A Labview Project: Design of an Automated Water Heating System

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Abstract

The task to attract students to science, technology, engineering and mathematics (STEM) fields is becoming more challenging. There is a need to introduce students to one important function that most engineers and technologists are involved in, which is system design process.

In this paper, a student project to design a complete automated water heating system is presented. Both software simulations and hardware implementation are shown. This application serves as a tool to introduce freshman engineers, and technologists to systems design starting from conceptual ideas to final implementation. The advantages of using Labview as a graphical language to develop this type of applications and its use as a tool to attract students to STEM fields are discussed.

Introduction

As the engineering, science, and technology fields become more challenging, there is a need to introduce design projects in the freshman year curriculum and even in high school curriculum. This process will help students to understand what they can accomplish by enrolling in STEM (Science, Technology, Engineering and Mathematics) fields, and more importantly is to equip them with tools that will make learning STEM subjects more interesting.

One of the tools that are widely used in the academia and industry is National Instrument's Labview data acquisition hardware and software to acquire data, process and control [1]. These integrated hardware-software tools use computers increased computational capabilities to assist

the user in the design, development, and control of complex systems in a much shorter time [2-10]. As a result, STEM fields are under pressure to incorporate the use of advanced tools into their curriculum so their graduates can be well trained in the use and application development to serve the needs of the industrial community.

In a typical Engineering curriculum, hands-on and real world problem-solving approaches are an integral part of the design learning process. Such a process can be broadly described and categorized into defining a need, background research, design criteria and constraints, building and testing a prototype, redesign and retest if necessary. To implement such a process, students usually work in teams to design and develop an idea as a solution to a valid existing open-ended technical problem through application of the engineering design process. Before starting any design project, the team must answer a set of questions which include: (1) Is there a need for the product? (2) Is a new version of an existing product with a solution already available? (3) What are the advantages of the redesigned product [11]? Once the project team realizes a solution to the technical problem is not available or not convincing, then a decision to develop a solution to the problem and eventually build the final product is made.

Good engineers look at a variety of different possible designs before moving forward. Once the design is made, it is build and the prototype is tested repeatedly for flaws that require a rectification. Validating, rectifying and justifying are prime attributes to solve a technical problem. This entire process will teach students all the steps that are required to obtain the best design that meets all specifications.

This project is a control system that could be included in an engineering/technologist curriculum to demonstrate the process of converting theoretical knowledge into practical implementation. This will boost the confidence in the engineering students and encourage them to come up with new ideas and solutions [12]. It has the strength to inspire students to be more interested in STEM fields by knowing the process that an engineer/technologist follows to develop new products, and solve challenging problems.

It is worthwhile to mention that the learning experience that students gain in an environment that integrates team oriented, hands-on learning and engaging them in the design and analysis process, is a must in today's technological needs. In this paper, a student project to design a complete automated water heating system is presented.

