373 Projects

10/1/2018

1. Introduction

For this phase of the course, you will specify, design and implement a microprocessor-system application. Applications can range from the traditional such as a home thermostat to the conceptual such as a Rubik's cube solver. The process of application challenges and reinforces your understanding of the course concepts and your laboratory skills.

2. Developing a Project Idea

Coming up with a project idea that is fun, challenging and meets the course requirements is not always obvious. It is very tempting to use the project requirements as your guideline and inspiration to "get the grade". While we understand this tendency, we want to encourage you to start by thinking big, dream a little and don't worry too much about requirements or other restrictions. The first phase of the project is a proposal. Look at it as a sort of draft or sketch of your project idea. In the second phase, the project review, we will help you refine your idea so that it meets the project requirements and is feasible.

For example, one group not long ago wanted to implement a Segway. Although they did not intend to implement a complete version, they were rather ambitious with regard to the scale and range of motion. They imagined a large model about 3 feet tall. A model this large will require heavy duty motors and a large power source. In addition, the center of mass will be high complicating the balance control. Position would be sensed with gyro stabilized sensors.

So, we simply scaled back. We settled on an approximately 1 foot, light weight model. The motors were simple hobby style servos and we managed to supply all power with one hobby battery pack. The battery pack and other items were located as near to the axial as possible to keep the center of mass low simplifying the dynamics. Position sensing was accomplished with a "tail" and potentiometer instead. A foam board tail was fashioned and attached to the potentiometer and chassis to provide a voltage proportional to the angle of the Segway with respect to the surface. This considerable simplified the position measurement avoiding the gyro stabilized sensor.

So it's OK to dream and think big to start with. Consider several ideas if you like. Be sure and discuss your ideas with your group and the staff early.

3. Restrictions

3.1. Safety

Several safety issues must be in mind when dreaming about your project.

- **Spinning Devices:** High speed spinning mechanics must be contained so that in the event that they fail that they do not throw debris. This can cause eye injury and we must be very careful. You may also be required to wear safety glasses when operating this equipment.
- **Consumable Foods:** Food oriented projects that involve beverages or food have to avoid contact with toxic substances like lead based solder or toxic adhesives.
- **Alcoholic Beverages:** University Policy Prohibits use of alcoholic beverages on University Property including non-alcoholic beers.
- **Projectiles:** Projects involving projectiles must use soft materials and restrict velocities. Some form of containment might be required.
- **Heat:** Projects involving heat may require some form of insulation or isolation. High heat levels that can cause combustion will not be allowed.
- **High Voltage:** Projects requiring voltages like the line current from AC outlets must us special isolation devices available in lab.
- **Lasers:** Project using lasers must provide containment or shielding to prevent light from reflecting and potentially entering any ones eyes.

Note: You may not proceed with project components that involve safety issues until the approved by the staff.

3.2. Project Size

Be sure and consult the staff about projects requiring a great deal of lab space. Generally, we can accommodate you if it does not interfere with other projects and workstations. Since the kits lend themselves to mobile applications, it is possible to use areas outside the lab, but you should check with staff about using public areas such as the halls or atrium.

3.3.Alternate Processors

For very small footprint low power applications we have NXP kits such as the LPC1114 based on the low power MO ARM. The kit does not use an FPGA like the SmartFusion kit, but has the ability to interface to most standard devices. The software development environment is very similar to SoftConsole with several good reference designs.

Generally, alternate processors are not allowed. In some cases, we allow the use of alternate processor in an auxiliary role. We may also consider additional FPGA kits or alternates depending on the application.

4. Requirements

4.1. Summary

Category	Maximum Value	Good Project
Base Requirements	15%	15%
Difficulty Components (see note)	45%	40%
System Integration	20%	13%
Coolness	3%	1%
Extraordinary Technical Achievements	4%	0%
Proposal	3%	3%
Project Clean Up	5%	5%
Poster and Expo	10%	10%
Hardware/Software Documentation	2%	2%
Max Total	107%	89%

4.2. Base Requirement

Your project or application should demonstrate your basic laboratory skills with at least 3 of the primary lab topics:

1. Bus Interfacing (APB3 or serial device such as SPI or I2C)
2. ABI/Device Driver
3. Interrupts
4. General Purpose Timers (GPT)
5. Analog to Digital (ADC) or Digital to Analog (DAC) Conversion

4.3. Difficulty Component Requirement

Solving an application problem apart from what you have experienced in the lab, will challenge your laboratory skills and knowledge of the course concepts. For example, by the time you complete the last lab, it should not be very difficult to use basic IO on the SmartFusion kit and convert analog signals to digital values you can use in a software application.

On the other hand, if you need to use external devices such as displays, sensors or actuators, you would be facing a host of unknowns. While at first this task may seem formidable, you actually have all the skills and knowledge to tackle this challenge.

You begin by obtaining and reading the product specification. In the serial interfacing lab, we will learn to read the specification for a wireless radio and develop a device driver for its serial (SPI) interface. You will learn that the specification will provide you with a functional overview; power supply requirements serial timing requirements and functionality of the interface registers.

So, while you are dealing with new challenges, you are in fact applying concepts and skills you have tried at least once in the lab. Applying your knowledge and skills to an application category apart from what you have seen in the lab, defines the difficulty category.

Difficulty instances are scored from 0 – 20%. Consider the following examples:

- **Easy** (0%) Using SmartFusion Simple IO like switches and LEDs. Generally, anything that is a simple extension of the lab exercise does not earn difficulty value.

