) \cdot \cos(\omega_d t)$$

$$= \frac{1}{2} x_{(t)} \cos(\underline{(\omega_c - \omega_d)} t) + \underbrace{\frac{1}{2} x_{(t)} \cos((\omega_c + \omega_d) t)}_{\text{Filter out}}$$

- Output of LPF:

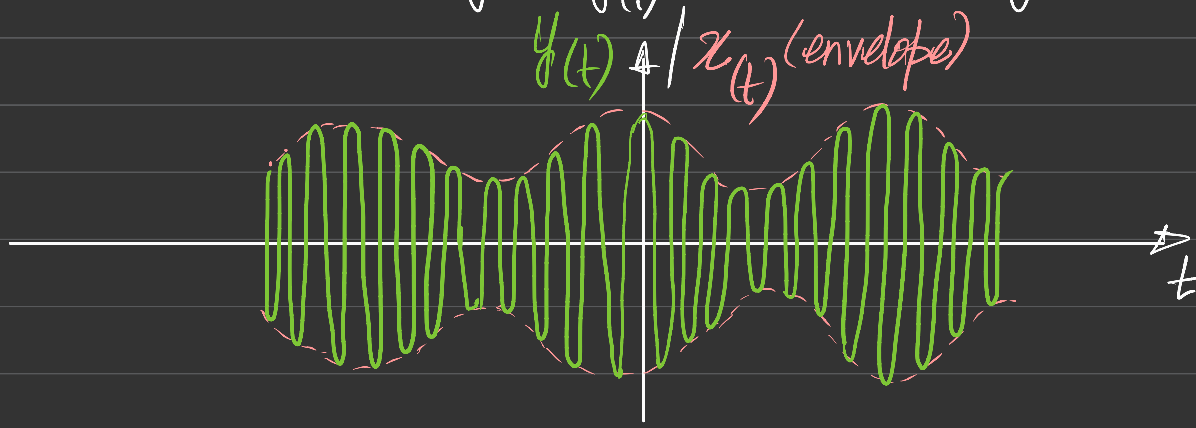
$$\underline{\cos((\omega_c - \omega_d) t)}\, x_{(t)}$$

I & II implies careful synchronization is needed b/w the modulator

& demodulator oscillator, which is often difficult.

