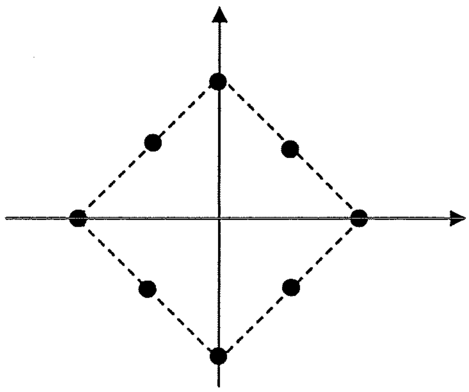
S.72-1140 Transmission Methods in Telecommunication Systems

Closed-book Exam on Wednesday 21.12.2005

1. a) Consider matching of a communication channel with $R_L = 30\,\Omega$, $L_L = 10\,nH$, $R_g = 10\,\Omega$ *and* $C_g = 1\,nF$. Describe goodness of matching as a function of frequency. Is there a frequency where matching is optimized?

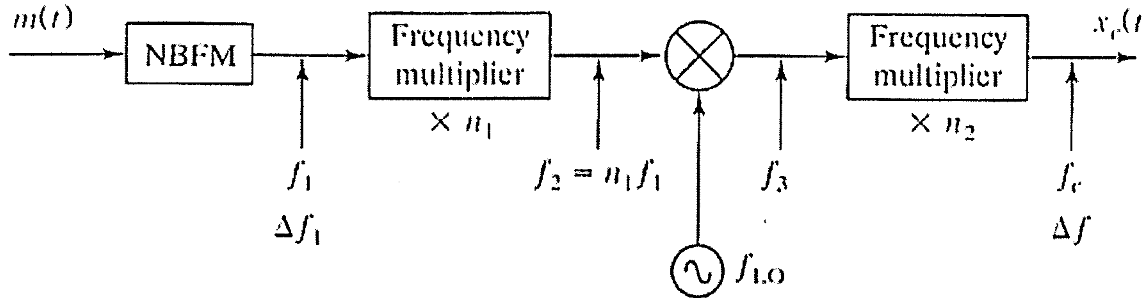
1 b). Calculate the BER as a function of SNR at the output of the matched filter for the eight-point constellation illustrated in the figure below.



2. Consider the (3,2) block code 000, 110, 011, 101. (a) What is its minimum Hamming distance? (b) How namy errors it can detect / correct? (c) Write down its generator matrix. (d) Is this a systematic code? If not, change its generator matrix such that it is!

3. A communication system has the average modulating signal power of $\overline{x^2} = \frac{1}{2}$, message bandwidth of $W = 10\ kHz$, channel noise power spectral density of $\eta = 10^{-15}\ \frac{W}{Hz}$ and the transmission loss of L = *10 dB*. Determine the average transmitted signal power S_T required to get post detection *SNR* = *40 dB* when the modulation is (a) SSB and (b) AM with the modulation indexes $\mu = 1$ and $\mu = 0{,}5$.

4 A block diagram of an indirect FM transmitter is show in the figure below. Compute the maximum frequency deviation Δf of the output of the FM transmitter and the carrier frequency f_c if $f_1 = 200\,\text{kHz}$, $f_{LO} = 10.8\,\text{MHz}$, $\Delta f_1 = 25\,\text{kHz}$, $n_1 = 64$, and $n_2 = 48$.



5. a) HDB-3 coding is used for the bit train `011000000011`. Sketch the RZ-pulse train.
b) A NRZ-coded base band signal is transferred in a cable, which attenuation is 20 dB/km. In a receiver the level of the white Gaussian noise is 150 fW. The error probability in the receiver is $2 \cdot 10^{-8}$. Calculate the maximum length of a cable when the transmitted power to the cable is 16 dBm.

Table of Formulas

$$x_\delta(t) = x(t)s_\delta(t) = x(t)\sum_{k=-\infty}^{\infty}\delta(t-kT_s), \; = \sum_{k=-\infty}^{\infty} x(kT_s)\delta(t-kT_s), \; P_{dB} = \log_{10}(P/P_{ref}),$$

$$X_\delta(f) = f_s \sum_{n=-\infty}^{\infty} X(f-nf_s), \; F[\exp(-at)u(t)] = (a+j\omega)^{-1}, a>0$$

$$d\phi(t)/dt = 2\pi f(t) = 2\pi[f_C + f_\Delta x(t)], \; d\phi(t)/dt = [\phi(t)-\phi(t-t_1)]/t1$$

$$\phi(t)-\phi(t-t_1) = t_1 d\phi(t)/dt = 2\pi t_1[f_C + f_\Delta x(t)]$$

$$< v_i(t) > = \frac{1}{T}\int_{-T/2}^{T/2} v_i(t)dt, < v_i(t) > = \lim_{T\to\infty}\frac{1}{T}\int_{-T/2}^{T/2} v_i(t)dt$$

$$< v(t) > = \int_A x p_v(x)dx, < v_i^2(t) > = \int_A x^2 p_v(x)dx$$

$$< v_i^2(t) > = \frac{1}{T}\int_{-T/2}^{T/2} v_i^2(t)dt$$

$$\phi(t) = \begin{cases} \underbrace{\phi_\Delta A_m}_{\beta}\sin(\omega_m t), & \text{PM} \\ \underbrace{(A_m f_\Delta / f_m)}_{\beta}\sin(\omega_m t), & \text{FM} \end{cases}$$

$$p_e = \overline{n}_n Q\left(\frac{d}{2\sigma}\right) = \overline{n}_n Q\left(\frac{a}{\sigma}\right), \; \gamma = \frac{S_R}{\eta W}$$

$$\begin{cases} n = \log_2 M, E = nE_b \\ p_e = p(E)/n \\ A/\sigma = \sqrt{2E/N_0} \end{cases}$$

$$\frac{V_g}{V_i} = \frac{Z_g + Z_L}{Z_L}, P_L = V_i I_i \cos\theta, , \quad \begin{matrix} \cos\theta = R_{tot}/Z_{tot} = R_{tot}/\sqrt{R_{tot}^2 + X_{tot}^2}, \\ X_{tot} = X_g + X_L, R_{tot} = R_L + R_g \end{matrix} \quad f_0 = (2\pi\sqrt{LC})^{-1}$$

$$q = M^v, \; |\varepsilon_k| \le 1/q, \; \left(\frac{S}{N}\right)_D = 10\log_{10}(3\times 2^{2n} S_x)$$

$$P(i,n) = \binom{n}{i}\alpha^i(1-\alpha)^{n-i} \approx \binom{n}{i}\alpha^i, \alpha << 1$$

$$l = d_{\min} - 1, \; t = \lfloor l/2 \rfloor, \; \mathbf{G} = (\mathbf{I}_k \mid \mathbf{P}), \; \mathbf{X} = (\mathbf{M} \mid \mathbf{C}) = \mathbf{MG}$$

$$f_2(t) = nf_1(t) = nf_{c1} + f_\Delta x(t), 2\pi f_\Delta T = n\phi_\Delta, \; \text{FM: } n\phi_\Delta = 2\pi f_\Delta \int_t x(\lambda)d\lambda$$