

Low Cost Data Acquisition, Monitoring and Control for Small Scale Industries

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Abstract—

This paper focuses on implementation of low cost Data Acquisition and Control focused on small scale industries. The method proposed in this paper consists of eliminating several hardware components such as the DAQ boards, PLCs and implementing integrated one-board solution for both acquiring and controlling the process. Changes have also been implemented in the SCADA software where low cost software is used. The method proposed in this paper can be adopted for 16 channel analog data acquisition and 54 digital data acquisition.

Index Terms— Supervisory Control, Microcontroller, DAQ, Arduino, Monitoring, Centralized Control, SCADA

Introduction

Data Acquisition systems are the products used to collect information to document or analyse some process such as manufacturing or transmission of electricity [1].

Usually, Data Acquisition has been through sensor interface to DAQ boards (for example, National Instruments PCI-6221) and the output of this board is given to the computer hosting Lab View and/or Data Acquisition/logging software. The expenses incurred in the procurement of DAQ hardware and software is usually very high for small scale industries [2].

A simple alternative to this is through the use of microcontrollers and open source or low cost data acquisition software. For the experiments we are using Arduino board based on Atmel Atmega controllers.

CONVENTIONAL SCADA SYSTEM

Conventional SCADA systems consist of a Remote Terminal Unit, which connect to the sensors and process the analog data (and in most cases take control action), a supervisory computer which logs the data from the RTU, a Human Machine Interface or

HMI to display the data acquired in real time and also to provide to manual control over the process [1]. Typically RTU is typically PLCs or microprocessor based system in conjunction with DAQ system. DAQ systems include ADCs and amplifiers to gather and amplify the signals from sensors [3]. For this purpose integrated DAQ boards are used. One such example is NI 6343 by National Instruments which costs approximately US\$ 2000. Another disadvantage is these boards are only compatible with just one or very few software which again add to the expenses [4].

LOW COST ALTERNATIVE

The alternate method suggested in this paper consists of one-board data acquisition and control. Instead of using a traditional system consisting of DAQ boards, use of Arduino Mega 2560 electronic prototyping board is used. The analog signals from the sensors are directly given as analog inputs to the board. The On board Analog to Digital convertor converts the analog signals from the sensors and transmits through serial communication port to the main computer. This data can then be displayed through low cost or open source data acquisition software [6].

WORKING

The system portrayed in Fig 1 acquires data from the sensors and the voltage of that sensor is given as an analog input to the microcontroller board. Using this analog signal as a reference, we can generate a relevant output from the microcontroller to be displayed on the computer which will be hosting the Data Acquisition Software [7].

The control can also be obtained, both manually and automatically. Manual control will call for continuous human monitoring, whereas the automatic control may be obtained through programming by setting the limits using sensor input. Once the defined value is crossed, the program will execute a predefined function[8].

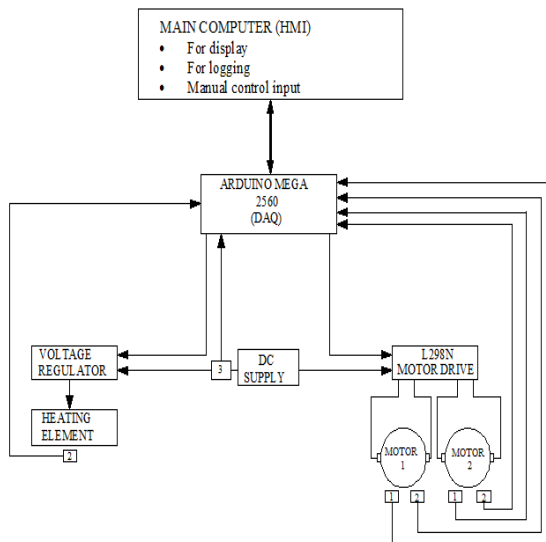


Fig 1: Experimental Setup

EXPERIMENTAL SYSTEM

The system we used to test this method consists of ARDUINO MEGA 2560 as an acquisition and control unit. The test process involves two DC motors controlled by PWM signals and a DC heating element controlled by a voltage regulator, as shown in Fig1. The motors are driven by L298N motor drive with an external DC supply. The speed of the motors is controlled by PWM signals generated by ARDUINO board. Hall Effect sensors are placed near the shaft for RPM measurement. LM35 sensors are placed near the winding for temperature measurement. Hall Effect current sensor is connected in series with the DC motors to measure the amount of current drawn by each motor. The motor RPM temperature and current is constantly monitored and is compared with reference values. If the values obtained cross the pre-set values appropriate actions are taken by the micro controller as programmed [11]. For e.g. - If temperature exceeds a tolerable value the motors are temporarily disconnected until the temperature drops to its normal level. The temperature of the heating element is controlled by on-off technique i.e. the heating is on for a period until it reaches the upper pre-set value of temperature and is turned off as it reaches that value, it again turns on after reaching the lower pre-set value of temperature.

The temperature of the heating element is acquired by LM35 and depending on this value; the Arduino turns the voltage regulator on or off. The micro controller is constantly in communication with the main computer. This allows real time display of data acquired from the sensors and also manual control over the motors through serial communication port.

The real-time data on MakerPlot for the experimental system is shown below in Fig 2. The plot depicts the RPM of two motors, temperature of

the heating element and motors, and current drawn by the overall system.

