

## Remote Data Acquisition using LabVIEW

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### Abstract

In this paper, a remote data acquisition laboratory project is presented for a senior technical elective telecommunications course in the Electrical Engineering Technology Baccalaureate Program at Penn State Erie, The Behrend College. There are several unique characteristics of this project. First, the project is multidisciplinary in nature since it combines material from the telecommunications course with material from a junior level instrumentation and measurements course, where students learn how to use LabVIEW as a programming language and how to program a data acquisition (DAQ) card for analog input and output operations. Second, the project encompasses several laboratory experiments which are integrated together to form the complete project.

The remote data acquisition project consists of a hardware setup phase and a software development phase. The hardware setup phase consists of a dedicated remote PC with a DAQ card for monitoring analog input signals and a local PC to allow the user to define the control parameters for the remote DAQ card and to initiate the data acquisition process. Each PC will be connected to a phone jack through an internal modem.

The software development phase consists of two separate programs written for two PCs. The first program is the remote PC program. The objective of the remote PC program is to automatically acquire analog input data, which is initiated from a user at the local PC, and to upload the complete file. The second program is the local PC program. The objective of the local PC program is to automatically send the parameter information needed by the remote PC program to control the DAQ card and to download the file.

### I. Introduction

The objective for this remote data acquisition project is for the students to build upon their knowledge of using LabVIEW for data acquisition by remotely controlling the operation of the DAQ card. The project is designed to correlate together with material presented within the lecture for the telecommunications course. During the lecture course, the students learn about the functions of the RS232 serial port in the PC, the hardware handshaking for the control pins on the serial port, digital modulation and demodulation techniques for modems, and the modem AT command set for controlling the modem. The students also learn how to use LabVIEW to program the serial port for read and write operations and how to send the proper string commands to the modem. During the laboratory portion of the telecommunications course, the students are given several laboratory experiments which are combined together to complete the remote data acquisition project. These experiments consist of a data acquisition control program, an RS232 terminal program, and a file transfer program.

The first experiment is for the students to develop a program to control the DAQ card. The DAQ card is a National Instruments Lab-PC-1200 DAQ card which is configured as device number 1 and can process analog signals with full-scale input and output voltages of +/-5V with 12 bits of resolution<sup>1</sup>. This program will acquire samples from an analog input source and store the data to disk. The next experiment is for the students to develop an RS232 terminal program. In this program, the students develop a full-duplex communication program to chat between two PCs. In order to simplify the development of their program, the modems are first bypassed by using a null modem configuration that connects the two PC serial ports directly together. After this part of their program is working correctly, the null modem is removed and the internal modems are used for communicating over telephone lines. In order to communicate over the telephone lines, modem command strings are sent to initialize the modems and to configure them to dial and answer. After the modems have been configured and the appropriate training signals have been sent between each modem such that they have established a communication link, they are used to connect the PCs together through the telephone lines for chatting. The next experiment in the development of their overall project is to develop a file transfer program. In this step, the students learn that the file transfer program is simply a modification of the terminal program to upload and download a file instead of chatting information. In order to properly send and receive the complete file, header information is sent first to indicate the proper number of bytes contained in the file. Then, the header information is received first and used to specify the number of bytes to receive the complete file. Finally, the last experiment in the development of their project is the integration of the previous programs together into a specific remote PC program and a local PC program. The remote PC program is executed on the remote PC and the local PC program is executed on the local PC. The remote PC contains an internal modem and a DAQ card for acquiring analog input signals. The internal modem is connected directly to a telephone jack so that it can be remotely dialed. The local PC is also connected directly to a telephone jack through an internal modem and is used as the user interface for controlling the remote DAQ card. The transmission medium is through telephone lines.

## II. Data Acquisition Program Experiment

Since LabVIEW is a graphical programming language, subprograms called subVIs are available for controlling the DAQ card. A description of each of these subVIs for acquiring analog input data is readily available in the literature<sup>2</sup>. The process for acquiring input data begins with a configuration subVI that specifies the device number, channels to scan, and the number of scans to acquire for creating the proper buffer size in the PC RAM. The next function specifies the scan rate and starts the data acquisition process. The data is then stored in computer memory. Once the data has been stored, the data is read from the computer memory so that it is accessible to the program, displayed on the computer screen, and stored to disk. After the data has been collected and read, the last function deallocates the buffer space from computer memory. The block diagram of an example of such a LabVIEW program is shown in Figure 1.

