ECE 146B Final Solutions

1. $x(t) = \sum b(n)\, p(t - nT_s)$

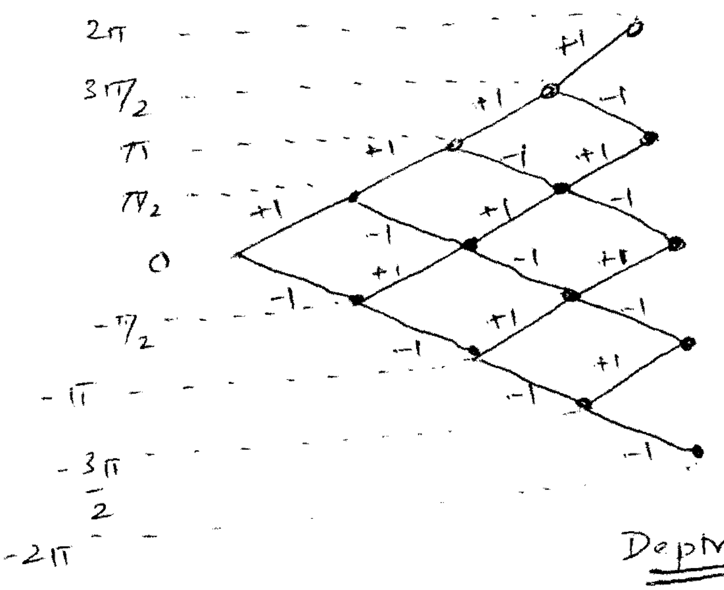
$$S_{xx}(f) = \frac{1}{T_s}\sigma_b^2 |P(f)|^2 + \frac{m_b^2}{T_s^2}\sum_k \left|P\left(\frac{k}{T_s}\right)\right|^2 \delta\left(f - \frac{k}{T_s}\right)$$

$m_b = 0$, $P(f) = T_s \operatorname{sinc}(T_s f)$

$$S_{xx}(f) = \sigma_b^2 T_s \operatorname{sinc}^2(T_s f)$$

2. The transmitted phase of the sequence $-1, -1, +1, -1, -1, +1, +1, +1$ is:

$\Rightarrow$ $-\pi/2$ $\quad -\pi$ $\quad -\pi/2$ $\quad -\pi$ $\quad -3\pi/2$ $\quad -\pi$ $\quad -\pi/2$ $\quad 0$



Depth-4

3. Let $\phi_1(t) = \sqrt{\frac{2}{T_b}} \cos 2\pi f_c t$

$\phi_2(t) = -\sqrt{\frac{2}{T_b}} \sin 2\pi f_c t$

The waveforms are

$s_1(t) \quad \frac{-3}{\sqrt{10}} \phi_1(t) + \frac{3}{\sqrt{10}} \phi_2(t)$

$s_2(t) = \frac{-1}{\sqrt{10}} \phi_1(t) + \frac{1}{\sqrt{10}} \phi_2(t)$

$s_3(t) = -3/\sqrt{10}\, \phi_1(t) - \frac{1}{\sqrt{10}} \phi_2(t)$

$s_4(t) = \frac{-1}{\sqrt{10}} \phi_1(t) - 3/\sqrt{10}\, \phi_2(t)$

$s_5(t) = \frac{1}{\sqrt{10}} \phi_1(t) + 3/\sqrt{10}\, \phi_2(t)$

$s_6(t) = \frac{3}{\sqrt{10}} \phi_1(t) + \frac{1}{\sqrt{10}} \phi_2(t)$

$s_7(t) = \frac{1}{\sqrt{10}} \phi_1(t) - \frac{1}{\sqrt{10}} \phi_2(t)$

$s_8(t) = \frac{3}{\sqrt{10}} \phi_1(t) - 3/\sqrt{10}\, \phi_2(t)$.

4. For CDMA:

$$P_k(e) = Q\left(\frac{\frac{W}{B}\sqrt{E_k}}{\sqrt{N_0 \sum_{i \neq k} P_i}} \right)$$

P_i = Received power of i^{th} user

$\frac{N_0}{2}$ = Noise variance.

