(10%)

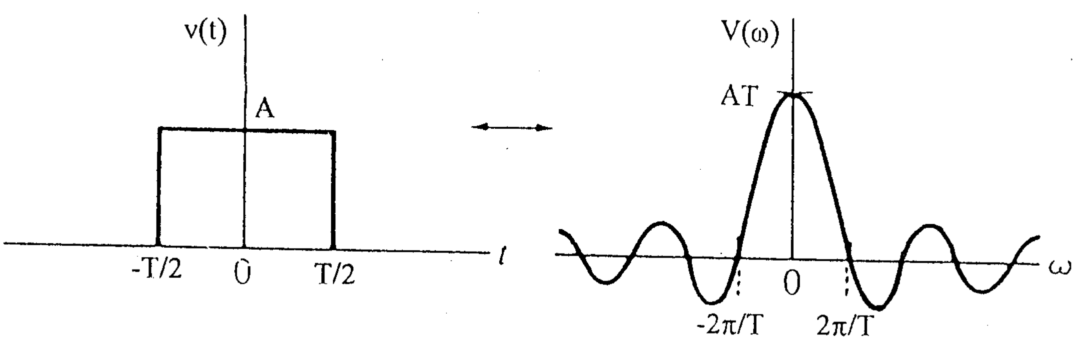
1). A 15 km optical fiber link uses fiber with a loss of 1.5 dB/km. The fiber is jointed every kilometer with connectors which given an attenuation of 0.8 dB each. Determine the minimum mean optical power which must be launched into the fiber in order to maintain a mean optical power of 0.3 μW at the detector.

(15%)

2). A square pulse v(t) of amplitude A and duration T has a frequency spectrum $V(\omega)$ as shown in Figure P2. With such square pulse, a carrier of frequency $f_c >> 1/T$ is On-Off Keyed into an RF square burst $v(t)\cos(2\pi f_c t)$. A matched-filter receiver is used to make an optimum reception on such burst square. The system output is therefore a convolution of input square burst and impulse response of the matched receiver.

(a). Sketch the impulse response of the matched filter and the frequency spectrum of the input RF square burst.

(b). Sketch the time waveform and frequency spectrum at the output of the matched-filter receiver.



(10%)

3). A carrier wave of frequency 120 MHz is frequency-modulated by a sine wave of amplitude 20 v and frequency 100 kHz. The frequency sensitivity of the modulator is 25 kHz/v.

(a). Calculate the frequency deviation $\Delta f = K_f A_m$ and the corresponding value of the modulation index $\beta = \Delta f / f_m$.

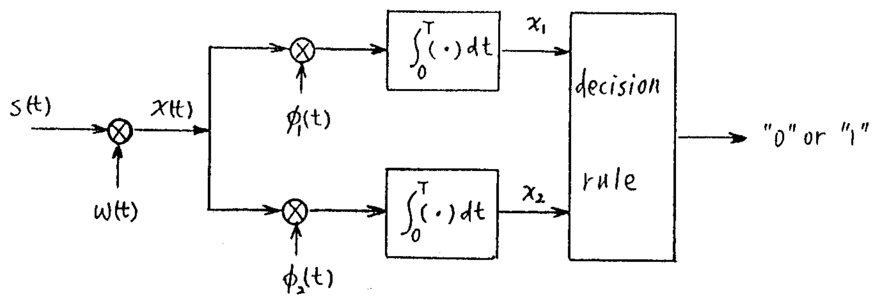
(b). By using Carson's rule $B = 2f_m(1+\beta)$, determine the approximate bandwidth of the FM wave.

(c). Assume that the amplitude and the modulation frequency of the modulating wave are both doubled, what is the resulting Carson rule bandwidth?

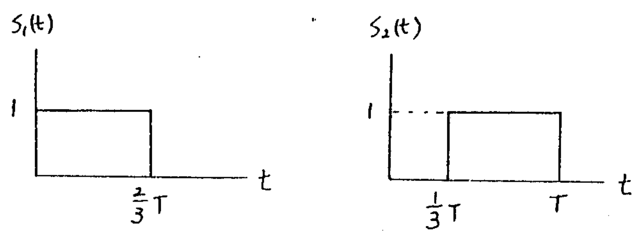
(10%)

4). A mixer is used in a short-wave superheterodyne receiver. The receiver is designed to receive transmitted signals between 5 and 10 MHz. High-side tuning (that is, higher local oscillator frequency than the received signal) is to be used. Determine the tuning range of the local oscillator for IF frequencies varying between 400 kHz and 2 MHz.

(20%)
5). Consider a correlator receiver shown in Figure P5.



w(t) represents a white Gaussian noise with power spectral density $N_o/2$.
$s(t) = s_1(t)$ if "0" is sent, $s(t) = s_2(t)$ if "1" is sent. The waveforms of $s_1(t)$ and $s_2(t)$ are given below.



$\{\phi_1(t), \phi_2(t)\}$ is a set of orthonormal basis functions for $s_1(t)$ and $s_2(t)$, that is,

$$s_1(t) = s_{11}\phi_1(t) + s_{12}\phi_2(t),\ 0 \le t \le T$$
$$s_2(t) = s_{21}\phi_1(t) + s_{22}\phi_2(t),\ 0 \le t \le T$$

where

$$s_{ij} = \int_0^T s_i(t)\phi_j(t)dt.$$

Assume that $\phi_1(t) = c\, s_1(t)$, c is a constant.

(a). Find and plot $\phi_1(t)$ and $\phi_2(t)$.

(b). Due to noise, the values of x_1 and x_2 are random in nature. Let X_1 and X_2 represent the random variables whose outcomes are x_1 and x_2 respectively. Calculate the mean $E[X_i \mid s_j]$ and variance $Var[X_i \mid s_j]$ of X_i given that $s_j(t)$ has occurred respectively for i = 1,2 and j = 1,2.

(c). Find the probability density function $f(\bar{x}|s_i)$ of $\bar{x}$ given that $s_i(t)$ has occurred, for i = 1,2. $\bar{x} = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$.

(d). Calculate the minimum of the error probability of the receiver, p_e^{min}. Assume that the a priori probabilities for $s_1(t)$ and $s_2(t)$ are equal.

(15%)

6). The performance of a digital channel is evaluated in terms of R_b, p_{be}, P_{av} and B_T. R_b is the data rate defined as the number of bits transferred through the channel per second. p_{be} is the error probability per bit. P_{av} and B_T are the average power and bandwidth required by the channel.

(a). If P_{av} and B_T are kept fixed, how do the values of R_b and p_{be} change (increase or decrease) when the signaling of the channel is switched from BASK (OOK) to QASK. Give your rationale.

(b). If R_b and p_{be} are kept fixed, how do the values of P_{av} and B_T change when the signaling of the channel is switched from BASK to QASK. Give your rationale.

(c). If R_b and p_{be} are kept fixed, how do the values of P_{av} and B_T change when the signaling of the channel is switched from BASK (OOK) to BPSK (PRK). Which is more power efficient, BASK or BPSK ? Give your rationale.

(20%)

7). In convolutional codes, parity-check symbols are calculated for a constraint span of information symbols. For the convolutional encoder shown in Figure P7, three output symbols are generated for each input symbol yielding a code of rate 1/3.

(a). Determine the state diagram, giving the output for each state transition.

(b). Draw the trellis diagram through the first set of steady-state transitions.

(c). Describe Viterbi algorithm to properly decode the received sequence 110 101 011 111.