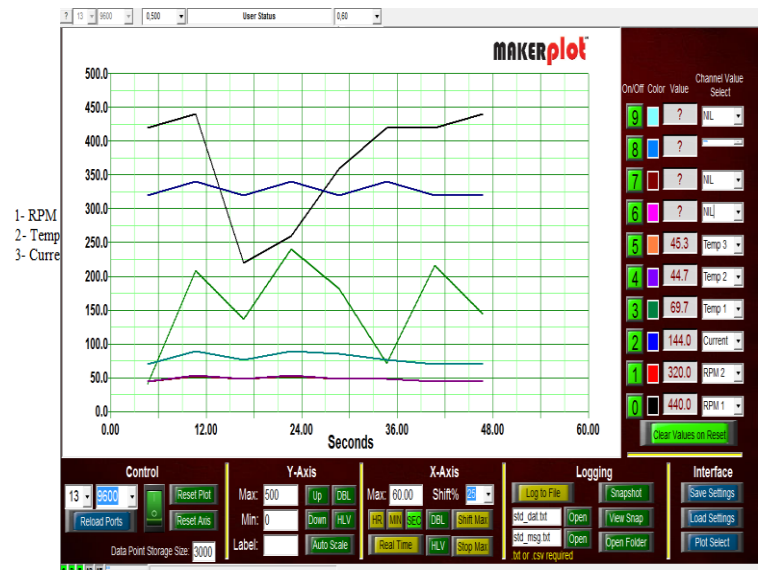


Fig 2: Plot Obtained for the experimental system.

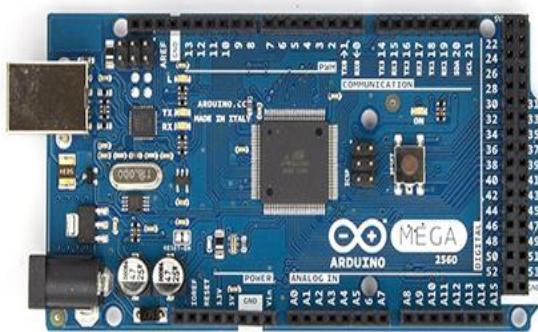
HARDWARE PLATFORM

A. Introduction to Arduino 2560

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 [10]. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. [5]

Summary

Microcontroller	Atmega 2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (15 provide PWM O/P)
Analog Input Pins	16
DC Current per I/O Pin	40mA
DC Current for 3.3V Pin	50mA
Flash Memory	256KB
SRAM	8KB
EEPROM	4KB
Clock Speed	16MHz



ARDUINO Mega 2560 R3

B. Memory

The ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the bootloader), 8 KB of SRAM and 4 KB of EEPROM [5].

C. Input and Output

Each of the 54 digital pins on the Mega can be used as an input or output, they operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 k Ohms [5].

D. Communication

The Arduino Mega2560 has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega2560 provides four hardware UARTs for TTL (5V) serial communication [5]. An ATmega16U2(ATmega 8U2 on the revision 1 and revision 2 boards) on the board channels one of these over USB and provides a virtual com port to software on the computer (Windows machines will need a .inf file, but OSX and Linux machines will recognize the board as a COM port automatically[5]).

E. Programming

The Arduino Mega can be programmed with the Arduino software. The ATmega2560 on the Arduino Mega comes pre-burned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer [5].

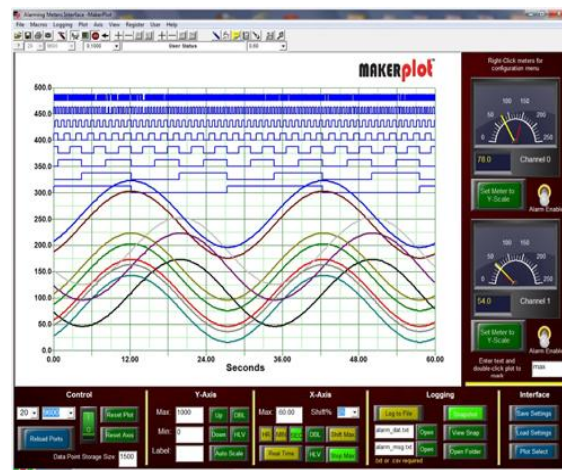
SCADA SOFTWARE

A. Introduction to MakerPlot

MakerPlot is Windows software for plotting analog and digital data generated by the microcontroller and other devices with ASCII serial outputs. No proprietary hardware is required – just a serial connection from your microcontroller or other device to PC [12].

B. Analog and Digital Data Plotting

Combinations of analog and digital data can be plotted as moving-line graphs and displayed in text boxes and on meters. It is possible to customize the display and user interface to accommodate up to 100 data points from input devices[12].



C. Applications

Besides hobby applications MakerPlot is ideal for Process Control, Robotics, Circuit Board Diagnostics, Engine Monitoring, Water Quality (pH, ORP), Air Quality (SOX, NOX), Bodily Function Monitoring, Scientific Experiments. MakerPlot can be used as a Windows supervisory control and data acquisition (SCADA) application for monitoring and control of devices through a serial connection [12].

CONCLUSION

It can be concluded from the discussion that it is possible to implement Data Acquisition, Monitoring and Control using widely available microcontrollers and sensors, incurring significantly less expenses as compared to conventional method. Changes are done by integrating functions performed by individual hardware components into one board which is used to as both control and acquisition hardware. Significant reduction in cost is also obtained by choosing a software that is less expensive or free of cost (open source)[10][12].

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