- **Moderately Difficult** (1% - 7%) OLED display on SmartFusion kit. While this is extension of one of the labs, there is some difficulty in adapting to a new application.

- **Difficult** (8% - 12%) External LCD display that requires significant application work and working with product specification.

- **Very Difficult** (14% - 20 %) Difficult device application requiring significant work. Perhaps, custom printed circuit, additional signal conditioning such as filters, amplification or current buffering. This type of application usually requires a great deal of device characterization. For example, a I2C interfaced power monitoring device requiring a custom printed circuit board and characterization of inductive pickup.

A list of standard devices available in the 373-project inventory can be found in this document in *appendix E*. We are in the process of obtaining new project components to work with the SmartFusion kit. You are encouraged to consult the outside sources such as SparkFun for possible components. Most of these components are within scope of our budget.

We are also lenient when it comes to mechanical components. This is not a mechanical engineering lab, so we do not expect mechanical devices to work perfectly. We expect you to do your best matching a mechanical component to your application, but if a component falls off during a demo because the double sided sticky tape failed we will not consider this a great failure.

4.3.1. Maximum Difficulty Value

Points are scaled to ¼ value for each point scored after 40 points. The maximum difficulty value is **45%**.

Difficulty Score (**max 45**) = 40 + 1/4*(difficulty points > 40)

4.3.2. Difficulty Component Weighting for Group Size

Learning to work in a group is an important part of your project experience. In industry, it is not uncommon to have several groups of 3-5 persons supporting a project. As a group, you will have to decide how to distribute your tasks and cooperate to integrate each part.

Typically, a project group consists of your semester's lab partners; however, it is permissible to form alternate groups. In fact, you can form larger groups if you wish. Larger groups can produce some great projects because of the additional resources. In fact groups of three can be very effective and easily offset the weighting factor. You may work alone if you wish; however, you will need the permission of the course or lab instructor.

To compensate for different groups sizes, the **difficulty portion** of the projects will be weighted accordingly:

Group Size	**Difficulty Weighting Factor**
1 or 2	1.0
3	0.8
4	0.7

Note: **The group-weighting factor is applied before the maximum cap adjustment**! See the following the example.

4.3.3. Difficulty Scoring Example

Consider a group of 4 that scored 60 difficulty points. The total difficulty score is then:

Difficulty Score Adjusted for Groups Size = 60 * 0.7 = **42**
Difficulty Score Adjusted for Maximum Value = 40 + 1/4(2) = **40.5**
Total Difficulty Score = 40.5

4.4. System Integration Requirement

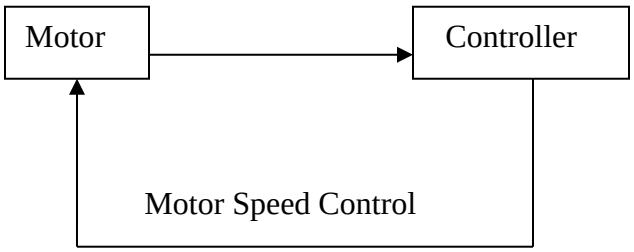
At some point, you will have to integrate the project components into a functional application. It is quite possible that your system components work well independently, but do not work to serve your application. You should be able to answer the question: Do the components of the project work as a cohesive whole? Specifically, consider the following:

- Are the components relevant to the application?
    - Do the sensors support the application or are they superficial?
    - Is display information relevant?
- Is component performance relevant and appropriate to the application?
    - Sensor Range/Response?
    - Actuator Range/Resolution?

    - Display Capacity/Response?
- Is the application reliable and repeatable?
    - Is it necessary to reset the entire system after each trial?
    - Do mechanical parts fall off?
    - Do connections break?
    - Do components require physical adjustment after each trial?
    - Do electrical components (potentiometers, etc) require adjustments between trials?
- Is system function appropriate for application?
    - Is the system responsive?
    - Functional ranges adequate?

For example, consider a simple motor speed controller. A sensor and motor control circuit can be implemented to sense and control the speed of the motor with a traditional feedback path.

Functional Diagram



It is possible that the display, motor speed control and speed sensing all work independently, but the system does not function well as a whole. For example, does the motor controller system:

- Hold motor speed as a function of load?
- Respond to load changes fast enough?
- Display the motor speed accurately?

This factor measures the success of your application. Keep in mind that refinements can be very time consuming. It is better to address the significant functional components first. For example, a motor controller that does a good job of providing regulation over a limited load range is better than one that works crudely over a broad load range. Or, nuances in the display function are insignificant if the application performs poorly.

4.4.1. General Evaluation Criteria for System Integration

1. Components do not work well together. **(0 points)**
2. Some components work together while others do not. **(4 points)**
3. Most components work together. **(7 points)**

4. All the components fundamentally work together, but under some conditions the system significantly fails. **(11 points)**
5. All the components fundamentally work together, but under some conditions the system experiences minor failures. **(13 points)**
6. All components work together under reasonable application conditions seamlessly with no bugs or problems of any kind. **(16 points)**
7. The system works well enough you would be satisfied buying it. It is responsive, fast, does something interesting, bug free, etc. **(18 points)**
8. Works better than you would expect from a typical functional product. That is, it not only functions well for the application, but is an extraordinary solution for the application. **(20 points)**

4.5. Coolness Factor (optional Requirement)

We will assign a 'coolness' factor to projects, which exhibit unique, interesting attributes. While this factor is subjective, the best way to define it is to consider the response of an unbiased observer. For example, if freshmen engineering student's first words after seeing your project were "that's cool", the project is probably cool. We have all experienced this. Just because an application solves a significant or representative engineering problem does not make it "cool". Past projects with coolness attributes are Spider, Rubik's Cube Solver, Servo Climber and several others. Look them over and see what you think.

