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Digital Hardware

Data Acquisition Box (DT50 Replacement) (J. D. Nelson)
Design a replacement for an obsolete microcontroller data acquisition system. This project includes:

- Planning the project
- Gathering and defining the requirements
- Designing the hardware and software
- Writing the software
- Testing and documentation of the finished device

Required Skills and Interests: An interest in microprocessor systems is required. Ability to program a microcontroller in C is required, A team approach is possible, with part of the team doing hardware, and part doing software.

Monitor and Control Interface Board (J. D. Nelson)
Design a replacement for an obsolete microcontroller monitor and control system

- Planning the project
- Gathering and defining the requirements
- Designing the hardware and software
- Writing the software
- Testing and documentation of the finished device

Required Skills and Interests: An interest in microprocessor systems is required. Ability to program a microcontroller in C is required, A team approach is possible, with part of the team doing hardware, and part doing software.

Design Daughter Cards for the MOD 5270 microcontroller base card (Tim Weadon)
The NRAO has a standard design for a motherboard using the Netburner mod 5270 microcontroller modules. The modules can be used for many purposes. This project is to design daughter cards for specific applications. The project work consists of:

- Planning the project
- Gathering and Defining the requirements
- Designing the hardware and software
- Writing the software
- Testing and documentation of the finished device

Each card could be designed by a separate team of students, and they could follow along each semester with a different card.
Required Skills and Interests: An interest in microprocessor systems is required. Ability to program a microcontroller in C is required, A team approach is possible, with part of the team doing hardware, and part doing software.
Active Surface Control System Hardware
The GBT has an active surface control system that is obsolete, and over the next several years will need to be replaced. A series of projects could be done to provide a new control system. The project work consists of:

- Planning the project
- Gathering and Defining the requirements
- Designing the hardware and software
- Writing the software
- Testing and documentation of the finished device

There would be a need for:

- An Analog input system reading 16 LVDTs
- An H-drive module controlling 16 motors
- A communications module to connect them all together

Required Skills and Interests: An interest in analog systems and microprocessor systems is required. Ability to program a microcontroller in C is required. A team approach is possible, with part of the team doing hardware, and part doing software.

A study on water-cooling of digital hardware and ADCs
The Digital group is experimenting with using water-cooled devices to stabilize temperatures and get rid of excess heat. There has not been much work to date on the temperature stability of water cooling methods and practices. The project work consists of:

- Planning the project
- Gathering and Defining the requirements
- Designing the experiments and collecting the data
- Data Analysis
- Writing a paper

Required Skills and Interests: An interest in analog systems and microprocessor systems is required. Ability to program small microcontrollers for acquiring data and using software for data analysis and presentation is required.

A controller design for water-cooling of digital hardware and ADCs
The radio astronomy instrumentation needs precise temperature control of analog components to get good stability from the RF systems. One way to do this is to use a closed-loop control system for cooling sensitive parts. This project will be to design and build a control system for temperature stabilization of a digital signal processor's analog subsystem and FPGA chip. The project work consists of:

- Planning the project
- Gathering and Defining the requirements
- Designing the hardware and software
- Writing the software
- Testing and documentation of the finished device

Required Skills and Interests: An interest in analog systems and microprocessor systems is required. Ability to program small microcontrollers for controlling the temperature, acquiring data and using software for data analysis and presentation.

**Microwave Hardware**

**Wideband Artificial Pulsar (Randy McCullough / Jason Ray)**
This project involves the design and construction of a wideband artificial pulsar, to be used as a test source for GBT pulsar backends. This project involves microwave RF components, as well as digital electronics for control and monitoring of the system. The project involves the following steps:

- Planning the project
- Gathering and defining the requirements
- Designing the hardware and software
- Writing the software
- Testing and documentation of the finished device

Required Skills and Interests: An interest in communications, microwave technology, or radio astronomy systems is required. Ability to program a microcontroller in C is required, A team approach is possible, with part of the team doing hardware, and part doing software.

**Battery Powered Broadband Noise Source (Carla Beaudet)**
This project involves the design and construction of a compact broadband noise source for use in testing Radio Frequency Interference shielding

- Planning the project
- Gathering and defining the requirements
- Designing the hardware
- Testing and documentation of the finished device

Required Skills and Interests: An interest in communications, microwave technology, or radio astronomy systems is required.

