

Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science

6.111 - Introductory Digital Systems Laboratory

Report Guide

Introduction

The purpose of this memorandum is to describe general requirements for the reports you must write for laboratory exercises and for the final project.

Good writing is more important than you think. The documents you produce are the principal way of communicating your work. Well written reports reflect well on your work and on you. Badly written documents, on the other hand, will produce negative impressions, even if those documents represent very good technical work. It is worth the effort to pay careful attention to your writing.

A well-written document contains more than clear language, correct syntax, grammar and spelling. It must also reflect clear thinking. Particularly with documents such as those you will produce in 6.111 (dealing with complex technical issues), it is important that care be taken to ensure that the writing clearly and accurately describe the topic. Pictures such as wiring and timing diagrams should be incorporated into the text and be clearly described.

Report Style and Audience

Write for your colleagues. You should assume an audience with technical capabilities similar to your own. It should be possible for other students and for faculty to understand your report. Thus you can assume general technical knowledge on the part of your reader. You should not assume that your reader has a lot of specific knowledge about your subject area.

Write for yourself. A careful job of documenting your work can help you to organize your project. This can be particularly helpful if done early in the project. Your own carefully thought out explanation of how each element of your circuitry works can help in the process of design. Describe the function of each element and how the elements work together. Then think about what you have written. A surprising number of design errors can be discovered by this process, even before you start wiring.

Organize your work carefully and do a neat job. Each of the reports should be typed. Powerful word processing tools are readily available to students in 6.111. Use them. Figures should be drawn with drafting aids (template and straight-edge) or a computer graphics system (Xfig, ...). Lettering on figures can be done by hand, but must be neat and legible.

Remember to leave yourself enough time to do the report properly. Proofread your report! Eliminate typographical and spelling errors. Remember, your report is representing you to the world (and to the good folks who determine your grade!).

Organization

Your reports should be long enough to fully describe your work, but no longer. We expect that your reports for Labs 2 and 3 will be perhaps ten or twelve pages long. Phase II papers must be at least ten pages of text, not counting front matter, back matter, or graphics. The project proposal document should be only a few pages, but the project report will probably exceed twenty pages (in some cases by a substantial amount). Your report should include schematic, timing, and state diagrams and other figures, where appropriate. These pictures, with appropriate descriptions, will help to make your report clearer.

Term projects in 6.111 are team efforts. You will be working with one or two other students to build a (hopefully) working system. It may be appropriate to submit a joint report. This is permitted (but not required), but it is important that the work of each student be clearly labeled.

Your reports should have the following parts:

- Title and Abstract
- Table of Contents
- List of Figures
- Overview
- Description
- Conclusions
- Appendices

In the title, identify the device that you have created. Avoid such deadwood as "Report on" or "Specifications of". The abstract, which should appear on the title page, is a one-paragraph description of your project. The same abstract may appear in both the project proposal and final report, or it may be necessary to modify the abstract to reflect changes in scope or direction after the proposal.

If the report has joint authorship, the Table of Contents should disclose the authorship of different sections.

Style Considerations

Accuracy and Completeness:

Be sure that your report accurately and completely describes your work. One of your colleagues (fellow students, teaching assistants or faculty) should be able to understand what you have done and to, on the basis of your descriptions, reproduce your work.

Well-organized, logical structure:

Each section of the report should state an objective, provide examples and reach a conclusion. The paper should proceed systematically; and transitions from each section, paragraph and sentence to the next should be smooth and coherent.

Appropriate language and tone:

Technical terminology will, of course, be used, but you should avoid jargon. Write simply and clearly.

Correct grammar, spelling, punctuation and capitalization:

Proofread carefully. Rid your paper of little bugs.

Thoroughness:

Do not assume that your reader already knows what you are writing about. You are not taking a quiz. Avoid answering questions with:

Part B) 30 nanoseconds

What does that mean? How did you measure it? Without the lab handout, someone reading this doesn't know what this measurement refers to. Describe what you measured, how you measured it, what calculations (if any) were involved in arriving at this answer. Describe logic analyzer or oscilloscope traces if appropriate.

