Josh Andrews

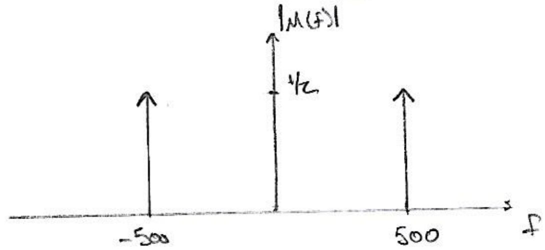
ECE 484

Homework 4

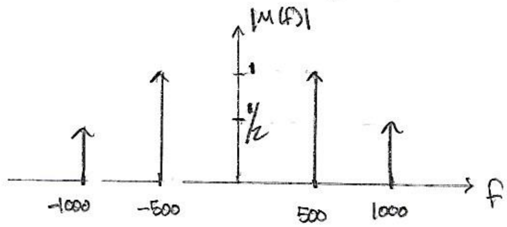
4.2-1 given the signals:

a) Sketch the spectrum

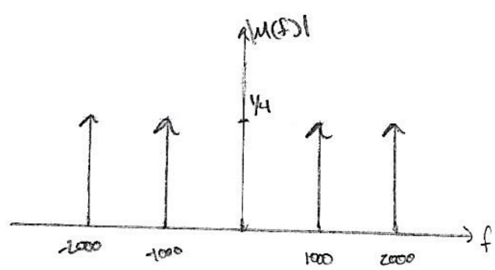
i) $m(t) = \cos 1000\pi t \Leftrightarrow M(f) = \frac{1}{2}[\delta(f+500) + \delta(f-500)]$



ii) $m(t) = 2\cos 1000\pi t + \sin 2000\pi t \Leftrightarrow M(f) = [\delta(f+500) + \delta(f-500)] + \frac{1}{2j}[\delta(f+1000) - \delta(f-1000)]$

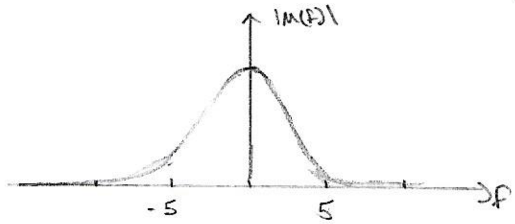


iii) $m(t) = \cos 1000\pi t \cos 3000\pi t \Leftrightarrow M(f) = \frac{1}{4}[\delta(f+1000) + \delta(f-1000) + \delta(f+2000) + \delta(f-2000)]$

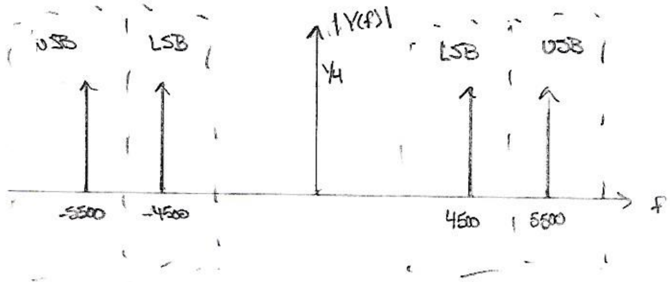


Josh Andrews HW 4 ECE 484

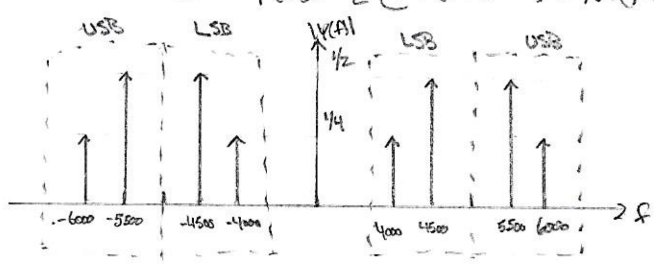
4.2-1) a) iv) $m(t) = e^{-10|t|} \Leftrightarrow M(f) = \frac{20}{100 + (2\pi f)^2} = \frac{0.2}{1 + (\frac{\pi f}{5})^2}$



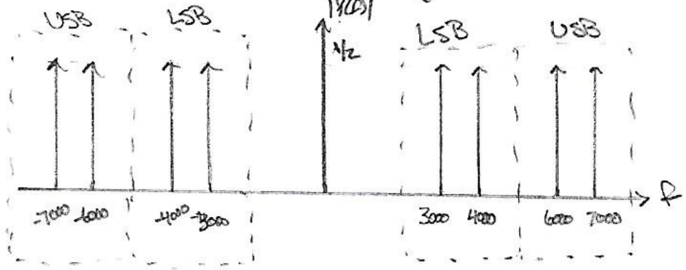
b and c) i) $y(t) = m(t)\cos 10{,}000\pi t \Leftrightarrow Y(f) = \frac{1}{2}\left[M(f+5000) + M(f-5000)\right]$



