

Please read "Style Guide" on pages 20-25 before you start to write.

FARNUM 9/06

ESE-441 Report Guidelines

This memo documents the format for your technical reports. The report that you are required to submit in late October is only the first draft of a technical report which will be edited and resubmitted many times during the year. I think you will find that each revision of the report will be easier to write than the previous version as it is merely an update or an inclusion of a new section.

The report focuses on analysis and technical description. An engineer analyzes a problem to propose an economic solution, describes the proposed approach, and justifies the approach with technical analysis. Building the item or performing the experiment is merely the proof that the proposed solution is the correct one. This report is NOT a narrative of "My Senior days in the EE lab"!

All revisions of the paper will be edited and graded. Note that I edit grammar----and grade on it, too!

Most of the formal information on how to write a report was obtained from "The Elements of Technical Writing" by Gary Blake and Robert Bly, Macmillan, Inc., 1993. I got my copy at Borders Book Store for \$10! I know most of you are not going into "Hardcore" design engineering. However, all of you are going to be doing a lot of writing after you graduate and this book gives you all you need to know right down to punctuation rules and common mistakes (VERY valuable!). It obviously has a technical slant and all of the examples deal with technical issues. My suggestion is that you get a copy of this book or one similar to it and keep it on your desk right next to your dictionary and thesaurus.

A second source of information was Mr. Louis Sickles, formerly of Lockheed-Martin. In the early days of his career, Mr. Sickles was in the Advanced Development group and wrote many Independent Research and Development reports---both soliciting funds (Proposals) and giving results (Final Reports). Later on he was a Manager in the Systems Engineering Department, responsible for many large proposals.

The informal "stuff" is my own opinion. The last fifteen years of my career, I did a lot of writing.....proposals and reports mainly. My style is something I have grown comfortable with and will try to pass on to you in my editorial comments.

Please follow the format I have specified. In general, it's wise to follow the instructions given to you by your customer, supervisor, or professor. For a number of reasons he's spent some time of his own creating this format and expects to see it followed. It may be that this format is easier to grade, is easier to read, or that it is guiding you in what

you should consider. In industry a proposal is normally “thrown out”, **never even considered**, if the specified format is not followed!

Typical page allocations for the final report have been given for each section. These allocations are not “hard and fast” but are intended only as a guide. Submissions before the final report will obviously be “thinner”, particularly in the Strategic Plan and Accomplishments sections.

I’d like you to be consistent with respect to the style of the report. Please use the following settings for your word processor:

- Font: Helvetica (preferred) or Arial MT
- Size: 12 point
- Spacing: Single Space
- Margins: One Inch (All Four Sides)
- Pagination: Bottom, Centered

This memo is divided into a number of sections:

- Report Format
- Sections Required for Each Revision
- Miscellaneous Style Comments (from reading previous reports)
- Appendices (sample sections of previous reports)

One last item.....with each new submission I want you to hand in the previous revision. You’ll get them both back but I expect to see that you have addressed my previous comments.

I’m looking forward to working with you this year. Let me know if anything in this memo is not clear.

Mr. Farnum

SECTIONS REQUIRED FOR EACH REVISION

Sec. No.	Section Title	Rev. 1 (Late Oct.)	Rev. 2 (First Day of Final Exams)	Final (End of 2nd Semester)	Notes
	Title Page	X	X	X	
	Abstract		X	X	
	Table of Contents			X	
1	Motivation / Goals	X	X	X	
2	Introduction	X	X	X	
3	Discussion of Previous Work	X	X	X	
4	Strategic Plan	3 Artwork (Min.); Schedule	6 Artwork; Schedule	9 Artwork; Schedule	Notes 1,2
5	Results	Preliminary	X	X	Note 2
6	Lessons Learned			X	
7	Equipment / Fabrication Needs	X	X	X	
8	Conclusions and Recommendations			X	
9	Nomenclature	X	X	X	
10	References	X	X	X	
11	Bibliography	X	X	X	
12	Financial Information	Preliminary	X	X	
13	Ethics			X	
14	Software Documentation		X	X	
	Appendices				

- Note: 1. Artwork consists of block diagrams, schematics, flow charts, logic diagrams, photographs, or any figure or table.
 2. The minimum artwork which is required may be divided between Sections 4 and 5.

REPORT FORMAT

Title Page

The style and font size you use for the Title Page is your own choice, but the following items must be included:

- University Name
- School Name (i.e. Moore School of Electrical and Systems Engineering)
- Course Title
- Project Name (Bold Print, Larger Font)
- Author's Name
- Date
- Advisor's Name and e-mail
- Revision Number
- Group Number

The group number should be in the upper right corner of the page.

Revision numbers should be in the lower right corner of the "footer" where they can be printed automatically on each page. Use a smaller font (9 point) than that which is used for the rest of the report so that the revision number doesn't detract from the text on the page.

The initial submission should be "Rev. 1"; the next submission will be "Rev. 2". Please note that pagination does NOT begin on the Title Page.

A sample Title Page is in Appendix A-1.

Abstract (Half Page--Stand Alone)

The abstract is an informative, concise, statement of the work performed, its objectives and scope, and the major conclusions reached (Blake & Bly).

The abstract should be single-spaced, 12-point font, 250 words or less. Project title, department and author name(s) are to be clearly indicated at the top of the sheet. Abstracts should include the following important aspects of the project:

- Brief background
- Statement of problem
- Methods (approach) and main result. Keep other accomplishments out of the abstract. (Blake & Bly). In Rev 2 talk about the anticipated main result.
- Conclusions (Rev 3 only).

A sample abstract is given in Appendix A-2.

Table of Contents (One Page--Stand Alone)

The Table of Contents lists every section heading and subheading and the page number on which they appear (Blake & Bly).

1 Motivation/Goals (Half Page)-- Start pagination with this page. Start paragraph numbering with this section.

This section addresses the need or use for this project. Can you justify it?

“A motivation and goal statement should include an identifiable need and a clearly measurable (quantitative) goal” (Sickles).

A sample “Goal Statement” is in Appendix A-3. You should have a sentence similar to “The goal of this project is-----”. Do not list more than three (3) goals; one is sufficient.

Note: List only project goals, not personal ones! For example, learning Labview may be a necessary task to accomplish your project but it is not a project goal.

2 Introduction (Half Page to One Page)

The introduction tells the readers--including those not familiar with the subject matter--the purpose of the project. It differs from the “motivation” in that it is more detailed. It provides general background material, theory, and explanation of why the work will be done and what will be accomplished. The introduction should also provide the reader with the rationale for why the particular approach is appropriate.

A sample Introduction is in Appendix A-3.

3 Discussion of Previous Work (Half Page to One Page)

This section of the proposal should contain specific information on the background of the project (what other people have done), not the technical background of the author.

It is a summary and discussion of previous work relating to the problem. The discussion should summarize the results of each approach and their pros and cons. There must be literature references which are properly cited. Use a number enclosed in square brackets to identify the source eg. [1]. Any source cited in the text of your paper must also be listed in Section 10, “References”. See the “Electrical Engineering Style Guide” on the EE-441 Senior Design web site for details on how to cite references.

Be careful! Don’t “accidentally” plagiarize when you do your research. There is a lot more to plagiarism than failing to give credit to an author! Adding a few words of your own to text someone else has written or re-arranging text you did not write is still plagiarism. See the EE-441 Senior Design web site for more details on what constitutes plagiarism and how to avoid it. Note: the university has severe penalties for students who submit plagiarized material.

The Engineering Library (217 Towne) provides access to both print and electronic resources in the field of engineering. The librarians are available to assist you in searching the literature. See "A Guide to Information Resources for your Senior Design Project" on the EE-441 Senior Design web site.

4 Strategic Plan (Three Pages to Five Pages)

This section is the area where most of your effort should be focused for Revision 1 of your report. Use artwork to enhance your text. See the table on page 3 for the MINIMUM pieces of artwork which must be in each revision of your report.

Do NOT put your artwork in the appendix. Flipping back and forth between the text and the appendix makes the report difficult to read. I do not require you to embed your figures into the Word document. Just slip the figure into your report immediately after it has been referenced and paginate the figure by hand---i.e. "10a" if the figure has been inserted between pages 10 and 11.

The following sections discuss some of the items that belong in the Plan.

Note: There should always be a few lines of introductory text in Section 4 which introduce and summarize the information which appears in sub-sections 4.1, 4.2....

4.1 System Proposed Approach / Theory of Operation This part of the write-up should include a high level description of the proposed technical approach to designing your system.

A system block diagram (hardware) or a system flow chart (software) must be included to help the reader understand the approach that the author is taking to solve the problem. The diagrams should be referenced in the text and explained. Assume that your reader is a reasonably intelligent person with a technical background so that you don't have to explain every block---only the major ones.

In Appendix A-4 and A-5 I have included artwork for a sample design--an AM/FM tuner for a home entertainment system. Appendix A-4 contains a system block diagram of the tuner, a block diagram of one of the tuner subsystems (Switching Matrix), and a block diagram of one of the Switching Matrix subsystems (Input Switching Matrix). The later may also be referred to as a sub-subsystem block diagram of the tuner. Note that the sub-subsystem diagram is more detailed than the system diagram....not quite a schematic but almost. Appendix A-5 contains specifications for the subsystem and sub-subsystem diagrams. Note that the specifications are quantitative, not qualitative.

Sample software flowcharts are shown in Appendix A-9.

If your project is the construction of an apparatus, it should include a theory of operation and mathematical calculations of expected performance. I would expect to see:

- A description of what it is to be
- How it is to work
- Theoretical, mathematical, or logical analysis of the operation
- Expected performance (which ties into the previously stated project goals)

Frequently the project is a mixture of both investigation and construction. In this case the approach description will likely focus on a discussion of the alternatives and how they will be investigated.

