Assignment 2

CSL 858

Due date: January 25, 2007 (Thursday)

Topics: Transmission Media, Signal Theory, Modulation

1. Find out the following properties of the transmission medium that is used by the computer network in your hostel or favorite laboratory on campus or in your work-place. You may consult the system administrator of the network.

   (a) type (twisted-pair, coaxial, optical fiber, wireless etc.)

   (b) layer-2 technology used (Ethernet, switched Ethernet, DSL etc.)

   (c) maximum speed in bits/sec allowed by the technology (in theory)

   From a machine in this network, download a file (which file is your choice) from 3 different Internet websites located outside the network. What is the typical download speed you get? Compare these to the maximum speed allowed by the technology used in your network.

2. Typically commercial radio stations use either Amplitude Modulation (AM) or Frequency Modulation (FM). In the former, the information-carrying signal (e.g. voice, music) modulates the amplitude of the carrier signal and in the latter it modulates the frequency of the carrier signal. Typically FM is the choice for music stations? List a few reasons for this choice. You may look up the Internet for answers or any text book.

3. Denote the Fourier transform of signal $g(t)$ by $G(f)$. Computer the Fourier transform of the following in terms of $G(f)$.
   (i) $g(t - t_0)$ where t_0 is a constant
   (ii) $\frac{dg(t)}{dt}$ (assume that this derivative exists and that $g(t)$ is of finite duration).

4. Recall the definition of the sinc function.

$$\mathrm{sinc}(x) = \begin{cases} 1 & \text{for} \quad x = 0 \\ \frac{\sin(x)}{x} & \text{for} \quad x \neq 0 \end{cases} \tag{1}$$

   Derive an expression of the Fourier transform of the following function in terms of sinc functions.

$$g(t) = \begin{cases} 1 - t & \text{for} \quad t \in [0, 1] \\ t + 1 & \text{for} \quad t \in [-1, 0] \\ 0 & \text{for} \quad t \notin [-1, 1] \end{cases} \tag{2}$$

   (Hint: You can use the results of the previous problem).

5. Ultra-wide-band (UWB) technology uses short pulses to transmit information. One such pulse and its Fourier transform are given by

$$v(t) = 2\sqrt{3}\frac{t}{\tau}e^{-6\pi(\frac{t}{\tau})^2} \tag{3}$$

   and

$$V(f) = -j\frac{f}{3\sqrt{2}f_c^2}e^{-\frac{\pi}{6}(\frac{f}{f_c})^2} \tag{4}$$

   respectively, where $f_c = \frac{1}{\tau}$ and $j = \sqrt{-1}$. Using a mathematical plotting tool (e.g. matlab, mathematica, scilab, octave etc. or any online plotting tool such as webmath.com) plot $v(t)$

and $|V(f)|$ for $\tau = 0.5$ ns. Find out the range of frequencies in which $|V(f)|$ is larger than 0.5 times $\max_f |V(f)|$. The width of this region is called the 3dB bandwidth. The claim is that the UWB pulse has a 3dB-bandwidth greater than f_c Hz. Is this claim true according to your plot?

6. A modem uses the constellation depicted in Figure 1 to transmit information symbols. The basis functions $\phi_1(t)$ and $\phi_2(t)$ are orthogonal and each has unit energy. The modem signal goes through an AWGN channel which adds noise $n(t)$ to the signal. The noise has a flat (white) spectrum of height $|N(f)|^2 = N_0/2$ for all f. Call the received signal $r(t) = v(t)+n(t)$, where $v(t)$ is the signal transmitted by the source.

   The receiver computes the vector $\underline{r} = (r_1, r_2)$, where $r_i = \langle r(t), \phi_i(t)\rangle$ for $i = 1, 2$. Using $\underline{r}$, design a detector that guesses which symbol was transmitted. For this detector, compute the probability of incorrectly detecting symbols. Write your answer in terms of the $Q(.)$ function which is defined as

$$Q(z) = \int_z^\infty \frac{e^{-x^2/2}}{\sqrt{2\pi}}\, dx \tag{5}$$

   In your calculations, assume that all symbols occur with the same probability.

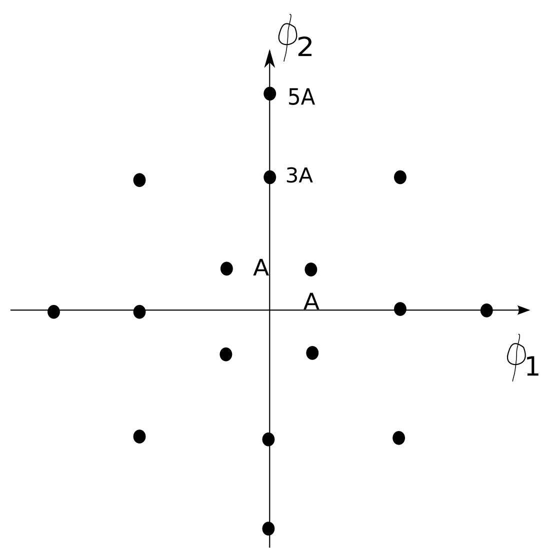

Figure 1: V.29 constellation