ECE 195B/218B Homework #1 Solutions

#1

$P_{min} = KTFBQ^2 \qquad F = 5dB = 3.16$

$= (1.38\times10^{-23} J/K)(300K)(3.16)(1\times10^6 b/s)(36)$

$P_{min,received} = 4.71\times10^{-13} W = -93.27 dBm$

Friis transmission in fair weather: ($\alpha = 0$)

$$\left(\frac{P_{received}}{P_{transmitted}}\right) = \left(\frac{D_t D_r}{16\pi^2}\right)\left(\frac{\lambda^2}{R^2}\right) \qquad \lambda = \frac{3\times10^8 m/s}{1GHz} = .3m$$

$D_t = D_r = 1.64$

$$\frac{P_r}{P_t} = \left(\frac{1.64^2}{16\pi^2}\right)\left(\frac{.3m^2}{10km^2}\right) = 1.53\times10^{-11} = -108.15dB$$

$$P_{trans} = \frac{P_r}{P_{att}} = \underline{14.87dBm}$$

The rain attenuation graph is already given in dB/km. No need to convert to base e

$f_c = 1GHz$ & $50mm/hr.$: $P_{loss,atm.} = 2\times10^{-3} dB/km \cdot 10km = 2\times10^{-2} dB$

$$\frac{P_r}{P_t} = \left(\frac{D_t D_r}{16\pi^2}\right)\left(\frac{\lambda^2}{R^2}\right)e^{-\alpha R} = \left(\frac{1.64^2}{16\pi^2}\right)\left(\frac{.3}{10{,}000}\right)^2 - 2\times10^{-2}dB = -108.17dB$$

$$P_t = \frac{P_r}{P_{att}} = \underline{14.89dBm}$$

$A = \pi H^2 = \pi R_1 \lambda/2 = \pi(200m)(.3m)/2 = \underline{94.25m^2 = A}$

dipole antenna: $\ell = \lambda/2$

$\underline{\ell = 0.15m}$

#2

$f_c = 100\text{ MHz}$ $\quad P_{min,\,received} = -93.27\text{dBm}$ from #1

$$\lambda = \frac{3\times10^8\text{ m/s}}{100\text{ MHz}} = 3\text{m}$$

$$\frac{P_r}{P_t} = \left(\frac{1.64^2}{16\pi^2}\right)\left(\frac{3\text{m}}{10\text{Km}}\right)^2 = 1.53\times10^{-9} =$$

$$P_{trans} = \frac{P_{received}}{P_{att}} = .308\text{mW} = \underline{-5.12\text{dBm}}$$

Rayleigh scattering λ^{-4} slope $\approx \dfrac{3\text{decades(dB)}}{\text{decade(Hz)}}$

$$P_{loss,atm.}(100\text{MHz}) \approx 2\times10^{-6}\text{dB/Km}\cdot10\text{Km} = 2\times10^{-5}\text{dB}$$

$$\frac{P_r}{P_t} = \left(\frac{1.64^2}{16\pi^2}\right)\left(\frac{3\text{m}}{10\text{Km}}\right)^2 - 2\times10^{-5}\text{dB}$$

$$\underline{P_t \cong -5.12\text{dBm}}$$

$$A = \pi r^2 = \pi R_1 \lambda/2 = \frac{\pi(200\text{m})(3\text{m})}{2} = \underline{942.5\text{m}^2 = A}$$

dipole antenna: $\lambda/2 \Rightarrow \underline{1.5\text{m} = l}$

#3 $f_c = 10\,GHz$ $\underline{P_{min.rec.} = -93.27\,dBm}$

$$\lambda = \frac{3\times10^8\,m/s}{10\,GHz} = .03\,m \qquad D_t = 1000\ (30\,dB) \quad D_r = 1.64$$

$$\frac{P_r}{P_t} = \left(\frac{1000\cdot1.64}{16\pi^2}\right)\left(\frac{.03}{10000}\right)^2 \qquad \cancel{e^{-\alpha R}}\approx 1$$

