EECS 452 Design Project Information, Fall 2014

1 Overview

Each project team will consist of 3-4 students. The project ideas/subjects typically originate from the students, along with a few sponsored by Harris Communications (see some examples at end of the document). The effort expended on a project should be consistent with the effort needed for three to four students taking an eight-week four-credit course. If your project turns out to be easy, add to it. If it turns out to be much more than anticipated, stage the development so that at the end of the semester there is something to demonstrate.

You should think of the project as emulating the early stage product development process at a commercial company. Your goal as a team is to take your idea to a proof-of-concept stage by developing a working prototype.

Each project involves

1. A design specification;
2. An application of material learned from earlier courses (say EECS 216 or EECS 451 and others such as EECS 270, EECS 373);
3. Real world constraints involving cost, reliability, safety, and production;
4. Evaluation and/or testing with regard to the design specification and constraints.

Some things to keep in mind

1. A significant component of the project is the application of digital signal processing (DSP). DSP is typically an enabling technology rather than an end goal itself. That is, DSP makes products possible or better than they would otherwise be. Because DSP is an enabling technology this means that the projects will mostly be shaped by other technologies. For example if a project is to design a configurable software radio then an understanding of the following areas would be essential: (1) modulation theory; (2) basic radio design practice; (3) DSP implementation. If you do not have a background appropriate for a particular project then you will have to either acquire it or look into another project.
2. Be careful in setting the scope of your projects. A project needs to be more than trivial but still within reach of available resources. Projects need to be doable with about 8 week's part time effort by a small team.
3. *Start early*. This is the key to success.
4. A project does not have to target end users. A project can create something that is to be incorporated into other products. An example is development of a speech recognition chip or technology. For example, there is a voice controlled robot on the toy market that uses speech recognition technology that was purchased rather than created by the toy maker. In the cell phone industry Qualcomm sells its CDMA3 technology to cell phone system creators. The Fraunhofer Institute sells its MP3 technology in the form of actual code for a variety of DSP processors. A couple of years ago there was a class project sponsored by Delphi in developing an IIR filter design tool for car stereos.

2 Example projects

2.1 Low cost hearing aid/enhancement device

Background and overview Modern hearing aids are technical marvels, with prices to match. There are many people who suffer mild to moderate hearing loss that do not normally use a hearing aid but who would occasionally benefit from the use of a low-cost portable hearing amplifier. For example in a theater sitting in the back seats trying to understand what is being said on stage might find this useful.

In a clinical audiology lab, hearing loss is determined in a quiet room by testing whether the subject hears a series of tones tranmitted at different frequency and with varying amplitude. Each ear is tested independently. The subject indicates whether or not the tone is heard by responding ”yes” or ”no” using a handheld push-button. The responses are recorded and used to estimate the frequency response of the users hearing at each ear. If the frequency response is flat over the range tested then the subject has normal hearing. Otherwise, depending on the severity of the frequency dependent loss, a hearing aid may be recommended.

A recent Sunday newspaper advertisement included a simple battery operated amplifier with a set of ear buds attached for such use. The price was on the order of $40. A problem with such a device is that hearing loss is frequency dependent. One can hear that something is being said, but cannot understand what it is. The frequency dependency of the hearing loss interferes with intelligibility. The device proposed here provides a means for allowing a user to measure their hearing loss and then uses the measurement results to implement a low-cost frequency-compensated hearing aid.

Proposed project effort We will develop a device that will incorporate both a hearing aid and a hearing test capability. In the hearing aid mode, the device will act as an frequency selective amplifier that boosts frequency ranges where there is hearing loss. In the testing mode it will determine the users hearing range using tone generaltion and user feedback. A DSP board will be used to randomly generate a set of tones over the auditory range, collect the user ”yes” or ”no” responses, analyze the flatness of the frequency response, and synthesize a frequency equalizing filter. This filter will then be used to process the audio from one or more microphones with the result being sent to ear buds or a higher quality headset. All that is really required is to increase intelligibility. We might use a single ear Bluetooth headset minimizing the need for dangling wires.

Likely the TI DSK and the FPGA board will be initially used to develop algorithms. The entire project is expected to eventually be contained in a single FPGA (with appropriate I/O support such as LEDs, display, switches, amplifiers, ADC, DCA, etc.).