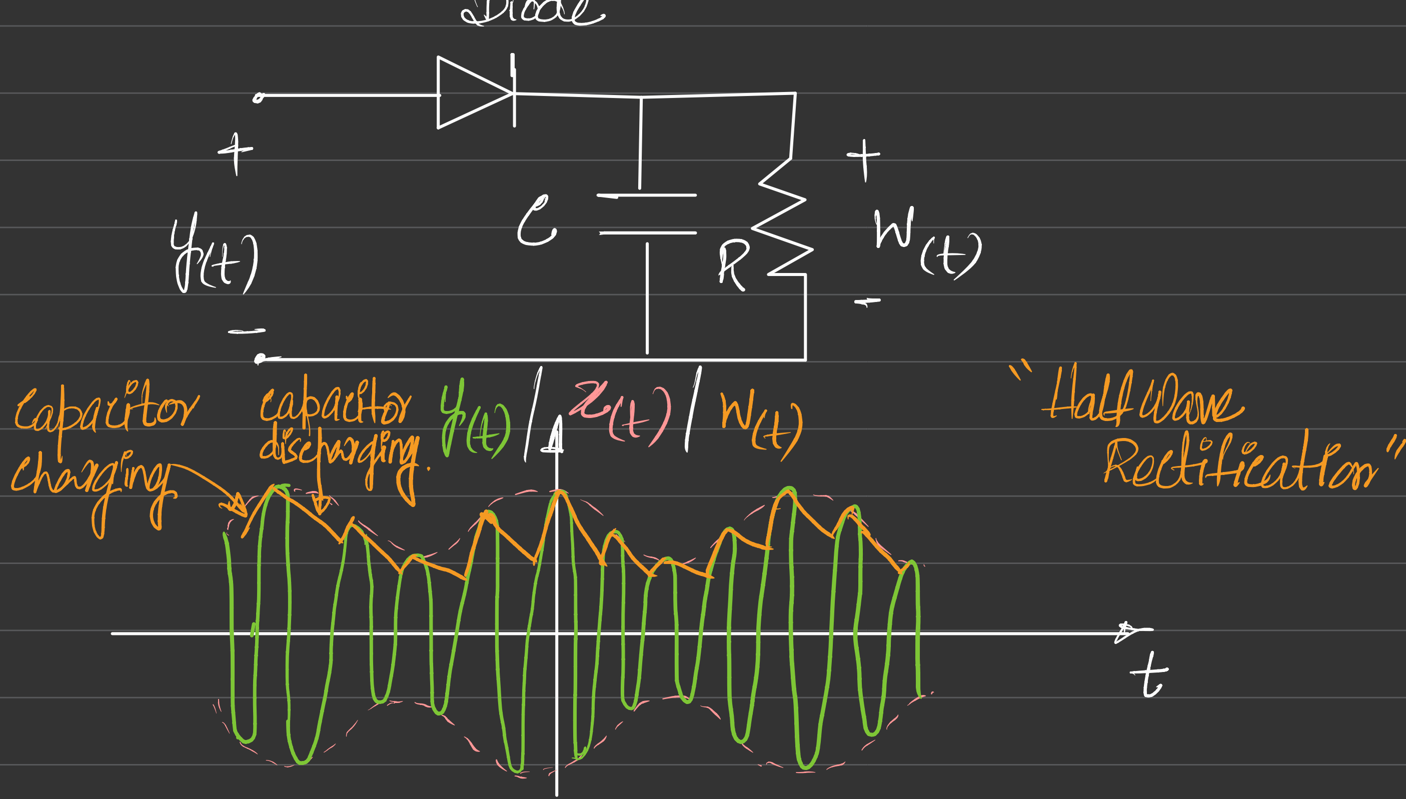
② Asynchronous Demodulation:

- Avoids the need for synchronization b/w modulator & demodulator.
- In particular, suppose $x_{(t)} \geq 0$ for all 't' & $\omega_c \gg \omega_M$
- The modulated sig., $y_{(t)}$ will then be given as:



- $x_{(t)}$ could approximately recovered through the use of system that tracks these peaks to extract the envelope.

Envelope Detector



NOTE

① When $\omega_c >> \omega_M$, $w(t) \simeq x(t)$

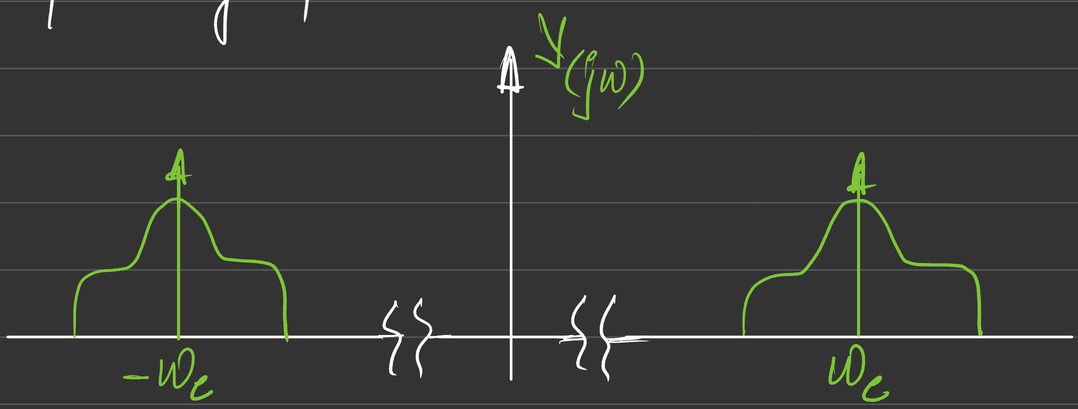
② $w(t)$ is usually sent to LPF to smoothen it more. (less ripples)

③ Non-linear System.

