Review Test 1

- Signals & Systems
  + time
  + frequency
  + Fourier Trans Theorems
  + Bandwidth
  + Signals Through systems (filters)
  + Power & Energy
  + Period signals - FS

- Power Spectral Density

$x(t) \rightarrow \boxed{H(f)} \rightarrow y(t) \quad S_y(f) = S_x(f)\,|H(f)|^2$

$$P_x = \int_{-\infty}^{\infty} S_x(f)\, df$$

$$B_N = B_e = \frac{1}{2}\int_0^{\infty} |H(f)|^2 df \Big/ |H(0)|^2$$

- Ideal Filter
  + ILPF
  + IBPF

- Distortionless Transmission $y(t) = Kx(t-\tau)$

$H(f)$

- Quadrature rep of signals

$$y(t) = x_I(t)\cos(2\pi f_c t) + x_Q(t)\sin(2\pi f_c t)$$

Amp Modulation

- DSB-SC
  + $B_{RF} = 2B_x$
  + Sync receiver → carrier recovery
    pilot tone

- DSB-LC (Standard AM)

$y_{RF}(t) = A_c(1 + k_a x(t)) \cos 2\pi f_c t$

$k_a|x(t)||_{max} = m$

$m \leq 1$

+ $B_{RF} = 2B_x$

+ $P_c = A_c^2/2$ $P_s = \frac{A_c^2 m^2 P_x}{2}$ P_x = Power in $x(t)$ $|x(t)|_{max} = 1$

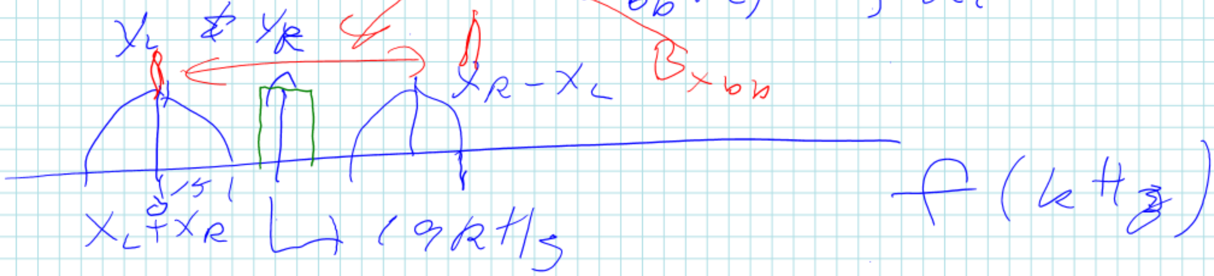
+ $\mu = \frac{P_s}{P_s + P_c}$ If $x(t) = \cos(2\pi f_m t)$

$\mu = m^2/(2+m^2)$

$\mu_{max} = \frac{1}{3}$ $m = 1$

+ Poor Power Efficiency
+ Simple Rec. → Envelope Det
+ Poor Low frequency response

- FDM $x_1(t) \ldots x_n(t) \longrightarrow$ use a part of RF spectrum to share
  + $x_i(t) \longrightarrow$ RF f_{sub_i}
  + $x_1 \ldots x_n(t)$ — form composite BB signal $x_{bb}(t) \longrightarrow$ RF



Calculate B_{RF}
Sketch RF spectrum

- Superhet
  + Block Diagram
  + $f_{LO} = f_c + f_{IF}$
  + BW & center frequency of components
  + Image Frequency

- SSB
  + $B_{RF} = B_x$
  + need sync rec
  + $y_{SSB}(t) = x(t)\cos 2\pi f_c t - \hat{x}(t)\sin(2\pi f_c t)$

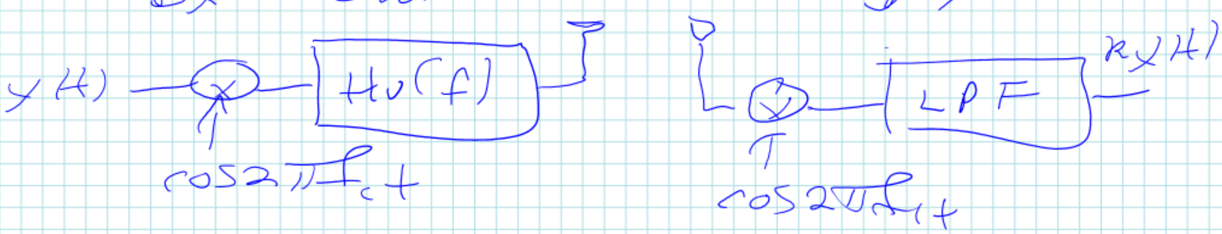
$$x(t) - \boxed{90^\circ} - \hat{x}(t)$$

