Acquisition of Biopotentials Using LabVIEW

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Instructor's Portion

Summary

This project is an introduction to data acquisition using LabVIEW. It is part of an instrumentation course in which students have already built a biopotential amplifier, but have not covered the fundamentals of sampling.

Uses

This is meant for an upper level undergraduate/ graduate biomedical engineering students, although the basic procedure can be applied to any course that requires an introduction to data acquisition

Equipment List

- NI DAQCard-1200
- NI BNC 2081 connector board
- Differential amplifier
- Function generator
- ECG electrodes and leads

Setup

1. Each lab station should have available each of the following things
    a. Computers with DAQ cards (in our case, students used their own laptops)
    b. Function generator
    c. Oscilloscope

d. Biopotential amplifier (in our case, this was built by the students on a prototyping board in a previous laboratory).

e. ECG electrodes and leads

References

- A good design for the differential amplifier can be found in chapter 5 of "Introduction to Biomedical Engineering" by Enderle, Blanchard and Bronzino (2000).
- An discussion of techniques for electrocardiograms can be found in "Medical Instrumentation: Application and Design, Third Edition" By John G. Webster (1998)

Student's Portion

Introduction

This experiment serves as an introduction to data acquisition using LabVIEW software.

Objective

After this experiment, students should be able to do the following

- Build a Virtual Instrument (VI) in LabVIEW that can be used for data acquisition.
- Understand the importance of sampling frequency in digital data acquisition
- Be able to write data to a file from a LabVIEW VI
- Use their own LabVIEW VI to acquire an electrocardiogram waveform.

Theory

The basic theory being studied in this lab is the Nyquist sampling theorem. However, students are asked to learn about the Nyquist theorem during the course of this laboratory, with no prior knowledge. The Nyquist sampling theorem suggests that the minimum sampling frequency must obey the following relationship.

$$f_{nyquist} = 2 \cdot f_{max}$$

where f_{max} is the maximum frequency present in the input signal.

Pre-Lab Preparation

Students should have working knowledge of how to record a 3-lead electrocardiogram. In our class, students have already built a biopotential amplifier and have recorded analog electrocardiograms in a prior lab exercise.

Workstation Details

Students should have each of these

- Laptop computer w/ spreadsheet software. (Bring your own)
- Data acquisition cards (DAQCard-1200 cards fit in the PCMCIA port of your laptop)
- NI-DAQ driver CD
- LabVIEW CD (you must remove this program from your laptop at the end of the quarter)
- Microsoft Excel, or other spreadsheet program
- BNC breakout box (with cable to connect to DAQ card)
- Function generator
- Oscilloscope
- Biopotential amplifier (built in a previous lab)
- ECG electrodes and leads

Lab Procedure

1. Place the DAQ card into the PCMCIA slot in your computer
2. Install the appropriate drivers on your computer by running the setup program on the CD marked NI-DAQ

3. Install LabVIEW on your computer from the program disk at your station
4. Once running, work through the LabVIEW tutorial, activities 1,2,3 and 9.
5. Build a LabVIEW VI that will acquire 3 second of a signal from channel 0 of the data acquisition card, display the acquired waveform on the screen, and write the data to an output file.
6. Generate a 100 Hz sine wave using a function generator connected to channel 0 of the BNC breakout box. Display this sine wave on the oscilloscope in order to accurately assess the frequency.
7. Using your LabVIEW VI, acquire and display the input sine wave.
8. Repeat 7, using a range of 5-10 different sampling frequencies (remember, you will have to alter the number of samples to maintain a total sampling time of 3 sec). Be sure to choose frequencies well above and well below the 100 Hz of the input signal. For each response, determine if the sampled waveform accurately mimics that actual waveform on the oscilloscope.
9. Alter the function generator settings so that it is producing a sine wave with a frequency of 50 Hz. Repeat the steps that were taken for the 100 Hz. sine wave experiment in step 8.
10. Remove the function generator from channel 0 of the breakout box and replace it with the output of a biopotential amplifier. Connect the leads of the biopotential amplifier to one of your team in the normal configuration for the 3-lead electrocardiogram.
11. Use your VI to record 3 seconds of one of the leads of the ECG and transfer the data to a spreadsheet file for graphing.

Lab Report

Your informal lab report should include the following figures and answers the following questions pertaining to the steps above.

1. In using the acquire waveform sub-VI, what input variables need to be defined?
2. What was the effect of altering the sampling frequency on the representation of the sine wave in sections 8 and 9 above?
3. Make a graph showing instances where the sampling frequency resulted in a good and not so good representation of the sine wave at the input. Do this for both the 50 Hz and 100 Hz sine waves.

4. What is the minimum sampling frequency that you would use to sample a sine wave with a frequency of 400 Hz? Explain your answer.

5. Make a graph showing the digitized ECG waveform.