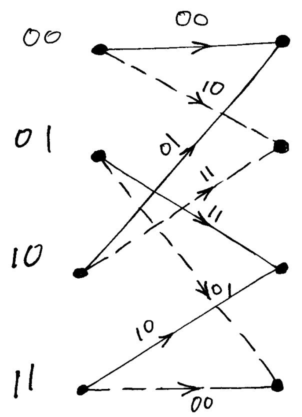
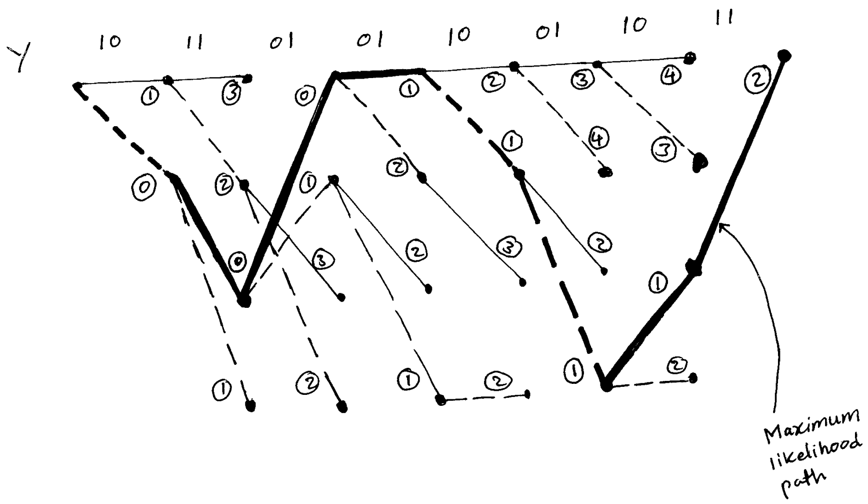
E 3.1 Construct the code trellis diagram for a (2,1,2) code with

$$x'_j = m_{j-1} \oplus m_j \qquad\qquad x''_j = m_{j-2} \oplus m_{j-1}.$$

a) Apply the Viterbi algorithm to find $Y+\hat{E}$ and $\hat{M}$ when Y=10 11 01 01 10 01 10 11. If two paths arriving at a given node have equal running metrics, arbitrarily keep the upper path.

ANS:





$Y+\hat{E}$ 10 11 01 00 10 01 10 01

$\hat{M}$ 1 0 0 0 1 1 0 0

E 3.2

From the following equation

$$G_{lp}(f) = G_i(f) = \frac{M^2-1}{12r}\text{sinc}^2\frac{f}{r} + \frac{(M-1)^2}{4}\delta(f),$$

find the average power $\overline{x_c^2}$ and the carrier-frequency power P_c of an *M*-ary ASK signal. Then form the ratio $P_c / \overline{x_c^2}$ and simplify for M=2 and M>>1.

ANS:

$$\overline{x_c^2} = \int_{-\infty}^{+\infty} G_c(f)df = \frac{A_c^2}{4}\int_{-\infty}^{+\infty}\left[G_{lp}(f-f_c)+G_{lp}(f+f_c)\right]df$$

$$= \frac{A_c^2}{4}*2*\int_{-\infty}^{+\infty}\left[G_{lp}(f)\right]df \quad \text{[Since } G_{lp}(f-f_c) \text{ and } G_{lp}(f+f_c) \text{ do not overlap if } f_c>>r]$$

$$= \frac{A_c^2}{2}\left[\frac{M^2-1}{12r}\int_{-\infty}^{+\infty}\sin c^2\left(\frac{f}{r}\right)df + \frac{(M-1)^2}{4}\int_{-\infty}^{+\infty}\delta(f)df\right]$$

$$= \frac{A_c^2}{2}\left[\frac{M^2-1}{12r}*r + \frac{(M-1)^2}{4}\right]$$

$$= \frac{A_c^2}{12}(M-1)(2M-1)$$

$$P_c = 2*\frac{A_c^2}{4}*\frac{(M-1)^2}{4}$$

$$\frac{P_c}{\overline{x_c^2}} = \frac{3M-3}{4M-2} = \begin{cases} \frac{1}{2} & when \quad M=2 \\ \frac{3}{4} & when \quad M>>1 \end{cases}$$

E 3.3

The envelope and phase variations of a QAM signal are

$A(t) = A_c\left[x_i^2(t) + x_q^2(t)\right]^{1/2}$ And $\phi(t) = \arctan\left[x_q(t)/x_i(t)\right]$ respectively.

(a) By considering the time interval *kD<t<(k+1)D*, obtain expression for A(t) and $\phi(t)$ with a rectangular pulse shape $P_D(t)$.
(b) Redo part a with an arbitrary pulse shape *p*(t) whose duration does not exceed *D*.