**Novel OMT Design (Mike Stennes)**
A novel OMT and waveguide probe that is easier/cheaper to produce. The electrical concept has been designed, built, and proven, but it would be nice to investigate other mechanical configurations and fab techniques. This is possibly a good project for mechanical engineering students, or one of any engineering discipline who has a talent, or a particular interest in mechanical concepts, properties of materials, and manufacturing methods.
Required Skills and Interests: An interest in communications, microwave technology, or radio astronomy systems is required. Knowledge of Computer Aided Design for mechanical systems is required.

**Low Polarization Sensitive PIN photo-diode detector (Steve White)**

Polarization sensitive photo-diodes limits the gain stability of analog over fiber links. Typically these diodes are fashioned with an angle polished fiber surface and an air gap before illumination of the PIN diode. This project involves investigating PIN diode construction and the attachment of fiber to the semiconductor. Optical modeling is required to establish return loss and coupling efficiency predictions. Also prototyping and measuring the diode characteristics are required to verify the modeling.

Required Skills and Interests: An interest in semiconductor technology, microwave technology, optical technology, electromagnetics or physics is required. Knowledge of Computer Aided Design for optical simulation and 3D modeling is required.

**A Local Oscillator system for the 40 foot telescope (John Ford)**

The 40 ft telescope's local oscillator is in need of replacement. This project would involve using a synthesizer to provide the LO signal, a microcontroller to interface to the front panel display and control knobs.

- Planning the project
- Gathering and defining the requirements
- Designing the hardware and software
- Writing the software
- Installation, testing and documentation of the finished device

Required Skills and Interests: An interest in communications, microwave technology, or radio astronomy systems is required. Ability to program a microcontroller in C is required. A team approach is possible, with part of the team doing hardware, and part doing software.

**A new Low Noise Receiver System and Fiber optic RF transmission system for the 40 foot telescope (John Ford)**

The 40 ft telescope's RF chain needs to be upgraded. A new lower-noise RF receiver, fiber-optic transmission system, and downconverter module needs to be designed, constructed, and installed at the 40 ft telescope.

- Planning the project
- Gathering and defining the requirements
- Designing the hardware
- Testing and documentation of the finished device

Required Skills and Interests: An interest in communications, microwave technology, or radio astronomy systems is required.
Analysis/Software/Firmware

A test software system for automated receiver testing (Steve White)
This software system would step the LO and test the whole passband of a receiver with the lab spectrometer and a GPIB-controlled LO synthesizer. The project involves the following steps:

- Planning the project
- Gathering and defining the requirements
- Designing the software
- Writing the software
- Installation, testing and documentation of the finished system

Required Skills and Interests: This would be written in the Python programming language, and involves control of IEEE-488 based microwave instruments. An interest in communications, microwave technology, or software systems is required. A team approach is possible, with part of the team doing hardware, and part doing software.

Thermal Monitoring and Shutdown System (Rich Lacasse)
This project involves designing a software system to monitor and shut down a hardware device if it is overheating.

- Planning the project
- Gathering and Defining the requirements
- Designing the software
- Writing the software
- Testing and documentation of the finished system

Required Skills and Interests: This would be written in the Python and C/C++ programming languages. An interest in communications, digital systems, or software systems is required.

An Extended Proximate Time Optimal Control System for a Mirror Positioning System (Graduate student) (John Ford)
This project involves the analysis, design, simulation, and testing of a mirror control system for positioning a 1 meter mirror in the ALMA telescopes. Most of the work will be done in Simulink and Matlab, with final implementation of the design in the Labview system.
Required Skills and Interests: Matlab, Simulink, and Labview programming languages are used. Strong knowledge of digital control systems is required, along with some experience modeling mechatronic systems.

A QPSK Demodulator
Build a QPSK demodulator using a Xilinx FPGA and Xilinx ISE tools. The demodulator would accept analog data at a bandwidth of 140 MHz, and output QPSK demodulated symbols.
Required Skills and Interests: Matlab, Simulink, and VHDL programming languages are used. Strong knowledge of communications systems is required, and an interest in digital signal processing.
Monitor and Control Software Projects

GBT Engineering User Interface
Re-architect, re-design and implement the GBT Engineering User Interface (CLEO) to utilize data streaming with a supportable GUI technology (e.g. C++ (QT), Python). Requires a good grasp of full-life cycle software development, basic data structures and effective software design.

