Lab Report Guidelines

General guidelines:

- Focus on what you learned. If you are describing what you did, try and do so in the context on what you learned from it.

- Do use plots, pictures and/or math to explain what you observed or learned. Plots need not be exact (you can sketch them by hand), but do try and label any relevant parts you are referring to.

- If you did/observed anything interesting and you think you learned something relevant to communications, do explain it, even if it isn’t mentioned in the guidelines.

- You don’t have to repeat any information that is already in the lab guide, such as block diagrams, unless you did something differently.

- You can number the items in your report if you like, use sub-headings, or just divide it into paragraphs. Anything that is not too confusing is acceptable.

- There is no minimum or maximum length for the report. Use as much or as little space as you need to explain everything you learned.

- 70% of the lab report grade is based on your explanation of what you learned from the main experiment, and the rest is based on the extensions. The total grade for each experiment will be based on the lab report as well as the pre-lab grade, if there is one (the first 2 experiments don’t have a pre-lab grade). The “B” boundary will be around 70% for the course total at the end of the course, although that is not a strict rule.

- Of course, if you write about something, you should have actually done it in the lab. If you would like to do more and add to your report, let the instructor know so you can work an arrangement out.

- The following example is just that, an example. You don’t have to follow it closely, or explain things in the same way. Any side observations will depend on what you saw/learned, and so might not be the same as what is given here.

Sample lab report snippet (based on the first part of Lab 1):

Cosine signals show up as a sinusoidal signal on the oscilloscope, and approximately as 2 spikes on the spectrum analyzer, one on the positive frequency side, and one on the negative frequency side. With the carrier \( c(t) = \cos(2\pi f_c t) \), this matches with the Fourier Transform:

\[
\mathcal{F}[\cos(2\pi f_c t)] = \frac{1}{2} (\delta(f - f_c) + \delta(f + f_c))
\]
which has 2 delta functions at $f_c$ and $-f_c$. The magnitude of the spike is related to the magnitude of the cosine signal (as linearity of the Fourier Transform suggests). Varying the frequency of the signal does move the spike in the spectrum plot to the left and right.

When using an audio signal instead of a pure (single-frequency) cosine signal, the spectrum consists of a range of values, in the range -20 KHz to 20 KHz, with larger spikes in the -5 KHz to 5 KHz range. This matches the conventional understanding that audio signals usually need a bandwidth of 20 KHz (on the positive frequency side), although a bandwidth of 5 KHz is still comprehensible. This can also be checked by passing the audio signal through a low pass filter, with cutoff around 5 KHz. The quality of the audio is reduced, but it is still comprehensible.

We then use the audio signal generator module to generate a cosine signal for $m(t)$ (of, say, frequency $f_1$, which can be measured on the oscilloscope if needed), and build the block diagram from the lab guide, so that the output is $(c_1 + c_2m(t)) \cos(2\pi f_c t)$, for some value of $c_1$, $c_2$. We can vary the adder gain connected to $m(t)$ to adjust $c_2$, and vary the adder gain connected to the DC signal and/or the DC signal strength, to change $c_1$. The Fourier Transform of the output is as follows:

$$
\mathcal{F}[(c_1 + c_2 \cos(2\pi f_1 t)) \cos(2\pi f_c t)] = \mathcal{F}[c_1 \cos(2\pi f_c t)] + \mathcal{F}[c_2 \cos(2\pi f_1 t) \cos(2\pi f_c t)]
$$

$$
= \frac{c_1}{2} (\delta(f - f_c) + \delta(f + f_c)) + \mathcal{F}[c_2 \cos(2\pi f_1 t) \cos(2\pi f_c t)]
$$

$$
= \frac{c_1}{2} (\delta(f - f_c) + \delta(f + f_c))
$$

$$
+ \frac{c_2}{4} \left[ \delta(f - (f_c - f_1)) + \delta(f - (f_c + f_1))
\right.
$$

$$
\left. + \delta(f + (f_c - f_1)) + \delta(f + (f_c + f_1)) \right]
$$

When we connect the output $(c_1 + c_2m(t))c(t)$ to the spectrum analyzer, we should see 6 spikes (or equivalently, 3 spikes on the positive frequency side), at the respective frequencies, which we do. Changing the constants $c_1$ and $c_2$ varies the magnitude of the spikes, and changing $f_1$ changes the position of the left and right spikes (the spikes move further away from the center spike as $f_1$ is increased, which matches with the theory). Figure 1 is a sketch of the spectrum (the entire spectrum from negative to positive frequencies cannot be seen at the same time on the spectrum analyzer, but we can zoom in and look at one portion at a time).
Figure 1: Sketch of spectrum analyzer display

![Image of spectrum analyzer display with labeled frequencies and magnitude of the spectrum.](image-url)