4.2 System Specifications It is OK to state in the project submission form that (for example) you “want to build a tuner for a home entertainment system.” By the time you write Revision 1, however, you should be more specific and have a table that lists the quantitative characteristics of the system you are designing and that you will test against in April. For example:

Table 4.2 AM / FM Tuner System Requirements

- Receive commercial AM and FM band stereo transmissions (1 uv sensitivity).
- Drive two loudspeakers (100 watts per channel).
- Interface with tape deck and CD player (both IN and OUT).
- Provide three band equalization (+ / - 10 dB), volume control (-40 dB), and loudness control.
- Provide illuminated display visible in ambient light of (to be determined).
- Contain internal power supply (115 VAC / 60 Hz input power).
- Be packaged in a housing smaller than 17” (w) x 3” (h) x 12” (d).
- Operate over an ambient temperature of +10 C to +45 C without a fan.

These specifications may change and many more can be added as the design matures. That’s OK. However, in most cases, unless you have system specifications, you can’t go on to the next step of listing hardware or software requirements.

Note: Do NOT list in this paragraph the specifications of the hardware or software you will be using to do the design....i.e. do not list that you need a motor with 20 inch ounces of torque or a PC with a 500 MHz processor. They are tools which you will use to meet your hardware and software requirements and should be discussed in paragraphs 4.3.1 and 4.3.2

4.3 Hardware and Software Requirements Some projects won’t have System Requirements but all projects will have hardware or software requirements. These requirements will really be an introduction to what we are going to see next April. If either Section 4.3.1 or 4.3.2 is not applicable to your project, merely type the section number and title followed by “Not Applicable”.

4.3.1 Hardware Requirements and Design Approach In this section (and the next) you should get down to the “nitty-gritty” details of your design. You should list the quantitative tasks which the hardware must do in order to meet the system specifications. You should then generate subsystem and sub-subsystem block diagrams which show how the hardware is interconnected. See samples in Appendices A-4 and A-5. These drawings will help you generate detailed schematics at a later date.

Justification should be given for the selection of each component characteristic in your block diagrams (gain, bandwidth, compression level, to name a few). Again, the inclusion of some simple equations or curves as back-up gives the reader confidence that the author knows what he is talking about.

If your system uses a computer, you should discuss the reasons you chose the particular operating system you are using in addition to clock speeds, memory size, and allowances for growth. You should also talk about input and output data rates, the format of the data (ie RS-232), protocols, and any outside influences. For example is the system required to recover automatically from a power failure or just crash?

Even if your hardware is entirely digital, don't forget to include analog filters! You'll need them to decouple the power lines (minimize “ $L di / dt$ ” spikes caused by line inductance) or to prevent aliasing in the operation of A/D converters. Be sure to band limit your data input lines with low pass filters matched to the highest data rate! We've had many problems in the past with “wide open” data input ports that were accepting high frequency interference in addition to the desired data. Although your design may be processing only one kilobit data, the components are fast enough to respond to interference as high as 100 MHz.

4.3.2 Software Requirements and Design Approach Software projects require the same detail as hardware projects. This section should discuss requirements that your software has to fulfill in a generic sense and how you intend to do them. (Don't include the actual code).

In the Golden Retriever project (a robot that ran around a tennis court picking up balls), the software had to do many things, some of which were:

- Equalize the speed of the two drive motors so that the robot ran in a straight line
- Update the robot's calculated position on the tennis court so that it wouldn't wander onto an adjacent court
- Interface with the processor in the “eyes” subsystem so that it could go to the nearest ball that the “eyes” had observed

Merely listing the requirement is insufficient; you must discuss how you are going to address it. Using algorithms and flow charts will make your discussion easier to understand. If you are using purchased software, you should explain why you chose that particular software and what tradeoffs influenced your choice.

As the project matures, you can present charts listing all the major sections of your code as boxes and show all “go into’s” and “go out of’s” and all the global variables in each.

Some practical questions you may want to ask yourself as you think about the operation of your code are:

- Can the code handle a power supply interruption?
- Can the code handle inputs which are not in the proper format? (i.e. the code wants the operator to respond with either a “YES” or “NO” input but he responds with “MAYBE” or perhaps doesn’t respond at all).
- Can the code automatically get out of continuous looping problems or does it “loop” forever?
- Can the code handle overflow problems?
- Can the code be single stepped so that a specific failure point can be identified?
- Is the code sufficiently “commented” so that it is understandable?
- Is the code “testable”?

4.3.3 Interface Control Documents (ICDs) If your hardware or software is part of a bigger system then you should have an Interface Control Document in which you clearly state in quantitative terms each and every interface between your subsystem and the next higher level system. The ICD should have a cover page, revision page, and a place for approval signatures in addition to a description of the interfaces. Include the ICD in the appendix of your report.

It would be a good idea to have a similar document describing the interfaces between your own subsystems. An internal ICD can be less formal and can be written in a lab notebook and initialed by the designers of the two subsystems.

The purpose of the ICD is to prevent “surprises” during integration. No manager wants to hear one of his employees say: “But I thought you were going to do that!” Clearly defining interfaces early in the design phase allows engineers on both sides of an interface to correctly simulate the source or load on the other side of the interface.

For hardware systems the ICD can include (but not be limited to): amplitude of waveforms, DC offsets, source and load impedances, distortion, bandwidths, risetimes, overshoots, connector styles, pin assignments, etc. Environmental conditions are often in ICDs (temperature, humidity, vibration, shock).

Software systems can also have ICDs. The format of the data should be defined as well as protocols, clock speeds, and data rates. In addition, what is being done with the data should be defined (i.e. "I will give you raw data in this format; you will process it according to this algorithm and give the result back to me in this format").

A sample ICD is shown in Appendix A-6.

4.4 Test and Demonstration (Not required for Rev 1)

Design managers in industry feel very strongly about the subject of "Test". It is definitely not a topic which they want considered at the last minute! They want their designers, both hardware and software, to think about how they will test the end product while they are considering the actual design itself.

The following statements were received from two engineers in industry. Although they were responding to a question I asked about software, their comments are equally valid for hardware projects.

Jessica Fossler-Microsoft (Penn 2000)

"Its very scary to have an all or nothing project. What I mean by that is that it's not good to schedule things in such a way that you can't find out if the system works until you've glued it all together. The idea is to break the project up into milestones and set expectations for what (each portion of) the software will be able to do.

In the case of Jem2K (her project), that might be testing the coin collection mechanism by using switches instead of the serial port, or by writing a quick piece of code to test the server to see that it's responding in the correct way. The world doesn't have to be in a pretty state, but it's definitely good to be in a known state!"

Roger Ubben -Lockheed Martin (Retired)

"In my opinion, testing is the most important part of any design. As the computer types say: "Without it, it is "vaporware!" Only through testing can a functioning set of code be brought to reality. All major software companies release "beta test" software before the final release. They do this so they can release a product in the best functioning form when the public sees it. The same goes for software before your customer, or the president of your company, sees it. I would not have wanted to show my boss untested software!"

4.4.1 Test (One Page)

Include in your report a short section on how you intend to test both your hardware and software so that the integrated design will meet the system requirements of Section 4.3. Do not confine yourself to a discussion of system level test but also discuss how you will test each of your software modules or your hardware sub-sub-systems. Do not generalize; be specific and quantitative.

For example.....if you were designing the entire Penn Solar Car, you would have a test paragraph for each of the following:

- Transmission
- Engine
- Suspension
- Tires
- Telemetry
- Etc., etc.

The Telemetry test section would, as a minimum, have test block diagrams and limits for transmitter power output, receiver sensitivity, and modulation bandwidth.

4.4.2 Demonstration (One Half Page)

It's never too early to discuss what you will be showing on "Demo Day". After all, that's what the whole purpose of the project is. The earlier you can state what you will be presenting, the more you will be focused in your work for the balance of the year. You may also find that there are some special needs or special test equipment required for your demonstration which you don't need in the development of the hardware or software. It is better to procure that special equipment early in the program than waiting until obtaining it becomes a last minute panic!

4.5 Schedule (One Page for Schedule, One-half Page Text)

Making a realistic schedule is one of the toughest assignments that an engineer can be given! Believe me, it doesn't get any easier, even after forty years on the job!

The reason that it is so tough is that you are always guessing what tasks have to be done and how long any given task will take. If you are too conservative, then the schedule is too long, the labor cost estimate is too high, and you don't get the job. If you are an aggressive scheduler, you may get the job but you risk missing your delivery date and having an unexpected cost over-run if anything is overlooked. That doesn't make your supervisor happy either!

You will probably be asked to rework your 442 schedule many times in the next year as we try to put more detail into it. That happens in industry, too, so don't be discouraged.

4.5.1 Format: Schedules are to be done in a "Task-Timeframe" format using Excel or any "Schedule-Making" application. Schedules should fit on an **8.5" x 11" sheet of**

paper in Landscape format. For detailed schedules a second page may be used but the full time period of September 1 - April 25 should appear on each page of the schedule. Refer to Appendix A-10 for a generic example. Your schedule needs lots of specific details!

Dates should be shown in the header using the Sunday date to identify the week. Do NOT use week numbers to identify the date. Nobody knows when the 37th week of the year is.

Schedules should be easy to read. I've seen some which were generated in Excel but had the font turn "weird" when converted to Word or PowerPoint. There is no excuse for saying: "Here's my schedule. I know you can't read it but".

If you are using Excel, use different symbols for Tasks Scheduled and Tasks Completed. Use lower case "o" for Tasks Scheduled and UPPER CASE "X" for Tasks Completed.