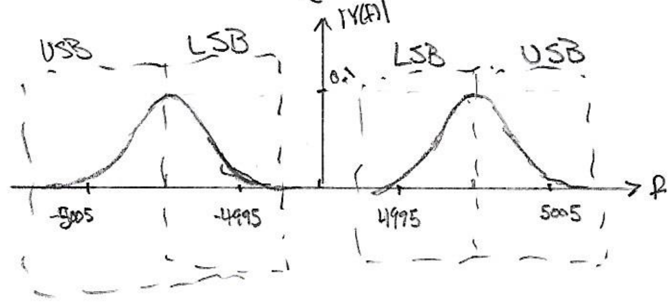
ii) $y(t) = m(t)\cos 1000\pi t \Leftrightarrow Y(f) = \frac{1}{2}\left[M(f+5000) + M(f-5000)\right]$



iii) put a copy of m(t) centered at ±500 with 1/2 magnitude



4.2-1) b2c) (v) shift to ± 5000 and ½ magnitude



4.2-5)

$$e_{o_1}(t) = \left(\frac{R}{R+r}\right)[A\cos(\omega_c t) + m(t)]$$

$$e_{o_2}(t) = \left(\frac{R}{R+r}\right)[-A\cos(\omega_c t) - m(t)]$$

and $e_o(t) = e_{o_1}(t) + e_{o_2}(t)$

and if $w(t) = \frac{2\pi}{\omega_c}$ $\Rightarrow$ $e_o(t) = \left(\frac{2R}{R+r}\right) m(t) w(t)$

a. $w(t) = \frac{1}{2} + \frac{2}{\pi}\left[\cos(\omega_c t) - \frac{1}{3}\cos(3\omega_c t) + \dots\right]$

but goes through band pass filter with ω_c $\Rightarrow$

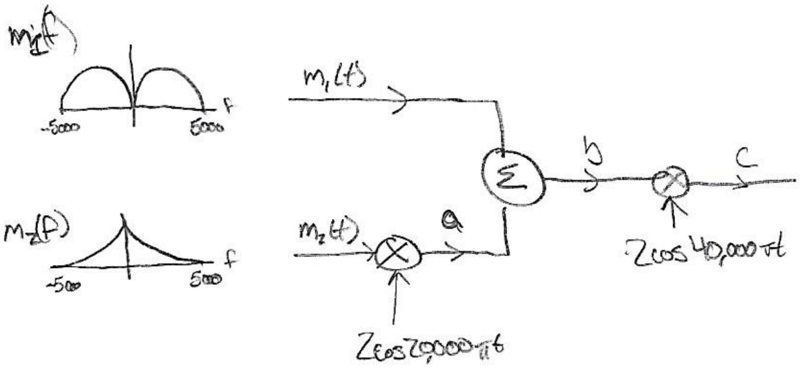
$$e_o(t) = \frac{2R}{R+r}\left[\frac{2m(t)\cos(\omega_c t)}{\pi}\right] = \underbrace{\frac{4R}{\pi(R+r)}}_{K}[m(t)\cos(\omega_c t)]$$

$\Rightarrow$ $\boxed{\text{yes, can be used } \; e_o(t) = Km(t)\cos(\omega_c t)}$

b. taking the bandpass filter output and passing through a low pass filter would de-modulate the signal

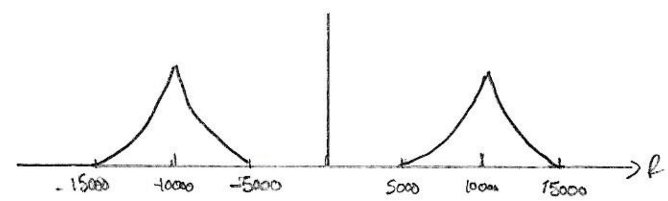
$\underline{Km(t)}$

4.2-7)

