2006-48: WIRELESS LOGGERS FOR REAL-TIME DATA ACQUISITION AND ANALYSIS

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Wireless Loggers for Real-Time Data Acquisition and Analysis

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Abstract

Data acquisition is a very important aspect in the engineering world of today. There is constantly a need for new data to be logged and analyzed. This paper describes the use of wireless data loggers in an application where data is transferred wirelessly through a portable device to a base station for analysis and storage. The data is transmitted wirelessly through a modem, received by a personal computer, and analyzed through the use of different software programs. The paper also presents test results of a practical example.

Introduction

Data logger units are versatile equipment used in today's industry and is being taught in many engineering and engineering technology curricula [1-4]. Such units provide useful information that allows an analyst to perform a variety of tasks, including: (a) Creating models, testing prototypes, analyzing results, and adapting to changing test and measurement needs, (b) Validating product concepts and ensuring product durability, functionality and safety, (c) Performing industrial control, networking, alarm management, and historical trends, (d) Ensuring product function and physical attributes by automating tests, taking faster measurements and increasing quality, (e) Evaluating maintenance needs, calibrating equipment and repairing products, and (f) Simplifying business tasks such as connecting databases and publishing information.

A user friendly wireless logger allows a sensor to be installed and connected directly to it. The data can then be sent through a wireless modem to another modem connected to a personal computer where the data is stored and analyzed. Data is recorded in a pre-set time manner or in a real-time manner for watch monitoring. This type of wireless data acquisition and analysis is applicable in a variety of situations and used in many different types of industry [5]. One manufacturer of this type of product is the Fluke Corporation. Fluke manufactures the Hydra Series Data Loggers, which are very portable and user friendly. Once the units are set up and functioning properly, operation is simple. They can accept inputs from almost any IEEE approved measurement device and send data to a base station [6] within a relatively long distance. This paper shows how one of these devices was used to simulate a real world situation. Data was transmitted wirelessly, recorded, and analyzed. A J-type thermocouple and a set of testing leads were used to measure temperature and voltage. The thermocouple is not extremely accurate; however, it proved to be just fine for the experiment.

System Design

The system is mainly comprised of the Fluke Hydra Series II Data Logger and base station. This device has 21 input channels and is capable of monitoring all of these channels and sending the data. The system requires a sensor to measure data, a J-type thermocouple as stated earlier. The system was used to take temperature measurements. The supplied leads were also used to take voltage measurements. The leads plug into the front of the Fluke similar to a digital multi-meter. For voltage and resistance measurements no extra sensors are required.

Two simultaneous processes were monitored during the course of the experiment. The processes are started at the same time the data logger is started. The sensors measure the data which is then sent directly to the printer port of the Fluke data logger, to which a wireless modem is connected. This modem communicated with another wireless modem that was connected to a personnel computer that runs the Fluke software. Once the data is received the software is used to perform analysis. This process as a whole simulated a real world situation of data being sent from one location, the field, to another, a control room, where the data can be of specific use. The following figure shows a block diagram of the overall process.

