Introduction:

My summer internship at the Central Development Laboratory involved several projects. Each project assigned to me applied to the SIS mixer test system. Superconducting-Insulating-Superconducting (SIS) mixers are critical components in the signal receiving units of radio telescopes and are a key focus of CDL research and design. Each mixer test system consists of a cryogenically-cooled Dewar that houses the mixer and includes a vacuum pump, and a refrigerating system. The test system is connected to various meters, a computer, and other electronic devices that are mounted on a test rack. An example of a mixer system and its test rack is shown in Figure 1. The first project that I undertook was to become familiar with the computer language Visual Basic. This gave me the tools to take on other projects. Such projects include writing software to control various measurement devices. Another project assigned to me was the design and construction of a device to be used in the automatic control of a vacuum pump in a particular mixer test system. My final project was the investigation of the response of an electronic device called a Square Law Detector. The following details the specifics of my individual projects.

Figure 1: SIS Mixer Test System; Left: Test Rack; Right: Dewar with refrigerating system and vacuum pump
Visual Basic:

Visual Basic is a computer programming language that is integrated into several Windows applications that are utilized extensively at the CDL. This version of Visual Basic is called Visual Basic for Applications. One application uses the spreadsheet program Excel for monitoring of values displayed by measuring devices. These values can be placed into a spreadsheet along with other information. Data taken by a Visual Basic program can be placed into and manipulated by an Excel spreadsheet. A second application is the monitoring and remote control of a device’s configuration. This application can be used with the former application to gain remote control and record information from a test system.

My first assignment of the summer was to learn the code structure, or syntax, of the Visual Basic programming language so that I would have the tools to take on future projects. After which, I learned of the interfacing techniques between the Visual Basic program and the hardware. This required me to become familiar with the National Instruments General Purpose Interface Bus (or IEEE-488) interface system.

After learning the basics of the language and of how communication with devices occur, I was assigned to create a program that would eventually be used with the switch I was to design and construct later in the summer. The program checked the readings of a Lakeshore 218 temperature monitor and instructed the monitor to toggle the position of a relay in the temperature monitor chassis when a temperature being read fell below a specified value.

A second program that I created was a program to be used with a local oscillator system, called the LO plate. The LO plate was worked on by Tim Thacker, another CDL summer student. This program instructed the YIG oscillator on the LO plate to output a signal of a certain frequency and then instructed an Anritsu power meter to read the power delivered by the LO plate after it was amplified and multiplied in frequency. The power level, frequency, and other data were then placed in an Excel spreadsheet. The program allows the user to have the system sweep through a user-specified range of frequencies and records the corresponding power levels. The user can then observe a program-generated chart that displays power level vs. frequency.

The final program I created was used to test a Square Law Detector. This involved communication with a power meter and a precision multimeter. More detail of the program’s application is discussed in the section of this report devoted to the Square Law Detector.

During the design phase of each program, documentation was required. This primarily consisted of creating sequence diagrams for the programs. A sequence diagram illustrates how a program functions by charting how objects interact with each other. **Figure 2** shows a part of a sequence diagram for the program used with the LO plate.

High Voltage Switch:

The design and construction of a high voltage switch was a project I worked on for the majority of the summer. Several steps were taken in the completion of this project, and they were spread out over a few months due to priority changes and other factors. The function of this device was to allow remote control of the vacuum pump on our JT-2 mixer test system. The device, in conjunction with a computer program, turned a vacuum pump on or off when a specified temperature was reached in a particular region of the Dewar also specified by the user. This required the writing of new software (as described above), hardware design, and hardware construction.
Under the guidance of the CDL’s technical staff, I selected components to be used in the construction of the device based on the current and voltage handling requirements of the system. The components selected were two Potter and Brumfield solid state relays and a Jacobian AC to DC Power Module. Once the components were ordered and received, the hardware was mounted in a chassis and the proper connections were then made. A cable was also constructed to connect the chassis to the vacuum pump and the temperature monitor. The final product is shown in Figures 3 and 4.
Square Law Detector:

My final project involved a device called a Square Law Detector. A signal is input into the device, and the device outputs a voltage proportional to the power of the signal. Ideally, the output voltage should respond linearly to a change in input power on a logarithmic scale (output volts are directly proportional to input watts). My assignment was to set up a configuration of hardware that would allow the measurement of output vs. input and also to write software that would plot the relationship. Once data was taken and plotted, we observed how linear the relationship was. In order to improve its linearity, I was assigned to make adjustments to potentiometers on the Square Law Detector. This effectively changes the response of the device. There are three potentiometers in the device and adjusting them together in a particular sequence results in an improvement of linearity. I currently am trying to find this sequence, along with a quantitative way to measure how linear the response is. Adjustments are made, and the response is then plotted on an Excel chart using the software written by me. Figure 5 shows an example of a data set with its plot.

![Data spreadsheet and chart for a Square Law Detector test](image)

Figure 5: Data spreadsheet and chart for a Square Law Detector test

Summary:

My summer internship at NRAO’s Central Development Laboratory involved several small projects, each of which taught me very much. Such projects involved writing software, constructing hardware, and applying them to the SIS mixer test system. I would like to thank Al Wooten, John Hibbard, and John Effland for selecting me for the NRAO Summer Student Program. I would also like to thank the NSF for sponsoring me. The lectures, program activities, and social events were very interesting and beneficial.