  + SSB+LC
    * use envelope detector
    * not power efficient

\- + USB

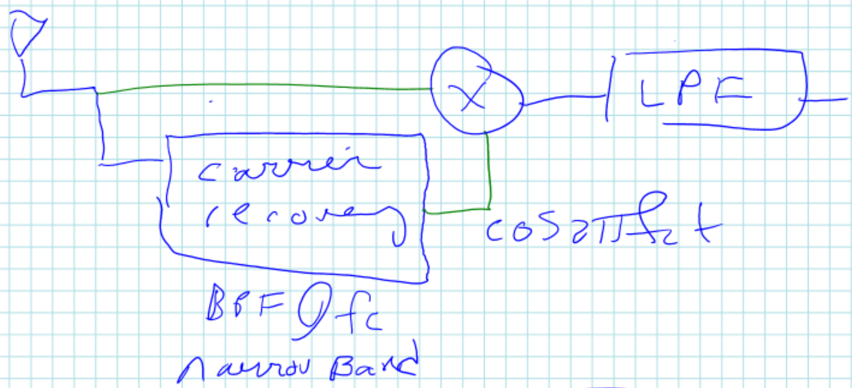
$B_x < B_{RF} < 2B_x$

Sync



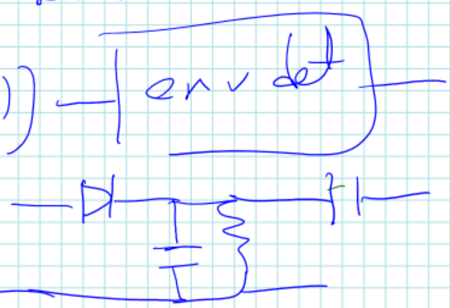
+ USB + LC

Sync rec



Env det

$y_{RF}(t)$ (or $y_{IF}(t)$)



Angle Mod

$$y_{RF}(t) = A_c \cos(\theta_i(t))$$

$$f_i(t) = \frac{1}{2\pi}\frac{d\theta_i(t)}{dt} \quad Hz$$

FM $f_i(t) \propto m(t)$

PM $\theta_i(t) \propto m(t)$

FM $y_{FM}(t) = A_c \cos\left(2\pi f_c t + k_f \int_0^t m(\lambda)\, d\lambda\right)$

FM is non linear

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

$$y_{FM}(t) = A_c \cos(2\pi f_c t + \beta \sin(2\pi f_m t))$$

$$= A_c \sum_{n=-\infty}^{\infty} J_n(\beta) \cos(2\pi(f_c + n f_m) t)$$

$J_n(\beta)$ → Table

Parameters

$$\Delta f = |x(t)|_{peak}\, k_f \quad \text{for special case}$$

$$= A_m k_f$$

$$\beta = \Delta f / f_m$$

Bandwidth

If β small $B_{RF} = 2B_x$

β large $B_{RF} = 2\Delta f$

ROT $B_{RF} = 2B_x(1+\beta)$

Power $P_T = A_c^2 / 2$

$$P_c = (A_c J_0(\beta))^2 / 2$$

1) $f_c + n f_m$ $\quad P_n = (A_c J_n(\beta))^2 / 2$

2) $f_c \pm n f_m$ $\quad P_{pair\ sidebands} = (A_c J_n(\beta))^2$

y_{WBFM}

Transmitters

+ Indirect $y_{NBFM}(t)$ → LPF → BPF

+ Pilot $f_i(t) = \frac{v_{in}(t)}{2\pi\sqrt{L\,C(t)}}$

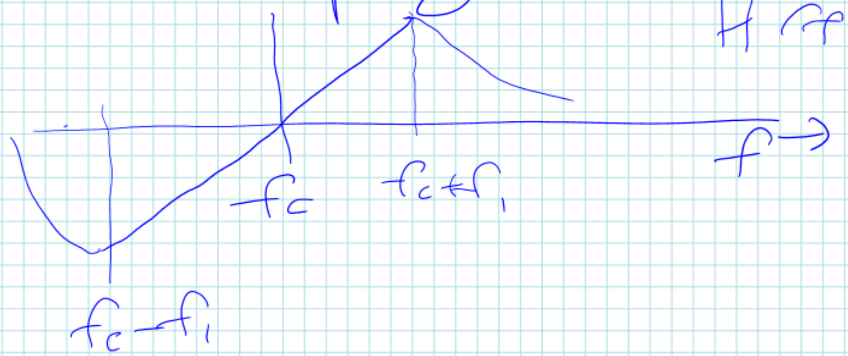
VCO $\qquad c(t) \propto m(t)$

Receivers

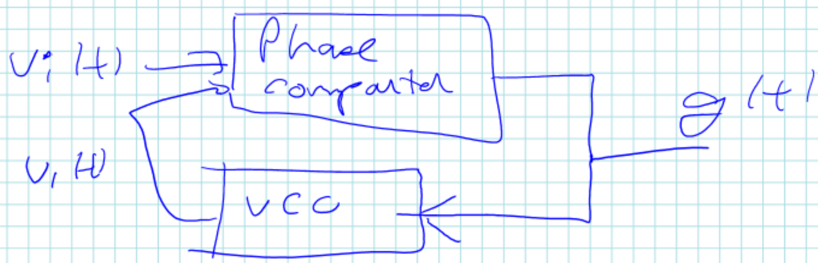
+ $\frac{dy_{FM}}{dt} \longrightarrow$ AM