Events happening in the first semester should be reasonably detailed; those occurring next year may be less detailed but should indicate the steps needed to finish the design by late April.

Leave time for integration, optimization, oversights, and mistakes (Refer to the Appendix on "Lessons Learned"!). I think your schedule should show that your hardware (or software) is together and doing roughly what it should by "early to mid" March. That will allow you a full month to "polish" and characterize the design.

Be realistic in your schedule. You will be having a lot of job interviews and taking trips for second interviews. You don't need to show "job interviews" on your schedule but don't ignore the time they will take.

"Shade-in" the time period for Finals, Christmas vacation and Spring break unless you are planning to work on your project during those time periods. The shading will remind you and the reviewer that these are "non-productive" time periods as far as Senior Design is concerned.

Each major task should be measurable; the task description should start with a verb (i.e. "Modify architecture", "Design preamp" "Partition software")

If two or more people are working on a project, put the initials of the responsible student behind each task. Different students may be responsible for sub-tasks but only one student (one set of initials) should be responsible for any given task. DO NOT show that a task is being shared by two students (i.e. PF / KL).

Update the schedule for each "one-on-one" review and for each revision of the report. Give it a critical look to see if it reflects what is in the Strategic Plan. It doesn't make

sense to see a plan which says "I'm going to do tasks A, B, and C" and then see a schedule which shows a time line for tasks D, E, and F.

A schedule should be included in your final report submitted in May showing what was (or was not) accomplished.

4.5.2 Text: Starting with the Rev 2, please add a half page to one page discussion to the "Schedule" section of the report . This discussion should clearly state if you are on schedule, ahead, or behind (and by how much). If "behind", discuss what your "Catch-up" plan is. Your discussion should justify your statements by referring to the Strategic Plan and Accomplishments sections of the report.

Some of the students who were behind last year asked if they could make a new schedule instead of showing a "schedule slip" on the current schedule. I have no problem with that after a couple of slips have been shown and the schedule gets too messy. However, you must discuss why you changed it. Showing a new schedule with the simple statement of: "The project is now on schedule" without any justification is unacceptable.

In the final report submitted in May, your discussion can state that you did (or did not) finish all tasks that were scheduled. If not, why not? Was the work load performed at a uniform rate or was there a monumental blitz at the end? Why? Would you have allocated more time for a special task if you had to make the schedule all over again?

5 Results (One Page--if there are any results--for Rev 1 Report, otherwise leave blank; One-Two Pages for Rev. 2 Report; Seven-Ten Pages for Final Report. Do NOT exceed 15 pages. Any text past page 15 will be ignored!)

This is the area where most of your effort should be focused for Rev 2 and Final Reports. Introduce it with a strong, positive statement such as:

"A ten pound Widget was designed, fabricated, and tested. Ninety percent of the project goals were met and shown to the press on Demo Day. The most significant goal, that of being able to lift a ten ton elephant, was met with a fifty percent margin."

A simple list of accomplishments is not really sufficient as the reader won't understand what you're talking about.

I think the Results section should attempt to track the Strategic Plan. If the Plan says you are going to do Tasks A, B, and C, then I ought to see results relating to Tasks A, B, and C in the Results section.

Do **NOT** list results in chronological order! A report is not a diary. Discuss the most important result first....then lesser accomplishments.

Use artwork to describe your results--block diagrams, simple schematics, curves of results, waveforms, flow charts, and sequence diagrams are just a few. Don't include tables of raw data, calculations, or data sheets; they belong in appendices. However, a table summarizing results is fine. So would one which summarized the results of a tradeoff between two or three possible approaches.

Don't forget the VG's you'll make during the year! "Copy" them if you had tables or curves in them. Just shrink them down and introduce them and explain them with a sentence or two. This was the approach one of my students in '96 used and her comment was: "That was the easiest report I've ever written. All I did was wrap a few sentences around some key VG's and write an introduction and conclusion.".....and this was a comment about a report which was being written from "scratch", not one which had been submitted a few times and was merely being edited.

For those of you who have done a lot of lab work...be careful! Don't document everything you've done or you'll be writing for weeks and grossly exceed the page guidelines. HIT THE HIGHLIGHTS and forget about the little things you did to accomplish them!

DO NOT discuss issues which were unsuccessful; they are NOT accomplishments. It's OK to discuss in detail how you solved a problem and then mention other approaches which were tried but were unsuccessful. However, the discussion of the unsuccessful approaches should only be a small paragraph so that it does not detract from the discussion of the successful attempt.

6 Lessons Learned (Half Page)

This section is NOT one where the author describes how he "Messed Up"! It's a place where you can give a warning to next year's students as to how you would have tackled the project differently were you to be given the chance to do it over again. Some good samples are given in Appendix A-7.

One of my "Lessons Learned" was not to put high gain, high frequency amplifiers on a proto board! With my concurrence, a student put a 70 dB gain, 10.7 MHz IF chip on a proto board. He eventually got it to work but the layout was EXTREMELY critical due to the lack of a low impedance ground plane. A lot of sweat, a lot of struggling by the two of us.....life would have been a lot more pleasant had we initially invested some extra time and built a simple PC board with a good copper ground plane!

7 Equipment / Fabrication Needs (Half Page)

Attempt to use equipment which is easily available. If your project falls into this category, then a simple declarative statement stating that fact is all that is needed in this section.

Special equipment which is not available in the EE Lab or items which need to be fabricated or purchased should be identified as early as possible so that the financial problem can be worked out. Machine shop help, in particular, takes a long time to get and is expensive! Shop work will not be authorized unless a dimensioned drawing, approved by your supervisor, has been submitted and reviewed by the course instructor.

The need for special software packages or special PCs should be addressed in this section. Do NOT list easily available equipment.

8 Conclusions and Recommendations (Half Page)

The conclusions are a series of numbered statements showing how the results answered questions raised in the stated purpose of the project. On the basis of the results and conclusions, the author can make recommendations about whether further work is needed (Blake & Bly). This extra work might be a candidate for a Senior Design project for next year.

9 Nomenclature (Half Page)

This section lists, in alphabetical order, the symbols, acronyms, or words used in the report which are unfamiliar to most readers. Acronyms and abbreviations should be defined. A brief description should be provided for unfamiliar terms. i.e.

SAW	Surface Acoustic Wave
VSWR	Voltage Standing Wave Ratio. The ratio of the maximum to the minimum voltage measured on a transmission line.
Xmtr.	Transmitter

10 References (Half Page)

Include a numerical listing of the technical literature (books, papers, brochures, reports, conference proceedings) used as reference material. There should be a “one-to-one” correlation between the references listed in this section and those cited in the text. See the “Electrical Engineering Style Guide” on the EE-441 Senior Design web site for details on how to cite the different types of reference material.

11 Bibliography

Include an alphabetical listing of the technical literature used for general research but NOT cited in the text.

12 Financial Information

12.1 All senior projects will require the submission of a financial information. This statement applies even if you will have no expenses. For those projects with expenses, the rule is, "If you don't ask, you don't get". In all cases, to get reimbursed for out of pocket expenses, you must submit a receipt, signed by Mr. Farnum or Sid Deliwala, to the EE business office.

12.2 The financial information should be in accordance with the following guidelines:

- Rational: Brief (0.5 to 1 page) explanation as to why money is needed.
- Budget: List of items exceeding \$10, with vendor and model when possible. Also include items on hand or obtainable for free. Service charges, e.g. shop time, should be identified. Justification of expensive items or items not clearly needed should be provided.

12.3 If the project should change during its development, requiring a change in funding, it is only necessary to submit an addendum specifying the changes involved and a revised budget.

12.4 Total expenditures exceeding \$75 per student will not be approved if not authorized in the budget.

13 Ethics (One to Two Pages)

The ethics section of your project report should include a short analysis of possible ethical and social implications of your project. The content of this section will vary, but you will probably want to discuss the following issues:

- 1) The larger context (technical, social, economic, legal) in which your system might someday operate. Think about who will use this system, how, and what other systems (power, support, maintenance) might be required.
- 2) Analysis of ethical components of the system. Discuss the potential ethical issues, risks, possible harms, etc. associated with your system.
- 3) A set of recommendations for addressing possible ethical concerns. What could be done to avoid or alleviate them? These might include design changes, guidelines for proper use, documentation, the development of maintenance or training programs, etc.

Remember that you will probably need to use your imagination to answer some of these questions. You will be evaluated on the quality of your analysis, not on the presence or absence of ethical concerns.

Refer to Appendix A-8 for a sample of an "Ethics" section. The Senior Design web page has additional sample "Ethics" write-ups.

14 Software Documentation

Most engineers do not like to document their design approach or their progress. They just want to jump--feet first--into some small detail of the design. Software engineers are no exception!

Unfortunately, code which is not well documented is very difficult to follow. Somebody who wants to modify your code at a later date (i.e. your Senior Design partner who is trying to help you) will spend as much time trying to learn what you did and when you did it then he will spend in modifying the code.

Include in Appendix 1 of your report all versions of the code for one (not all!) of your software modules. List the latest version of the code first with preceding versions following in descending order (Version 3 is on top of Version 2 which is on top of Version 1). The software module you use in Rev 3 does not have to be the same one you included in Rev 2.

Do not print out all your code and append it to your report.. In your final report in May, you should include a disc which has your software. The discs will be audited to see that all sections have the proper documentation. This section deals **ONLY** with a sample of the documentation you used throughout all of your code.

The only text required for Section 14 of your report is “See Appendix 1 for a sample of Software Documentation” if your project has software or “Not Applicable” if your project does not have software.

