ECE 1473 – Digital Communication Systems
Simulation Project – Format for Reports

When preparing your report, the content should be divided into six sections: Introduction, Procedure, Results, Discussion, Conclusions, References. Details for each section are described below.

THE SHORT VERSION.

Introduction: Begin by describing your simulation at a high level, including the particular type of modulation you are using. Give some context, where might one experience this type of modulation in everyday life? Describe what is in the rest of the report at a high level, but don't summarize results.

Procedure: Go through all the steps of your simulation, and explain clearly what you did, but do not get bogged down in code-level details. Include block diagrams, and other figures if necessary, but do not include your results. This section MUST NOT read like comments for your code, but it must describe your design in succinct and lucid prose.

Results: Provide figures showing each step of the process, from baseband signaling, through modulation, channel, demodulation and bit/symbol detection. Present the results for PSD and bit/symbol error rate last. EVERY RESULT MUST BE DESCRIBED IN THE TEXT OF THIS SECTION, NOT JUST IN THE CAPTIONS OF YOUR FIGURES. What should the reader note about your figures?

Discussion: Discuss your results. Do they match what you expect? Why or why not?

Conclusions: What do you conclude about simulating digital communication systems in MATLAB, and for your modulation scheme in particular? What did you learn?

References: What references did you use? Did you cite them appropriately in the text? If this list reveals a lack of effort on your part, I often find that the entire report is of questionable merit.

THE MUCH LONGER VERSION.

1. <u>Introduction</u>: (10 points)
   - Function: The function of the Introduction is to:
     - Establish the context of the work being reported. This is accomplished by discussing the simulations that you performed and the phenomena that you investigated, with citations from appropriate references, and summarizing our current understanding of the engineering problems that you addressed;
     - State the purpose of the work in the form of the hypothesis, question, or problem you investigated; and,

- Briefly explain your rationale and approach and, whenever possible, the different outcomes the experiment might reveal (but not the results you obtained).
- Quite literally, the Introduction must answer the questions, "What were we studying? Why was it an important question? What did we know about it before we completed this experiment? How will this study advance our knowledge?"

- Style and length:
  - Use the active voice as much as possible. Some use of the first person is acceptable, but do not overdo it.
  - It should be written in paragraph form, not as an itemized list, and should not include extensive details.
  - The Introduction will typically comprise 2-3 paragraphs, and less than one page.

2. Procedure: (30 points)
   - Function: In this section you explain clearly how you carried out the simulation including all of the following elements:
     - the design steps you performed for each portion of the simulation;
     - block diagrams illustrating each of the subsystems: baseband signaling, modulation, channel effects, demodulation and bit/symbol detection;
     - descriptions of how each subsystem was implemented in MATLAB; and,
     - descriptions of the signals that were displayed to confirm the proper functioning of each subsystem.

     Organize your presentation so that your reader will understand the logical flow of the simulation(s); subheadings work well for this purpose. Each subsystem and the associated signals should be presented as an integrated unit, as opposed to presenting all of the subsystems followed by all of the input and output signals.

     In general, provide enough quantitative detail about how your build each component in MATLAB such that other engineers could reproduce your experiments, but wherever possible avoid making direct reference to MATLAB functions and operators. For example, it is possible to describe computing the element-wise product of two vectors, without having to necessarily describe the MATLAB `.*` operator.

     Many students writing reports for the first time need much more detail in this section, and others unnecessarily clutter the procedure by writing a user's manual for the test equipment. A good rule of thumb is to imagine that the reader is a student who has completed ECE 1552, and is just about to begin ECE 1473, who understands how to use MATLAB to compute and plot functions of time, but is not familiar with any of the details of your simulation.

   - Style:
     - The style in this section should read as if you were verbally describing the conduct of the experiment. You may use the active voice to a certain extent, although this section requires more use of third person, passive constructions than others. Avoid use of the first person in this section.

- Remember to use the past tense throughout - the work being reported is done, and was performed in the past, not the future. Certain exceptions to this rule are detailed below.
- Do not write a set of instructions for someone else to follow, as you might see in your lab manual. Instead, write this section as a documentation of the steps that were performed.

3. Results: (30 Points)
   - Function:
     - The function of the Results section is to objectively present your key results, without interpretation, in an orderly and logical sequence using both text and illustrative materials (Tables and Figures). The tables and figures should be numbered, have descriptive titles, have identifying names and units for any measurements.
     - Describe what the reader is to note about each figure in the body text using one or more complete sentences, written as a paragraph. **Never present any figure without describing it in the text!** If your results section is just a set of figures and captions, you should expect a grade of zero for this section.
     - The results section always begins with text, reporting the key results and referring to your figures and tables as you proceed. Summaries of the statistical analyses may appear either in the text (usually parenthetically) or in the relevant Tables or Figures (in the legend or as footnotes to the Table or Figure).
     - The Results section should be organized around Tables and/or Figures that should be sequenced to present your key findings in a logical order. The text of the Results section should be crafted to follow this sequence and highlight the evidence needed to answer the questions/hypotheses you investigated. Important negative results should be reported, too.