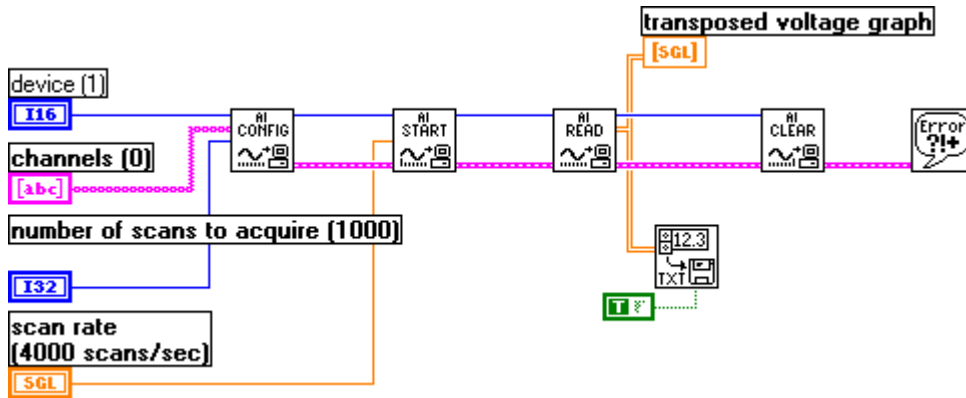


Figure 1. Data acquisition program for analog input.

### III. RS232 Terminal Program Experiment

The objective for this program is to develop a full-duplex communication program for chatting between two PCs using the RS232 serial ports. The experiment consists of two parts. First, a null modem configuration is used to directly connect the two serial ports. After completing this part of the program, the null modem is removed and the internal modems are connected to the telephone lines.

The first part of this program uses the serial subVIs available within LabVIEW. The first of these subVIs is the serial port initialize function which establishes the port number, the type of flow control for handshaking, the bit rate, the number of data bits, the number of stop bits, and the parity. Another SubVI is the bytes at serial port which provides the number of bytes contained within the receiver buffer of the serial port. Also, there are two SubVIs for reading and writing characters from and to the serial port, respectively. Finally, another SubVI is used for closing the serial port, which releases the serial port so that it can be used for other applications. A flowchart for implementing a full-duplex serial program is shown below in Figure 2.

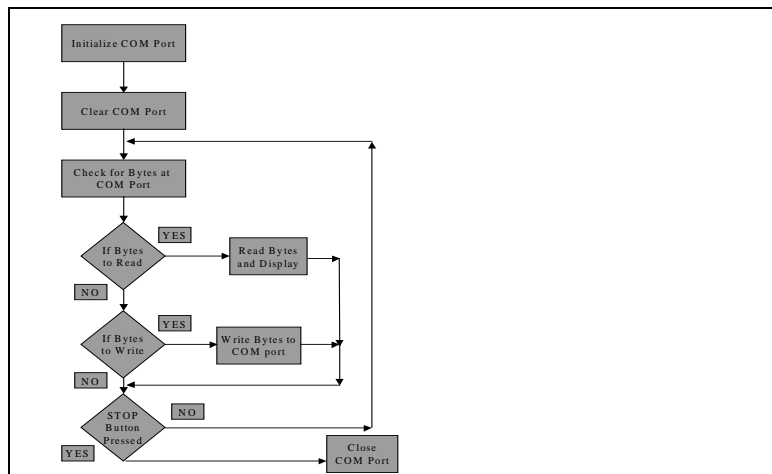


Figure 2. Flowchart for full-duplex serial communication program.

For the second part of this lab, the null modem is removed and the internal modems are connected directly to the telephone lines for transmission of the information. The same full-duplex communication program is used for this part of the lab, but several string commands are entered by the user to initialize and configure the modems<sup>3</sup>. These commands are listed below.

