Project Guidelines

Project Proposal

You must submit a multi-page project proposal containing the following:

Introduction explain why you chose your project. Provide links and references to background information and to similar projects.

Objective describe what you will demonstrate at the final demo (see below)

Diagrams use diagrams to describe the hardware and software components of your project. You may want to include scale drawings, schematics, flowcharts and any other graphic that helps describe how your project will be put together.

Parts List a spreadsheet with a list of parts that you will need to complete your project (see below) and the projected total cost.

Schedule a list of of the things you expect to be able to demonstrate in each of the five weeks allocated to the project.

Remember that your proposal may be published. Do not include personal, copyrighted or proprietary information.

Scheduling and Milestones

You will have approximately 5 weeks to complete the project. You should be able to devote about 4 hours per week to the project in addition to the 2 hours per week scheduled for the lab.

Work backwards from your deadline to come up with weekly milestones (measurable indications of progress) that you will need to have accomplished each week.

If the schedule seems unrealistic, revise your objectives or look for other way to meet them. Allow time for mistakes. Do not commit to an unrealistic schedule. Extensions are not an option.

Include the delay to receive your parts in your schedule. You may want to think about out how to test your design before parts arrive (e.g. simulations, replace sensors with switches, etc.).

Although you will not be marked on meeting your milestones, it is strongly recommended you communicate or demonstrate to the instructor what you have accomplished each week. Get help if you are falling behind.

Risk Management

Things invariably go wrong. As part of your planning, identify situations that could cause your project to fail (a component fails or is not adequate, a design task is too complex to complete on time, ...). Think about ways to minimize those risks (e.g. ordering over-specified or spare parts, starting by implementing a minimum subset of features, ...).

Ordering Parts

Use a copy of the spreadsheet on the course web site to list the parts you need to have ordered for your project. These will be ordered as a batch shortly after the due date for the proposal.

For each part you will need to add a row and fill in the following columns:

- project group number,
- the e-mail address of the person to contact in case of questions,
- for each of the the recommended and second sources:
  - supplier name (the name in the Source of Parts document,
  - the part URL (formatted as a link),
  - brief part description,
  - quantity,
  - unit cost, and

– extended Cost (as shown, probably in USD).

The different groups' spreadsheets will be combined and sorted by supplier. So you must follow the format in the sample spreadsheet: use the supplier names in the supplier list and include the group number and e-mail address on each line.

The part URL should be *formatted as a hyperlink*. Clicking on the cell should open a web page for the specific part so that the person doing the ordering only has to click on the link, enter the appropriate quantity and click on "add to cart."

If this is not possible, make sure the description has enough information that a search will find the part and that the desired part can be selected. Please be specific. The person ordering doesn't know what you need and has to process many orders – if the description is ambiguous the part will not be ordered.

You will not be charged shipping if the order is from one of the major suppliers listed on the course web site and you submit your spreadsheet on time.

If you miss the batch-order deadline you can still order parts but you will be charged shipping and it may result in an additional delay since routine orders are processed weekly.

Check stock before adding a part to your parts list. Include a second source if there's any chance your item may not be in stock with the first source. Note that if the part is not in stock and you don't have a second source the part will not be ordered. You will then need to find an alternative. This will result in additional delays and the cost of shipping will be counted against your budget.

Don't forget to include connectors, cables and hardware.

You can also purchase parts locally. See the the "Sources of Parts" document on the course web site.

Demonstration

During the final lab sessions you will have 5 to 10 minutes to demonstrate your project to the instructor and the other students in your set.

While planning your project, decide on the features you will demonstrate and how you will demonstrate them. This could affect the features you decide to include in your project (e.g. battery life, demo track size, etc).

Working in Groups

Most engineering projects are done by groups of people. An objective of this project is to give you experience working in a small group.

At the start of the project you will want to:

- document who will be responsible for completing each task and by when
- arrange to communicate on a regular, minimum weekly, basis to review progress against your schedule
- arrange logistics: where will you store and/or work on your project? how will you share files?