   - Style:
     - Write the text of the Results section concisely and objectively. The passive voice will likely dominate here, but use the active voice where possible.
     - Extensive tables of raw data should be omitted entirely, unless specifically required by the laboratory assignment. Do not use both tables and graphs to represent the same information. Choose the best one for the particular situation.
     - Use the past tense; certain exceptions to this rule are detailed below.
     - Avoid repetitive paragraph structures. If you find that each result is presented using the same wording and sentence structure, consider how the results can be described differently.
     - Do not interpret the data here. The transition into interpretive language can be a slippery slope. The descriptive language that should be included in this section tells the reader what their eyes should be drawn to so that they understand this result: “what should I see here?” The interpretive language that should be reserved for the Discussion section answers questions such as “why did we obtain this particular result?”
     - Use specific values rather than general terms, e.g., instead of saying "a high frequency" specify the frequency as 1 MHz or whatever value you used.

4. Discussion: (15 points)
   - Function: The function of the Discussion is to interpret your results and to explain our new understanding of the problem after taking your results into consideration. The Discussion will always connect to the Introduction by way of the question(s) or hypotheses you posed and the literature you cited, but it does not simply repeat or rearrange the Introduction. Instead, it tells how your study has moved us forward from the place you left us at the end of the Introduction.

   - What should be included in the Discussion:
     - Go through each of your primary results and explain why you obtained the data (signals, spectra, bit error rates, plots, features) that you did.
     - If you have any means to compare the results you obtained with what was expected, then that comparison should be made in the Discussion section, along with a reasonable justification for any deviation from the expected result.
     - As an example, one could argue that percent error calculations can reasonably be included in either the Results section or the Discussion, but the explanation for why a certain percent error was obtained should be reserved for the Discussion.

   - Additional questions to answer in the Discussion include:
     - Do your results provide answers to the questions posed in the Introduction? If so, how do you interpret your findings?
     - Do your findings agree with what others have shown? If not, do they suggest an alternative explanation or perhaps an unforseen design flaw in your experiment (or theirs?)
     - Given your conclusions, what is our new understanding of the problem you investigated and outlined in the Introduction?
     - If warranted, what would be the next step in your study, e.g., what experiments would you do next?

   - Style: Use the active voice whenever possible in this section. Watch out for wordy phrases; be concise and make your points clearly. Use of the first person is okay, but too much use of the first person may actually distract the reader from the main points.

5. Conclusions: (10 points)
   - Make a set of conclusions based on the results you obtained and your discussion.
     - What are the most important lessons that were learned in this experiment?
     - Which principles of communications theory, signal processing, mathematics or computer programming explain the most significant results?
     - Summarize the most important elements of the Discussion, but do not simply restate what appears in that section.
     - If you are not sure which conclusions are most significant, and which are less significant, ask the Instructor!

- Additional questions to answer in the Conclusions.
  - Which positive or negative results surprised you?
  - Were you able to come up with reasonable explanations for your results? For example, what portion of the percent error you reported can be accounted for by your explanation, and what portion remains unexplained?
  - Did you learn anything new about the algorithms you designed, the design procedure or the measurements you made?
  - What do you conclude about the software tools employed, the measurements procedure, and your design?

6. References: (5 points)

   List any relevant references.
   - Be sure to include all text references, web references and human references that you used in completing the experiment and writing the report. Text references are always preferable when available.
   - Any reference you list should be cited somewhere in the report.
   - Do not include circuit components or test equipment, but do include data sheets and course documents (e.g. the lab manual) if appropriate.
   - If you use material from sources, and do not include appropriate references in this section, or do not provide proper citations where the material was used, you may lose points in the section where the citations are missing.

Additional Notes and Suggestions

1. Proper Tense:

   This is something that most students struggle with when writing lab reports. Think carefully about what is being said in each sentence to determine the correct tense.
   - In describing anything that you and your lab partner did in completing the experiment, use the past tense. Almost all of the Procedure and Results sections will be written in this way. You will also use the past tense in the other sections when referring to what was done to obtain the results.
   - There are some items, such mathematical relationships and electronic components that exist throughout time and should be referred to (abstractly) in the present tense. So for example, "the hybrid-pi model for the BJT states that, for small AC signals, the transconductance *is* given by the equation...," or "the 2N222 *is* a small, low-power, NPN bipolar junction transistor, which..."
   - When describing a specific instance of a component, or what you did with a mathematical equation as part of your design, you must write in the past tense: "the hybrid-pi model for the transistor *was* used to derive the following equations relating the AC voltages and currents...," or "the 2N222 transistor *was* inserted in the curve tracer, and the parameters for the test *were* selected as follows..."