Thoroughness also means including all the necessary pieces in your lab report. If you program a CPLD, PAL, or EPROM, you must include the programming files (VHDL files, Code assembler source (.as) and specification (.sp) files, etc.). Most of the time it is appropriate to put these computer printouts in an appendix.

Always fully document any ``non-standard'', clever or ``hack'' mechanisms. It will help others to understand your design as well as remind you why you built that thing that way in the first place.

Overview (1 - 2 pages)

The most important rule of thumb for organizing a technical description is ``Describe the whole before the parts''. This rule is based on the assumption that the device which you are describing is unknown to the reader and that a general view of the purpose and construction is needed before the details can be understood.

With this rule in mind, start your 6.111 report with an overview of the purpose, use and design of the device, what a user does with it and how he or she would do it. Describe in

general the subsystem organization of the device. Emphasize those internal features which implement the main user-visible features.

Description (5 - 7 pages)

The device must be described in enough detail for a skilled engineer to understand how it works and to enable reconstruction of the same functions. This is the heart of any technical description.

The description normally includes the project functional specifications, the design used to implement these specifications and a detailed description of how the design works. Descriptions are usually organized in a way that mirrors the design of the device. Thus, there is a separate subsection for each module. A useful criterion for ordering the subsections is the flow of information (input to output) within the device as a whole. When this criterion is not applicable, it often suffices to specify more important modules before less important ones.

Your 6.111 project report has the special requirement that each subsystem be described by the partner who is responsible for it. Thus, use a sub-heading to identify the subsystem and the modules within subsystems. Use this sort of organization:

Subsystem 1 (by Richard Francis Burton)

Normalizing Shift Module
Master Control Module

Subsystem 2 (by Alistair Cooke)

Rule-Interpreter Module
RAM-Control Module
Analog Conversion Module

Include at least one-sentence introductions at each level (e.g., "The device consists of two subsystems which ...").

Illustrate the descriptions with the block diagrams that you prepared earlier in the project (you may want to re-draw them). Refer to these by figure number. Detailed logic diagrams usually belong in an appendix.

Testing and Debugging (2 or 3 pages)

Very infrequently will something you have built actually work the first time you turn on the power. Testing and debugging are natural parts of the engineering process. If your circuit is comprised of several smaller subsystems, you should include a description of how you tested each one after you built it. If a subsystem did not work as you had planned, give an overview of the debugging steps that you followed to make it work. In

the worst case, if you just could not get a lab project working, describe which subsystems worked and to what extent. You should also indicate what the remaining problems and obstacles were and what your next testing and debugging steps would have been to solve those problems.

Conclusion (1 - 2 pages)

The conclusion of a project report typically summarizes the most important or innovative design features. The conclusion also often suggests ways in which the design could be improved. In your 6.111 report you should also make a point of summarizing the test results. If these were not fully satisfactory, they provide a natural basis for suggesting improvements. As a guide to others, it is very helpful to include some discussion of the problems you met in your initial design and what you did to overcome these problems.

Circuit Diagrams

Circuit diagrams help convey information about a piece of design work you have accomplished and implemented. Learning to "speak the language" of circuit diagrams will facilitate getting your ideas across to others and make things easier to build and debug.

Points to remember:

1. **Always** use a template and straight-edge, or use a computer-based drawing package.
2. Where possible, information "flows" across circuit diagrams from left to right and top to bottom.
3. Pin numbers, part numbers and part locations are essential for a diagram of a circuit you are actually going to build. It makes both wiring and debugging easier, as you will not have to search for a gate on a particular chip by tracing wires. Part location is most easily derived from the column (pads A through E, left to right on your kit) and row (chip position, from top to bottom) coordinates.
4. Adhere to the convention of gate input on the left, output on the right whenever possible. For chips containing small gates (including buffer and register chips), draw out the individual gates. Do not draw a block that represents a chip, with wires connected to the pins in their real-world positions. This practice leads to confusing diagrams that obscure the functions of circuits. Larger, complicated chips (counters, adders, etc.) should be drawn as blocks, but label them by function (signal inputs together, outputs together, similar control inputs together, etc.), not by the physical layout of the chip's pins.
- 5.

