

ELEC 320
Lab 2: Project 1
**Satellite Communications: sinusoidal signals, delay, phasors, power,
echoes, fading, Matlab® and Simulink®**

Project Report Due Dates

Monday Lab: **September 14, 2009**

Wednesday Lab: **September 16, 2009**

References

- *Signals and Systems: Continuous and Discrete*: Fourth Edition, D. R. Fannin, William H. Tranter, and Rodger E. Ziemer, Prentice Hall, 1998
- *Fundamentals of Electrical Engineering*, Leonard S. Bobrow, Oxford University Press, New York, 1996.(ELEC 120 text)
- *Electric Circuits* (8th Edition), by J.W. Nilsson and S.A. Riedel, Prentice-Hall, 2008. (ELEC 225,ELEC 226 text)
- *Microelectronics Circuits (5th Edition)*, A. S. Sedra and K.C. Smith, Oxford University Press, 2004. (ELEC 350 text)

Communication devices provide us with excellent applications of important concepts studied in ELEC 120 and ELEC 225-226. We will use this project to review our background of sinusoidal signals and learn how to apply them using a satellite communication example [Fannin, Tranter, and Ziemer]. Here we will try to understand the effects of delays, echoes, and fading. In addition, we will provide you with an opportunity to use Matlab and Simulink to better appreciate fundamental concepts.

As described in class, let:

$x(t) = \cos(\omega_o t)$ be the transmitted signal from the ground transmitter,

$x_{sat}(t) = a * x(t - \tau)$ be the signal received by the satellite,

$x_{refl}(t) = a * b * x(t - 2\tau)$ be the reflected signal to the ground station, and

$y(t) = x(t) + x_{refl}(t)$ be the total signal at the ground station.

Also, assume that $0 \leq t \leq T + \tau$ where $x(t)$ is transmitted over $[0, T]$

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. Find the amplitude (envelope) and phase of y using phasor methods.
2. Find the envelope of y using trigonometric identities. Hint:
$$a \cos(x) + b \sin(x) = c \cos(x - d), \text{ where } c = \sqrt{a^2 + b^2}, \cos(d) = \frac{a}{c}, \text{ and } \sin(d) = \frac{b}{c}.$$
3. Find the phase of y using Euler's identities. Recall: $\cos(x) = \frac{1}{2}(e^{jx} + e^{-jx})$
4. Plot x vs. t for various values of ω_0 .
5. Plot $a * b * \cos(\omega_0 * (t - 2\tau))$ vs. t for various values of ω_0 .
6. Plot the figures of question 4 and question 5 on one plot using the `subplot` function of MATLAB.
7. What is the power of x ?
8. What is the power of y ?
9. Plot the single-sided spectrum of x . (Amplitude and phase).
10. Plot the single-sided spectrum of y . (Amplitude and phase).
11. Show that the envelope of $y(t)$ is as shown above using Euler's identities for sinusoidal terms. Recall $e^{jx} = \cos(x) + j \sin(x)$
12. Plot the double-sided spectrum of x . (Amplitude and phase).
13. Plot the double-sided spectrum of y . (Amplitude and phase).
14. Suppose $y(t)$ exists from $0 \leq t \leq T$, write a mathematical expression for $y(t)$ using step functions.
15. Load and run the Simulink program provided by the instructor.
16. Read your favorite poem into a microphone and experiment with reciting it as you vary $a * b$ and the delay.
17. Have you ever experienced delays using your phone?
18. Have you ever experienced echoes when using your phone? Why do echoes occur?
19. Plot the amplitude of y vs. $\omega_0 \tau$.
20. Why do we experience fading? Explain why it occurs.