Principles of designing an automated water heater

The ultimate aim of this project is to help the reader to design a water heater that heats up the water to a certain temperature and regulates it according to the user willingness, depending upon a threshold temperature being set up. The complete design flowchart is shown below. The design consists of three basic steps to be followed: (1) reading the input data, (2) processing the data, and (3) generating a variable corresponding to the DC output to control the actuator (i.e. a relay).
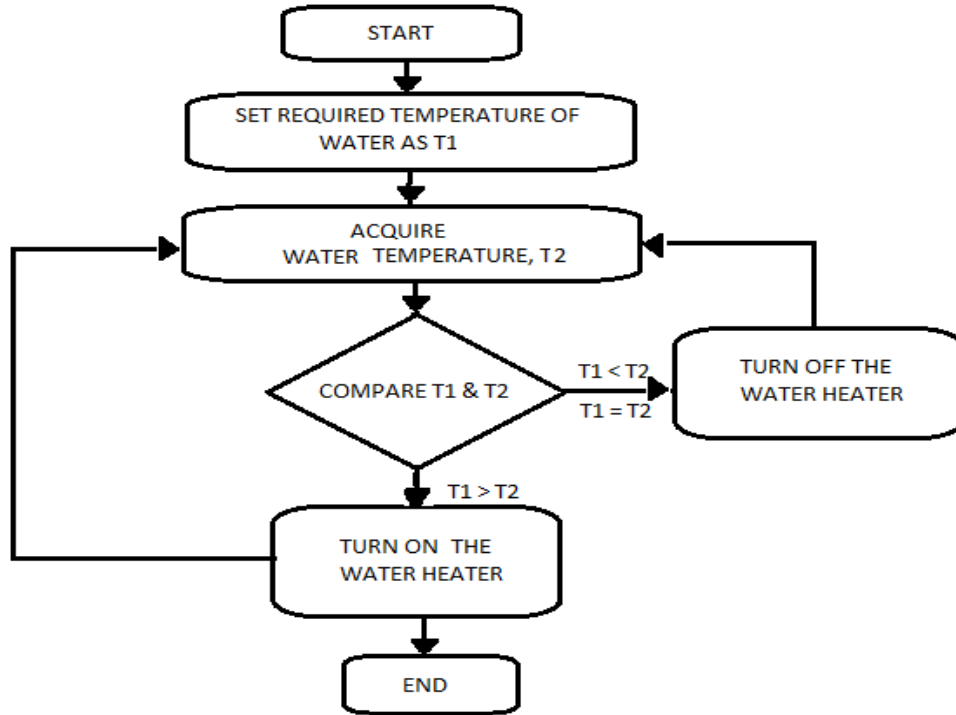
This design uses a temperature sensor shown in figure 1 to sense the temperature of the water and generates a signal in volts corresponding to the heat.

Figure 1: Temperature sensor

The acquired voltage v is converted to temperature in terms of Celsius using the equation shown below, where v is the voltage variable and C is the Celsius temperature.

$$C = 106.0*v - 270.9;$$

As the LCD of the sensor displays temperature in Fahrenheit, the temperature sensed is converted from Celsius scale to Fahrenheit scale to increase the user-friendliness of the design. This conversion is based on the following equation.

$$F = (9/5)*C + 32;$$

Labview is the core of the measurement systems. The signal from the DAQ card is processed. The software is composed of two parts: the front panel and the block diagram. The front panel shown in figure 2 is designed with the primary aim of making it user friendly as it acts as an interface between the human and the system.
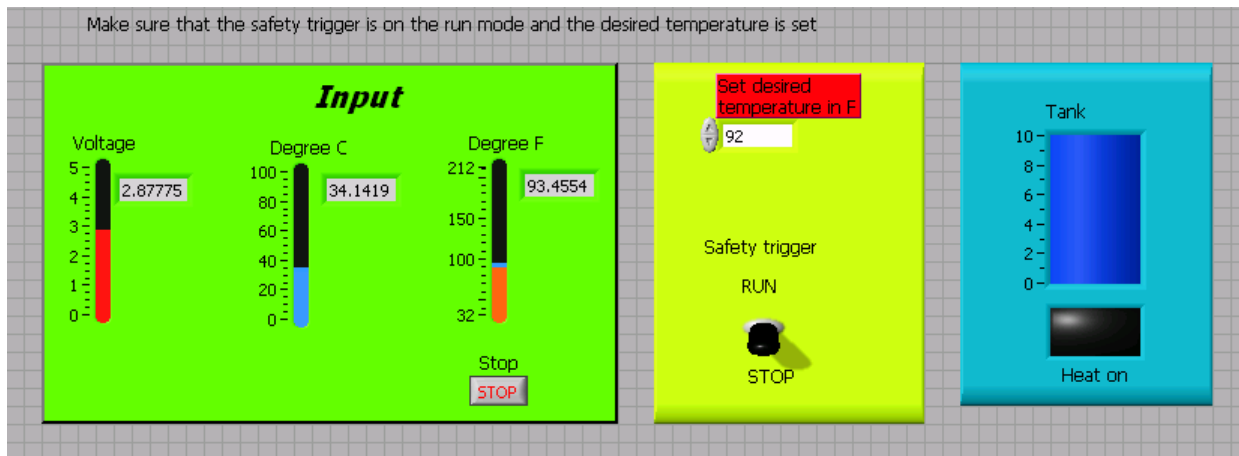

Figure 2: Front panel of the Application

The input parameters to the system are provided through the control modules.