Label all input and output signals to a circuit. One starting point for each is best, splitting the signal as required for multiple inputs. In dense diagrams, this may not be possible. In that case, label all instances of a signal. A logic diagram fragment is shown in Figure 1.

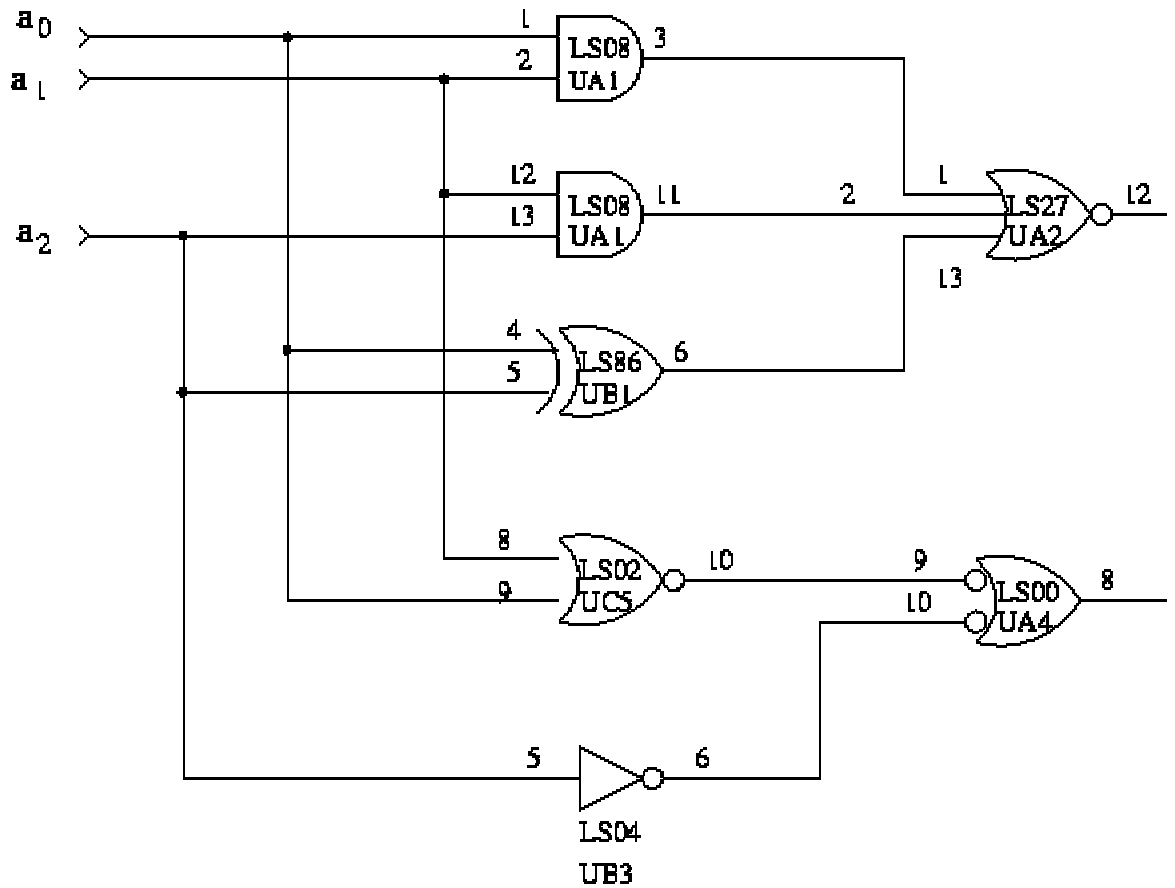


Figure 1: Logic Diagram Fragment

6. Wires: use horizontal and vertical lines only, drawn with a straight-edge. Connections are noted by dots. Do not use "hop-overs" to indicate non-connection points. (See Figure

