

Problem 3.1  $s_1(t) = \cos(2\pi f_1 t + \phi_1)$   $s_2(t) = \cos(2\pi f_2 t + \phi_2)$

(a)  $f_1 = f_2$   $\& \phi_1 = \phi_2$   $f_2 = 1/T_2$

$$\int_{-1.5T_2}^{1.5T_2} s_1(t) s_2(t) dt = \int_{-1.5T_2}^{1.5T_2} s_1^2(t) dt \neq 0$$

$\therefore$  not orthogonal.

(b)  $f_1 = \frac{1}{3} f_2$   $\& \phi_1 = \phi_2$

$$\int_{-1.5T_2}^{1.5T_2} s_1(t) s_2(t) dt = \frac{1}{2} \int_{-1.5T_2}^{1.5T_2} \cos 2\pi \left(\frac{2}{3} f_2\right) t dt +$$

$$\frac{1}{2} \int_{-1.5T_2}^{1.5T_2} \cos 2\pi \left(\frac{4}{3} f_2\right) t dt$$

$$= \frac{\sin 2\pi \left(\frac{1}{3}\right)}{4/3 \pi \left(\frac{1}{3}\right)} + \frac{\sin 4\pi \left(\frac{1}{3}\right)}{8/3 \pi \left(\frac{1}{3}\right)} = 0$$

$\therefore$  orthogonal.

(c)  $f_1 = 2 f_2$   $\& \phi_1 = \phi_2$

$$\int_{-1.5T_2}^{1.5T_2} s_1(t) s_2(t) dt = 0 \quad \therefore \text{orthogonal.}$$

(d)  $f_1 = \pi f_2$   $\& \phi_1 = \phi_2$

$$\int_{-1.5T_2}^{1.5T_2} s_1(t) s_2(t) dt \neq 0 \quad \therefore \text{not orthogonal.}$$

Problem 3.1 cont.

$$(e) \quad f_1 = f_2 \quad \text{and} \quad \phi_1 = \phi_2 + \frac{\pi}{2}$$

$$\int_{-1.5T_2}^{1.5T_2} s_1(t) s_2(t) dt = \int_{-1.5T_2}^{1.5T_2} \sin(2\pi f_1 t + \phi_2) \cos(2\pi f_1 t + \phi_2) dt$$

$$= 0 \Rightarrow \text{orthogonal.}$$

$$(f) = \quad f_1 = f_2 \quad \phi_1 = \phi_2 + \pi$$

$$\int_{-1.5T_2}^{1.5T_2} s_1(t) s_2(t) dt = \int_{-1.5T_2}^{1.5T_2} \cos^2(2\pi f_1 t + \phi_2) dt \neq 0$$

$$\therefore \text{not orthogonal.}$$

Problem 3.4.

$$P_B = Q\left(\frac{a_1 - a_2}{2\sigma_0}\right) = Q\left(\frac{1 - (-1)}{2}\right) = Q(1) \\ = 0.1587$$

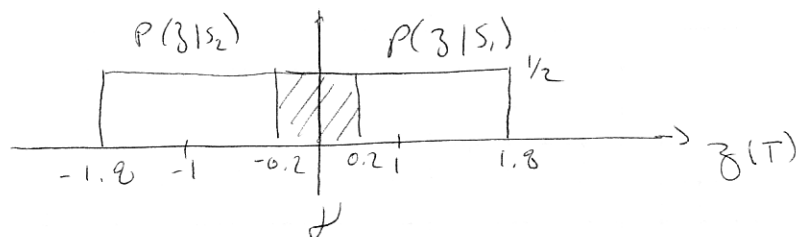
Problem 3.5

$$P_B = Q\left(\sqrt{\frac{2E_b}{N_0}}\right) \leq 10^{-3} \quad E_b = A^2 T = T$$

$$\Rightarrow \sqrt{\frac{2E_b}{N_0}} = 3.09 \quad \Rightarrow E_b = T = 4.77 \times 10^{-3} \times 2$$

$$\therefore R = \frac{1}{T} \leq 104.8 \text{ bits/sec.}$$

Problem 3.7



$$P_E = P(s_1) \int_{-0.2}^0 \frac{1}{2} dz + P(s_2) \int_0^{0.2} \frac{1}{2} dz \\ = \left[ \left(\frac{1}{2}\right) z \right]_{-0.2}^0 = \frac{0.2}{2} = 0.1$$