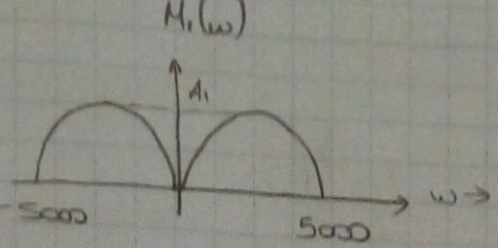
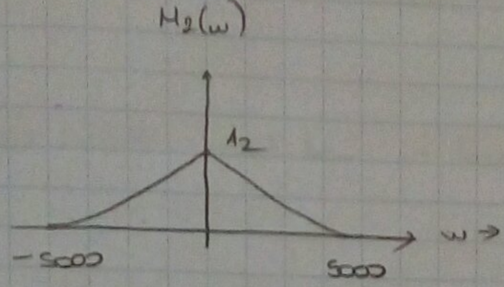
16.04.2018 (PS V)

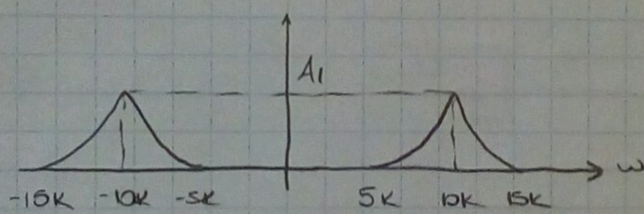
Q1)



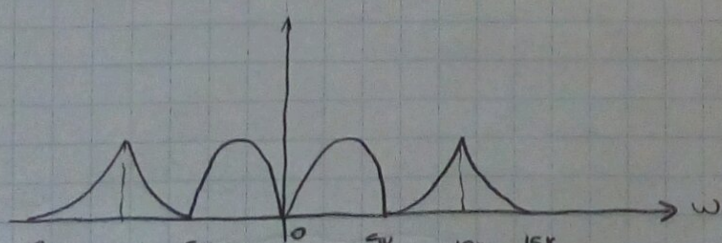


@ pt. a → $M_2(\omega)$ is modulated by $2.\cos 10000t$

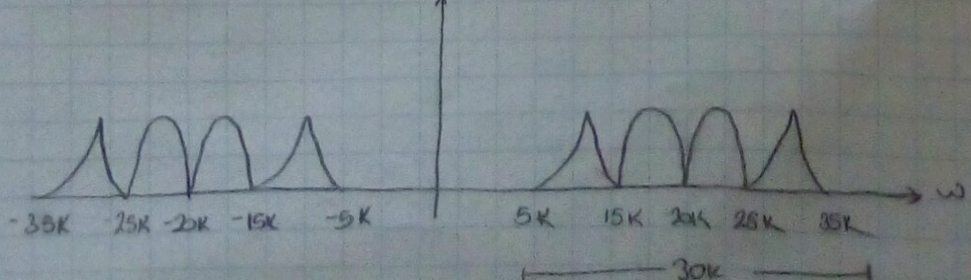
- Amp. of the modulated signal's spectrum remains the same.
- Spectrum is shifted by 10K



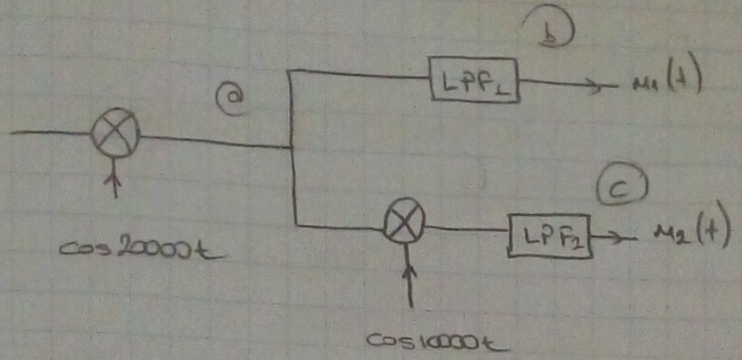
@ pt. b → $M_1(\omega)$ + Above spectrum



@ pt. c → Above spectrum is modulated by $2\cos 20000t$

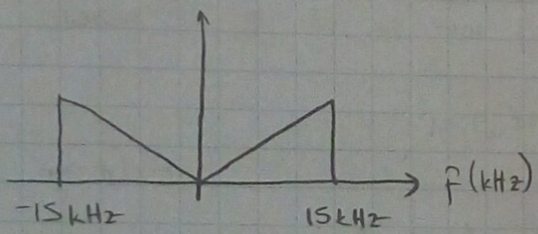


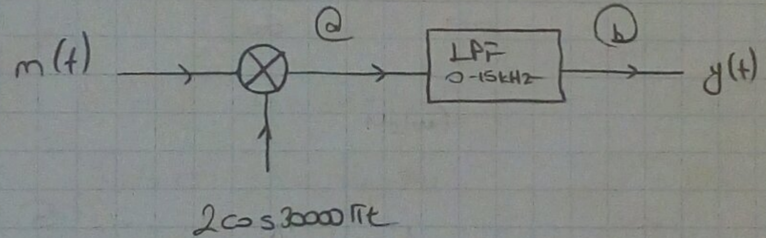
• Demodulation



b) Bandwidth must be at least 30000 rad/s (from 5K to 35K rad/s)