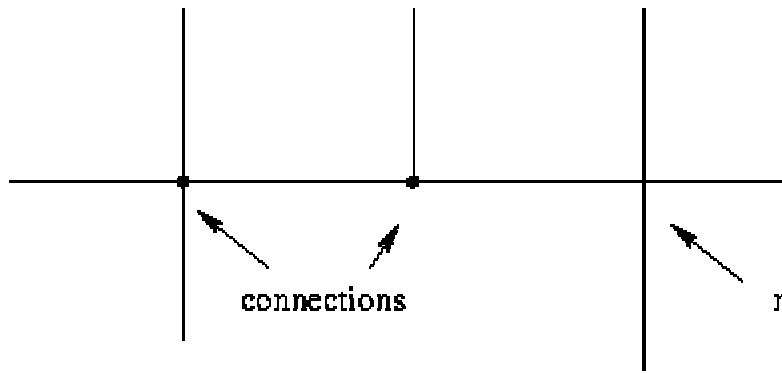


Figure 2: Depiction of Wires

7. Use proper symbology: Inversion bubbles should match up, as shown in Figure 3.

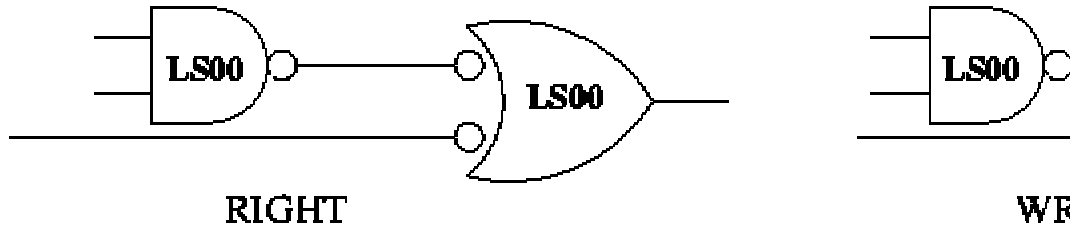


Figure 3: Symbology

Timing Diagrams

Timing diagrams demonstrate that the signals within a system behave in an orderly fashion to achieve a design goal. They show the cause and effect relationships between signals.

Points to remember about timing diagrams:

1. Try to group signals by operations of short duration. Examples include memory reads and writes, data buffering, video frame sync, etc. Draw separate diagrams for each operation.
2. Show only the relevant signals. These include control signals and some indication of the state of data lines (usually showing "valid" and "invalid" states).
3. Show a clock signal in synchronous systems.
4. Draw a separate trace for all signals shown, even if the trace is identical to that of another signal. Label all signals.
5. Propagation delays do not usually have to be shown.
6. Indicate situations where an edge on one signal causes a change in another signal, as shown in Figure 4.

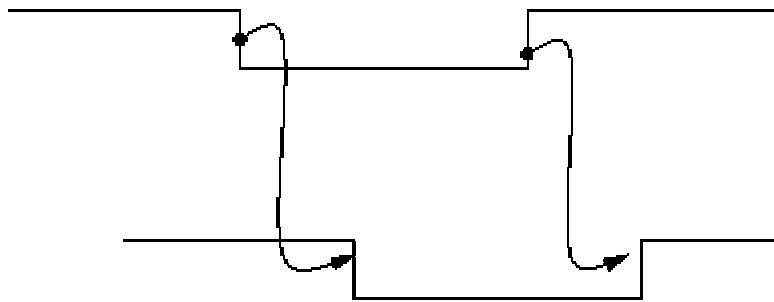


Figure 4: Cause of Signal Change

7. Data bus contents should be abbreviated as shown in Figure 5, unless one of the data bits must be drawn separately for one of the reasons above.