14.1 Header

Each software module shall have the following information as part of a header:

- Title and Revision Number
- Author
- Date Created
- Brief Description of What is to be Accomplished
- Location and Date of Last Back-up
- Revision List Containing:
 - o Description of Revision
 - o Revising Author
 - o Date Revision was Implemented

This information is to be imbedded in the software. It is not to be in a cover sheet attached to the software.

14.2 “Comments”

Your code should be well commented to help you remember what is going on or to keep a reader (co-worker or supervisor) from going astray. Comments should be added as the code evolves, not as a “last minute task” in April.

Jessica Fosler (Microsoft, Penn 2000) gave the following advice with respect to comments:

“Too many comments make the code unreadable -as they get distracting. My rules of thumb are:

1. Write comments above all functions / subroutines etc.
2. If you have a class or structure, comment what each member is supposed to do.
3. Comment anything you had to think hard about, "clever" things you do in code, or anything you think others may not find intuitively obvious.”

14.3 Test Code

Test Code for this particular module should be included as part of the material you submit in Appendix 1. If it is a separate module, place it in Appendix 2.

14.4 Additional References

The Senior Design web page has additional comments from industry on Software Documentation.

Appendices

I include items in an appendix which may interest some people but are really “back-up” material to the main report. Any item in the appendix should be referenced in the main body of the report.

Appendices should be separated from the main report by a breaker page. This page should be titled “Appendices” and then the individual appendices should be listed. You do not have to list page numbers on the breaker.

APPENDICES

A1	Code for Software Module “XXXXX”
A2	Data Sheet for Motorola MLT04, “Four Quadrant Multiplier”
A3	Derivation of Phase Locked Loop Characteristics

Each individual appendix should be clearly labeled and paginated. If an appendix has more than one page, then each sheet should have a page number, i.e.

A1-1
A1-2

You may paginate appendix material by hand. You do not have to paginate an appendix which has only one page.

Note: Do NOT include in the appendix the data sheet of every component you used or piece of code you wrote. Include only those items which you think have a special interest to the reader.

MISCELLANEOUS STYLE COMMENTS

1. **Figures and Tables** Figures and tables are to be referenced in the text BEFORE they appear in the document. Reference them by the figure (or table) number. DO NOT SAY “In the table below.....”. Instead say “In Table 1, it can be seen that...”.

It is desirable to have the reference to the artwork and the artwork itself be on the same page. If that can't be done, the artwork should be on the next page.

The text on figures must be legible! Do not shrink an original so much that one can't read the text. Print in Landscape mode if the artwork does not fit in Portrait mode. If necessary, print the figure on 11" x 17" paper and have it as fold-out artwork.

If you have a graph which is a screen shot, do not forget to type the titles of the X and Y axes. Remember that the independent variable goes on the X-axis with the dependent variable on the Y- axis. If you were plotting a curve of "Growth vs. Time", "Time " would be on the X-axis.

Titling a figure as "Fig. 1" is insufficient. It must have a descriptive title such as: "Fig. 1 System Block Diagram for -----".

The title for a table is typed ABOVE the table. The title for a figure is typed BELOW the figure.

Tables which are printed in Landscape format should be inserted into the report such that the table title is adjacent to the LEFT side of the report. Figures which are printed in Landscape format should be inserted into the report such that the figure title is adjacent to the RIGHT side of the report.

After referencing a table in the text, it is better to print the entire table on the following page rather than printing half on the reference page and half on the following. If a table is very long and must flow onto a second page, then repeat the table headings on the second page.

2. **Use of the Word "Etc."** Using the word "etc." implies some knowledge by the reader and should be avoided. In technical writing, the writer tries to convey information and the less the reader has to fill in, the smaller the chance of his misunderstanding something. If "etc." is used, it should be preceded by at least three items in the series and the remaining items (though not mentioned) should be obvious.

For example, how would you feel if you went into a clothing store and the salesman said, "We have lots of colored shirts: Red, etc." ? You wouldn't have the faintest idea if he carried blue or green shirts. If, however, he had said, "Our shirts come in

every color of the rainbow: Red, orange, yellow, etc.” then you might have more confidence in finding that blue or green shirt.

3. **Use of the Words “I” and “We”** With few exceptions, one does not use personal pronouns in technical writing, particularly in a proposal. It’s O.K. if one is speaking for the corporation such as the General Manager does in his cover letter to the proposal or if one wishes to avoid needless repetition of terms such as corporate names, customer titles, or job titles.

One could argue that the use of “we” in these papers is O.K. as the authors are speaking for the total team (and hence were assuming the roles of President and General Manager!). That argument may be true but probably will not be applicable next year when you will be out in industry and will be small members of a big team--better to try and change the style now.

4. **Use of the Words “He”, “She”, and “He/She”** With very few exceptions pronouns denoting gender are not used in technical writing.....PARTICULARLY the politically correct “He/She”. That form may be OK for a legal document but not for a technical one!

Instead of saying “The operator adjusted his/her chair so that he/she could see the monitor more easily” say “The operator adjusted the chair so that the monitor could be seen more easily.”

5. **Use of the Word “First”** If the word “first” is used to introduce a series of actions or events, it should be followed by the words “next” or “second”. Omitting these words and the other events leaves the reader hanging.

I think it’s perfectly clear what my plans are if I say, “First, I’m going to analyze the problem, then I’m going to buy my long lead items, and finally I’m going to build a prototype.” If all I said was, “First, I’m going analyze the problem”, I’m sure your reaction would be “What’s next?”

6. **Indenting** I like to “bulletize” and indent a series of items or events that are mentioned--especially if they’re important. Using this technique makes the words stand out and catches the reader’s eye, particularly if the page is filled with text.

To make them stand out a little bit more, add a blank line between the introductory paragraph and the first bullet and a second blank line between the last bullet and the following text. Which is clearer, the text about my design plans in the preceding paragraph or that which appears below?

- <----- Add a blank line before bullets
- Analyze the Problem
 - Buy Long Lead Items
 - Build a Prototype

<----- Add a blank line before new text

I'm sure you'll agree that the text in "bulletized" format is easier to read than the text in paragraph format.

7. **Slang / Jargon** Be careful not to use slang or jargon (technical slang) in your reports...they have no place in technical writing.

For example, in casual conversation, I might say: "You are designing too much gain into that amplifier; I'm afraid it is going to take off". In formal writing I would use the word "oscillate" instead of "take off" as many people outside the RF and analog worlds would have no idea what I meant by "take off".

8. **Paragraph Separation** Indenting five spaces is no longer used in technical writing. Add a blank line between paragraphs to separate them.

There are many forms of numbering paragraph titles. I like to use the following form as the importance of the paragraph can be implied by the font used in the title.

1 **SECTION TITLE** (CAPS, BOLD, UNDERLINE, LEFT JUSTIFICATION)

1.1 **FIRST LEVEL PARAGRAPH** (CAPS, BOLD, LEFT JUSTIFICATION)

1.1.1 **Second Level Paragraph** (Upper / Lower Case, Bold, Underline, Left Justification)

1.1.1.1 **Third Level Paragraph** (Upper / Lower Case, Bold, Left Justification)

For very large reports (over 100 pages) with many sub-paragraphs one can "center" the section title (**CAPS, BOLD**) and have the **FIRST LEVEL** paragraph be **CAPS, BOLD, UNDERLINE, LEFT JUSTIFICATION**. Do not go beyond a fourth level (four decimal points) as the number becomes too difficult to read.

9. **Hanging Paragraph Titles** Watch out for titles with no text! They look weird. Include at least one line of text on the same page as the heading. If there is not room for at least one sentence under a title, insert a "Page Break" and have the title appear at the top of the next page.
10. **Possessive** Inanimate objects do not use the possessive form. It's OK to say: "My dog's paw is sore" but not OK to say: "My car's door was dented". Instead say: "The door of my car was dented."
11. **Abbreviations** Use capitals properly in your abbreviations. For example, those of you planning to enter the RF world should know to use "kHz" not "Khz" and "MHz" not "MHZ".

When you have a number in front of an abbreviation, leave a space between the number and the abbreviation just as you would had you not used an abbreviation. For example, frequencies should be typed using the form “10 MHz”, not “10MHz”.

12. **Acronyms** Unless an acronym is well know and commonly used in everyday speech, it should be introduced before being used in text. This introduction is done by spelling the full name of the acronym and then immediately enclosing the acronym in parenthesis.

It is all right to say “My parents came to the US when I was nine years old” because most everyone knows that “US” stands for “United States”. However, most of you would be lost if I were to tell you that my wife teaches at GCC. It’s better to say “My wife teaches at Gloucester County College (GCC). After that I can use the acronym “GCC” and you would know what it means.

Be careful not to use too many acronyms or your text will look like alphabet soup! Maybe you know what the acronyms mean but many of your readers won’t and your text will be very difficult to read.

If there are a number of acronyms used, it is best to have a table of acronyms in the rear of your paper defining them.

13. **Numbers / Percents** Write out all numbers less than 10. Write out the word “percent” unless it is being used in a table.

Do not start a sentence with a numeral or a symbol (1,2,3,\$). Write out the word (One, Two, Three).

14. **Leading Zero Missing on Decimal Numbers Less Than One** It is too easy to miss a decimal point in text if your eye is not looking for it. There is little distinction between a decimal point and a spec put on the paper by a reproduction machine. The best way to avoid this problem is to place a “zero” in front of the decimal point for all decimal numbers with a magnitude less than one. For example:

- One centimeter equals approximately 0.4 Inches (Good)
- One centimeter equals approximately .4 Inches (Bad)

15. **Useless Words** Get rid of useless words such as: “As mentioned above……” They add nothing to the proposal. There is no need to say something twice.
16. **Leading Conjunctions** Conjunctions such as: “And, But, Or, Nor, For, Yet, So” are used to link the two halves of a sentence, not introduce a single sentence.
17. **Humor** Delete humorous or personal statements such as:

- “We worked awfully hard to get this proposal in on time.” (Who cares?)
- “Fall Break. Thank Goodness!”