4.5.1. General Evaluation Criteria for Coolness

1. A high school senior might make a casual remark like "hey, it's pretty cool". **(0 points)**
2. A high school senior would find it interesting. **(1 points)**
3. A high school senior would find it remarkable. **(2 points)**
4. A high school senior would tell talk about telling their friends for weeks. **(3 points)**

4.6. Extraordinary Technical Achievements

Occasionally, a group will accept and overcome unexpected significant technical challenges. Students in this category are often interested in a particular area and surprisingly overcome application challenges beyond the scope of the course. Merit in this category is rare and may only amount to a 1 or 2.

4.6.1. General Evaluation Criteria for Extraordinary Technical Achievements

1. Project meets requirements, but no major technical hurdles were overcome. This is typical of most projects. **(0 points)**
2. The project includes significant technical achievements of one sort or another. For example, a non-trial device never before used was used in a challenging way. **(1 point)**

3. The staff thinks there were huge technical hurdles to overcome. This is rare! **(3 points)**
4. Technically nearly impossible. These are rare also and may not occur for several semesters. **(4 points)**

4.7. Proposal Requirement

You must provide a written project proposal. The proposal should contain:

1. High-level description of your application
2. Functional block diagram
3. Component level diagram
4. Preliminary component list:
   - If the component is from the 373-project inventory, state its description clearly.
   - If the component is not from the inventory, provide a description and suppliers link. The component will need to be readily available and approved by the lab instructor. *We are flexible about "unusual" components.* But we need to be sure they can be quickly acquired.

A proposal example can be found in *appendix A* of this document. Your proposal will be reviewed for practicality and merit during a scheduled review near the beginning of the project period. Please see the project schedule for details.

4.8.Project Clean Up

You will be expected to disassemble your project, sort the components and generally restore and cleanup up after the project exhibition. This must be completed no later than one day after the final exam. Specific instructions will be provided after the exhibition. You can request to keep your project or keep it assembled for future work.

4.9. Poster and Project Exhibition

Your project will be presented at a 373 project exhibition. All members should attend some part of the exhibition and be prepared to answer questions. At this time the course staff will visit each exhibit and evaluate the project. You will also be expected to provide a poster illustrating the key features and goals of your project. Example posters and the logistics for having your poster printed are provided on the lab webpage under the projects section.

4.10. Hardware and Software Archive

You must provide a final version of your hardware and software. Hardware will be in the form of a archived Libero Project. Software will consist of any C and assembly source code. Submission guidelines are detailed in appendix B.

4.11. Design Expo

Groups may choose to bring their project to the Engineering Design Expo. You will need to make this decision about 3 or 4 weeks before the Expo. If you have a functional project at this time you will get one to three points.

Balancing your Efforts

You can score well by balancing your efforts over all the project categories. The project scoring is designed to encourage you to produce a project with sufficient number of difficulty components to successfully address your application and provide good system integration. Consider the following to balance your efforts:

- **Difficulty Components**: Choose devices and functionality that supports your application.
    - **Displays:** Use a display that supports your application: do you need graphics or just relevant text?
    - **Sensors:** Use sensors that support your application. Do they have the range, resolution, dynamic response?
    - **Actuators:** Use actuators that support your application. Do they have the range of motion, precision, power, etc?
    - **Manual Input:** Do you need a joystick or simple button matrix?
- **Number of Difficulty Components:** Do you have enough or too many for your application?
    - Your application may have required another sensor, actuator etc to improve better control and system integration.
    - You may have sensors or actuators that do not help your application when your time would be better spent on system integration.
- **System Integration:** Make sure you allocate time to insure yours device and functional components work well together.
- **Group Size vs Difficulty:** Make sure your application is on par with your group size.
    - Are there enough members to support the application?
    - Is the application sufficiently difficult for the group size?
    - An additional member can add approximately 10 points of difficulty and offset weighting. See table.
    - Most advance project require 3 to 4 people

Group Size	Group Weighting	Difficulty Points	Total Adjusted Difficulty
2	1	35	35
3	0.8	45	36
4	0.7	55	38.5

- **Do the Essentials:** Be sure and spend some time on the easy points:
    - **Hardware/Software Points:** Get it in on time
    - **Proposal:** See example and get it in on time
    - **Base Requirement:** Usually easy
    - **Webpage:** Spend some time and see docs and past examples

See the Appendix C for evaluation examples of good and bad ways to balance your efforts.

5. Example Project Evaluations

Several **example** project evaluations are provided in *appendix C* of this document. Note, while these examples are based on real projects, the evaluations are fabricated to illustrate good or poor use of project components and do not in any way reflect actual evalutions.

6. Device Sources

Be sure to see the 373-project inventory list in *appendix E*. If you do not find something you're interested in, feel free to ask or review the following sources. Be sure to provide a supplier link in your proposal and check on availability. We do have a limited budget, so it is possible to acquire other items. Approval will be based on applicability, cost and future use. It is important that we learn about special purpose components early to allow for lead times.

- Jameco Inc. www.jameco.com A good general-purpose electronic components supply.
- Digikey Inc. www.digikey.com A complete general purpose electronic supply house. Lots of product specs and manufactures links available.
- Acroname http://www.acroname.com A good robotics supply house. They stock many of the sensors that we have in stock. This is good source for specs on the sensor we use.
- Spark Fun Electronics http://www.sparkfun.com A good source of various electronics sensors, etc for the hobbyist.
- Images SI Inc http://www.imagesco.com A good source of various robotic and electronic components for the hobbyist.
- The Internet; Search for components, specs and use of components on the net. Many times a hobbyist is using a component you are working with and will provide easy to use information. Beware, this information may or may not be accurate.