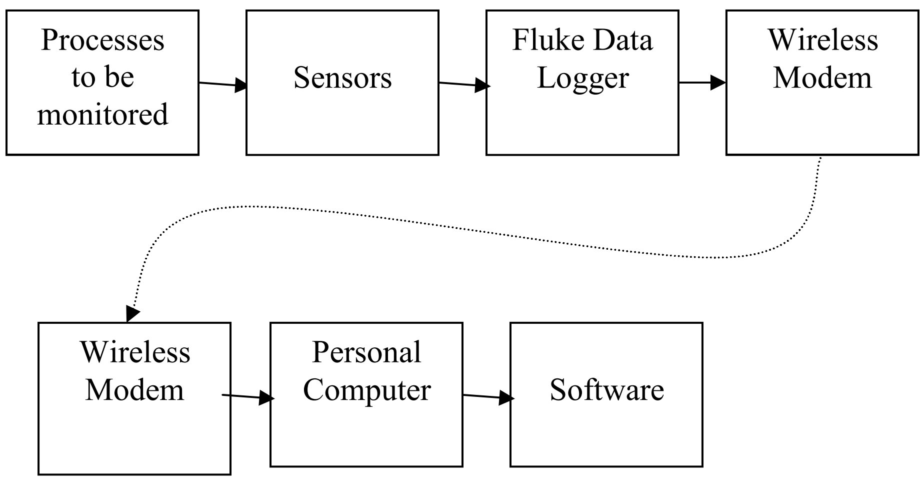

Figure 1. Overall system diagram

The first process consists of a resistive circuit. As we know, power is dissipated in the form of heat when passed through a resistive element. For this process, we may measure the heat produced by a resistor when a dc voltage was placed across it. In order to get an idea of what type of plot this would produce and also to give an ideal graph to compare the results to, a plot was produced in Microsoft Excel. First, the power of the resistor that would be dissipating is calculated. This value is found by first finding the current through the circuit. From Ohm's law, voltage is equal to current multiplied by resistance. A1.0 K-Ohm resistor and 25 Volts DC were used for this demonstration. Using the given value of the resistor, we get a 25 mA current. Power is equal to voltage multiplied by current. This gives us 625 mW. To produce a graph, power used over time was plotted.

Power simply increases by .625 every second for one minute in this situation. The result is a straight line graph with a slope of about .6. Fig. 2 shows this plot.

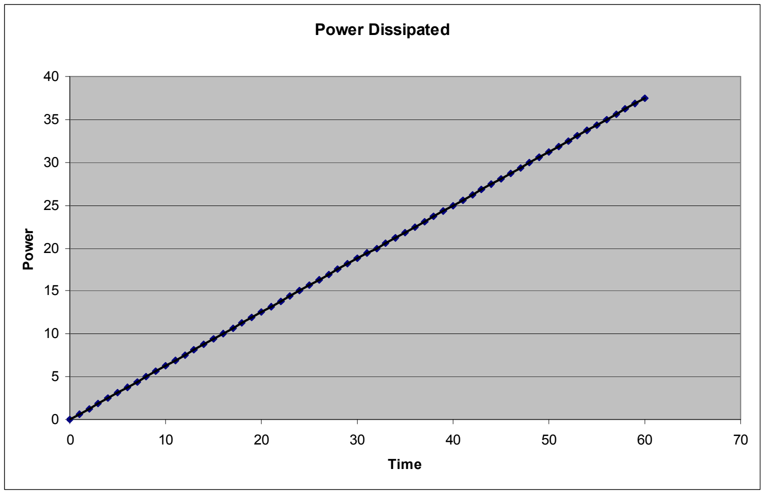

Figure 2. Power dissipated by a resistor over time

For the second process, a series resistive capacitive circuit is used, as shown in Fig. 3.

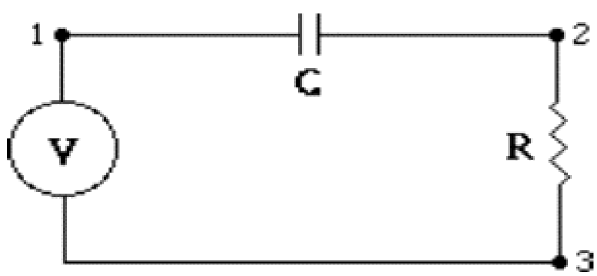

Figure 3. A series RC circuit

This simple circuit represents a first order lag process. A first order lag process is characterized by the energy output being proportional to the energy stored by the capacitive element. Voltage reading across the capacitor, points 2 and 3 in Fig. 3 is recorded. Plotting this value against time in seconds would produce a step response curve for the system. This type of plot is commonly used for quick characterization of a control system. With this type of data the response time and rise time can be found. The time constant τ can also be computed. This time constant is the amount of time; seconds in this case, the system takes to reach 63.2% of its maximum value. This time constant repeats throughout. For example if the system takes 9 seconds to reach 63.2%, 9 seconds later the system will be 63.2% closer to the final value. As stated above, this data is logged with the Fluke data logger and sent wirelessly to the computer, which runs the software. The software allows the user to view the data being recorded and generate useful plots.