④ If $x(t)$ is not always non-negative, use $(x(t)+A)$ such that $(x(t)+A) \geq 0$, $\forall t$ $\Rightarrow$ requires more transmit power.

$$y(t) = (x(t)+A)\cos\omega_c t$$

- Corresponding Spectra.



- Here transmitted carrier (the impulses at $\pm\omega_c$)

"transmitted carrier mode"

(vs. "suppressed carrier mode")

⑤ More transmission power in Asynchronous Demodulation vs. Complex Receiver in Synchronous Demodulation.

Eg. Cheap Radio versus Satellite Radio.

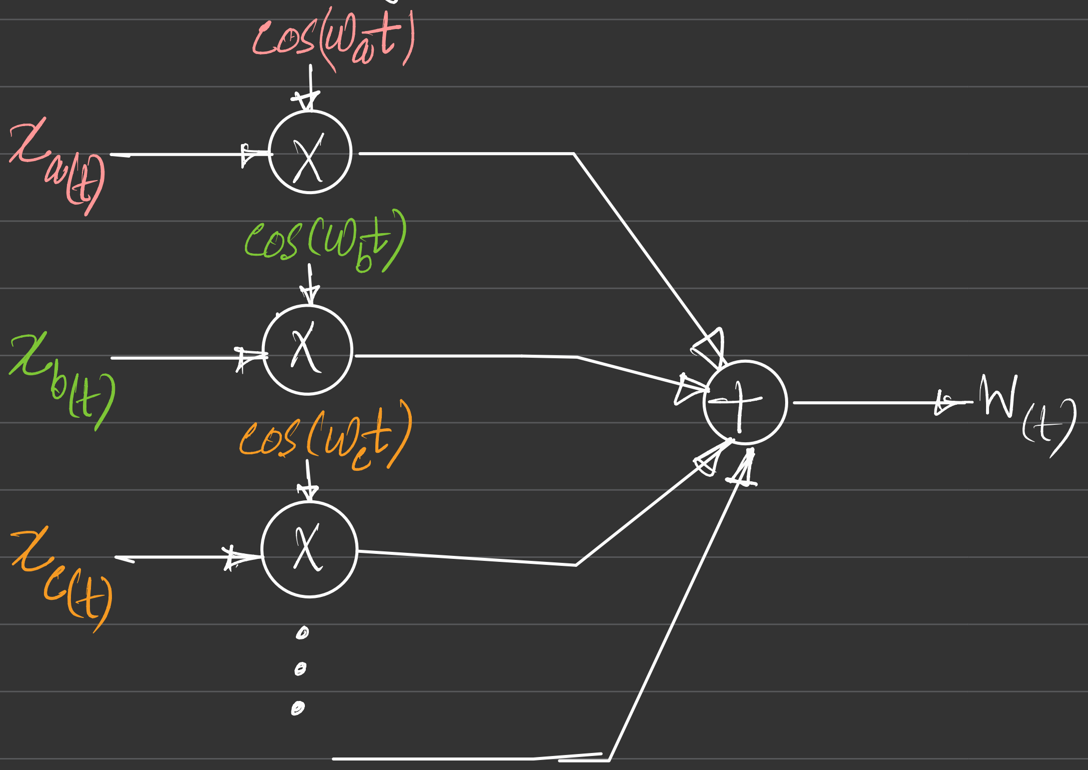
Ch. 8.3. FREQUENCY DIVISION MULTIPLEXING (FDM)