Invariably, these comments get overlooked by the technical editor and end up being printed and submitted to the customer in the final document. Your supervisor is then embarrassed and has a lot of explaining to do for you. Not a good way to enhance your career.

18. **“Flowery Bull----”** Delete “bull” statements such as: “This project will once again allow me to work with Dr. X. who is undoubtedly the finest EE professor at the university.” Or, how about: “I’m happy about this project as it will be the culmination of my undergraduate career at Penn, bringing together all the knowledge I’ve gained in the past three years.”
19. **Parallel Construction** Words in a pair or series should have a parallel structure. By balancing the items in a pair or series so that they have the same structure, you will make the sentence clearer and easier to read. For example:

Not Balanced

My job includes checking the inventories, initialing the orders, and *to call* the suppliers. (Not balanced).

Balanced

My job includes checking the inventories, initialing the orders, and *calling* the suppliers. (A balanced series of -ing words: checking, initialing, and calling).

The Eagles looked alternately clueless, lifeless, and hopeless in the first half--Phil. Inquirer, 8-15-98. (A balanced series of “-less” words).

20. **“This”** The word “this” should be used with caution. It must have a clear, direct reference when used as a pronoun. If not, there will be confusion as to the author’s meaning:
- “I love a surprise. This makes my day!” (OK)
 - “I’ve read 35 papers today, all dealing with software! This is awful!”

(What is awful? Reading 35 papers....or the fact that they all deal with software?)

21. **“Utilize”** Technical writing has a way of bring weird styles out in authors. Using the word “utilize” is one. It makes technical editors cringe! I have never heard a single person use that word in conversation but I’ve seen it a “zillion” times in drafts of technical text.

For example, when you were a child did you ever hear one of your parents say, “You have food on your face. Utilize your napkin!”? I’ll bet the answer is “Never!”

However, I’ve seen (more than once!) statements such as “Utilizing an oscilloscope or a DVM, observe that the supply voltage is + 5 VDC.”

I’ll pass on a saying given to me by a tech editor when she had gotten through correcting one of my submissions (which used “utilize”):

Never use “Utilize” when you can utilize “Use” !

APPENDICES

- A-1. Sample Title Page
- A-2. Sample Abstract
- A-3. Sample “Goal”, “Introduction”, and “Background” sections
- A-4. Sample System, Subsystem, and Sub-subsystem Block Diagrams
- A-5. Sample Subsystem and Sub-subsystem Requirements
- A-6 Sample ICD
- A-7. Sample “Lessons Learned”
- A-8. Sample Ethics Section
- A-9. Sample Software Flow Charts
- A-10. Sample Schedule

A-1 SAMPLE TITLE PAGE

Group 17

University of Pennsylvania
Moore School of Electrical and Systems Engineering

ESE 441 / 442 Senior Design

PROJECT TITLE

Author's Name (Alphabetical order if more than one author)

Date

Advisor: Professor XYZ
e-mail: xyz@seas.upenn.edu

A-2 SAMPLE ABSTRACT

Moore School of Electrical Engineering
University of Pennsylvania

Authors: Daniel Araujo & Jorge Trujillo

Real-Time Facial Tracking System (1)

Abstract

The subject of tracking faces and facial features has recently become an area of intense study. Several approaches to the problem of following a moving subject's face in a live video stream have been developed, and each possible solution presents different computing requirements and performance characteristics.

It is said that a picture is worth one thousand words, and in this sense video conferencing represents the future of business and personal communication. Unfortunately cameras are static objects and significantly limit the flexibility of video conferencing. Giving the camera the ability to follow a subject would improve this method of communication and bring it one step closer to a face-to-face experience.

In the chosen approach, color information from the user is first extracted and stored. This information is then used in a statistics based algorithm that operates on individual pixel color values to identify the location of the subject's face. To minimize computational overhead, a smart search algorithm that searches around $1/24^{\text{th}}$ of the total number of pixels in a frame was devised. Finally, two servo-motors rotate to point the camera in the face's direction.

The full implementation of the system allows for real-time tracking of a subject's face at a rate of over fifteen frames per second and can follow this subject over a 180° field. The system is also robust enough to track people of different skin colors in varying light levels, although performance does decrease with poor lighting. Nevertheless, the current implementation of the system is well suited to any video conferencing or web cam application.

(1) Printed with permission of the authors.

A-3 SAMPLE “GOAL”, “INTRODUCTION”, AND “BACKGROUND” SECTIONS (1)

1.0 MOTIVATION / GOALS

There is tremendous hope that present day imaging techniques for the detection of breast cancer can be vastly improved. Since the detection of breast tumors is sufficiently difficult that no single imaging technique is adequate, technologies implemented together efficiently and effectively should result in improved detection and diagnosis of breast cancers. The hypothesis behind the project states that the sensitivity and specificity of ultrasound examinations of small lesions in the human breast will be increased by a combination of ultrasound and near-infrared (NIR) diffuse light imaging techniques. There are three specific goals to the project:

- To construct a two-dimensional ultrasound and NIR array capable of acquiring ultrasound and NIR data in real time from human subjects.
- To evaluate ultrasound-light and ultrasound-alone images using human observers.
- To quantitatively compare detection sensitivity and specificity of the combined technique with conventional ultrasound by measuring Receiver-Operator Characteristic (ROC) curves.

2.0 INTRODUCTION

Breast cancer is the leading cause of cancer deaths for women in the United States today. Even though significant discoveries and strides have been made in recent years, there is no known prevention for breast cancer. In addition, treatment is usually most beneficial only if the cancer is detected early. Current detection techniques include:

- X-ray mammography
- Magnetic Resonance Imaging (MRI)
- Ultrasound
- Near-Infrared Diffuse Light Imaging (NIR)

(1) Patel and Rosenstock, “Near Infra-red Diffuse Light and Ultrasound Imaging for the Detection of Breast Tumors”, EE 441/442 Final Report--1998)

2.1 X-RAY MAMMOGRAPHY

At present, X-ray mammography is the only screening tool for detecting non-palpable breast cancers because its resolving power is better than the other imaging techniques. Unfortunately, X-ray mammography is limited in its inability to distinguish between benign and malignant lesions.

2.2 MAGNETIC RESONANCE IMAGING (MRI)

MRI offers exciting potential for increased tissue characterization, because it has the advantage of high soft tissue contrast that can detect small breast tumors and lesion structure. However, MRI is very expensive.

2.3 ULTRASOUND

Standard ultrasound imaging is excellent in distinguishing cysts from solid lesions and is commonly used in conjunction with X-ray mammography. Ultrasound imaging can resolve objects a few millimeters in size in a homogeneous medium, and its resolution in the inhomogeneous breast is gradually improving. Unfortunately, the sensitivity (the ability to measure small degrees of change) and specificity (the ability to distinguish and be precise and particular in measure) of ultrasound are low.

2.4 NEAR-INFRARED DIFFUSE LIGHT IMAGING (NIR)

NIR diffuse light is expected to have high specificity and sensitivity because it provides five novel biochemistry parameters, which differ in tumors and normal breast tissues. These five parameters are blood concentration, blood saturation, mitochondrial light scattering, water concentration, and concentration of exogenous contrast agents. However, NIR diffuse light suffers poor spatial resolution because of the diffuse nature of NIR light in human tissue. Presently, the technique can distinguish simple structures of approximately 1 centimeter in size, and sharp edges are usually blurred by a few millimeters (Yodh and Chance).

2.5 ULTRASOUND AND NEAR-INFRARED DIFFUSE LIGHT IMAGING

The innovative combination of ultrasound and NIR diffuse light methods proposed in this project has the potential to improve detection sensitivity and specificity. This dual-imaging technique will take advantage of ultrasound imaging capability and NIR high specificity and sensitivity potentials to improve detection of small growing breast tumors. The NIR data will provide a Region of Interest (ROI) for human observers to search for possible lesions in the ultrasound images. It will act essentially as a pointer by identifying specific areas where doctors should look for potential tumors. In addition, the NIR images will add diagnostic information to the images obtained through ultrasound imaging. If successful, this could result in an inexpensive screening device, which could assist X-ray mammography for early detection of breast cancers and

reduction of false breast biopsies. It could also have a highly beneficial impact on the early treatment of breast cancer.

3.0 DISCUSSION OF PREVIOUS WORK

3.1 OPTICAL SPECTROSCOPY AND IMAGING

Over the last two decades, the scope and relevance of research being conducted on optical methods for spectroscopy and imaging have increased dramatically (Yodh and Chance). Spectroscopy is useful for the measurement of time-dependent variations in the absorption and scattering of large tissue volumes. Imaging is vital when localization of heterogeneities inside tissue is involved. A spectrum window that exists within tissues in the 700-900 nanometer region (NIR), in which photon transport is dominated by scattering rather than absorption, makes optical spectroscopy and imaging of body structure and function possible. Thus, NIR photons diffuse through relatively thick tissues, such as 10-20 centimeters of a large human breast.

The promise of the NIR diffuse method has led to the first clinical studies of the diffusive wave optical technique in the human breast. In these experiments, diffuse waves were applied to human tissue in the transmission mode in conventional x-ray compression parallel plate source-detection geometry. Wave amplitude and phase data were collected and then processed using a phase-corrected linear back-projection procedure (Graber, Chang,...). The inversion procedure did not separate scattering from absorption. Nevertheless, the technique gave images of approximately 1-centimeter diameter tumors in roughly 60-70 percent of the cases congruent with x-ray mammography of the same breast (Graber, Chang,...). There were also relevant exceptions, but the results were the first, clear indicator that the method is potentially very important and that further investigation is required.