- Another instance where it is appropriate to use the present tense is in referring to figures that appear in your document, but you must use the past tense to refer to any steps that were performed in obtaining the figure. Note how the following sentence mixes the past and present tenses correctly: "Figure 2 *shows* the waveforms that *were* obtained with the oscilloscope, with the function generator amplitude set to 36.5 mV P-P."

2. Active vs. Passive Voice:
   One element of style that is a subject of some debate with regard to technical writing is the use of the active and passive voices. These terms refer to the way verbs are used in sentences, and whether the subject of a sentence is clearly taking some sort of action.

   - *Active Voice*: The subject of the sentence is an agent, i.e. someone or something that is taking an action, and it is clear from the construction of the sentence who or what the agent is. For example: "The student measured the output voltage," in which the student is the agent, and measuring is the action.
   - *Passive Voice*: The subject of the sentence is acted upon by an agent that may be unnamed or unclear, and the action is the emphasis of the construction. The use of a form of the verb "to be" such as is, was, were, has been, or have been, followed by a verb in the past tense, will often indicate the passive voice. For example: "The output voltage *was measured* by connecting the multi-meter to point A in Figure 1, and…," in which it is not at all clear who was doing the measuring. Nevertheless, passive constructions such as this are perfectly acceptable in many parts of a lab report, because it is clear from the context that you and your lab partner did everything.

   Good technical writing makes use of both the active and passive voices, and this will vary from section to section in your lab report, as detailed above. In the Procedure and Results sections, passive constructions in the third person will be used frequently.
   - Incorrect: "We connected the function generator to the circuit input, and then we set the frequency voltage to 1 kHz."
   - Improvement: "The function generator was set to produce a 1 kHz sine wave and connected to the input terminals of the circuit."

   The active voice can be used in the Introduction while remaining in the third person.
   - "An operational amplifier provides a very high input impedance, typically in excess of 1 MΩ, to any signal source connected to the input terminals."

   Limited use of the first person is acceptable in the Introduction, Discussion and Conclusions sections, provided that its use adds strength and clarity to the writing. The best writers will make judicious use of both the active and passive voices in these sections.
   - Discussion: "The data from Figures 2 and 3 indicate that the output voltage was more than ten percent lower than the design specification of 5 Volts peak-to-peak. We were able to alleviate this problem by redesigning our circuit to shift the cutoff frequency…"

There are many resources available with helpful suggestions for report writing, and specifically addressing use of the active and passive voices. Two documents available on the internet are:

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- http://education.mrsec.wisc.edu/Edetc/research/slides/Active-passive_handoutA.pdf

3. Revision:

Perhaps the most important step in writing any document is editing and revision. After you have written your report, read it carefully and consider how it can be improved.

- Read what your lab partner has written, and don't be hesitant about making revisions. All good writers benefit enormously from editing performed by other people.
- Check for grammar, spelling and similar errors. Have you included meaningless statements?
- Have you used complete sentences or fragmented segments?
- Is the report concise and complete? Does it show that you understand the experiment and results?
- Is each section labeled? Is there material in one section that does not belong or repeats material from other sections? Do sections overlap in content?

4. Copying and Plagiarism

There is no reason to copy material from the lab manual, any other course documents provided to you, or any other source, into your pre-labs and lab reports. Doing so is a violation of the Academic Integrity policy of the University of Pittsburgh, and students in ECE 1473 must not submit documents that include copied materials. Pre-labs and lab reports that contain copied material will be subject to a grade penalty, and this penalty will increase for instances of plagiarism that are repeated or particularly egregious, up to and including a failing grade for the course.

Clearly, plagiarism of the work of another student, either currently enrolled in the course or who has completed the course in the past, is strictly forbidden and subject to the penalties described above. If you are provided with computer code as part of the course materials, all students are free to make use of it in developing their own software, but it is under no circumstances acceptable to use code written by another student or any other person.

The only other exception to this policy is the limited use of figures provided to you with the course materials: you may copy circuit diagrams and other figures from the lab manual, but only if they cannot be reasonable reproduced, and only if you provide credit for the figure by placing a citation to the appropriate reference in the caption of the figure. The circuit simulation tool PSPICE can be used to create circuit schematics, and other freeware drawing tools are available.