Who might use such a device? It is expected that many hearing challenged people would be interested, especially if the cost can be held low.

2.2 Automatic modulation classifier

Background and overview

Background and overview Cognitive radio (CR) is relatively a new technology which enables an efficient usage of radio frequency spectrum. Smart Radios equipped with CR technology utilizes empty spaces in both licensed and unlicensed spectrum, called white spaces, to deliver a ground breaking performance; unmatched by any other wireless technology. The basic idea is to monitor and detects empty spectrum holes, then utilize them until their rightful owner shows up again. Afterwards, CR will change frequency to another hole and possibly another set of modulation and coding. This procedure is most likely to occur frequently, which imposes a

large feedback to the receiver for every time the modulation and/or the coding change. One proposed solution to this problem is the utilization of a type of DSP analysis called automatic modulation classification. These simple DSP calculations can determine the type of modulation very accurately using a set of simple features to differentiate between modulation schemes. However, most work in this area is military oriented; applied to HF channels, and cannot be applied directly to GHz range, additive white Gaussian Noise (AWGN) channels.

Proposed project effort The primary objective of this project is to develop and implement a real-time implementation of Automatic Modulation Classifier (AMC), which can work in AWGN and able to detect both single carrier and multi-carrier schemes in the 2.4 GHz range. The first step is survey literatures about this topic and find out if anyone have done any real-time implementation of AMC modules. Afterwards, design stage commences with clear definition of the problem and proposed solutions. Simulate algorithm using MATLAB and identify elements which influence the performance. The third step would be implementation on hardware platform. FPGA boards would make a perfect candidate for the DSP calculations required by the AMC. AMCs are not computationally expensive and do not require large memory either. Therefore, a mid-range FPGA board will suffice. Also, a complete RF chain; antenna, RF filter, and mixer, working in the range of 2.4 GHz is needed for the implementation too. Finally, testing would require transmitter with multiple modulation and coding schemes and a relatively quiet area in the 2.4 GHz band.

Who might use such a device? Users of next generation global cell phones that have the capability of identifying ambient modulation format (CDMA, GSM, etc). FCC who wants to identify and classify rogue transmitters. Law enforcement agencies that want to demodulate suspicious communications signals.

2.3 Low cost RF based localizer/tracker

Background and overview A recent EECS 452 project involved the use of a ultrasonic frequency source in a speaker tracker for the MScribe project. The goal is to allow a video camera to automatically track a speaker as he/she moves around the white board and lectures.

This project looks at the possible use of low cost ($15) RF transmitter/receiver devices operating in the unlicensed RF bands for this and other potential applications.

RF energy propagates at a rate of approximately 1 ns per foot. Measuring pulse arrival times to this accuracy directly is likely to be difficult. However, measuring the relative phase (transmitter/receiver) at, say, 400 MHz a 1 ns time difference corresponds to approximately 144 degrees.

An alternative technology might be to place an RFID tag on the speaker. Again phase response differences at multiple receivers would be used to locate the speaker.

Proposed project effort This is a bit of a high risk project. However, it should be challenging and fun.

The RF units under consideration are those sold by SparkFun such as

`www.sparkfun.com/commerce/product_info.php?products_id=7816`

Some time ago a student investigated how these units might used for applications not originally intended. The receiver IF output is available (nominally 455 KHz). It might be possible to used several receivers as a phase interferometer after modifying them to use the same timing source. The phase differences from a single transmitter ping to several phase coherent receivers can then be used to solve for the desired position. The transmitter might ping randomly. Alternately the speaker might have a unit that is a transceiver that echoes (with precisely known delay) a ping sent by the locator electronics.

Pulse compression waveforms might be useful in building up signal-to-noise ratio allowing long operating ranges. Probably would design a small AD1 replacement board using an A/D converter that has a higher sample rate. Low cost devices that sample at rates up to 3 MHz are available.

Who might use this device Operators of automated video cameras for recording lectures or speeches. People who use security cameras to monitor motion within a given area. Animal behavior researchers who study animal movements.

3 Project development timeline

3.1 Pre-project ideas (PPI): due Thurs 9/11

You must draft two project ideas (in the format of "Example Projects" above) and submit them electronically as pdf files under the CTools PPI Assignment. This pre-project ideas assignment is a means to generate a pool of project suggestions. It is designed to get you started early to think about DSP-oriented projects that may become a class project. *You are to submit suggestions for two possible project topics as two separate project ideas. The form of your submissions should follow that of the examples given above. All work must be individual and the writing must be in your own words.*

This assignment will be graded by the instructors like a regular homework (up to 50 points for each suggestion).