$$P_{atten.} = \frac{P_r}{P_t} = 9.35\times10^{-11} = -100.29\,dB$$

$$P_t = P_r(dB) - P_{atten.}(dB)$$

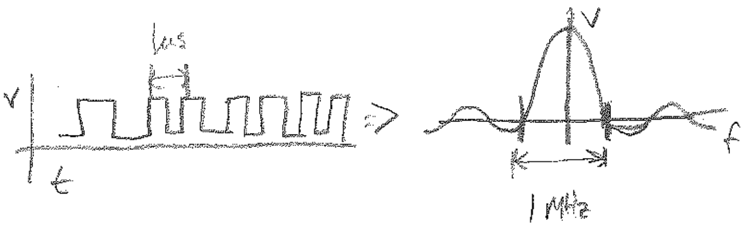
$$\underline{P_{trans.} = 7.02\,dBm}$$

50mm/hr @ 10GHz $f_c \approx 1.8\,dB/Km \times 10\,Km = 18\,dB$

$$\frac{P_r}{P_t} = -100.29\,dB - 18\,dB = -118.29\,dB$$

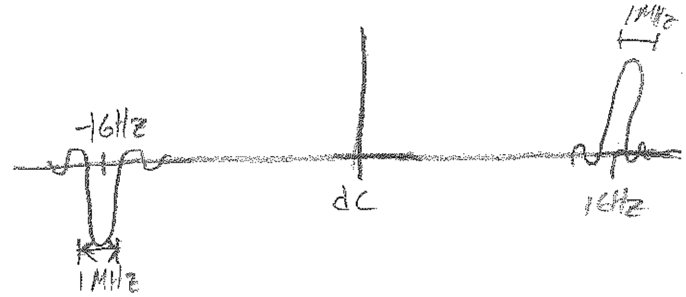
$$\underline{P_{trans} = 25.02\,dBm}$$

4

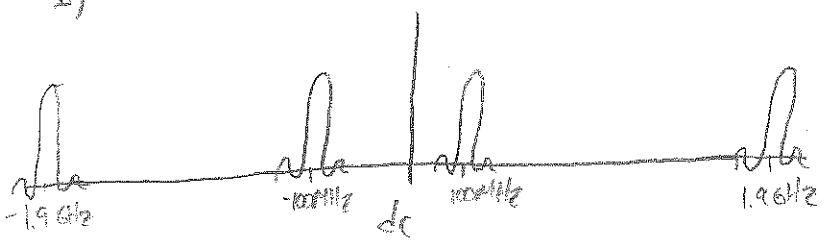


a) V real (I)

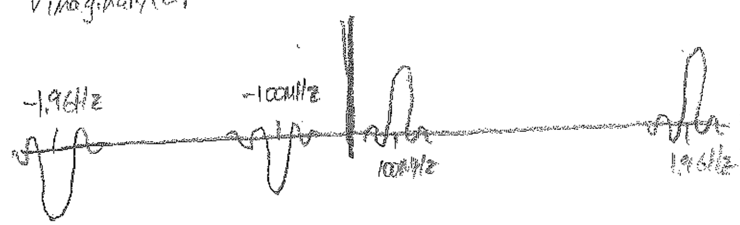
V imaginary (Q)



b) Vreal (I)



Vimaginary (Q)



c) Bandpass filter after 1st mixer will remove 1.9GHz signals.
Left with:

$$V_{B,I}(t)\cdot \underbrace{\cos(\omega_{IF}t)} + V_{B,Q}(t)\cdot\sin(\omega_{IF}t)$$

$$V_S(t) = V_{B,I}(t)\left(Z_{IF}^{1}+Z_{IF}^{-1}\right) + V_{B,Q}(t)\cdot\left(Z_{IF}^{1}-Z_{IF}^{-1}\right)$$

$$I:\ V_S(t)\cdot\cos(\omega_{IF}t) = V_S(t)\cdot\left(Z_{IF}^{1}+Z_{IF}^{-1}\right) = V_{B,I}(t)\left(Z_{IF}^{1}+Z_{IF}^{-1}\right)^2 + V_{B,Q}(t)\left(Z_{IF}^{1}+Z_{IF}^{-1}\right)\left(Z_{IF}^{1}-Z_{IF}^{-1}\right)$$

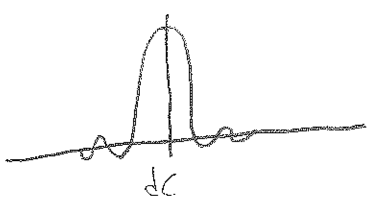
$$= V_{B,I}(t)\cdot\left(Z_{IF}^{2}+2+Z_{IF}^{-2}\right) + V_{B,Q}(t)\cdot\left(Z_{IF}^{2}-Z_{IF}^{-2}\right)$$

$$= 2V_{B,I}(t) + V_{B,I}(t)\cdot\cos(2\omega_{IF}t) + V_{B,Q}(t)\cdot\sin(2\omega_{IF}t)$$

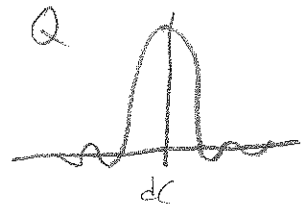
$2\cdot\omega_{IF}$ terms get filtered out leaving you $2\cdot V_{B,I}(t)$

similarly for Q: $2V_{B,Q}(t) + V_{B,Q}(t)\cdot\sin(2\omega_{IF}t) + V_{B,I}(t)\cdot\cos(2\omega_{IF}t)$

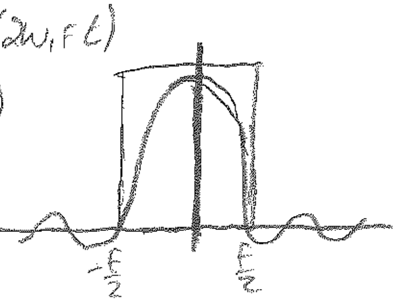
I



Q



d)



filter BW = f_{bw} = 1 MHz