3.2 OPTICAL PHASED ARRAY

A simple optical phased array system (OPAS) has been constructed that measures the interference intensity-modulated NIR diffuse light signals (in-phase 0° and out-phase 180°) at detector positions equidistant from two sources (Chance, Kang, He,...). In the absence of heterogeneities the signals will cancel, and the null plane is always at the bisecting plane (Figure 3.2a). If a hidden heterogeneity (light-absorbing object) is present in the medium, the balance of the sources on the bisecting line is perturbed, and the null line will deviate (Figure 3.2b). Measurements show that in the presence of this light-absorbing object, the amplitude null and the interference plane becomes a curved surface, which is deflected toward the heterogeneity. The degree of deflection is related to the volume and the absorption characteristics of the heterogeneity and provides detection of the heterogeneity (Chance, Kang, He,...). This characteristic may provide localization information for the detection of this heterogeneity. For example, if the detector in Figure 3.2b is translated approximately to position -1.25, the detector would now see the amplitude null at this location as opposed to position 0 for Figure 3.2a. The newly formed null line defines the line-of-sight through either mechanical or

electronic scanning. This method provides a highly sensitive localization of very small (~1 mm) single objects to an angular accuracy of a few degrees (Chance, Kang, Liu,...). However, exact object shape and size information and optical properties cannot be obtained from the null imaging.

Figure 3.2 Illustration of object localization by Optical Phased Array System

3.3 DIFFUSIVE WAVE OPTICAL TOMOGRAPHY

This method uses a fast Fourier Transform for direct reconstruction. In addition to providing information about the position and shape of hidden objects, projection images can be used to deduce the optical properties of heterogeneities without the need for complex reconstruction procedures (such as matrix inversion) when the heterogeneities are thin and information on their depth is available (Li, Durduran, Yodh,...).

3.4 PULSE-ECHO ULTRASOUND IMAGING

A short burst of acoustic pulses is generated by a piezoelectric transducer array, which is capable of converting electrical energy to acoustic energy and vice versa, and is directed into the body along any scan direction; echoes are generated and travel back to the transducer. Ultrasound specificity is low due to the considerable overlap of acoustic characteristics between benign and malignant lesions (Havlice and Taenzer).

A-5 Sample Subsystem and Sub-subsystem Requirements for AM / FM Tuner

Table A-5.1 Switching Matrix Requirements for AM / FM Tuner

Characteristic	Requirement
Number of Inputs	4
Input Impedance	1 Kohm +/- 10 %
Input Isolation	80 dB minimum
Volume Control Range	40 dB minimum-Logarithmic Taper
Input Voltage	3 mv nominal (1-10 mv range)
Gain to PA	60 dB +/- 2 dB
Gain to Secondary Outputs	0 dB +/- 2 dB
Number of Secondary Outputs	4
Output Isolation	80 dB minimum
Signal-Noise Ratio (3 mv input)	80 dB minimum
Equalizer Requirements	
Band 1 (20-200 Hz)	+/- 10 dB
Band 2 (200-2,000Hz)	+/- 10 dB
Band 3 (2 kHz-20 kHz)	+/- 10 dB

Table A-5.2 Input Switching Matrix Requirements for AM / FM Tuner

Characteristic	Requirement
Number of Inputs	4
Input Impedance	1 Kohm +/- 10 %
Input Isolation	80 dB minimum
Volume Control Range	40 dB minimum-Logarithmic Taper
Input Voltage	3 mv nominal (1-10 mv range)
Insertion Loss	1 dB maximum
Bandwidth (1 dB)	20-20,000 Hz
Signal-Noise Ratio (3 mv input)	80 dB minimum
Load Impedance	1 Kohm +/- 10 %
Control Logic	
Multiplexer	2 wire-digital (0 /+5 volts)
Volume Control	5 wire-digital (0 /+5 volts)
Power	+5 VDC @ 10 ma maximum
Spare Pins	2 minimum

A-6 Sample Interface Control Document (ICD)

Input Switching Matrix Interface Control Document

The Input Switching Matrix accepts one of four audio inputs, adjusts its level and passes the signal off to the preamp in the switching matrix. A description of the signals on connector J1 is provided in the following paragraphs

J1-J4 Audio Input Signals

Channel Number	Source
1	AM/FM Tuner
2	CD Player
3	Tape Deck
4	Spare

The nominal level is 3 mV with a range of 1-10 mv. The bandwidth of the signals is 20-20,000 Hz and the input and output impedances are 1 kohm +/- 10 percent.

J5-J11. Control Signals A level of +5 VDC +/- 0.25 VDC shall be a logic high; a level of 0.25 VDC +/- 0.25 VDC shall be a logic low. The logic high will always be at least 0.1 volts lower than the supply voltage. The control voltages for the input switching matrix are in Table A6-1.

Table A6-1 Switching Matrix Control Logic

<u>Channel Selected</u>	<u>J1-5</u>	<u>J1-6</u>
1	0	0
2	0	5
3	5	0
4	5	5

The control voltages for the volume control are in Table A6-2. J1-11 is the least significant bit and J1-7 is the most significant bit. The attenuation change shall be a nominal of 1.5 dB per bit.

Table A6-2 Switching Matrix Control Logic

<u>Attenuation</u>	<u>J1-7</u>	<u>J1-8</u>	<u>J1-9</u>	<u>J1-10</u>	<u>J1-11</u>
Minimum	0	0	0	0	0
1.5 dB	0	0	0	0	5
3 dB	0	0	0	5	0
-----	---	---	---	---	---
43.5 dB	5	5	5	0	5
45 dB	5	5	5	5	0
Maximum	5	5	5	5	5

J12. DC Power The DC input voltage will be 5 +/- 0.25 VDC. The current drain shall be less than 10 ma.

J13. Ground

J14-J15. Spare

A-7 LESSONS LEARNED

1. "The schedule planned out in the beginning of the year proved to be too tight and no room was left for any setbacks. Future project undertakers need to be cautioned that they should leave room in between different phases of the project so that one setback would not induce major delays to the remaining parts of the project."

Ang, Tong, Yoon----- "CMOS Camera", 1997.

2. "The most important lesson learned through this project was with regard to hardware documentation. The hardware and documentation were secured late in the first semester. However, once in hand, the documentation proved to be much more difficult to interpret than had been anticipated. There was a steep learning curve associated with learning to understand the technical language and then eliminating the information that was not relevant to the project at hand. Much more time should have been scheduled to simply understanding the documentation and experimenting with the hardware. "

Patel, Weingarten-----Design of a T1 HDLSL Modem, 1997

3. • Always work with a language that allows you to represent your results in a clear, easy, fast, and accurate way. It is too hard to try to understand what is going on in a simulation from numbers or ambiguous representations.
- Always understand the concept and procedure behind a technique.
 - Try to figure out how the parts will add up to the whole at the end.

Lacaze--- "Rogaine® for Jack®", 1997

4. • ALWAYS ORDER SPARE PARTS! Our processor got burned at a crucial time and we did not have an extra.
- Perform better research of hardware components needed for the project. We started using Xilinx and Cypress parts and by the second semester realized it would have been nearly impossible to finish the project on schedule.
 - Divide responsibilities according to experience and expertise. This is one area where we performed brilliantly throughout the year! It MUST be done in order to finish a project of this complexity.

Roman and Moreno-----Interface Between an Image Sensor and a PC Monitor

5. "Learned the value of referring to textbooks from previous courses. Able to use this to refresh concepts that we then used in our design.

Learned to double check the accuracy of the test equipment. We lost one afternoon worth of work looking for errors in our circuit, while the problem was in the test equipment.”

Un and Cultu-----Frequency Error Detection Scheme (FEDS), 1997

6. “ Do not assume that a process that worked once will work forever. Much time was wasted in this project by assuming that the chemistry was stable. After a month of searching in the wrong direction, we realized that the “glue” was to blame. All it took was an hour long test that could have been performed earlier in the project.”

Paransky-----Photonic Crystals, 1997

7. “The greatest lesson was the importance of a detailed system design. It is incredibly valuable to clearly understand how several parts of a project are integrated together”.

Patel and Rosenstock-----Near-Infrared Diffuse Light and Ultrasound Imaging for the Detection of Breast Tumors, 1998

8. “Whenever tackling a VLSI fabrication project, one must always set aside ample time in the schedule so that any setbacks encountered would not result in the loss of an entire project.”

Chew and Romm----Neuromorphic Transceiver Chip, 1998

9. “Attention to small details can save one a great deal of time. Both filters were needlessly re-built because a time scale was misread.”

Nguyen-----Design and Development of a Phlebotic Guidance System, 1998

10. “It is important to have advisors with relevant expertise.....Initially we were relying on the advise of doctors in the medical school. When it came to developing strategies at the EE level, the doctors were not able to provide a great deal of input. They simply did not know what could and could not be done.”

Hammam and Park-----Near Vision Monitor, 1998

A-8 SAMPLE ETHICS SECTION

NOTE:

The text in *italics* should not be in your report. It was included only so that you might know what the Ethics section was describing.

Wireless Multi-User Music Sampler

Currently record stores provide their customers with the ability to listen to certain preselected CDs (or worse yet, single tracks from CDs), often representing only best-selling artists or new promotions. The user is limited by a lack of flexibility in song selection and variety.

