

ELEC 320
Lab3: Project 2

Data Communications: periodic signals, Fourier series, harmonics, phase shift, power, bit rate, ASCII code, modems, Matlab and/or Pspice and time response

Project Report Due Dates

Monday Lab: **September 21, 2009**

Wednesday Lab: **September 23, 2009**

References

1. *Electric Circuits* (8th Edition), J.W. Nilsson and S.A. Riedel, Prentice-Hall, 2008 (Chapter 16)
2. ASCII Code Table, Mesa Community College
3. *Computer Networks* (3rd Edition), Andrew S. Tanenbaum, Prentice-Hall, 1996, (Chapter 2, pp. 78-81)
4. *Agilent 33220A 20 MHz Function Generator/ Arbitrary Waveform Generator User's Guide*

In this project, we will focus on Fourier analysis of periodic signals and applications to data communication. In particular, we are interested in determining the harmonic content and the time-response of both the transmitted signal and received signal. As discussed in class let us assume that we have a communication channel with capacity **C bits/sec** and data is transmitted over a communication channel with bandwidth **B Hz**. Assume we are transmitting 8-bit ASCII characters and we neglect control signals.

Please write a project report that addresses the following questions, using the IEEE Regional Student Paper Contest Guidelines. You are encouraged to expand on these questions and our class discussions and applications.

Questions

1. In your own words describe the **Fourier series**. What does it tell us? Why are we interested in it?
2. What do the following terms mean:
(A) **Harmonic**. (B) **Baud rate**. (C) **Bit rate**.
3. Suppose the bit rate is **C** bits/sec (bps), how much time does it take to transmit 8, 16, 32, 64 and 128 bits?
4. What is the bandwidth of a telephone line?
5. Suppose the bandwidth of a line is 3000 Hz, what is the number of the highest harmonic passed by this line?
6. Suppose C is 9600 bps, what is the frequency of the first harmonic?
7. Suppose the ASCII "b" signal [**0 1 1 0 0 0 1 0**] is passed through a 3000 Hz low pass filter.
 - a. What is the time response of the output?
 - b. What is the time response due to the first harmonic?
 - c. What is the time response due to the second harmonic?
 - d. What is the time response due to the third harmonic?
8. What is Nyquist's theorem for maximum data rate using two voltage levels?
9. What is Shannon result for a maximum data rate in a noisy channel?
10. What is a modem?
11. Obtain the binary 7-bit ASCII code for the first letter of your first name and last name.
 - a. What is the 8-bit code using odd parity? Where did you put the parity bit (MSB or LSB)?
 - b. What is the 8-bit code using even parity?
12. Let $C = 2400$ b/sec and $x(t)$ and $y(t)$ be the waveforms of your ASCII characters respectively.
 - a. Plot the waveforms of $x(t)$ vs. t and $y(t)$ vs. t .
 - b. What voltage levels did you use? Why did you use these levels?
 - c. Find the average power of $x(t)$.
 - d. What is the fundamental frequency of $x(t)$?
 - e. What is the fundamental frequency of $y(t)$?
 - f. Find the Fourier series of $x(t)$ and $y(t)$.
 - g. Plot the first 5 harmonics of $x(t)$ vs. t . What is the average power of each harmonic?
 - h. Let $B = 3$ kHz. How many harmonics of $x(t)$ can be sent over the channel? Plot the waveform at the receiver. What did you assume about the channel characteristics?
13. Program the Agilent 33120A Function Generator/ Arbitrary Waveform generator to produce the periodic waveform, $x(t)$. Capture the waveform $x(t)$ vs. t .
14. Design a low-pass filter with 3 kHz bandwidth and use $x(t)$ as your input. Capture the output waveform. Explain your observations.
15. Let $C = 1.544$ mega bits per second. **Repeat Question 12-g.**
16. What is the capacity of digital TV in North America?
17. What is the capacity of an analog TV?