DSP Research Project

The digital signal processing (DSP) research project is a core component of the Physics 351 digital electronics course. The research project component is structured as design, construction, and presentation competition.

I. Objectives

The objective of the project is to teach you how to plan, design, construct, and debug a working DSP device based on an FPGA with Physics research applications.

An important secondary objective is to teach the following experimental research skills:

- Team research work
- Device design
- Project budgeting
- Project proposal writing
- Finding, selecting, and purchasing device components
- Device construction
- Device debugging
- Web presentations of work

II. Schedule

The DSP projects will follow the schedule below:

October 19	Formal project proposals are due at 5:00 pm.
October 22-26	Parts will be ordered from Digikey on October 22 Prototype using components available in the lab.
October 29 – November 30	Project construction and debugging
December 5-7	Final presentation of projects and review.

III. Project Proposal

The proposal should contain the following sections:

Introduction

The introduction introduces what the proposal is proposing … and also motivates and explains in general terms what the device can do.

Device design

This section explains the device design. It should indicate the overall design and what types of components are to be used. **It must contain a specific parts list** of components with Digikey part numbers. For soft-hardware design (i.e. FPGA code), you should explain your FPGA design and where possible provide specific schematics and/or Verilog HDL code.

You will probably not have determined every last detail of the project design by the time the proposal is due (especially since we will have barely covered ADCs and DACs), but you have to convince the instructor that your design can work, even if some specific details still have to be worked out (hardware and software). You should include diagrams and figures to explain your design.

You should provide a detailed budget and a construction time-line for the project.

Conclusion

In this section you will briefly recap the previous two sections and explain how the device can be uniquely used to make specific measurement relevant to experimental Physics.

Note: only one project proposal per research team is required.

IV. Budgeting and Electronics Components

You have a budget of $150, which you should not exceed. In principle you should be able to construct the project for about $100-$150. Any excess funds should be used to buy duplicates of the same part (in case you have a circuit construction malfunction) or to try different parts out to see which ones work best. If the components are relatively cheap, then you should buy extras in case you break some. You should keep in mind that components take several days (even up to a week, if you are unlucky) to arrive after you order them.

Internet shopping is a great way to purchase electronics components. The site with the largest and most diverse inventory and quick shipping is Digikey (www.digikey.com) The William and Mary physics department is also set-up to buy things quickly from Digikey.

Lab components and ICs

You may NOT use any lab components in your final device, with the exception of wire unless it is approved by the instructor. You are free to use any components in the lab for prototypes on breadboard. You must supply all components that you solder.

V. General Design Considerations

Your design and construction will strongly influence the performance of your device and determine whether it works or not. Here are a few suggestions that will help improve your design:

Inputs and Outputs

- All inputs and outputs on your device should go through an op-amp, even if it is just a buffer (i.e. a 1-to-1 amplifier).

Wires

- All wires should be color coded and, ideally, labeled.
- You should use heatshrink to cover bare wire as much as possible.
- All connections should be soldered.

- Input and output wires should be in the form a twisted pair (one wire carries the signal, the other is at ground), this will limit cross talk between signal lines and limit noise from external sources.

ICs (i.e. chips)

- Use sockets for ICs so that they are easy to replace if you accidentally break them.
- Use a ~100 nF capacitor across the supply inputs of any IC. Make sure that the capacitor is a close as possible to the IC.
- Gold-plated sockets are preferable to tin, since they will not oxidize with time (and then lose the electrical connection).

PC Boards:

Printed circuit boards are difficult to make and nearly impossible to fix if you make a mistake in the design. It is strongly recommended that you use general purpose PC boards which have a few connection points and can be soldered Several are available in the lab from previous projects.

Power Supplies

- Use the MC79XX and MC78XX voltage regulators to further regulate the power you receive from your plug-in power supply. Watch out! On some of these regulators the case will have positive or negative voltage on it, which can make heat sinking a little more difficult.
- Generally, a 60 Hz transformer-based power supply is preferable to a high-frequency switching supply (though this must be weighed against cost).

Heat sinking

- Some components can get hot. They should be well heat sunk – ideally, to the device case. You can also use metal fins and a fan.
- Hot components should be avoided where possible, since they do not last as long. Heat can also lead to the deterioration of neighboring devices (i.e. wire insulation can deteriorate, ICs work differently when the device is first turned on than in steady-state).

Device Box

- A metal box is preferable (though a little more expensive) to a plastic box, since it can be used for heat sinking and provide some protection against external electromagnetic noise.
- The device box is generally grounded (either hard or soft ground).
- The device box should include a circuit diagram on the inside.

Knobs, Switches, and Displays

- Ideally, knobs are multi-turn potentiometers which give you a fine degree of control.
- A selector knob with a few positions can be used for coarse selection of values.
- Switches should be made of metal.
- Displays are nice, but are generally very time consuming to implement.

User Manual

Your device should include operating instructions or a manual. You should be able to compile a manual from the oral and web presentations which will take place at the end of the semester.

VI. Design, Construction, and Testing

While ideally your design will work exactly as you conceived it, you are encouraged to construct a prototype of your final device using components in the lab, including the DE2 board, breadboard, op-amps, ADCs, DACs, miscellaneous ICs, resistors, capacitors, transistors, etc … Once you have settled on a design that you are confident will work, you can start constructing the final device.

Since it can take time to order and receive parts, you should buy ahead of time all the components that you can, and especially those that do not depend on the exact details of the design (i.e. FPGAs, ADCs, DACs, possibly op-amps, etc …). This will reduce the probability that you are just waiting for your parts to arrive with nothing else to do.

VII. Team Lab Book and Wiki

Each team will maintain a group lab book and a web page or wiki "lab book". The lab book and the web page can complement each other (i.e. not everything that is on the web page has to be in the lab book, and vice versa). You may certainly keep records in your own lab book, but these should be photocopied into the team lab book.

A web page or wiki is great way for a group of people to collaborate on a project, especially one that involves lots of electronics files (plots, tables, images, Quartus II files, etc…). It allows several collaborators to share information from separate locations. There are many wiki webpage services on-line. (You can create a wiki at wiki.wm.edu, but it will not be private.) Your instructor can provide you with web space for a web page.

VIII. Oral and Web Presentations of Device

When the project is completed the team will make an oral presentation of their device. All team members must participate in the presentation. The presentation will cover the design, budget, difficulties, highlights, and final performance of the device. The webpage for the device must be posted before the end of classes and will cover the same topics as the oral presentation.