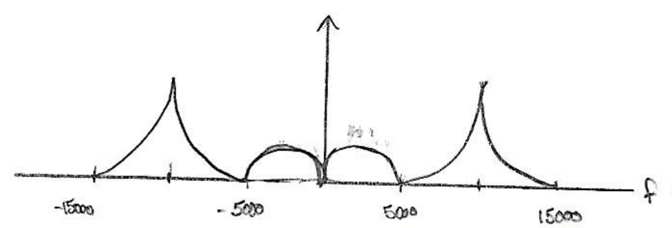


a. Sketch spectrum at a, b, and c

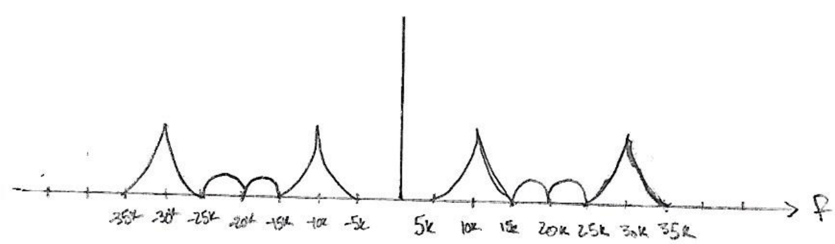
a →



b →

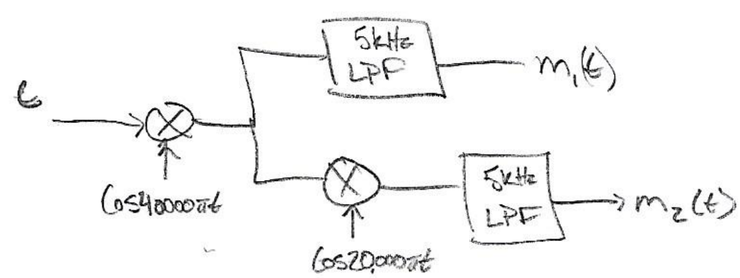


c →

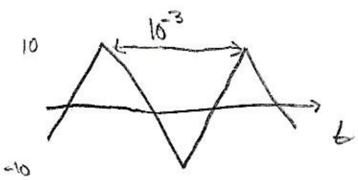


b. looking at positive side of graph above ↑ ⇒ bandwidth is 30KHz

c. It is much like the modulation above, multiply by a carrier and pass through low pass filter



4.3-3) given the AM signal with $m(t)$ and $\mu = 0.75$



a. Find the amplitude and power

$$\mu = \frac{m_p}{A} \Rightarrow A = \frac{m_p}{\mu} = \frac{10}{0.75} \Rightarrow \boxed{A = \frac{40}{3}}$$

$$P_c = \frac{1}{2}A^2 = \frac{1}{2} \cdot \frac{1600}{9} \Rightarrow \boxed{P_c = \frac{800}{9}}$$

b. Find power of sideband and η

$$P_s = \frac{1}{2} \cdot \frac{1}{10^3} \int_{-\frac{10^{-3}}{2}}^{\frac{10^{-3}}{2}} \left(\frac{20}{\left(\frac{10^{-3}}{2}\right)} t - 10\right)^2 dt$$

$$P_s = 1000 \int_0^{\frac{10^{-3}}{2}} 16 \cdot 10^8 t - 8 \cdot 10^5 t + 100 \, dt \Rightarrow \boxed{P_s = \frac{50}{3}}$$

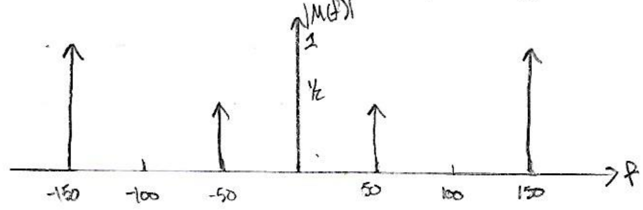
$$\eta = \frac{P_s}{P_s + P_c} = \frac{\frac{50}{3}}{\frac{50}{3} + \frac{800}{9}} \Rightarrow \boxed{\eta = \frac{3}{19} = 15.7\%}$$

4.3-6) if the input to each is $m(t)$ the DSB-SC output is $m(t)\cos(\omega_c t)$
and if the input is $A + m(t)$ then DSB-SC output is $(A + m(t))\cos(\omega_c t)$
which is the same as AM $\Rightarrow$ Can be used if a DC signal is added

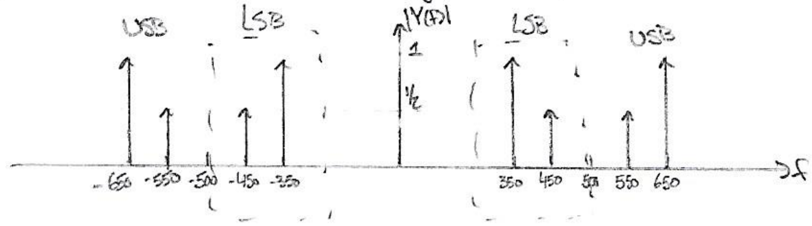
The converse is not generally true but can use two AM generators
DSB-SC signals in balanced scheme