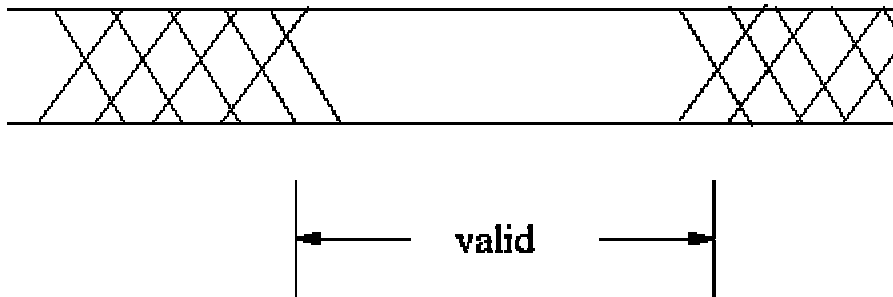


Figure 5: A Data Bus

Figure 6 shows an example of a timing diagram.

Register bank load operation:

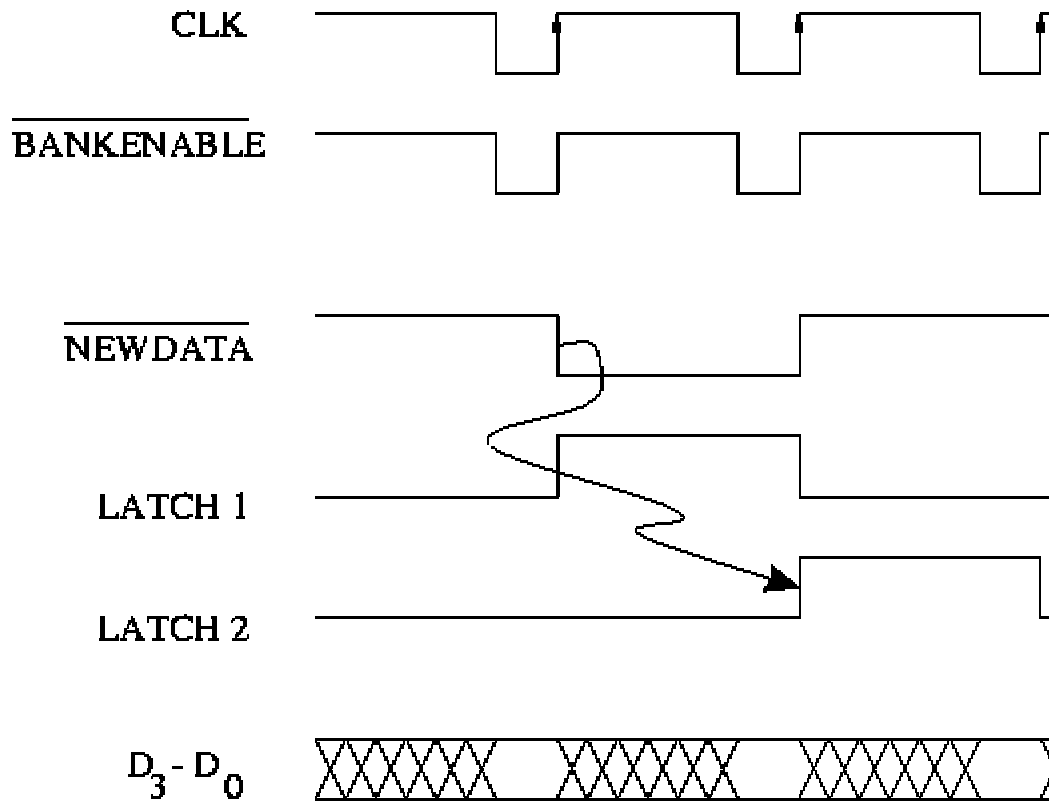


Figure 6: Example of a Timing Diagram