7. Project Ideas

See the past 373 projects posted on the course web page. Another great source is Cornell's EECS 476 course web page. There are several semesters of past projects posted. While many of these projects may be a bit advanced for 373, many are great source of ideas or can adapted.

EECS373
http://web.eecs.umich.edu/~brehob/proj373W16.html
EECS 476
http://instruct1.cit.cornell.edu/courses/ee476/FinalProjects/

Appendix A Proposal Example

Student Name 1
Student Name 2

EECS 373: Proposal for Final Project

Section 1: High Level Description

Our overall project design is a whack-a-mole game that the user interfaces with by using pressure sensors in a mat on the ground, with each sensor corresponding to a mole's position. We intend to use a "Dance Dance Revolution" pad for the ground sensor, shown below.

Figure 1. Dance Dance Revolution Pad.

For the moles, will attach 8 solenoids to a board in a square configuration, similar to the way the arrows and shape are lined up in the DDR pad above. A real live mole will be placed upon each solenoid for aesthetic purposes. In the center of the board will be an LCD screen that keeps score for the player. Additionally, successfully "stomping" on a mole will cause a sound.

The major functions of the project are as follow:

1. Create software to control the popping up of the moles
2. Interface the DDR pad with the board so that stepping on a sensor throw and interrupt, which we can use to determine if a hit has occurred.
3. If a hit occurs, do D to A conversion to create a sound so that the player is aware that he or she was successful

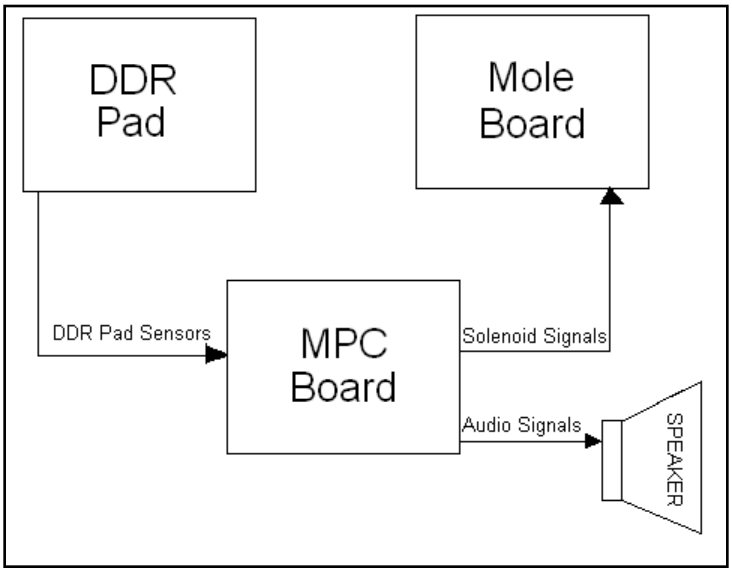
4. Interface with an LCD display to keep a countdown timer, and keep score

I/O

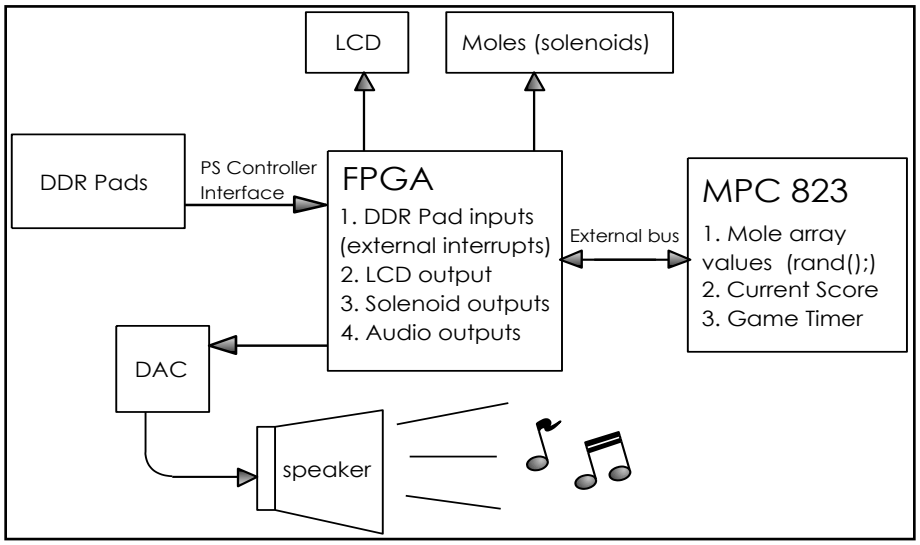
Inputs:
DDR Pad Sensors

Outputs:
Signal to activate sound with successful hit
LCD Screen
Signal to control the solenoids

Section 2: Functional Diagram



Section 3: Component Diagram



Section 4: Component List

Stock

1. Character LCD Display
2. Servos (solenoids)
3. Simple Switches
4. Amplified Computer Speakers

Non-Stock

1. Nintendo DDR pad

Appendix B Project Documentation Guideline

The final project documentation is a significant part of your project grade and will consist of the following parts:

1. Exhibit Poster
2. Hardware Project Archive
3. Software Archive
4. Group Demo Sheet
5. Technical Device Documentation

1. Exhibit Poster

You will be expected to compose a poster for the 373 exhibit. Examples of posters and formats are provided on the lab website in the projects section.