The block diagram shown in figure 3 has three main blocks that are responsible for (a) relating the voltage to the corresponding temperature in Celsius (b) conversion of Celsius into

Fahrenheit to improve the user friendliness and (c) comparison of the water temperature with the required temperature.

The output of every conversion is displayed on the front panel. A safety trigger has been installed to halt the system to ensure safety of the user in case the system runs out of control. The system uses two data acquisition assistants for input and output of the system, the input DAQ is set and connected to the first input pin and the output DAQ is connected to provide the output voltage as per the requirement.
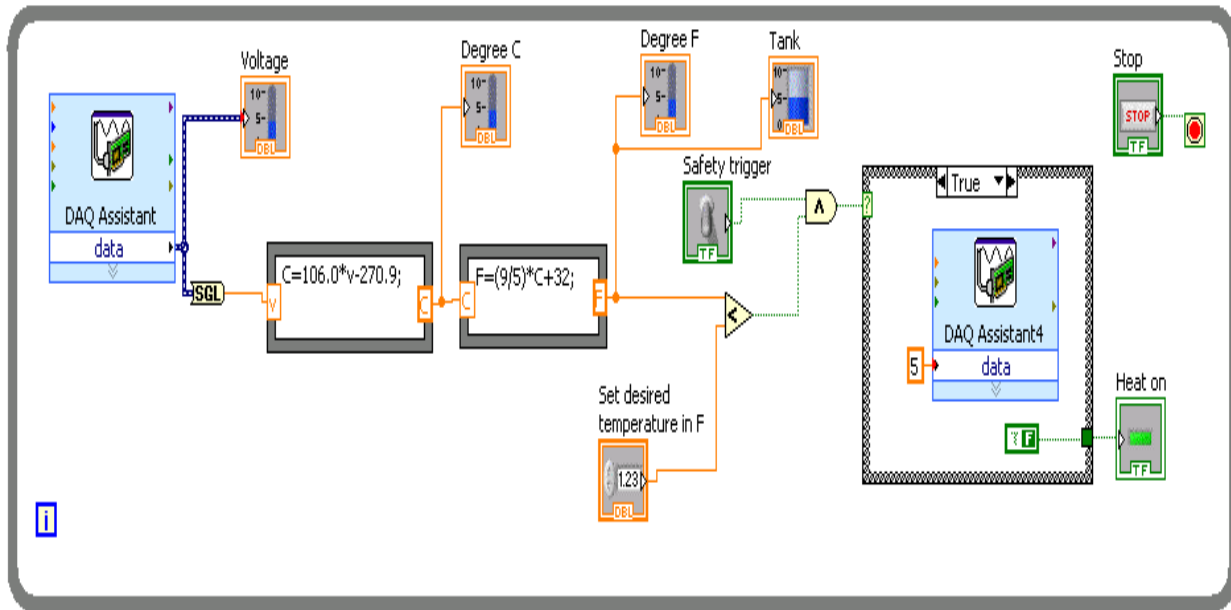

Figure 3 : Block Diagram of the system

Discussions

Initially, the block diagram is fabricated and the connections are made. The required temperature of the water is set in the front panel. By running the application, the temperature sensor acquires the temperature of the water, if the temperature of the water is lower, the water heater is turned on. Any increase in the temperature of the water is detected by the sensor and is exhibited on the front panel. When the required temperature is attained, the water heater turns off while the sensor acquires the temperature of the water continuously and maintains it at the desired temperature. It should be clear that the water heater does not have to remain in ON state continuously and thus the power consumption is reduced.

Conclusions

In this paper, a student project to design a complete automated water heating system was presented. Both software simulations and hardware implementation were shown. The advantages

of using Labview as a graphical language to develop this type of applications have been discussed. This simple project can be used as a teaching tool to attract students to STEM fields and inspires them to come up with new ideas and solutions to challenging problems.

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