Dynamic Scheduling System
The DSS scheduler interface was written in GWT and GXT. Better browser-based software technology has since been made available to web developers. For example, the GB PHT user interface was developed with extJS. Near term, we plan to replace GWT,GXT in DSS with extJS. This allows us to drop support for Eclipse/Java and consolidate GB SDD web application technology responsibilities. Requires a good grasp of full-life cycle software development, Javascript and effective code organization/modularization.

GBT Control System Session Monitor
As we begin to provide higher bandwidth displays (e.g. real time GFM, VEGAS data display) it becomes more important to be able to determine who is connected to the system and utilizing these displays. Currently it is not uncommon to find ten observers monitoring the GBT who have no relation to the currently running observations. This is often the result of observers closing the client end of the VNC session, believing the remote desktop will be closed also. Long term, we plan to build a tool which monitors sessions and monitor 'feeds'. This tool will help in cleaning up unused connections and save time debugging connection-related problems. Requires a good grasp of full-life cycle software development, C++ and effective software design.

IF Manager
The IF Manager simulates frequency characteristics of signals along the entire GBT IF system path - from the receiver to the backend. Although the IF Manager can be very helpful in diagnosing problems with system configurations or changes to the system, the software is difficult to comprehend and expensive to debug, maintain and modify. Given other changes to the system, viz. data streaming, the development of the GB archive and the expanded, vital role of the configuration tool, it is time to re-visit the architecture and design of the IF manager and create a plan to improve it. Requires a good grasp of full-life cycle software development, the ability to maintain a "big picture"/systems engineering perspective and effective software design.

Other Software Projects

GB Controlled Hunt Software program
The GB site holds a controlled hunt in conjunction with the WVDNR each year and the software to manage the applications is obsolete. The hunt applications are managed through a lottery system as only a certain number of hunting slots are available for each day of the hunt. This project includes:
• Reviewing the existing software package and requirements for execution
• Writing new software package as Windows-based application
• Testing and documentation of the finished package

Web Projects

An Interactive Plotting Tool Embedded Within Plone
NRAO uses the Plone content management system to support its web pages. An example web page is at:

https://science.nrao.edu/facilities/vla/observing/RFI/Ka-Band

We would like the ability to call up an application from within Plone, so that rather than the “plot” link simply displaying a static plot, it would provide the ability to pan and zoom the image. The first step of the project would be to confirm that such an application could coexist with the Plone content management system, and that this would be compatible with NRAO security policies. Then the student would implement the application, and update the Plone content appropriately. Requires a good grasp of web development programming.

Mechanical Projects

The effect of grain size and direction on cryogenic heat transfer
At cryogenic temperatures, especially in the newer generation of near 0°K cryogenic devices, the heat transfer rate of cooling straps and heat shields is extremely important. That annealing of copper improves its heat transfer rate is well known. What is not known is if the grain size and grain orientation have any effect on heat transfer rates.

Metal preparation methods for diffusion welding in vacuum and inert gas
Diffusion welding can bond similar and dissimilar metals using relatively low temperatures for low distortion and minimal material property changes. Exploration of preparation methods and welding environmental conditions could improve the feasibility of this process.

Bond condition evaluation of large area diffusion welded assemblies.
A way needs to be found to evaluate the mechanical and electrical bond in a diffusion welded assembly

Clean precise machining of UHMW and Teflon like plastics
Often a plastic lens is cut from a piece of stock. These lenses often include small close grooving or other precision features. Exploration of machining methods with more precise tolerances, less flash, and fewer pulled threads would improve the parts. One particular method of interested is supercooling the cutting tool with liquid Nitrogen but other methods are certainly of interest.
Metalizing precision plastic parts for use as feeds and signal processing components

This project could explore the feasibility and methods of fabrication of precision plastic components that then are metalized to form light, precise signal processing devices.

Numerical modeling of dynamic track loading that includes walking behavior.

There is no numerical model that includes the behavior of rail creep in the direction of travel. Without a model that includes this phenomenon significant rail stresses may be being overlooked. This project is applicable to all heavily loaded tracks. Besides us this includes railroads, stadium roofs, heavy cranes etc.