**EC310 Security Exercise 22**

**ASK/FSK**

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**Discussion:** A baseband signal is not compatible with communication networks (cable TV, telephone, or wireless). Therefore, we need to modulate the binary ones and zeroes. Digital modulation is different from analog modulation in that the analog carrier signal is modulated (or changed) by a discrete signal.

**Objective:** To provide hands on experience and further familiarize each Midshipman with some of the aspects of the simplest form of Amplitude Shift Keying (ASK), known as On Off Keying (OOK), as well as Frequency Shift Keying (FSK).

I. **On-Off Keying (OOK)**

In OOK, the amplitude of the digital signal controls the carrier signal, so that the carrier is turned on to represent a 1 and off to represent a 0.

Using your familiarity with the oscilloscope (o-scope) and function generator from your previous lab, set up the Function Generator with the following settings:

- Press the **Utility** button and set your Output Setup to High Z.
- Select the sinusoidal function by pressing the **Sine** button.
  - $f_c = 300$ kHz
  - Ampl = 1 V$_{rms}$
- Push **Mod** button with the following settings:
  - TYPE = AM
  - SOURCE = Int
  - AM Depth = 100%
  - AM Freq = 10 KHz
  - SHAPE = Square
- Connect the function generator Output (red to red, black to black) to CH 1 of the o-scope
- Connect the function generator Sync (red to red) to CH2.
- Push **Output** button to send the signal to the o-scope.
- Push AUTOSET on the o-scope.
- Adjust the o-scope with CH 2 on top (square wave) and CH 1 (carrier) on the bottom using the vertical positions on CH1 and CH2.
- Push the **Trig Menu** button on the o-scope and use the following settings:
  - TYPE = Edge
  - SOURCE = CH 2
  - SLOPE = Rising
  - MODE = Auto
  - Coupling = AC

**Note:** *You may need to adjust the Trigger level arrow to stabilize your display.*
Push CH 1 MENU to return.

Adjust the horizontal range and vertical ranges to 25 µsec per division,
Adjust CH 1 to 1.0 V per division
Adjust Ch 2 to 2.0 V per division

Note: Your scope display should look similar to Figure 1, below, except your digital signal is a square wave, 101010...

Figure 1

Question 1: Looking at CH1 and using the horizontal time scale to help you resolve the period, solve for the carrier frequency, f_c.

Question 2: Looking at CH2, find the bit rate, R_b? Is R_b different from the frequency of the square wave cycle, f_m=10kHz?

Change the o-scope to frequency domain by choosing MATH MENU and using the following settings:
- OPERATION = FFT
- SOURCE = CH 1
- 50 KHz per Division

The o-scope should look similar to the Figure 2 below.

Figure 2

Question 3: Find the carrier frequency from the o-scope display. (Hint: Count the number of (big) divisions from the left of the screen to the largest spike and multiply by the 50 kHz/div.)
Using the big divisions and step divisions, measure the bandwidth of the signal. (Hint: The bandwidth is determined by the first set of spikes to the left and right of the carrier. We will learn later that these are related to the half power points of the signal.)

**Question 4:** What is the “half power” bandwidth of the OOK signal (when \(f_m = 10kHz\))?  

Change the AM Freq on the frequency generator to 20 kHz, (so you are increasing your bit rate).

Measure the bandwidth of the signal between the first pair of sideband, as done in the previous step.

**Question 5:** Now, What is the bandwidth of the OOK signal (when \(f_m = 20kHz\))? 

**Question 6:** Based on the Questions 5 and 6, as the bit rate increases describe what happens to the bandwidth of the signal?

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**II. Frequency Shift Keying (FSK)**  
Frequency shift keying (FSK) is another digital modulation technique in which a continuous sine wave changes frequency when the digital bit stream changes between zero and one. The higher frequency represents a binary ‘1’ (also called mark) and the lower frequency represents a binary ‘0’ (also called space). FSK is used primarily in low speed applications (<500 Kbps) and noisy environments where accuracy is preferred over speed.

- Keep the carrier frequency the same (\(f_c\) is still 300kHz).
- Change the modulation mode to FSK:
  - Use the following modulation settings on the function generator (Mod):
    - TYPE = FM
    - SOURCE = Int
    - FREQ DEV = 200 KHz
    - FM Freq = 10 KHz
    - SHAPE = Square
- Push CH 1 MENU on the o-scope to return to the time domain.
- Set horizontal scale to 25 \(\mu\)s per division.

**Note:** Your display should look similar to Figure 3, below, where the ‘1’ = higher than carrier frequency and the ‘0’ = lower frequency.

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![Figure 3](image-url)
Question 7: Looking at the time domain representation of Frequency Shift Keying, how can you distinguish the transition between the increased carrier frequency and decreased carrier frequency?

☐ Adjust the picture on the o-scope to answer the next question by changing the horizontal range setting (sec/div).

Question 8: What is the high frequency? What is the low frequency?

☐ To see the difference in the bandwidth for the FSK signal, shift to the frequency domain. Push the MATH MENU button and use the following settings:
  o OPERATION = FFT
  o SOURCE = CH 1
  o 125 KHz per Division

☐ Measure the bandwidth between the sidebands (approximately) as shown in Figure 4. This will appear as the first sideband pair on the outside of the peak. It may be somewhat tricky to find this first sideband peak, so don’t give up.

![Bandwidth](image)

Figure 4

Question 9: What is the measured bandwidth? (Hint: Your answer should be much larger than your answer for #5.)

☐ Change the FM FREQ to 20 kHz and measure the bandwidth of the signal as shown in Fig. 4.

Question 10: What is the new bandwidth?

Question 11: Based on the above change, as the bit rate (Rb) increases, describe what happens to the bandwidth of the signal. What can you say about the comparisons of the Bandwidths for frequency modulation vs amplitude modulation?

☐ Turn off your equipment and clean up your lab bench.