This system would take advantage of new technologies - wireless communications, USB connections, and MP3 compression - to provide a greater range of options for consumers.

Users could use a bar-code scanner to select several tracks or CDs; these selections would be matched to a central database of MP3 music; the corresponding songs would be transmitted to wireless headphones via RF signals.

RF was chosen because, unlike IR, it does not require line-of-site; RF signals can travel through walls and floors; they provide greater coverage and bandwidth.

13.0 Ethics

There are several ethical issues which must be addressed before the design of the Wireless Multi-User Music Sampler can be considered finalized.

13.1 Description Of Larger Context

Some of the most important groups involved with the system are potential customers, the record store owners, the music labels, individual artists, and potential pirates and thieves.

3.2 Analysis Of Ethical Issues

One obvious concern posed by this system has to do with piracy. This is a technical issue posed by the use of RF signals that can travel through walls. What would prevent pirates from "listening in" on the wireless network? This is both a technical issue and a legal issue. It is quite possible that in the current legal environment, store managers might be held liable for intellectual property theft.

Another concern might be safety for the users of the system. Users may also be concerned about privacy issues - would their use of the system be monitored in any way?

The use of RF rather than IR signals requires the system to comply with FCC regulations and limitations. Certainly this is an issue that must be researched prior to final implementation.

On a more positive note, this system provide a way for smaller labels and artists to break the hold that large music distributors have on shelf and kiosk space in retail stores.

3.3 RECOMMENDATIONS

The privacy and piracy issues posed by this system are probably the most pressing concerns to be addressed. The solution might be technical (limiting signal travel, encrypting the signal and the central database, etc.), legal (contractual arrangements limiting liability), or market-based (possibly having some per-use charge associated with the system).

A-9 SAMPLE SOFTWARE FLOW CHARTS

Flowcharts in this section have been reprinted with permission of the authors (Lee Becker, Kanush Chaudary, and Tejsvi Rai) from their report titled "Low Power Wireless Security Network", ESE-442, May 2006. The figure numbers are as they appeared in the original report.

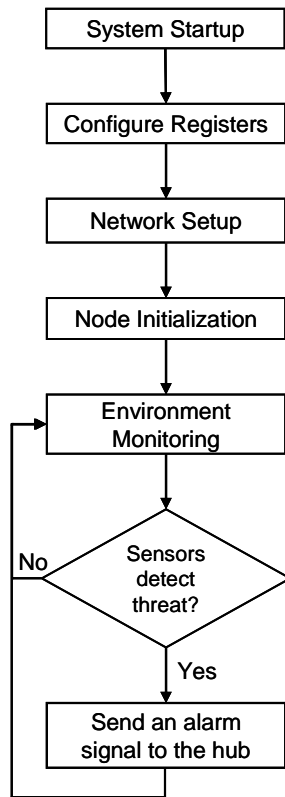


Figure 3: High Level Software Flowchart

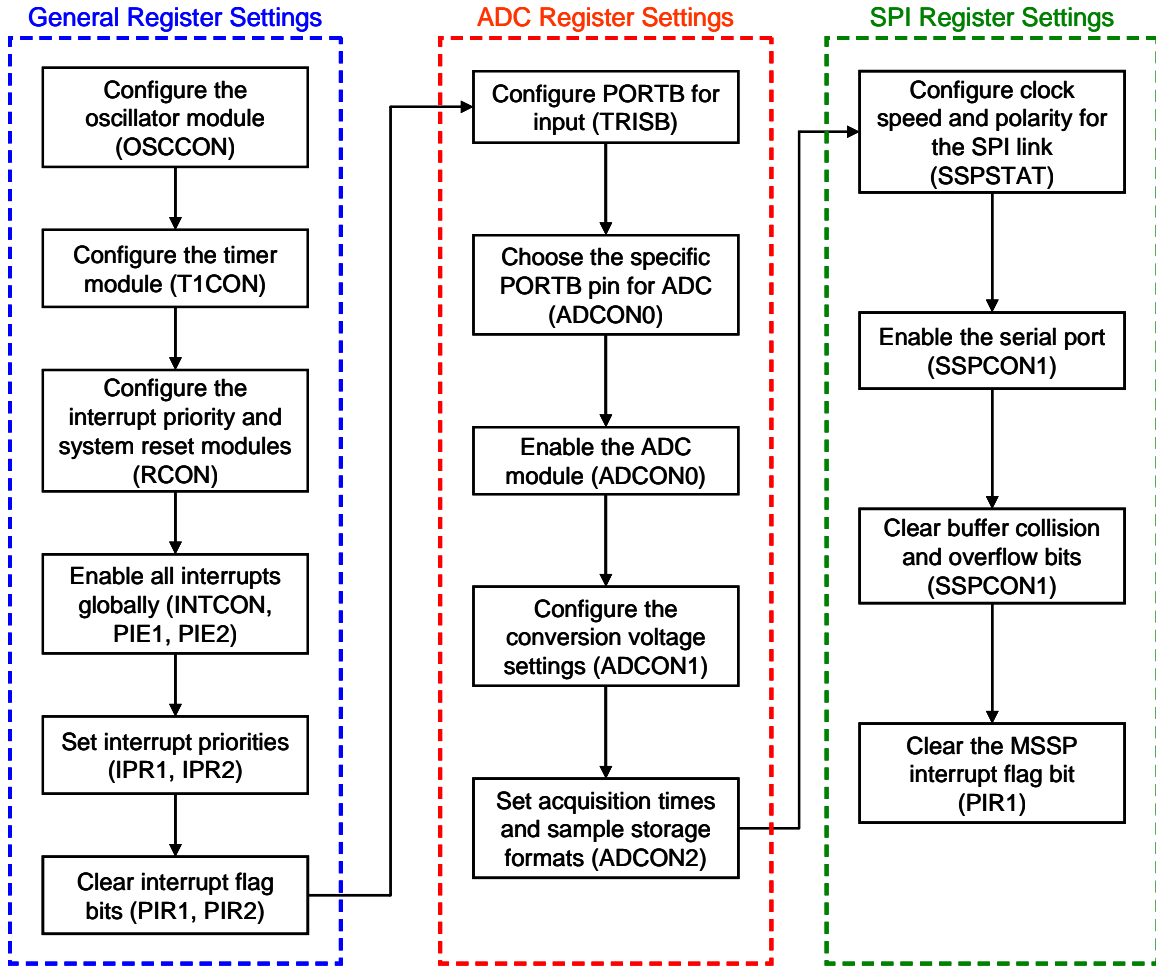


Figure 4: Register Bit Configuration Flowchart

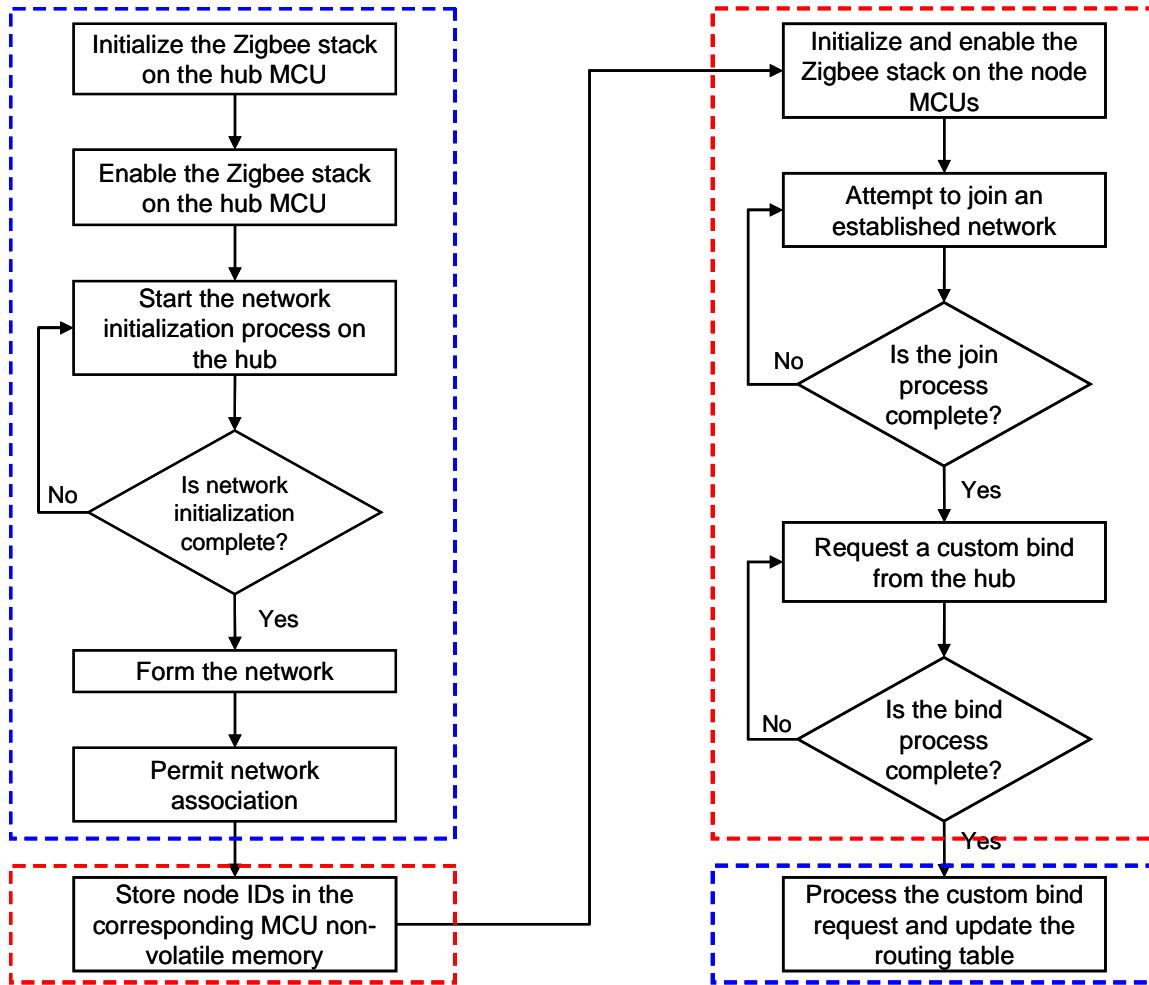


Figure 5: Network and Node Initialization Flowchart (ZigBee only)