E_k = Energy of k^{th} user.

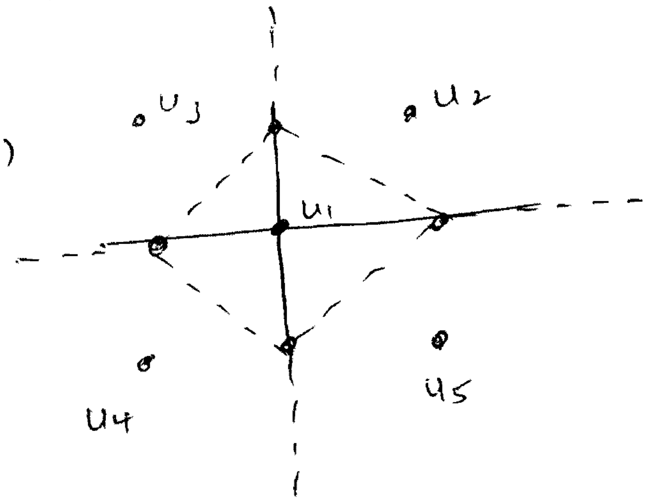
W = Channel B.W.

B = Information rate.

~~The near far problem can be explained~~

The other transmitters acts as noise (interference noise) to any device communicating with the basestation. We see that if all devices transmit at same power, the ~~near~~ devices near to the basestation jams the signals from the devices ~~cell~~ which are far off. Hence, dynamic power control is required in CDMA systems to prevent cell breathing.

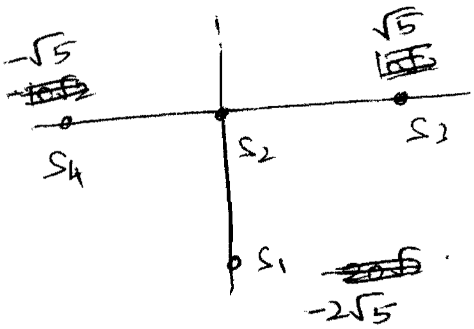
5. (a)



(b) $E_{av} = \frac{1}{5}\left(0 + 4 \cdot 2 \cdot \frac{d^2}{4}\right) = \frac{2}{5}d^2$

$$P_M \le 4Q\left(\sqrt{\frac{3E_{av}}{(M-1)N_0}}\right) \le 4Q\left(\sqrt{\frac{3d^2}{10N_0}}\right)$$

6.(a)



~~SHB~~.

(b) Shifting left or right $\uparrow E_{av}$

Shifting ~~up~~ down increases E_{av}.

Note: Equivalent $\Rightarrow$ Same structure. QPSK is not correct answer.

$\therefore$ We have to shift ~~down~~ up.

The terms involving y in E_{av} are

$$p(y) = 3y^2 + (2\sqrt{5} - y)^2$$

$$\frac{dp(y)}{dy} = 0 \Rightarrow 6y - 2(2\sqrt{5} - y) = 0$$

$$8y = 4\sqrt{5}$$

$$\boxed{y = \frac{\sqrt{5}}{2}}$$

7. $$\int_0^T \cos(2\pi f_c t + \phi_1)\cos(2\pi(f_c + m/T)t + \phi_2)\,dt$$

$$= \frac{1}{2}\int_0^T \cos\left(4\pi f_c t + \frac{2\pi m}{T}t + \phi_1 + \phi_2\right)dt$$

$$+ \frac{1}{2}\int_0^T \cos\left(\frac{2\pi m t}{T} + \phi_2 - \phi_1\right)dt$$

$$= \frac{1}{2}\left[\frac{\sin(2\pi m + \phi_2 - \phi_1)}{2\pi m/T} - \frac{\sin(\phi_2 - \phi_1)}{\frac{2\pi m}{T}}\right]$$

$$= \underline{\underline{0}}$$

$\therefore \cos(2\pi f_c t + \phi_1)$ and $\cos(2\pi(f_c + m/T)t + \phi_2)$ are $\underline{\underline{\perp r}}$.