3.2 Electronic responses to pre-project ideas (PPI): due Tue 9/16

Starting Sat 9/13, submitted PPIs will be available for review and comment (CTools Forum) and for ranking (CTools Test Center). You are required to skim through the PPIs on the Ctools Forum, and provide comments and feedback on at least two that are different from your own submissions. You should also track your own Forum PPIs and respond to comments and questions raised. The goal is to improve and refine each of the PPIs, regardless of whether you would want to engage that topic yourself.

By Tue 9/16, based on your reading of each PPI and running commentary, you should rank your top four choices using the CTools Test Center. The intent is to get a head start of forming teams around the top ranked ideas that are submitted. The rankings are not binding, but will be used in identifying the top PPIs and forming teams when the class meets to finalize PPIs and teams.

Both your comments/feedback and ranking will be graded (complete or incomplete).

3.3 Project group formation meeting: Thurs 9/18, 7-9pm, EECS 1311

This will be a teaming meeting where project topics will be selected and teams formed. Project topics and team memberships are not assigned by the instructors. Project topics are not restricted to those pitched nor to those in the collection of PPIs. If you walk out of the teaming meeting not being a team member or are on a team that doesn't have at least a tentative project topic, you have a problem.

Project teams can be formed at any time prior to the teaming meeting, and you are encouraged to talk to each other before the formation meeting, especially after the pitch session, but please keep the instructors informed.

3.4 Written project proposal: due Fri 9/26 at 5pm

The teams are expected to meet and write a brief document, the project proposal, describing what their project is about and how it is expected to evolve. See the website for the proposal template and more details on how to

do this.

3.5 Oral presentation of project proposal: Mon 9/29 6-10pm, EECS 1311

Your team will make a formal proposal presentation at this meeting. A time slot will be assigned to you after you have submitted your written proposal.

3.6 Project parts order: due Fri 10/10 at 5pm

You will need to order parts for your project by this deadline, but you are required to list all the anticipated parts in your proposal (see proposal template). The parts order form is available for download on the course website. You are to fill it out and upload it as a google doc and share it with the instructors (hero, ghw, metzger, kurzerjo) as the document is continuously updated with current status.

3.7 Milestone 1 meetings: all day Thurs 11/6, EECS 4419

You will meet as a team with the instructors to discuss your progress on Milestone 1. The milestone (what should be accomplished by this date) is set by your team in your project proposal. A sign-up doodle poll will be available for you to pick a time slot for the meeting.

3.8 Milestone 2 meetings: all day Thurs 11/25, EECS 4419

You will meet as a team with the instructors to discuss your progress on Milestone 2. The milestone (what should be accomplished by this date) is set by your team in your project proposal. A sign-up doodle poll will be available for you to pick a time slot for the meeting.

3.9 CoE Design Expo: Thur 12/4, noon-4pm

It is mandatory that all teams participate in the Design Expo. The project team will supply a poster describing their project and try to have someone available during the Expo to answer questions. Ideally, the team will have some show-and-tell to go with the poster. This is a high visibility event and a chance to show off and to talk with people who are likely to be interested in what you are doing. Project teams usually find participation rewarding. This is also a preview of the demos that teams will show to the class at the next event below.

3.10 Final project presentation to the class: Wed 12/10, 5-10pm, EECS 1311

This is the grand conclusion of your semester-long hard work. The presentations and associated demonstrations will have a significant impact on the grades given to the projects. Having something to demonstrate is a requirement. The typical format is to go through about half the projects, then break for pizza dinner, and then continue for the other half.

3.11 Final project report: due on Fri 12/12 at 5pm

A final project report from the team and a project self-evaluation statement from each student (one page max) is required. The format of the final report and the self-evaluation statement are provided on the course webpage. These must be emailed to instructors (hero, ghw) before 5PM on the due date.

4 Project ideas sponsored by Harris Communications

This year Harris has provided the following projects; detailed description please see course website for the individual flyers.

1. Information relay
2. Vitals monitoring system
3. Haptic device for the visually impaired
4. Intruder detection sensor system