2. Hardware Archive

Submit any custom HLD you designed for your project. If you did not provide any custom HDL, do not submit anything.

3. Software Archive

Provide all your source code files. If you used CodeWarrior, submit the project.

Documentation Submission

See the project schedule for the documentation due time. Place all the materials in a directory in your 373 class directory space (not your AFS space). Follow the following labeling and organization:

1. Label the document directory "Project Name" Documentation. For example, Rubik's Cube Documentation.
2. Provide three subdirectories labeled as such with the following contents.
   - **Report**

   Place the web documents and all associated folders in this directory. Your primary HTML document should work from this directory.
   - **Hardware**

     Place the project archive here
   - **Software**

   Place all software source files here.

When your directory is ready, email Matt Smith that the document folder is ready and which directory it is in.

4. Group Demo Sheet

While the above documents are submitted after the project demo, you must submit a project demo sheet the day of your demo. The sheet should include the following:

1. **Project Title**

2. **Date**

3. **Members**

4. **Member Task Distribution**

As above, list each member's duties and task associated with the project development and design.

5. **Member Contribution**

Each group is required to discuss and submit the extent of each member's contribution. It is not uncommon for members to agree that one or more members are better positioned to spend more time because of term workloads etc. You should submit each member's contribution totaling 100%. Please give this some careful thought. We may ask you to reconsider the distribution if it does not represent our views of your group member's efforts.

If you do not submit a member contribution, we will assume it is equal among the members. **The course instructor reserves the right to determine and override member contribution**.

Note: This information is confidential and will only be observed by the course instructors.

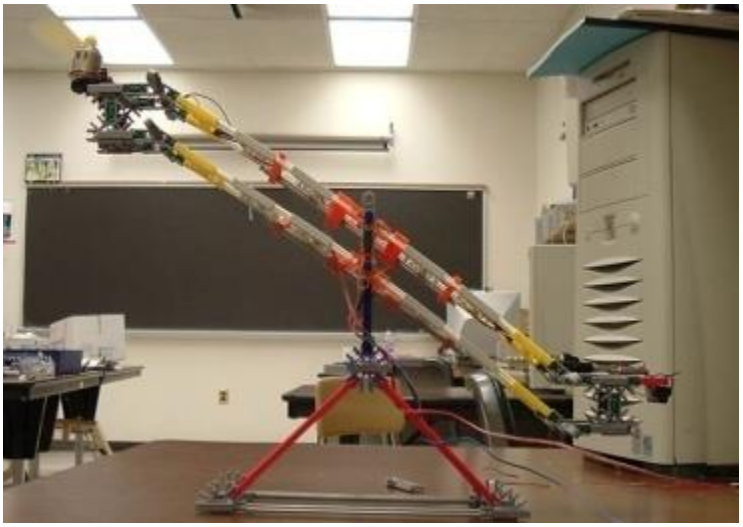
Appendix C Project Evaluation Examples

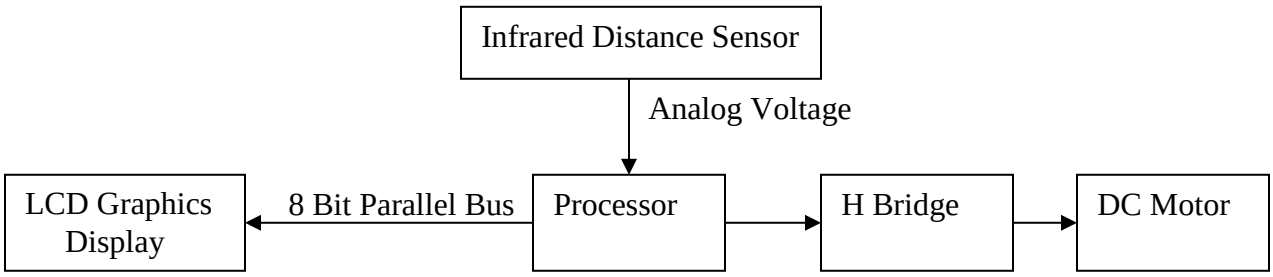
The following projects are hypothetical samples. While we've taken pictures and material from old projects, we have made up the evaluation (and in some cases project components). These scores (or even results) are NOT REPRESENTATIVE of what the groups actually did. We changed things as needed to illustrate the evaluation process.

The new course model does not lend itself to some of the specific component evaluations provided below. Be sure and consult the staff if you have any questions regarding the difficult and relevance of your project components.

Project Evaluation Example 1, Self-Righting Fulcrum

This is an example of a concept project. A fulcrum was constructed with toy "K-Nexs" with a propeller attached to one end and an infrared distance sensor to the other. The object was to adjust the propeller speed to maintain a given distance measured by the distance sensor. Status and distance were displayed on a character display.