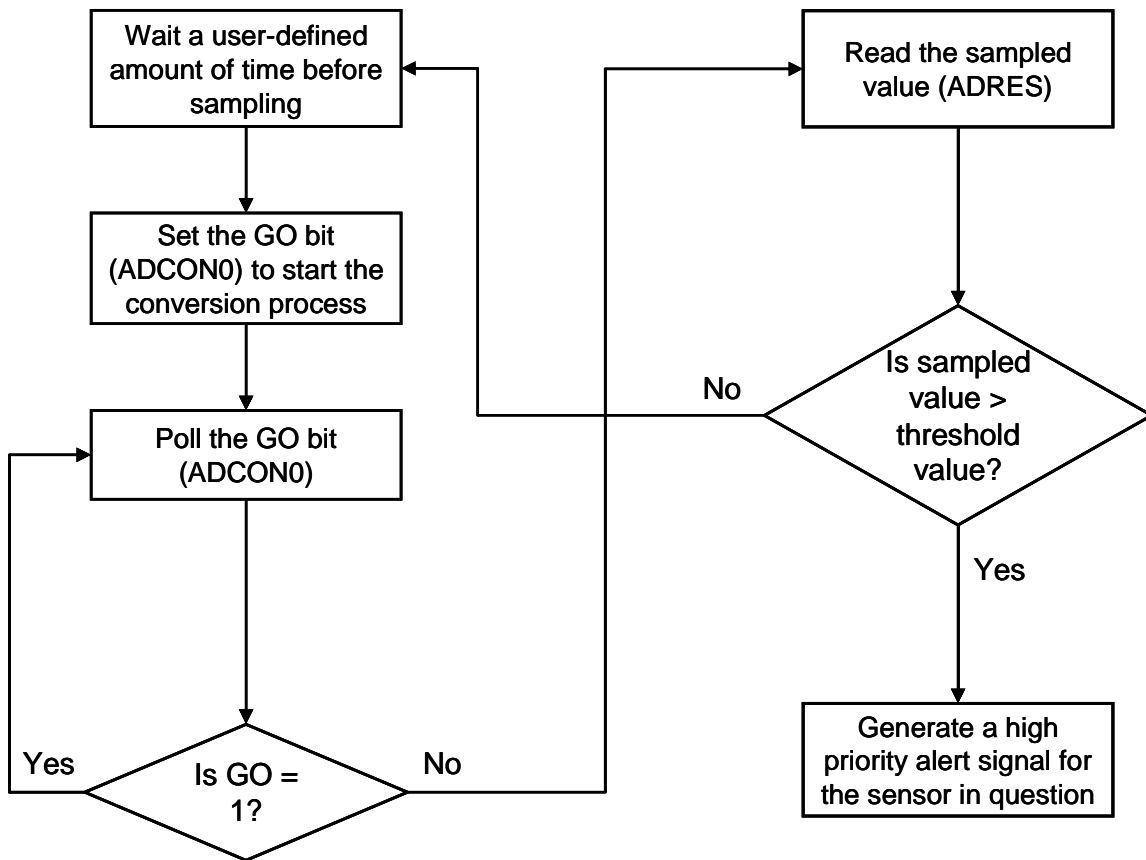


Figure 6: ADC Flowchart

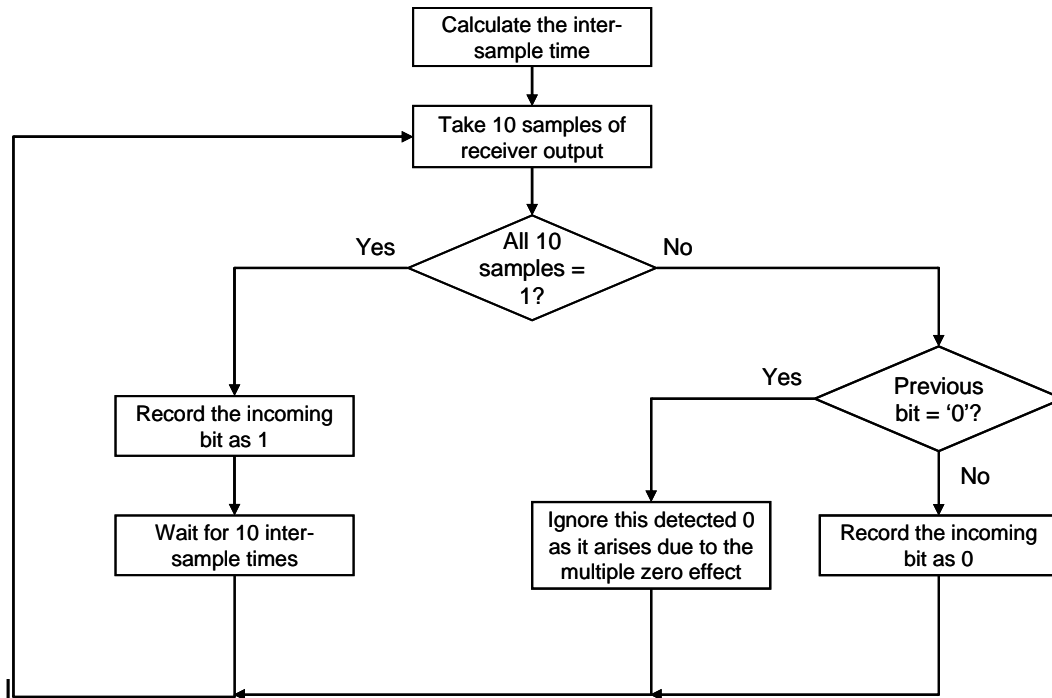


Figure 11: Flowchart 1 of algorithm used with receiver

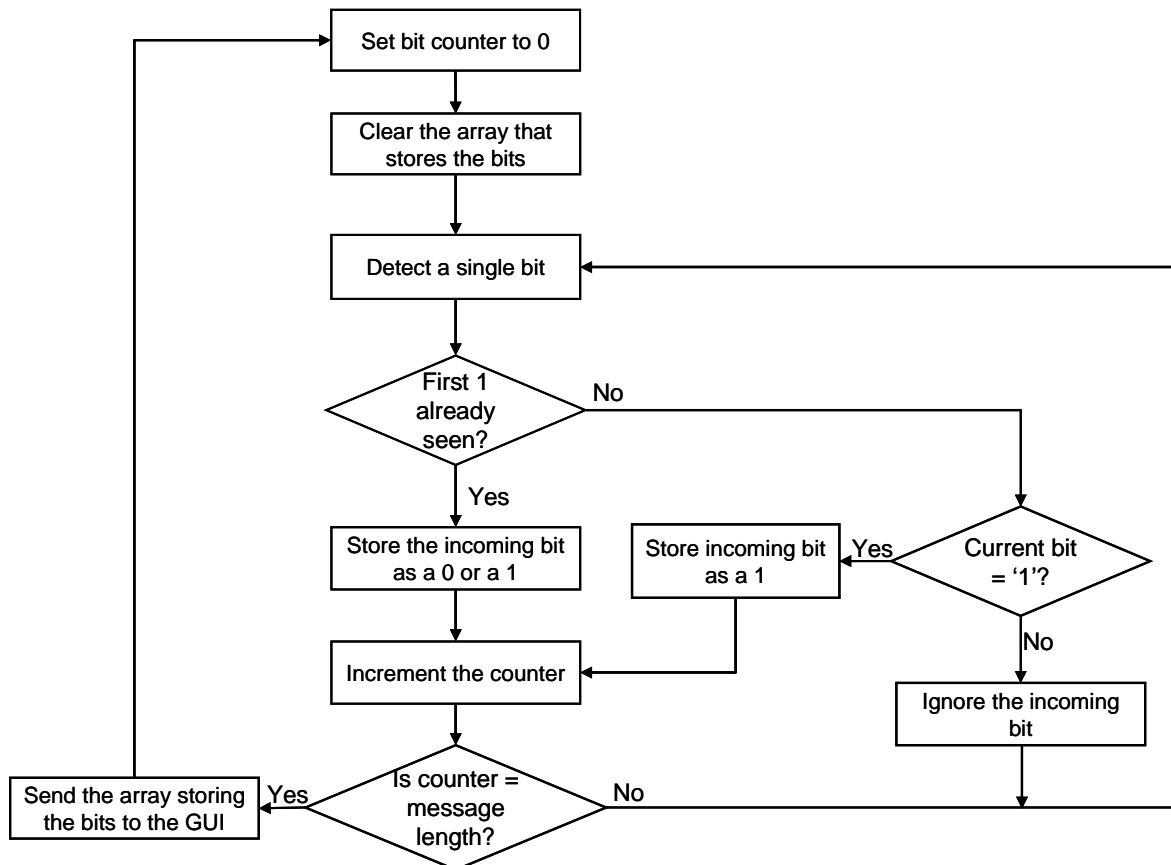


Figure 12: Flowchart 2 of algorithm used with receiver

A-10 SAMPLE SCHEDULE

See Excel "Schedule Example"