5.13 For $\rho = -10\,dB \doteq 0.316$,

$$\bar{\tau} = \frac{e^{\rho^2}-1}{\rho f_m \sqrt{2\pi}} \Rightarrow f_m = \frac{e^{\rho^2}-1}{\rho \cdot \bar{\tau}\sqrt{2\pi}} = \frac{e^{0.316^2}-1}{0.316\times10^{-3}\times\sqrt{2\pi}} \doteq 132.8\,(Hz)$$

$$f_m = \frac{v}{\lambda} \Rightarrow v = f_m\cdot\lambda = f_m\cdot\frac{c}{f_c} = 132.8\times\frac{1}{3} \doteq 44.3\,(m/s)$$

$$\Rightarrow d = v\cdot t = 44.3\times10 = \underline{\underline{443\,m}}$$

For $\rho = 1$, $N_R = \sqrt{2\pi}\cdot f_m\cdot\rho\cdot e^{-\rho^2} = \sqrt{2\pi}\times132.8\times1\times e^{-1} \doteq 122.4$ (crossings/s)

$\Rightarrow$ Total number of fade the signal undergo at the rms threshold level during a 10 second interval $= N_R t = \underline{\underline{408}}$

5.14 From Fig. P5.14, we have

$$v(t) = \begin{cases} 3t & 0 \le t < 10 \\ 30 & 10 \le t < 90 \\ 300-3t & 90 \le t < 100 \end{cases}$$

$$\lambda = \frac{c}{f_c} = \frac{3\times10^8}{900\times10^6} \doteq 0.33\,(m)$$

For $\rho = 0.1$, $T = 100$ Second, we have

$$N_R = \frac{1}{T}\int_0^T \sqrt{2\pi} f_m \cdot \rho \cdot e^{-\rho^2}\,dt$$

5.14 Cont'd

$$= \frac{1}{T}\int_0^T \sqrt{2\pi}\cdot\frac{V(t)}{\lambda}\cdot\rho\cdot e^{-\rho^2}dt$$

$$= \frac{1}{T}\cdot\frac{\sqrt{2\pi}}{\lambda}\cdot\rho\cdot e^{-\rho^2}\cdot\int_0^T V(t)\,dt$$

$$= \frac{1}{100}\times\frac{\sqrt{2\pi}}{0.33}\times 0.1\times e^{-0.1^2}\cdot\left[2\times\int_0^{10} 3t\,dt + \int_{10}^{90} 30\,dt\right]$$

$$= \frac{1}{100}\times\frac{\sqrt{2\pi}}{0.33}\times 0.1\times e^{-0.1^2}\times 2700$$

$$\doteq 20.1 \text{ (Crossings/s)}$$

$$\bar{\tau} = \frac{1}{N_R}\cdot P_r[r\le R] = \frac{1-e^{-\rho^2}}{N_R} = \frac{1-e^{-0.01}}{20.1} \doteq 4.95\times 10^{-4}(s)$$

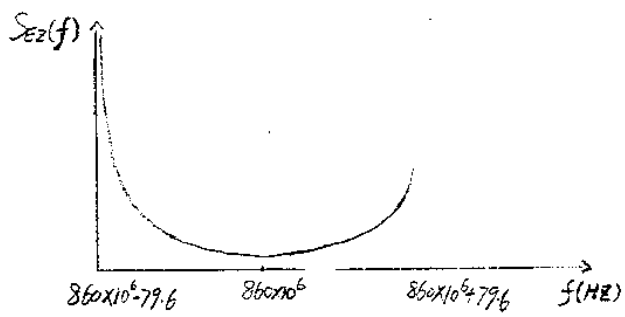
$$= 0.495\,(ms)$$

5.15 (a) $\lambda = \frac{c}{f_c} = \frac{3\times10^8\,m/s}{860\times10^6\,Hz} \doteq 0.349\,(m)$

$V = \frac{100\times10^3\,m}{3600\,sec} \doteq 27.78\,(m/s)$

$\Rightarrow f_m = \frac{V}{\lambda} = \frac{27.78}{0.349} \doteq 79.6\,HZ$

The Doppler spectrum is shown as follows.



(b) For $\rho = -20dB = 0.1$,

$N_R = \sqrt{2\pi}\cdot f_m\cdot\rho\cdot e^{-\rho^2} = \sqrt{2\pi}\times79.6\times0.1\times e^{-0.01} \doteq 19.7$ (crossings/s)

5.15 Cont'd

$$\bar{\tau} = \frac{e^{\rho^2}-1}{\rho f_m\sqrt{2\pi}} = \frac{e^{0.01}-1}{0.1\times79.6\times\sqrt{2\pi}} \doteq 0.5\,(ms)$$