- `at\r\n` → the modem should respond with OK to an attention command
- `at&f\r\n` → the modem is set to the factory default settings
- `atdt7282\r\n` → the modem dials extension 7282
- `ats00=002\r\n` → the modem answers after two rings
- `+++` → the modem enters the command mode
- `ath0\r\n` → the modem goes on-hook

The commands are terminated with a return and newline sequence. The modem interprets this as a command termination sequence and then responds to the command. After the modems have established a communication link between each other, the modems respond with a CONNECT result code and the users can begin the chatting session. Once a user wants to terminate the session, the command to cause the modem to hang-up is sent. Since the modems have been communicating between each other and one modem hangs-up, the other modem responds by hanging-up.

#### IV. File Transfer Program Experiment

Although the file transfer program uses the same subVIs contained within the full-duplex terminal program discussed earlier, the program is modified as follows. The program will first allow the user to select whether to originate the phone call or to answer the phone call. Then the user will select whether to upload or download the file, depending upon whether the user will be transmitting or receiving the file.

The lab experiment is broken into two sections. The first section of the lab consists of developing a program to upload and download a file between two PCs by using a null modem connection between the serial ports. In order to accomplish this file transfer, a header consisting of the number of bytes in the file will be transmitted first before the data is transmitted. This will allow the receiver to know how many bytes to read from the serial port.

The second section of the lab consists of modifying the program for the modem control. If the program is originating the phone call, the program will initialize and configure the modem to dial the other modem. Then, the program will upload or download a file, depending upon a user selected input. Finally, at the end of the program, just before closing the serial port and after uploading or downloading the file, the program will cause the modem to go on-hook and terminate.

If the program is answering the phone call, the program will initialize and configure the modem so that it will answer the phone call after two rings. Then, the program will download or upload a file, depending upon a user selected input. Finally, at the end of the program, just before closing the serial port and after uploading or downloading the file, the program will wait for the modem to hang-up and then terminate. A flowchart for implementing the file transfer program is shown in Figure 3.