ANS:

a) for $KD<t<(k+1)D$

$x_i(t)=a_{2k}$, $x_q(t)=a_{2k+1}$ with $a_k=\pm 1$

Thus, $x_i^2(t)+ x_q^2(t)=2$ for all t so that $A(t)=\sqrt{2}A_c$

Where $\Phi(t)=\sum_k \tan^{-1}(a_{2k+1}/ a_{2k})\, P_D(t-kD)$

b) for $kD<t<(k+1)D$

$x_i(t)=a_{2k}P(t-kD)$ and $x_i(t)=a_{2k+1}P(t-kD)$ with $a_k=\pm 1$

Thus, $x_i^2(t)+ x_q^2(t)=2\, P^2(t-kD)$; so, $A(t)= \sqrt{2}\sum_k |P(t-kD)|$

And $\Phi(t)=\sum_k \tan^{-1}[x_q(t)/ x_i(t)]\, P(t-kD)= \sum_k \tan^{-1}[a_{2k+1}/ a_{2k}]\, P(t-kD)$

E 3.4

Suppose an OOK signal has raised-cosine pulse shaping so that

$$S_1(t)=A_c \sin^2(\pi t/T_b)P_{T_b}(t)\cos\omega_c t$$

Draw and label the block diagram of an optimum coherent receiver using:

(a) matched filter;

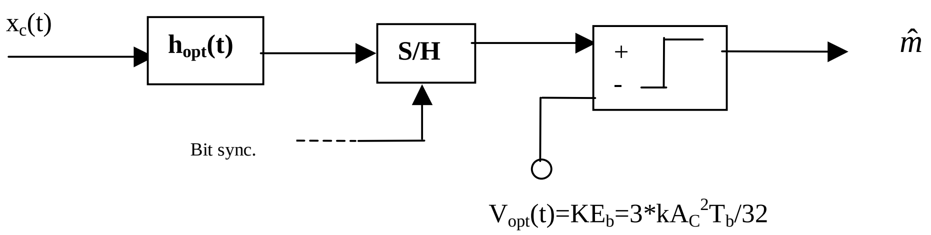
(b) Correlation detection.

ANS:

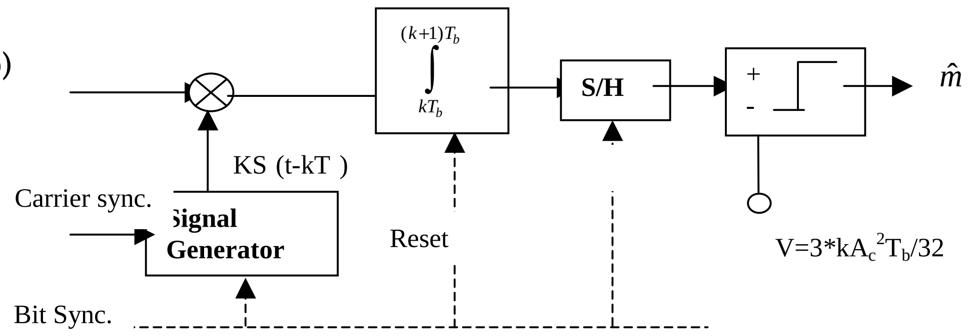
a)

$$h_{opt}(t)=kA_c\sin^2\left[\frac{\pi}{T_b}(T_b-t)\right]P_{T_b}(T_b-t)\cos(\omega_c(T_b-t))$$
$$=kA_c\sin^2\left[\pi-\frac{\pi t}{T_b}\right]P_{T_b}(t)\cos(\omega_c t-2\pi N_c)$$
$$=kA_c\sin^2\left[\frac{\pi t}{T_b}\right]\cos\omega_c t \qquad 0<t<T_b$$

$$V_{opt}(t)=\frac{k}{2}(E_1-E_0)=\frac{k}{2}\int_0^{T_b}s_1^2(t)dt=\frac{k}{2}*A_c^2\int_0^{T_b}\sin^4\frac{\pi t}{T_b}\cos^2\omega_c t dt$$
$$=\frac{k}{2}*A_c^2*\frac{3}{16}*T_b=\frac{3}{32}kA_c^2T_b$$



b)



Homework-3 Deadline February 18,2002 at 10.00

Homework return box is located at Otakaari 5, 2nd floor, near the E-wing. You can also return the answers to the assistant just before the class.

Suppose a binary FSK signal with discontinuous phase is generated by switching between two oscillators with outputs $A_c \cos(2\pi f_o t + \theta_o)$ and $A_c \cos(2\pi f_1 t + \theta_1)$.

Since the oscillators are unsynchronized, the FSK signal may be viewed as the interleaved sum of two independent binary ASK signals.

Use this approach to find, sketch, and label $G_c(f)$ for $f > 0$ when $f_0 = f_c - r_b/2$ and $f_1 = f_c + r_b/2$ with $f_c >> r_b$.