Assignment 2

Due Friday, November 20. Show your work. Submit your assignment using the appropriate dropbox on the course web site. Assignments submitted after the solutions are made available will be given a mark of zero.

Question 1

The 16550 is a UART IC that was popular on personal computers. UARTs integrated into modern microcontrollers often use the same control and status registers to remain compatible with existing 16550 driver software.

Go to digikey.com and search for 16550. You should find the data sheet for the TI PC16550D UART in the category Integrated Circuits (ICs) > Interface - UARTs (Universal Asynchronous Receiver Transmitter). Use it to answer the following questions:

(a) how many status and control registers does the 16550 have (include both possible values of DLAB)?

(b) assuming a clock frequency of 1.8432 MHz, what values would you put in which registers for operation at a baud rate of 19200 bps? What is the maximum baud rate that could be configured with this clock frequency?

(c) which bit of which register indicates a framing error? what value indicates an error?

(d) what condition on the input signal line causes the 16550 to detect a "break" condition?

(e) explain how the 16550 might detect false start bits (read the Receiver section of the Wikipedia article on UARTs if necessary).

Question 2

The following diagram[1] shows the magnitude of the frequency response of digital TV channels (transmitter plus receiver) used in North America:

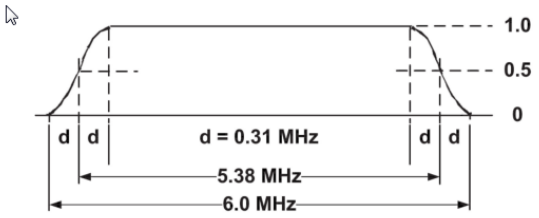

Figure 5.12 Overall VSB transmitter plus receiver linear amplitude response versus frequency (concatenation of linear-phase root-raised cosine Nyquist filters).

(a) What is the -6 dB bandwidth?

(b) What is the value of α?

(c) What is the -3 dB bandwidth?

Question 3

Section 25.4.9.2.4, "Differential near-end crosstalk (NEXT)," of the IEEE 802.3 Ethernet standard says the following:

> *In order to limit the crosstalk at the near end of a duplex channel, the differential pair-to-pair near-end crosstalk (NEXT) loss between the two pairs of a duplex channel shall be at least,*
>
> $$27.1 - 16.8 \log_{10}(f/100)\ dB$$
>
> *where f is the frequency over the range of 1 MHz to 100 MHz.*

You want to check for compliance with this specification. You use a signal generator to apply a 1 V sine wave at a frequency of 100 MHz to a pair at one end of the cable.

(a) Would you measure the NEXT at the end of the cable with the generator or at the other end?

[1] From ATSC Standard A/53, Part 2.

(b) For the cable to be compliant with the standard, what is the maximum voltage that you could measure?

(c) What is the maximum voltage you could measure if the test frequency was 1 MHz?

Question 4

A system transmits using NRZ with four equally-spaced levels balanced about zero. For example, the four possible levels could be -3, -1, +1 and +3 V. Each of the four symbols is equally likely.

The signal is scaled so the RMS signal voltage is 224 mVrms.

(a) What are the (DC) voltage levels[2]?

(b) A simple receiver makes decisions by looking at the level of the received signal. If we approximate the error rate as the probability that the noise voltage will exceed half of the difference between two adjacent voltage levels, what AWGN RMS noise voltage will result in an error rate of 10^{-6}?

(c) If we wanted to transmit at a rate of 1 Mb/s while ensuring there was no ISI, what is the minimum bandwidth required?

(d) If we used a more sophisticated transmitter and receiver but kept the signal and noise powers the same, what is minimum bandwidth required to achieve an arbitrarily-low error rate?

Question 5

A signal has a power spectral density that is well-approximated by the shape of the Gaussian probability density curve. The standard deviation of this curve is 10 kHz. What is the 99% power bandwidth? Include both positive and negative frequencies.

Question 6

Using the phase-shift measurement function of your 'scope you measure the phase shifts through a channel as 180 degrees at 1 kHz, 90 degrees at 1.5 kHz and -90 degrees at 2 kHz.

(a) Assuming the phase response is linear between the measured frequencies, what is the group delay at 1.1 kHz? At 1.89 kHz?

(b) You transmit a data signal whose symbols are sine waves of either 1.25 kHz (for a 0) or 1.75 kHz (for a 1). The symbol period is 3 ms. The data sequence 0,1,1,0,0 is transmitted. Which bit(s) will suffer from ISI? What fraction of the bit(s) will be corrupted by the ISI?

[2] As usual, show your work.