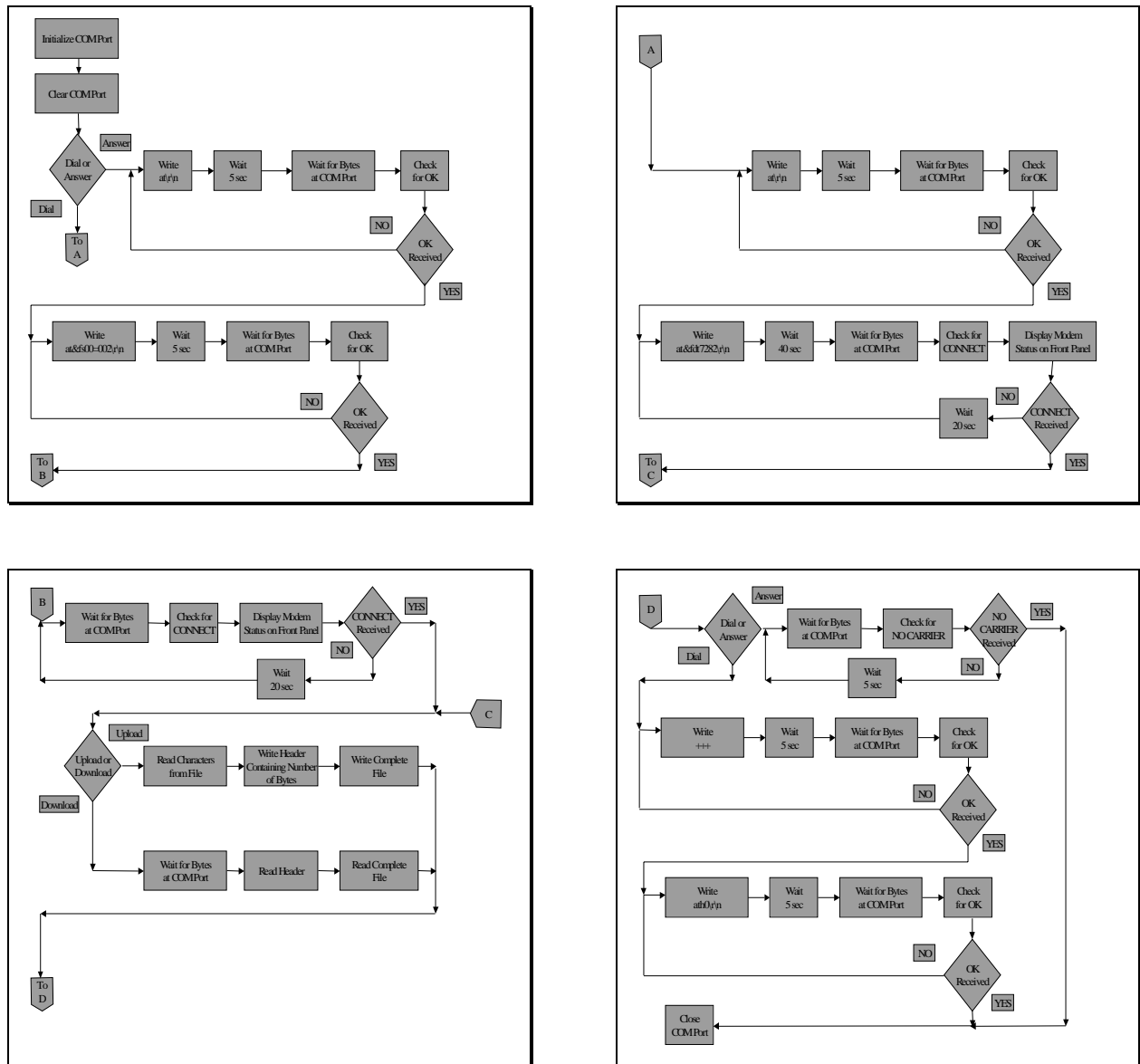


Figure 3. Flowchart for file transfer program.

## V. Remote Data Acquisition Experiment

This experiment consists of a remote PC program and a local PC program. These two programs are based upon the integration of the programs developed from the experiments presented above.

The objective of the remote PC program is to automatically acquire analog input data, which is initiated from a user at the local PC, and to upload the complete file. In order to accomplish this, the program will initialize and configure the modem so that it will answer the phone call after two rings. Then the program will receive parameter information containing the device number, channels to scan, the number of scans to acquire, and the scan rate. It uses this information to start the data acquisition process and stores the file to disk. The program then reads the file,

uploads the header containing the number of bytes contained within the file, and then uploads the complete file. The program then waits for the modem to hang-up and loops back to wait for more data to be received. A flowchart for this program is shown in Figure 4.

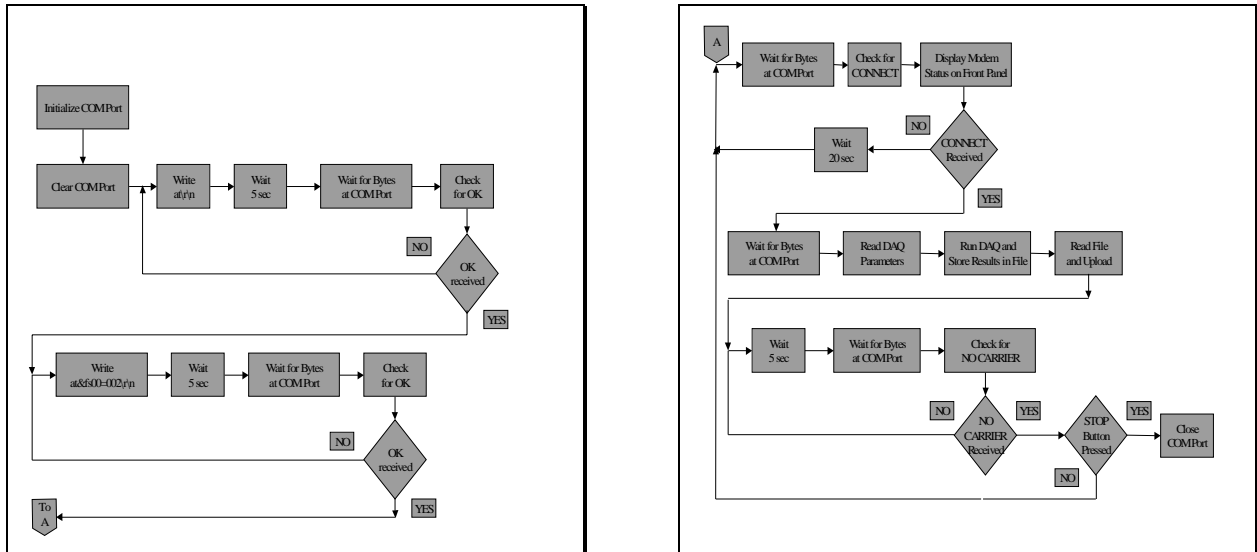


Figure 4. Flowchart for remote PC program.