4.4-2) given

a. i) $m(t) = \cos 100\pi t + 2\cos 300\pi t \Leftrightarrow M(f) = \frac{1}{2}[\delta(f-50)+\delta(f+50)] + [\delta(f-150)+\delta(f+150)]$



ii) if $y(t) = 2m(t)\cos 1000\pi t$ so signal is copied at ± 500



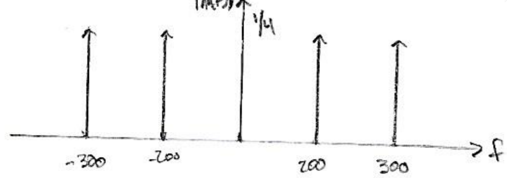
iii) plot same as above only without LSB signals removed

iv) only considering the USB signals $\Rightarrow \varphi_{USB}(t) = 2\cos(2\pi \cdot 650t) + \cos(2\pi \cdot 550t)$

v) and now looking at LSB signal $\Rightarrow \varphi_{LSB}(t) = 2\cos(2\pi \cdot 350t) + \cos(2\pi \cdot 450t)$

b. i) $m(t) = \sin 100\pi t \cdot \sin 500\pi t = \frac{1}{2}\left(\cos(2\pi \cdot 200t) - \cos(2\pi \cdot 300t)\right)$

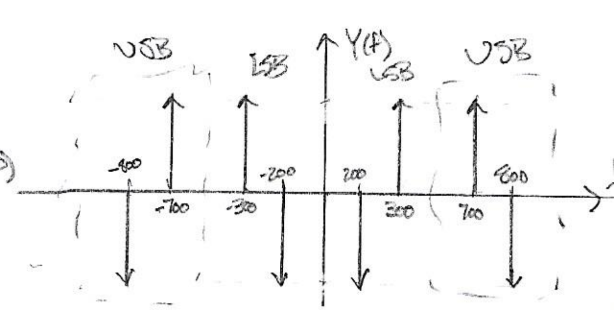
$M(f) = \frac{1}{4}\left[\left(\delta(f-200)+\delta(f+200)\right) - \left(\delta(f-300)+\delta(f+300)\right)\right]$



ii) $2m(t)\cos 2\pi f_c t \Leftrightarrow M(f-f_c) + M(f+f_c) \Rightarrow$

$Y(f) = \frac{1}{4}\left(\delta(f-700)+\delta(f-300)\right) - \frac{1}{4}\left(\delta(f-800)+\delta(f-200)\right)$

$+ \frac{1}{4}\left(\delta(f+300)+\delta(f+700)\right) - \frac{1}{4}\left(\delta(f+200)+\delta(f+800)\right)$



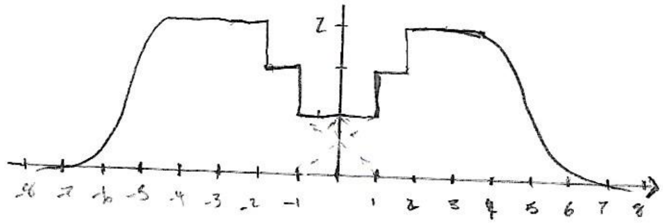
4.4-2) b. iii) USB signal is indicated on graph on previous page

$$\boxed{\varphi_{USB}(t) = \frac{1}{2}\left(\cos 2\pi(700)t - \cos 2\pi(800)t\right)}$$

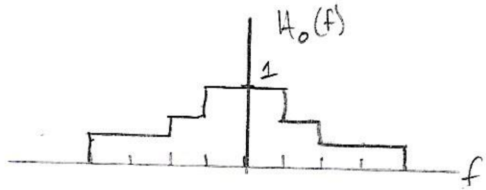
iv) LSB signal is indicated

$$\boxed{\varphi_{LSB}(t) = \frac{1}{2}\left(\cos 2\pi(300t) - \cos 2\pi(200t)\right)}$$

4.5-1) In order to get the transfer function of the equalizing, have to take the input transfer function and shift it $\pm f_c$, then the output filter will be reciprocal of the resulting transfeer function

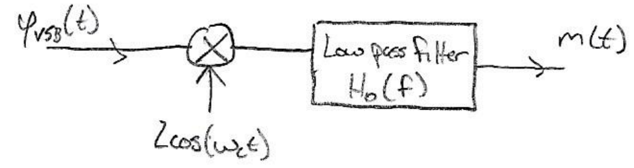


bandwidth is 4kHz of low pass filter its going through ⇒ dont need to worry about stuff over 4kHz



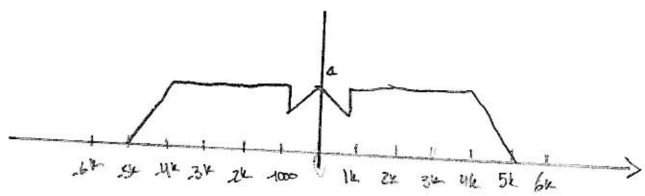
Josh Andrews HW 4 ECE 484 8

4.5-2) a.



b. From the vestigal filter the bandwidth is 4kHz (1.501 to 1.495 MHz)

c. Need to take input, superimposed & shifted



and then take reciprocal, ignoring parts above bandwidth to get output