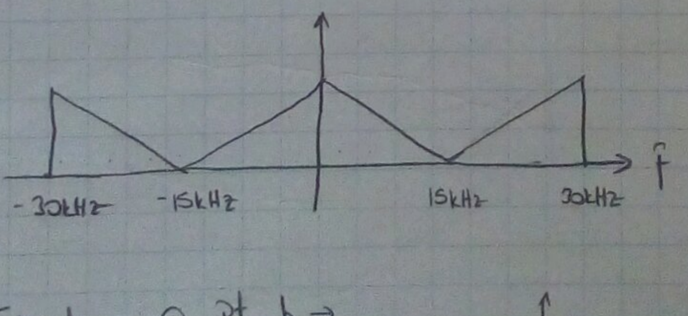
Q2) a) $M(\omega)$





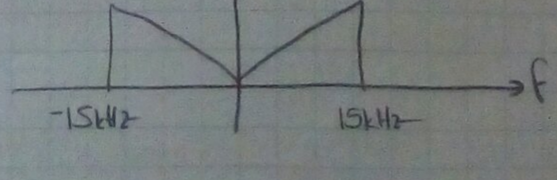
Spectrum @ pt. a → $\omega = 2\pi f$

$30000\pi = 2\pi f \rightarrow f = 15kHz$

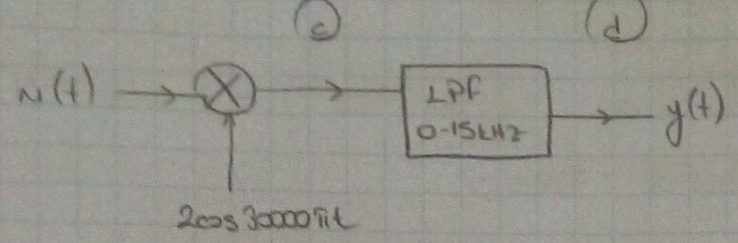


(Spectrum is inverted)

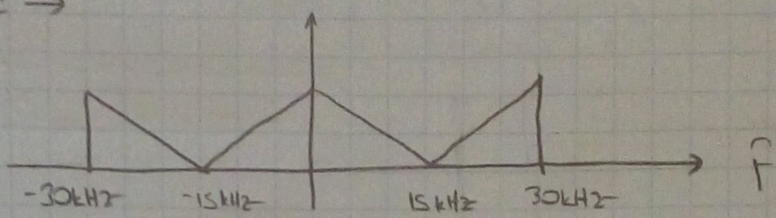
Spectrum @ pt. b →



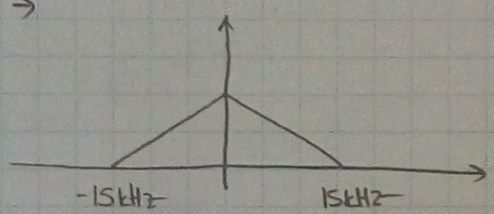
b) Descrambler



Spectrum @ pt. c →



Spectrum @ pt. d →



Q3) $m(t) = \cos(2\pi)10^6 t$

Carrier freq. = 1MHz

• Ring mod.

• BPF centered @ 400kHz.

• Sine wave gen. $\underbrace{(150\text{-}210\,\text{kHz})}$ ↓ Carrier freq. (200 kHz) ↳ $\times 2\pi$ $\underbrace{w_c = (400\pi).10^3}$

Desired signal → $c\,m(t).\cos(2\pi \times 400 \times 10^3 t)$

$c = ?$

• Input to the ring modulator is $m(t).\cos(2\pi)10^6 t$ instead of $m(t)$.

$v_i(t) = m(t).w_0(t)$

$= m(t).\cos(2\pi)10^6 t \,.\, w_0(t)$

$w_0(t) = \frac{4}{\pi}.\left(\cos w_c t - \frac{1}{3}\cos 3w_c t + \frac{1}{5}\cos 5w_c t - \dots\right)$

3

$v_i(t) = \frac{4}{\pi}.m(t).\cos(2\pi).10^6 t.\left[\cos w_c t - \frac{1}{3}\cos 3w_c t + \dots\right]$

$w_c = (400\pi)\times 10^3$

$$-\frac{1}{3} \cdot \cos 3w_c t = -\frac{1}{3} \cdot \cos 3 \cdot (400\pi) \cdot 10^3 t$$