The objective of the local PC program is to automatically send the parameter information needed by the remote PC program to control the DAQ card and to download the file. In order to accomplish this, the program will initialize and configure the modem to dial the other modem. Then, it will send the parameter information containing the device number, channels to scan, the number of scan to acquire, and the scan rate. It will then wait for bytes to be received in the receive buffer of the serial port. It reads these bytes which contain the number of bytes contained within the complete file. It uses this information to download the complete file. Finally, the program commands the modem to hang-up and terminates. A flowchart for this program is shown in Figure 5.

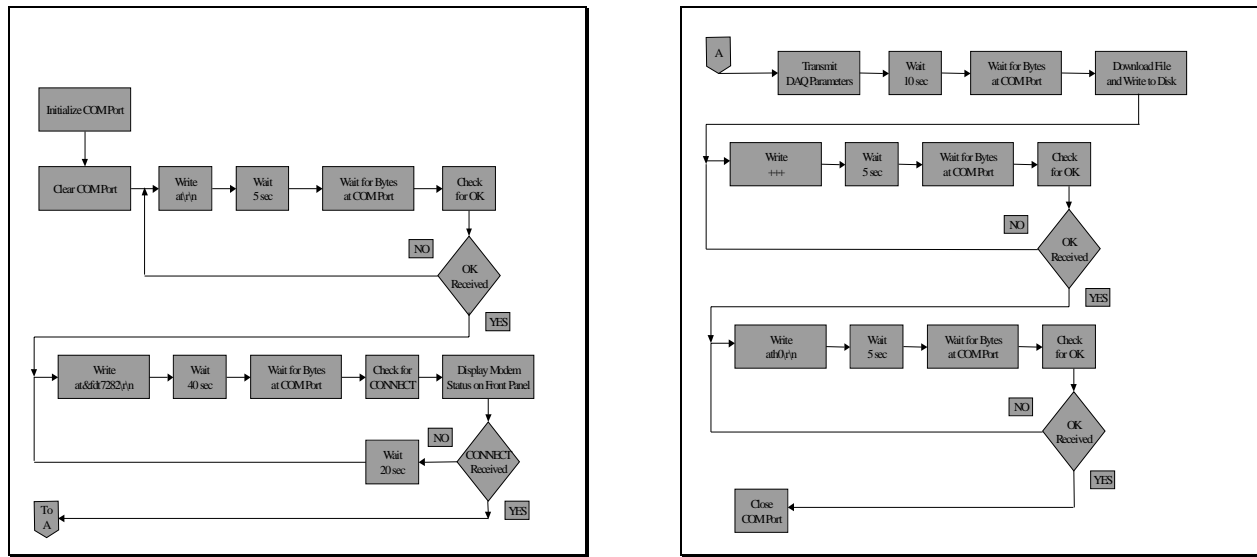


Figure 5. Flowchart for local PC program.

## VI. Conclusion

The unique characteristics of the project presented are that it is multidisciplinary and that it integrates several laboratory experiments to form a complete project. The project combines material from an instrumentation and measurements course with a telecommunications course, as well as material introduced from individual lab assignments.

There are several goals for having the students complete this project. First, the students build upon their prior knowledge of learning LabVIEW to discover other PC applications for the usage of LabVIEW. Second, a practical solution for a common PC data acquisition problem is presented. Third, the graphical programming nature of LabVIEW minimizes the complexity of software algorithms for implementing telecommunications solutions.

## Bibliography

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David R. Loker received the B.E.E. degree from Gannon University in 1984, and the M.S.E.E. degree from Syracuse University in 1986. In 1984, he joined General Electric (GE) Company, AESD, as a design engineer. While at GE, he was primarily involved in the design and development of military communication systems. In 1988, he joined the faculty at Penn State Erie, The Behrend College, in the Electrical Engineering Technology program, and currently holds the rank of assistant professor of engineering. His research interests include PC-based control systems, communication systems, and instrumentation systems.