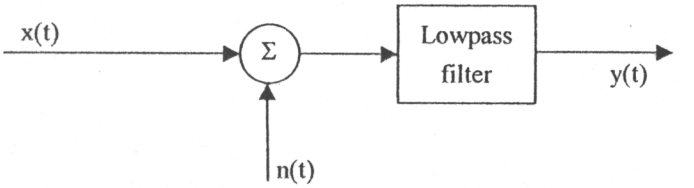
1. Consider the system shown in the diagram below. The noise n(t) is white with two-sided power spectral density (PSD) $N_0/2$. The PSD of the input signal x(t) is $S_x(f) = A/[1+(f/f_3)^2]$, $-\infty < f < \infty$. The parameter $f_3$ is the 3-dB frequency of the signal. The bandwidth of the ideal lowpass filter is $W$. Determine the signal-to-noise ratio of output signal y(t) as a function of $W/f_3$. [Note: $\int_0^{W/f_3}[1/(1+z^2)]dz = \tan^{-1}(W/f_3)$] (15%)




2. A narrow-band frequency-modulated signal has a carrier frequency of 100 kHz, modulation index 0.10, and bandwidth 5.0 kHz. A wideband FM signal with a modulation index of 10 and carrier frequency 100 MHz is to be generated from the narrow-band signal.
   (a) Draw the block schematic of a system utilizing a frequency multiplier, a down converter, and a bandpass filter. Give the required value of frequency multiplication. (10%)
   (b) With modulating signal frequency $f_m$ = 2 kHz, determine the frequency deviations and modulation indices at the output points of the down converter and the bandpass filter. (7%)

3. Stereophonic FM broadcasting is accomplished by using DSB modulation for multiplexing and FM modulation for transmission. Let $L(t)$ and $R(t)$ be the left and the right channel signals, respectively.
   (a) An FM system utilizes a deviation ratio of 5.0. Assuming that the bandwidth of the message signal is 15 kHz, compare the required transmission bandwidth of a stereophonic FM signal to a nonstereophonic FM signal. (8%)
   (b) By comparing the noise power in the $L(t)$-$R(t)$ channel to the noise power in the $L(t)$+$R(t)$ channel, explain why stereophonic broadcasting is more sensitive to noise than nonstereophonic broadcasting. (10%)

4. Draw the modulated waveforms of the binary sequence 1 1 1 0 1 0 0 0 1 0 1 0 0 1 1 by using the baseband formats of (a) AMI (Bipolar); (b) Manchester (Bi-phase); (c) 8-level NRZ with Gray code; (d) Duobinary without precoder; (e) Duobinary with precoder. (Note: A preamble of 0 is assumed if necessary.) (15%)

5. Consider the transmission of a message via OQPSK (Offset QPSK) signals over a bandpass AWGN channel with bandwidth = 125 kHz and two-sided PSD = $10^{-9}$ W/Hz.
   (a) What is the maximum data rate if null-to-null bandwidth is considered? (5%)
   (b) What is the maximum data rate that can be transmitted without ISI? (5%)
   (c) Determine the maximum data rate if raised cosine spectrum with roll-off factor $\alpha$ = 25% is used to assure ISI-free. Also determine the minimum received power (in dBm) if $P_b \leqq 10^{-6}$ is required. (Note: It is required $E_b/N_0$ = 13.5 dB for BFSK signal with coherent detection and $P_b = 10^{-6}$). (10%)

6. The mapping between messages and codewords of an (n, k) block code is given as

| Messages | Codewords | Messages | Codewords |
|---|---|---|---|
| 0 0 0 | 0 0 0 0 0 0 0 | 1 0 0 | 1 1 1 0 1 0 0 |
| 0 0 1 | 1 1 0 1 0 0 1 | 1 0 1 | 0 0 1 1 1 0 1 |
| 0 1 0 | 1 0 1 1 0 1 0 | 1 1 0 | 0 1 0 1 1 1 0 |
| 0 1 1 | 0 1 1 0 0 1 1 | 1 1 1 | 1 0 0 0 1 1 1 |

   (a) Determine the values of n and k. (2%)
   (b) Show the generator matrix **G** and the parity-check matrix **H**. (6%)
   (c) Determine the error-detecting capability and the error-correcting capability of this code. (4%)
   (d) If the received vector $\underline{r}$ = (0 1 1 0 0 0 1), what is the decoded message? (3%)