Product of the terms $-\frac{1}{3} \cdot \cos 3(400\pi) \cdot 10^3 t$ and $(4/\pi) m(t) \cdot \cos(2\pi) \cdot 10^6 t$ yields the desired term;

$$y(t) = -\frac{2}{3\pi} m(t) \cdot \cos(800\pi) \, 10^3 t$$

$$= c \cdot m(t) \cdot \cos(2\pi \times 400) \cdot 10^3 t$$

$$c = -2/3\pi$$

Q4) Signal @ pt. a $\rightarrow [A+m(t)] \cdot \cos w_c t$

" " " b $\rightarrow [A+m(t)]^2 \cdot \cos^2 w_c t$

$$\cos^2 w_c t = \frac{1}{2}(1+\cos 2w_c t)$$

$$= \frac{A^2 + 2Am(t) + m^2(t)}{2} \cdot \underbrace{(1+\cos 2w_c t)}_{\text{suppressed by the LPF}}$$

Signal @ pt. c $\rightarrow \dfrac{A^2 + 2Am(t) + m^2(t)}{2}$

*(Usually, $m(t) \ll A$)

$$= \frac{A^2}{2}\left[1 + \frac{2m(t)}{A} + \cancel{\left(\frac{m(t)}{A}\right)^2}\right]$$

$$y(t) = \underbrace{\cancel{\frac{A^2}{2}}}_{\text{DC term}} + Am(t) \longrightarrow y(t) = A \cdot m(t)$$

blocked by DC blocker

Q5)

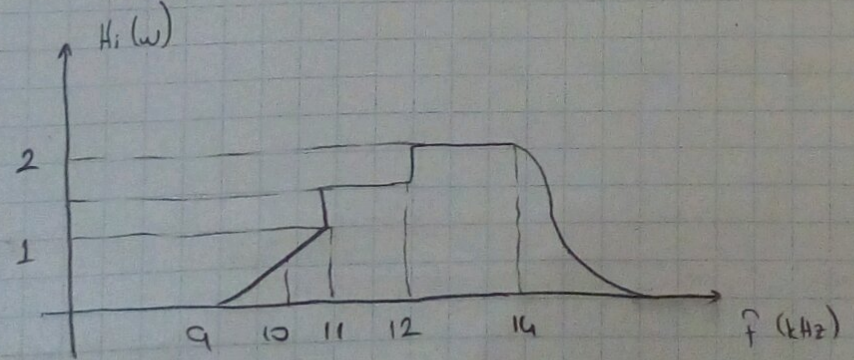
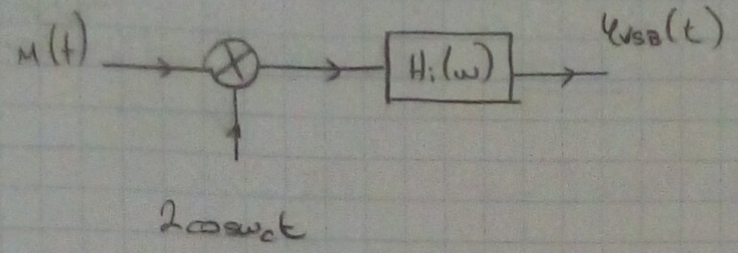
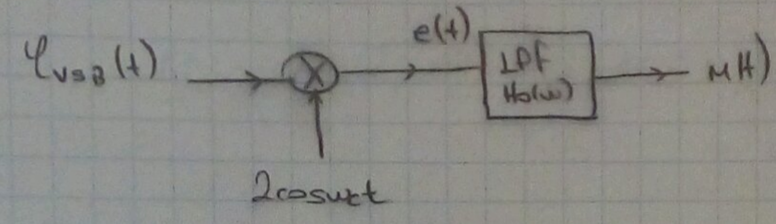


Fig. 4.22.



(Transmitter)



(Receiver)

- $\Phi_{VSB}(\omega) = [M(\omega+\omega_c) + M(\omega-\omega_c)] \cdot H_i(\omega)$

- $e(t) = 2\varphi_{VSB}(t) \cdot \cos\omega_c t \iff [\Phi_{VSB}(\omega+\omega_c) + \Phi_{VSB}(\omega-\omega_c)]$

- Output of LPF $\rightarrow$ $M(\omega) = [\Phi_{VSB}(\omega+\omega_c) + \Phi_{VSB}(\omega-\omega_c)] \cdot H_o(\omega)$

$$M(\omega) = M(\omega)[H_i(\omega+\omega_c) + H_i(\omega-\omega_c)] \cdot H_o(\omega)$$

($\pm 2\omega_c$ terms will be suppressed by the LPF)

$$H_o(\omega) = \frac{1}{H_i(\omega+\omega_c) + H_i(\omega-\omega_c)}$$

$$H_o(\omega)\left[(\cancel{M(\omega+2\omega_c)} + M(\omega)] \cdot H_i(\omega+\omega_c) + [M(\omega) + \cancel{M(\omega-2\omega_c)}] \cdot H_i(\omega-\omega_c)\right]$$

$$M(\omega) = M(\omega)[H_i(\omega+\omega_c) + H_i(\omega-\omega_c)] \cdot H_o(\omega)$$