+ Slope detector

+ Balanced frequency Discriminator

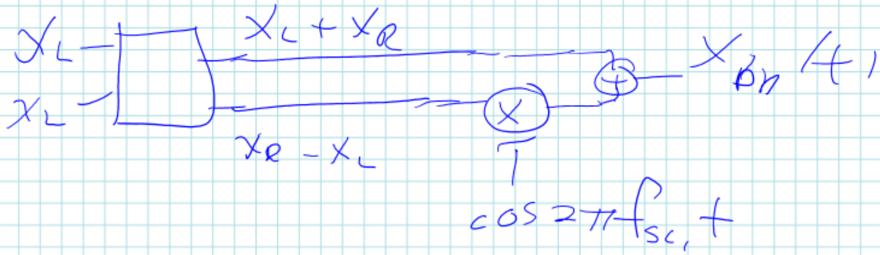


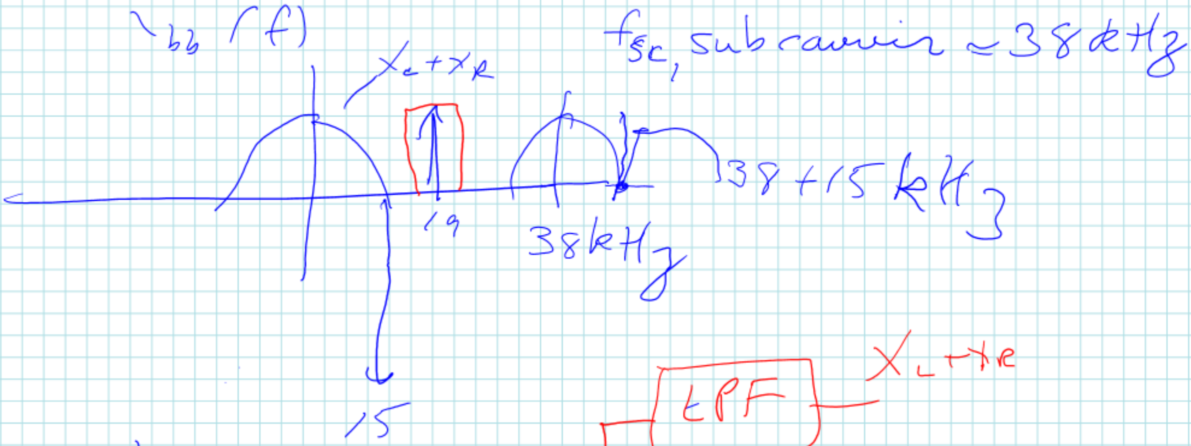
+ PLL

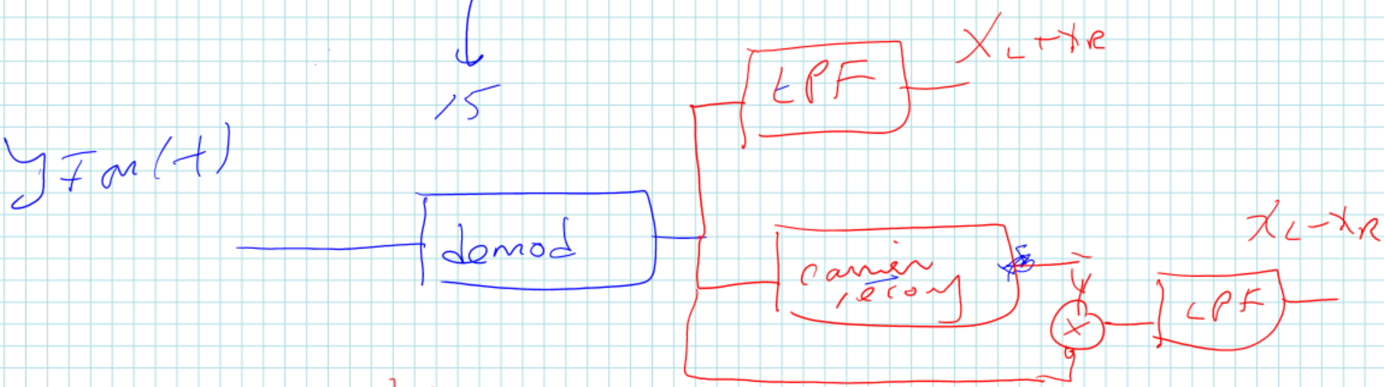


Input $f_i(t)$ of $v_i(t)$ to output $g(t)$

$f_i(t)$ is instantaneous freq of $v_i(t)$







HW#3 problem 1

$$m(t) = \cos(2\pi f_1 t) + .5\cos(2\pi f_2 t) + .25\cos(2\pi f_3 t)$$