You will be marked as a group. Invariably, some group some members will be able to contribute more than others. Don't let this bother you – do your best and take pride in your own work. Be flexible.

Design Reviews

Some groups may be invited to a brief design review. These will be required for groups that plan to work with external power supplies or inductive components or if the parts list contains components that may not be suitable for the project. Have a schematic and parts layout diagram ready for the review.

Hints for Completing the Project

Design

- Design Top-Down: divide your overall design into smaller parts then iteratively repeat for each part. This ensures that the higher-level portions of your design, which will be the hardest to change, get the most attention.
- Partition your design to minimize interfaces and dependencies. This minimizes the risk of a change in one part of your design affecting another.
- Define the interfaces as you do the top-down design to make sure the partition is practical. Large or complex interfaces are a hint that there may be a better partitioning with less coupling.

Implementation

- Implement Bottom-Up: Start with a minimal working system and add one component at a time. This makes it much easier to isolate faults.

- Unit Test: Test each component by itself using a simple testbench before connecting it up to the system. Test both typical and corner cases.

  You may be tempted to skip writing testbenches to save time but any new design is practically guaranteed to have errors and you'll find them faster if you test the new component on its own. You don't need to write complex testbenches for FPGA-based designs – most errors are found early in testing.

  Having your design handle invalid input in a reasonable manner will make your design more robust and easier to debug.

Debugging

When things aren't working as expected...

- Check First Things First: start with tests that are easy to do and address for the most common problems. If a circuit isn't working, always check the following – in the following order – preferably using an oscilloscope:

  - power supply and ground
  - clocks
  - inputs
  - outputs

  By far the most common reason for students' inability to resolve problems in a timely manner is failing to follow this recommendation.

- Divide and Conquer: add or remove components to narrow down the source of the problem.

- Guess: If you're still lost, don't give up. Guess at what the problem might be and test your hypothesis. Compare your observations to what you expected and you will eventually find a mismatch that will point you towards the problem.

Autonomous Operation

If you want to use the FPGA board autonomously (not connected to a PC) you will need to supply it with power and a source of configuration data.

Consult the DE0-Nano manual (on the course web site) for external power supply requirements (3.6 to 5.7 VDC) and connector pin-outs.

You may re-program the on-board EPCS64 configuration memory with your design (the configuration file must be less than about 64 Mbits). See the Appendix (Chapter 9) in the DE0-Nano manual for instructions. Please inform the instructor if you do this so that the default configuration can be restored for next year's labs.

Restrictions (or strong recommendations)

Solderless breadboards are unreliable and are not designed for high currents. Don't bet your project on components staying plugged into your breadboard. Use soldered connections and/or appropriately-rated connectors.

The following additional restrictions apply to projects using external power supplies or inductive components (motors, solenoids, relays, etc.) since these increase the risk of damage to the FPGA board:

- If using external power supplies, your proposal must explain, if applicable, how you will sequence multiple power sources and how you will interface different logic levels.

- If you are driving inductive loads your proposal must explain how you will deal with the back-EMF generated when switching the current off.

- Use of optoisolators is strongly recommended (and may be required) when high voltages or currents are involved.

- The instructor will help you conduct a design review before ordering parts and will help you test your interfaces before the FPGA is connected (see below).

Interfacing

The FPGA uses 3.3V on it's I/O pins. See the documents on the Content / Resources/ Interfacing section of the course web site for information on how to interface to different logic families.

Use of Lab Kits

To connect to the FPGA board you may use the second 40-pin port (JP2) or modify the lab wiring harnesses on JP1 and JP3. If you modify the lab wiring harness you must restore the original configuration before returning the kit so that it can be used in next years' labs. See the DE0 Nano Manual and the "Lab Wiring Harness" document for the pin assignments.

A limited number of connector housings and wires with pre-crimped pins are available from the instructor.

Before connecting any of the following:

- inductive components (motors, solenoids, ...),
- external power supplies, or
- voltages greater than 3.3V

to the FPGA board, the instructor must have reviewed and approved your design.