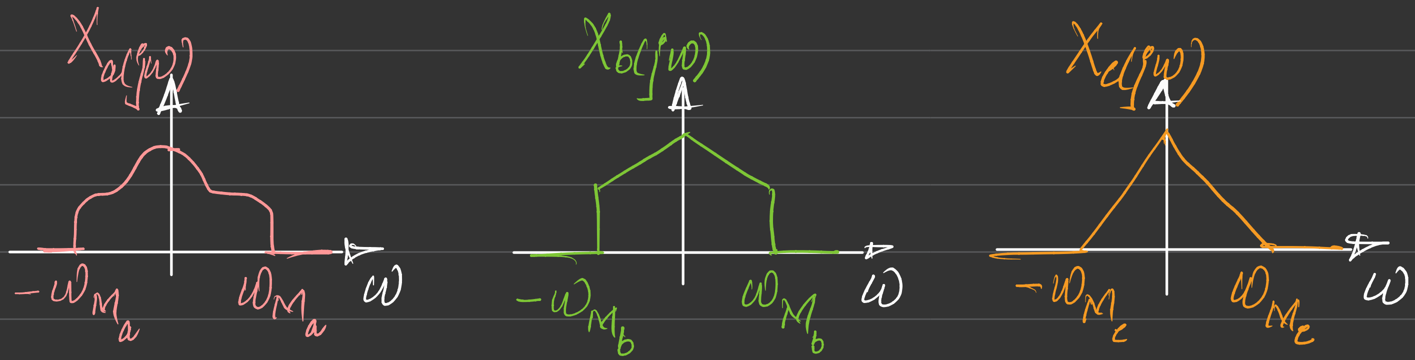
Goal: To simultaneously transmit multiple signals over a single wide band channel, for example a microwave link with a total bandwidth of several gigahertz.

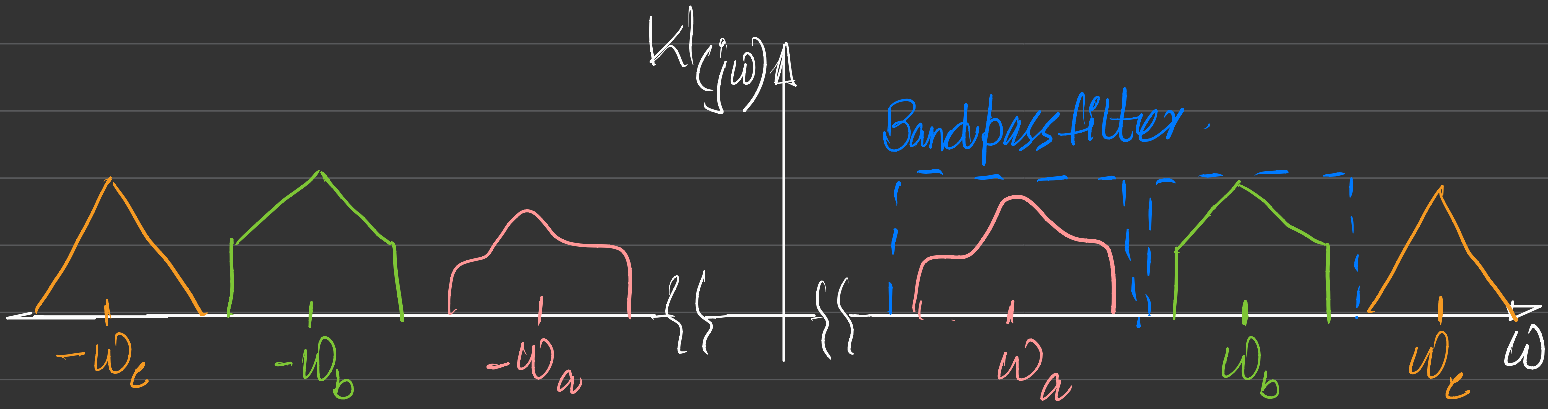
(Microwave Freq. Range is 300 MHz to 300 GHz)

- If the individual voice signals, which are overlapping in freq., have their freq. content shifted by means of sinusoidal AM so that the spectra of the modulated signals no longer overlap, they can be transmitted simultaneously over a single wideband channel.

- FDM → figure.







DEMULTIPLEXING: Bandpass Filtering.

Example: Radio Channels.