Example 1 Evaluation

Project Requirements	Scores	Notes
Base Requirement		
Bus Interfacing		motor and graphics IO
General Purpose Timers		PWM control
ADC		infra red sensor
Interrupts		PWM control and ADC sampling
ABI/Device Drivers		
Base Requirement core	15	minimum achieved
Difficulty Components		
1) DC Motor, PWM and H Bridge	12	responsive, stable, bi-directional operation
2) Infrared Distance Sensor	11	good range and resolution
3) Graphics Display	19	graphics mirror operation
Difficulty Components Sub-Total	42	
Group Size	2	
Adjusted for Group Size	42	
Adjusted Sub-total	40.5	
System Integration	13	within certain range works well, buggy at limits
Coolness	0	
Extraordinary Technical Achievements	0	
Project Documentation		
Proposal	3	on time, all categories satisfied
Poster/Exhibit	10	good poster
Hardware/Software Archive	2	submitted on time
Clean-up	5	
Total Project Score	**83.5**	

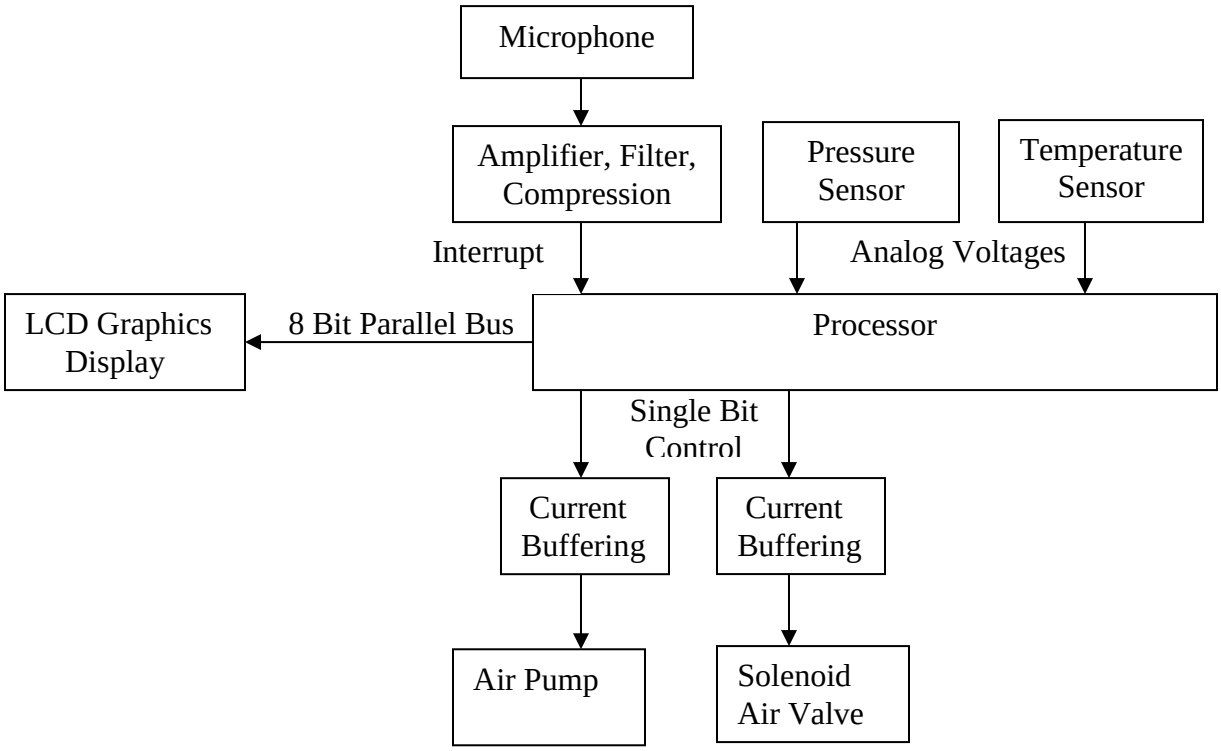
Comments

This is example of a well integrated project with 3 difficulty components for a group of 2. All components functioned well and scored high individually. Graphics display worked flawlessly with graphics mirroring fulcrum operation and relevant application information. The DC motor is controlled bi-directionally with appropriate range of speed for application. Infrared sensor characterized well for range and resolution. Infrared sensor non-linearity is well compensated. The system performed repeatedly without system resets, software or hardware adjustments. There were a few minor problems at the limits of travel, but rarely occurred. Notice, that alternatively a character display and a N8 controller for manual control could have been used in place of the graphics display with similar scoring potential.

Appendix C continued

Project Evaluation Example 2, Automated Blood Pressure Monitor

The second example is a traditional application. A mechanical blood pressure kit was adapted to work automatically. An air pump, electric solenoid valve, pressure sensor and pulse sensor were added to provide the necessary control and measurement. A character display provided status and measurement reading.



