CCE2310 and CCE2112 - Tutorial Sheet

Information signals

1.1 It is desired to transmit the binary sequence '11010111001' over a copper twisted pair cable using a bipolar NRZ code. The data rate is 1000 bits/second. Plot the transmitted signal in the time domain. Repeat the exercise for a bi-phase NRZ code and for a unipolar code. If the time duration for one bit is 1ms obtain an approximation of the signal bandwidth.

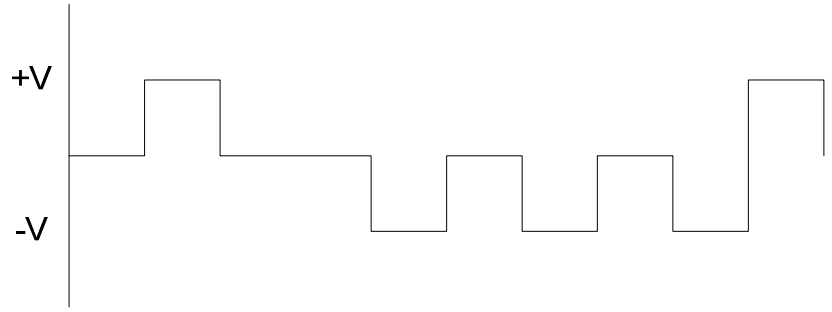
1.2 Calculate the bandwidth occupied by music that is digitized into 4096 amplitude levels and band-limited to 15kHz.

1.3 An essay written in the English language is 3000 words long. Assuming that the English alphabet consists of 26 upper case letters, 26 lower case letters, 10 numerals and 20 punctuation marks, and the average word length is 6 characters, (a) Calculate how long it will take to transmit the whole essay through a channel band limited to 2kHz. (b) How can the time calculated in (a) be reduced, without losing any information.

1.4 The resolution of a color digital video camera is 320x200 pixels. Each pixel is quantized into 8-bit numbers the frame rate is 25 per second. Calculate the rate in bits per second at which data is generated by the video camera.

1.5 A high end audio card on a PC has a sampling rate of 96kHz and a 16bit resolution. Calculate the resultant bit rate for a stereo recording. Explain why using such a high sampling rate will result in better quality sound.

1.6 The bipolar AMI waveform representing the binary sequence 0100101011 is transmitted over a noisy channel. The received waveform is shown below. Locate the position of the error and explain your answer.



1.7 1.7 One positive side effect of bipolar encoding is that a bipolar violation (two consecutive + pulses or two consecutive – pulses separated by any

number of zeros) indicates to the receiver that an error has occurred in the transmission. Unfortunately, upon the receipt of such a violation, the receiver does not know which bit is in error (only that an error has occurred). For the receiver bipolar sequence :

+-0+-0-+

which has one bipolar violation, construct two scenarios (each which involves a different transmitted bit stream with one transmitted bit being converted into an error) that will produce this same received pattern.

Channel Modulation and physical channels

2.1 Draw the phasor or constellation diagrams for the following digital modulation techniques; (a) ASK, (b) BPSK, (c) 4-level ASK, and (d) 16-QAM. Superimpose AWGN signals on the 16-QAM phasor diagram and show how these signals can lead to decoding errors at the receiver.

2.2 A 10kbps data source can be transmitted using either binary ASK or binary PSK. Calculate the ratio of the transmitter power required for the two systems if a BER of 10^{-4} is desired.

2.3 Data encoded as a unipolar signal is used to amplitude modulate a sinusoidal carrier. By first expanding the unipolar waveform as a fourier series of a square wave sketch the ASK waveform in the frequency domain.

2.4 It is required to convey a 6MHz video signal over a distance of 20km. The bandwidth-length product of a particular cable is 100MHz-km. Is the cable suitable for the task?

2.5 In a CATV system the power at a point is 5mW, where an in-line amplifier of gain 100dB is inserted. Calculate the power at the output port of the amplifier.

2.6 A copper-wire link in a packet switched network supports a data rate of 1Mbps. How many 600bit packets can be serviced per second. A computer connected to this node sends a 1.2Mbyte file down the link. If 20% of a 600bit packet is dedicated to overheads calculate the time it takes to transmit the whole file. Assume that the link is not busy at the time of transmission. Repeat the calculation for 200 bit packet with 30% overheads.

2.7 Calculate (a) the total losses, (b) transmitter output power required, and (c) the maximum data rate the cable can support for an optical system that has the following specifications; Light receiver sensitivity: 1.1μW, Cable length: 6km (cable available in 1km lengths), Cable attenuation: 2.8dB/km, Connector attenuation is 0.85dB/connector, LED to connector loss is 2.15dB, and Cable dispersion is equal to 10ns/km.

2.8 A radio link consists of a transmitter and receiver separated by a distance of 25m. Calculate the link loss if a 5GHz frequency is used and than if a 433MHz frequency is used.

Noise and SNR

3.1 Show that QPSK can be obtained from two BPSK signals in quadrature and explain why the performance of QPSK in noise is similar to that of BPSK but the bandwidth occupied by QPSK is half that of BPSK.

3.2 A sine wave is to be used for two different signaling schemes (a) PSK and (b) QPSK. The duration of each signal element is 10^{-5}s. If the received signal is of the following form :

$S(t) = 0.005\sin(2\pi 10^6 t + \theta)$volts

and if the measured noise power at the receiver is 2.5×10^8 watts, determine the E_b/N_0 (in dB) for each case.

Multiplexing schemes

4.1 Music channels are sampled at 40k samples/sec and each sample is digitized into 16-bits. Six stereo channels are time division multiplexed and coded into a bipolar waveform prior to storing the waveform on digital media. (a) Calculate the TDM recording channel bit rate, (b) Sketch a time-domain plot of a typical waveform, (c) Calculate the bandwidth of the system, and (d) Suggest a method of how the bits can be synchronized during playback and correct channel selection is ensured.

4.2 500 telephone channels are to be frequency division multiplexed on a coaxial cable. The smallest carrier frequency is 70MHz. If the modulated telephone channel is 10kHz (including the guard band), calculate the highest carrier frequency and the bandwidth of the whole group.

4.3 It is desired to monitor the temperature and humidity at five different

locations. Both quantities are sampled at a rate of 2 samples/second. Each quantity is quantized into 12-bit binary numbers. Before transmission the data is encapsulated into a binary frame. The frame includes 80 bits for synchronization and error detection. Calculate (i) the length of the frame in bits, (ii) the minimum data rate required for the whole system.

4.4 The air interface of a short-range digital cordless telephone system consists of 10 radio channels with a carrier spacing of 1.2MHz. Each radio channel is divided into TDM frames of 10 slots in length (see fig. 4.5). Time Division Duplex is employed, and 64kbit/s A-law PCM speech is transmitted directly (i.e. without encoding). (a) Calculate the radio bandwidth required for the system?, (b) Suggest a frequency band for the system, (c) What is the main advantage of using time-division duplex, (d) Calculate the total number of full-duplex information channels which can be supported simultaneously, (e) Calculate the radio channel bit-rate.