Tests and Results

The Fluke logger was set up with COM1 configured as follows.

BAUD RATE:	9600
DATA BITS:	8
PARITY:	None
STOP BITS:	1
FLOW CONTROL:	Xon/Xoff

When the operation of the system was verified, the circuits were constructed. The thermocouple was attached to the 1.0 K-Ohm resistor and the front leads of the Fluke data logger were attached to the capacitor. The dc power supply was set to 25 Volts and output was in the off state. The resistor with the thermocouple was positioned to one side and the RC circuit on another, though they shared the same power supply. The actual equipment setup is shown in Fig. 4

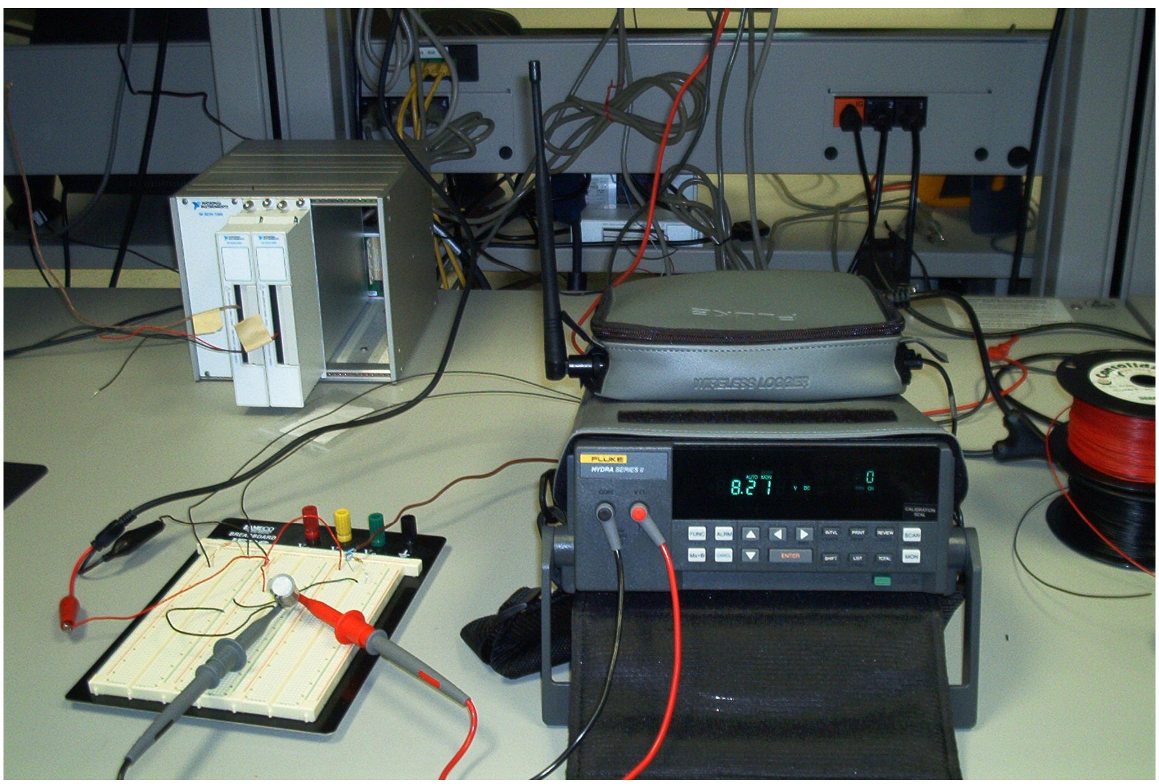

Figure 4. Setup of the experiment in the laboratory

The plot settings of the software were then set. This function enables the operator to set the channels he or she would like to plot. Time values are available from seconds to days. In this project, the plot settings were in the seconds mode and minimum values were set to zero. The maximum for temperature was set to 125^{o} F and for voltage to 25 V. The software also allows the operator to display both plots on the screen at the same time and plots the values as they are received. With the Hydra data logger communicating with the personal computer, the plots began. The circuit was then quickly given power. The step response curve was plotted at the same time the temperature of the resistor versus time plot was displayed. Both of the plots proved to be satisfactory. Eventually many test runs were made to get ideal results. The initial tests included a smaller resistor and capacitor. These values were increased to produce a nice plot in the given time interval. The system updates every second in the fastest mode. A circuit with smaller values of resistance and capacitance would