Example 2 Evaluation

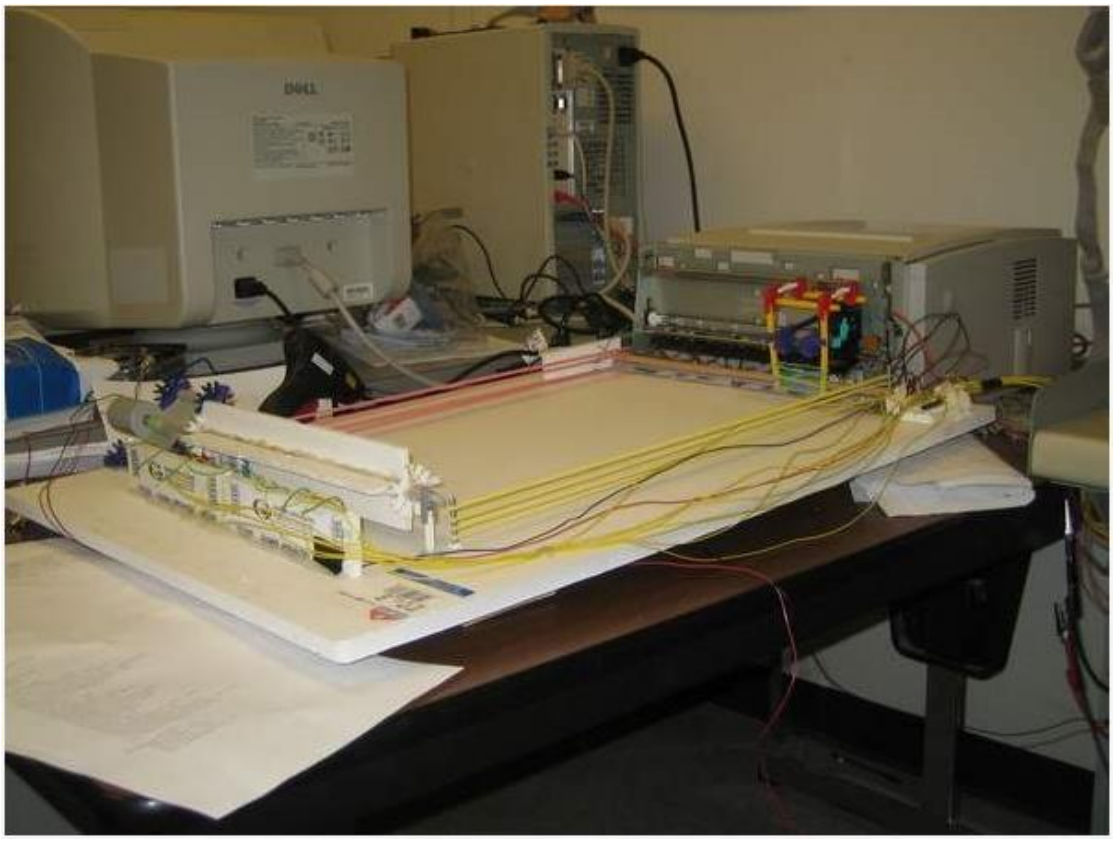
Project Requirements	Scores	Notes
Base Requirement		
Bus Interfacing		display, air valve, pump
General Purpose Timers		system timing, PWM
ADC		pressure sensor, microphone
Interrupts		PWM control and ADC sampling
ABI/Device Drivers		display, pressure sensor, microphone
Base Requirement core	15	minimum achieved
Difficulty Components		
1) Graphics Display	17	represents app, good graphics
2) Air pump control with PWM	7	variable pump control
3) Air valve control	3	simply binary interface with current buffering
4) Heart Rate Measurement (mic)	10	signal conditioning refined to drive interrupts
5) Blood Pressure Measurement (pressure sense)	10	good characterization, linearization, etc
6) N8 Controller to Select Menu on Display	7	reliable, works well with menu drive
7) Temperature Sensor	5	works well with analog interface
Sub-Total	59	
Group Size	3	
Adjusted for Group Size	47.2	
Adjusted Sub-total	45	capped
System Integration	4	Works some time. Significantly fails roughly 4/10 times
Coolness	0	
Extraordinary Technical Achievements	0	
Project Documentation		
Proposal	3	on time, all categories satisfied
Poster/Exhibit	7	marginal poster
Hardware/Software Archive	2	submitted on time
Clean-up	5	
Total Project Score	**76**	

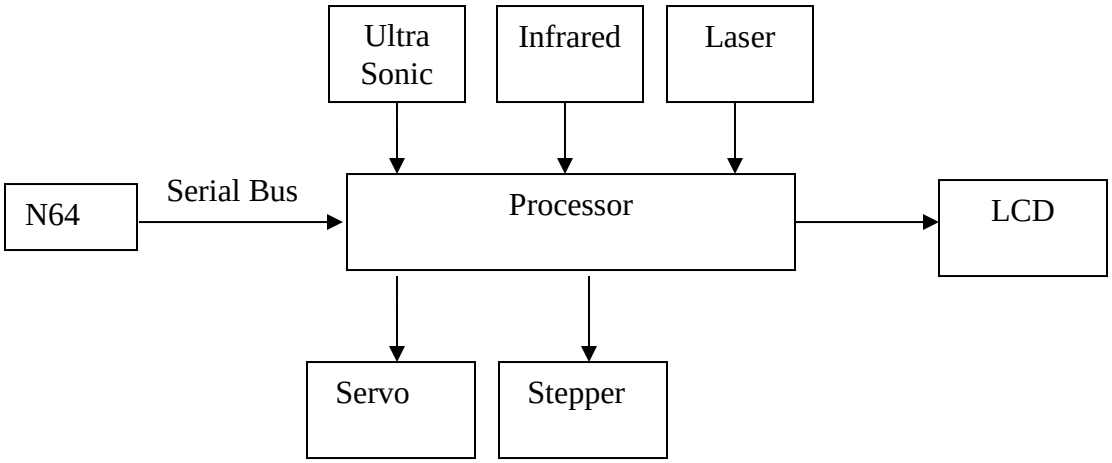
Comments

This is a good example of a project that requires 3 people to be successful. The graphics display alone, can take one person 1.5 weeks. Notice that this project only scores 79 when it has more potential. Although many components worked well independently, they did not work well together. In fact, the integrated operation was so poor that is distracted from some great work on done on component like the graphics display. More attention should have been given to system integration rather than accumulating components. Notice that the temperature sensor was not relevant to the application and was negated by the cap adjustment. This project could have easily scored near 90 with better system integration.

Appendix C continued

Project Evaluation Example 3, Automated Mechanical Pong





Example 3 Evaluation

Project Requirements	Scores	Notes
Base Requirement		
Bus Interfacing		N64, LCD, servos, etc
General Purpose Timers		motion control and system timing
ADC		infrared sensors
Interrupts		motion control, servos
ABI/Device Drivers		LCD, steppers
Base Requirement core	15	minimum achieved
Difficulty Components		
1) LCD Character Display	11	application relevant data, menu drive, flawless
2) N64	14	works well including analog joy stick
3) Stepper Motor Control	6	works well over intended range with needed resolution
4) Servo Motor Control	8	good smooth consistent control
5) Ultrasonic Sensor	10	reliably detects motion of objects over intended area
6) Laser Beam Implementation and Detect	3	consistent
7) Infrared Sensor	5	works well but just for short range detect
Sub-Total	57	
Group Size	4	
Adjusted for Group Size	39.9	
Adjusted Sub-total	39.9	
System Integration	14	Very consistent for application with a few minor probs
Coolness	1	
Extraordinary Technical Achievements	0	
Project Documentation		
Proposal	3	on time, all categories satisfied
Poster/Exhibit	10	good poster and exhibit
Hardware/Software Archive	2	submitted on time
Clean-up	5	
Total Project Score	**84.9**	

Comments

This is a good example of an application that needs 4 people to be successful. Several sensors and actuators were required to fully implement this application. Even though several devices are used they are appropriate for the application and adequately handled by a 4 people. Care was taken to integrate the components they used into a consistent, reliable functioning system.

Notice that a few more points could have been gained by using a graphics display. While this is possible for a 4 person group, consider first how your components will work in your system. For instances, while the graphics display might be appropriate for the

application, it probably was not essential unlike a game application. Notice, that the difficulty value is only a few points from saturation. While the other components are necessary for a complete system, spending too much time on a graphics display could have pulled time from important system refinements impacting the system integration score.

Appendix E, Standard Component Inventory

Note: These Difficulty Components are Subject to Revision Because of the Inventory Change with the new SmartFusion Kit. Please consult the staff for difficulty potential during the project proposal phase.

Consider SparkFun a standard inventory source. The components are appropriate for most 373 projects and our budget. See F11 Project Overview Slides posted on lab website for more components.

Devices	General Description	Dif %	Topics
Light Duty Servo	Precise angular displacement +/-90 degrees	4 - 8	Timers, Interrupts, FPGA timers
Heavy Duty Servo	Precise angular displacement +/-90, high torque	4 - 8	Timers, Interrupts, FPGA timers
Continuous Duty Servo	Not limited to +/- to degree displacement. Speed of rotation function of PWM. Not good for precise angular displacement. Easy rotation control for low torque application.	4 - 8	Timers, Interrupts, FPGA timers
Stepper Motors	Good angular control (a few degrees per step) but continuously (not limited to +/-90 degrees), torque depends on motor, more difficult to control then stepper and may require buffering	6 - 12	Timers, Interrupts, FPGA timers, Current Buffering
DC Motors with H-Bridge	Low Torque, good speed variation with PWM, uses H-Bridge to control direction and provide current buffering.	6 - 12	Timers, Interrupts, FPGA timers, Current Buffering
DC Motor	Without H-Bridge	1 - 5	Bus interfacing, current buffering
Gear Motors	High Torque, not much speed control	3 - 5	Current Buffering/ Optical Isolation
Solenoid Valves	Great gas or water valve switches	3 - 6	Current Buffering/Optical Isolation
Solenoid Linear Actuator	Limited force and range but responsive (fast)	3 - 6	Current Buffering/Optical Isolation
Character Display	Several serial (SPI or I2C) graphics displays are available from SparkFun	?	Bus Interfacing, Timers, Device Drivers
Graphics Display	Several serial (SPI or I2C) graphics displays are available from SparkFun	?	Bus Interfacing, Timers, Device Drivers
Numeric Keypad	4*4 numeric keypad matrix	6 - 11	Bus Interfacing, Timers, Device Drivers
Nintendo 8	Classic Nintendo 8	5 - 10	Bus Interfacing, Serial to Parallel, Device Drivers
Nintendo 64	Classic Nintendo 64, more features then N8	10 - 15	Bus Interfacing, Serial to Parallel, Device Drivers
Infrared Distance Sensor	Family of infrared distance sensors. Produce analog voltage proportional to distance	5 - 10	AtoD, Timers

Ultrasonic Sensor	Precise distance sensor, good range 3cm to 3m, Provides pulse delay as function of distance.	8 - 12	Timers, Interrupts, Bus Interfacing
Air Pressure Sensor	Senses air pressure, analog output	5 - 10	AtoD, timers
Force Sensor	Changes resistance as function of force.	5 - 10	AtoD, timers
Flex Force Sensor	Changes resistance as function of displacement from neutral position	5 - 10	AtoD, timers
Light Sensor	Photo Resistor 5k light 10M dark	6 - 10	AtoD, Timers, Signal Conditioning
Laser Beam Interrupt	Great for long range responsive beam interruption	3 - 6	Signal Conditioning, Interrupts
Temperature Sensor	Great for measuring temperature to 1 degree F	3 - 5	AtoD, Signal Conditioning
Condenser Microphone	Produces voltage proportional to sound and vibration	6 - 10	AtoD, Timers, Signal Conditioning
Accelerometers 1 Dimension	Produces voltage proportional to acceleration	7-11	AtoD, Timers, Signal Conditioning
Accelerometers 3 Dimension	Produces voltage proportional to acceleration	9-13	AtoD, Timers, Signal Conditioning
General Supplies	Op amps, voltage regulators, resistors, capacitors		