require millisecond readings. This is not possible with this equipment; the equipment is designed to monitor processes over longer terms. When used in industry it is likely that the unit would be set to monitor a process over long periods. When dealing with a large operation the process may need to be monitored for hours or even days in some situations. With satisfactory plots the analysis portion of the experiment began. For the first plot, temperature versus time was compared to Fig. 2. Fig. 5 shows the Fluke plot.

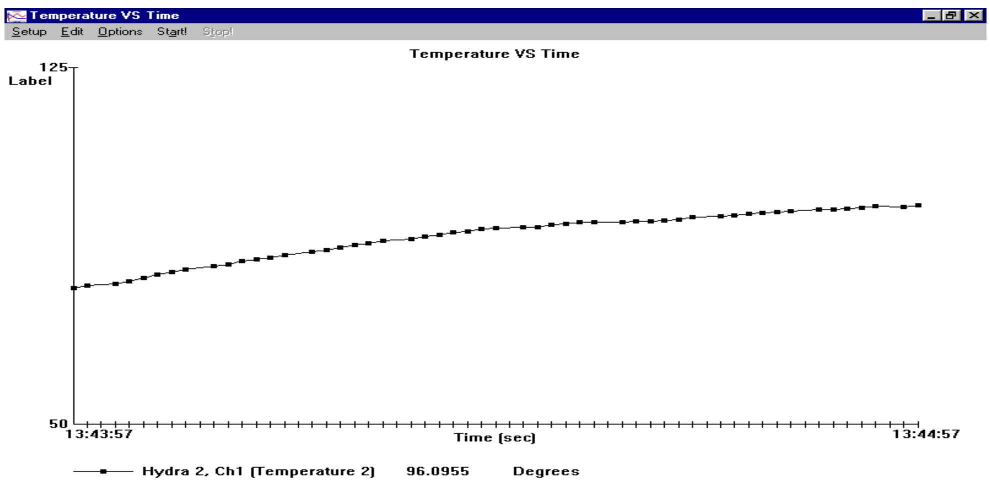

Figure 5. Temperature VS time

As can be seen, the plot resembles that of the theoretical behavior. The accuracy of the plot is lacking but is sufficient for demonstration purposes. The method used did not get a true temperature of the resistor. A better sensor would be required to improve the readings. Both plots, however, are straight lines with similar slopes. Some calculations were performed to find the slope of the logger plot and approximately .3 was found. As mentioned before, the slope of the theoretical plot is about .6. Efforts were then concentrated on the RC circuit. In order to get some comparison, some theoretical data for this system was created as well. The transfer function of the system was first derived. The transfer function is the output signal divided by the input signal. The transfer function of a first-order lag process is defined as: $Y/X = G/1+\tau s$. G is defined as the gain, which is always 1 in this system. The time constant τ is found to be R*C, the resistance value multiplied by the capacitance. For the experiment, a 7.4 K-Ohm resistor and a 1000µF capacitor were used. These values give 7.4 for τ. Matlab was then used to plot the step response using this transfer function. Fig. 6 shows the result.

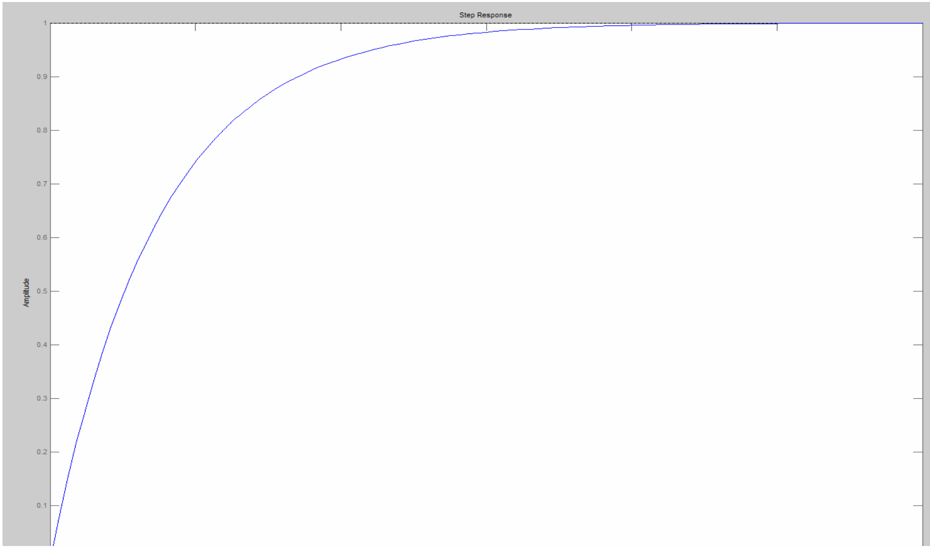

Figure 6. MATLAB plot

Fig. 7 is a screen shot of the Fluke Logger Software plot. This plot is the step response of the system. As you can see, the theoretical and actual curves compare very well. Further analysis was then performed using the actual plot. As stated above, there is a lot that can be seen from this type of plot. The 10 to 90 percent rise time was first evaluated. This is found by simply locating the point of the plot where the system reached 10% of its maximum value, 2.5 in this case. Then the point on the plot where the system reached 90% was located, and found to be 22.5. Both of these points were marked on the plot and found the distance to be 21 seconds for the system. The 98% response time was then found to be approximately 28 seconds. The time constant τ was then determined as 9 seconds.

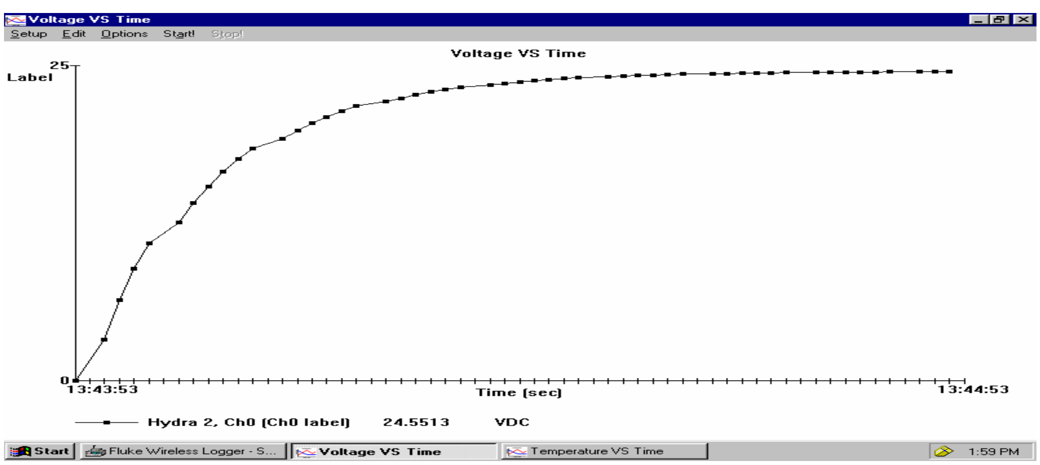

Figure 7. Step response from the system program

Conclusion

This paper described a wireless data acquisition system and presented test results that illustrate its functionality by measuring, transmitting, and processing data. The plots were generated using different software packages, including Matlab, Microsoft Excel, and a Fluke program. The system presented in this paper can serve as a good experiment in courses teaching wireless data acquisition.

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