Control of Industrial Pneumatic & Hydraulic Systems using Serial Communication Technology & Matlab

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Abstract— it has been observed that machines have become more intelligent, especially in manufacturing industries and power plants. Day by day use of hydraulic & pneumatic systems has been increasing rapidly. Some industries have only pneumatic systems for various operations. Instead of other rotary actuators industries are using pneumatic and hydraulic actuators to get better accuracy and smooth operations. Simultaneously engineers are focusing on computer control also. To construct a pneumatic system with a higher control features, the one and only option is computer control. It means that engineer would be able to control the whole system with the help of on board computer attached with the unit. To build such a system serial control techniques to control pneumatic & hydraulic systems have been shown in this paper. This system has been designed using Arduino Microcontroller (ATMEGA 168, 8 bit ATMEL), Matlab software, Arduino software, GUI (graphical user interface) toolbox, pneumatic components and some electromechanical switches. Verification of the pneumatic circuit can be done using Automsim premium software.

Key words: Serial communication, Matlab, GUI, Arduino, electromechanical switches, Automsim Premium software and pneumatic system setup

I. INTRODUCTION

The current high-growth nature of digital communications demands higher speed serial communication circuits. Present day technologies barely manage to keep up with this demand, and new techniques are required to ensure that serial communication can continue to expand and grow. The goal of this work was to research, design, implement, and test high speed serial communication with pneumatic and hydraulic circuits. [1]

In this paper Matlab software is used for serial communication. The purpose of this research is only to show the serial communication technique implemented between pneumatic/ hydraulic system and computer. However it can also be done between a microcontroller and the pneumatic system, but for better control computer has been used to provide a signal (serially) to the pneumatic setup.

Here in this paper arduino microcontroller used as a mediator between computer and the pneumatic system. In fact the whole program is written in Matlab. Matlab will communicate with Arduino (Microcontroller) and accordingly Arduino will generate a signal at its I/O ports, which will be used to activate the solenoid valve of the pneumatic system.

Now the question is: what is the need of Arduino microcontroller if Matlab can generate a serial port without any microcontroller? The answer is: Matlab can definitely generate outputs at serial port of the computer. But there are very less I/O pins are available at computer's own serial port, so to have more I/O pins arduino microcontroller has been attached with computer, so Matlab will communicate with Arduino instead of communicating with local serial port of the computer. Summary of the introduction in this fashion: "Matlab will control the pneumatic system through extra hardware called 'Arduino'. [2-4]

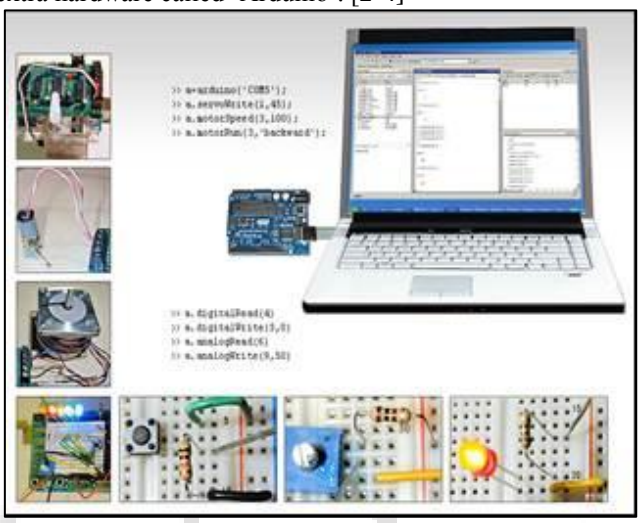

Fig. 1: communication between Matlab and Arduino [4]

II. BLOCK DIAGRAM OF THE SYSTEM

In figure 1 two devices are shown, the first one is the computer and the second one is Arduino microcontroller (In the blue one). As mentioned in the introduction part there is a serial communication between arduino and Matlab. USB to USB cable (2.0) is used for this purpose.

In figure 2 block diagram of the system is shown, in which one can understand the flow of signal also. Having gone through the introduction part it is very much clear that programming code should have been written in Matlab.

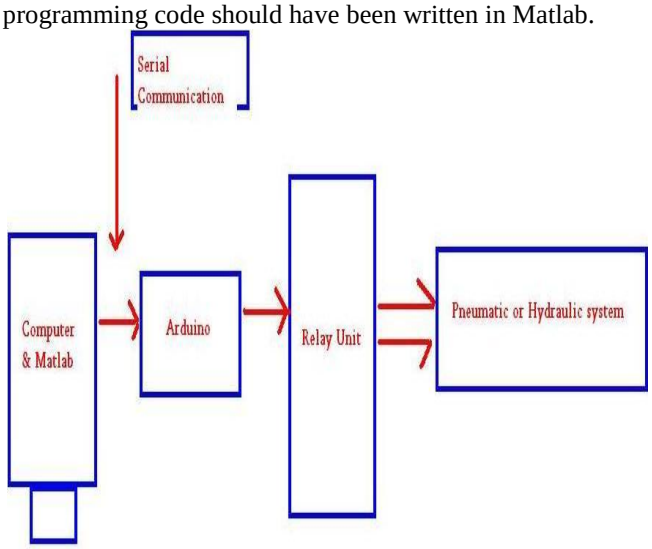

Fig. 2: Block Diagram of the system [2]

Having connected to Arduino using USB to USB cable, Matlab will give a signal to Arduino. Arduino will

generate a voltage signal at its I/O pins according to the logic fade in Matlab. In fact Matlab will force Arduino to do so. Then the signal generated at the I/O pins of the arduino will travel towards the Relay unit. Relay unit will provide the amplified signal to solenoid valve. Then solenoid valve would get actuated and pneumatic system will start working. [3][5]

III. ARDUINO MICROCONTROLLER

Arduino is a tool that makes the computers to sense and control the physical world. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board.

Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. Projects of Arduino can be stand-alone, or they can be communicating with software running on the computer (e.g. Flash, Processing, MaxMSP) The boards can be assembled by hand or purchased preassembled; the open-source IDE can be downloaded for free.[2][3]

Fig. 3: Arduino Microcontroller [3]

In this research work Arduino ATMEGA168 has been utilized. It has 14 digital I/Os and 6 Analog I/Os. It works on +5volts DC, 10 bit analog to digital converter and 14kb ROM. (www. ATMEL.com). Figure 6 shows the image of an Arduino ATMEGA168 controller. [2]

The Arduino is a tool. A little computer that can help designers interacts with the physical world. Ostensibly though, it's not much more than any other similar platform; what makes it special is how it's been designed and supported. "Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments" (Arduino, 2007). The key is its intention – intended for artists and designers, two groups of people whose backgrounds aren't necessarily technical ones (or if they are, they aren't likely to be deep in embedded computing). So, in the city where Olivetti once stood (it is now a part of Telecom Italia), the designers of Arduino substituted corporate ownership and support with community and openness. This shift is what makes the Arduino accessible, and it is what has caused its rapid growth and popularity in the communities using it. [6][7].

IV. SERIAL COMMUNICATION

Serial means "One after another". Serial communication is when we transfer data one bit at a time, one right after the other. Information is passed back & forth between the computer and Arduino by, essentially, setting a pin high or low. Just like we turn an LED on and o_, we can also send data. One side sets the pin and the other reads it. MATLAB can read/send the data from/to the serial port of the computer and process it.

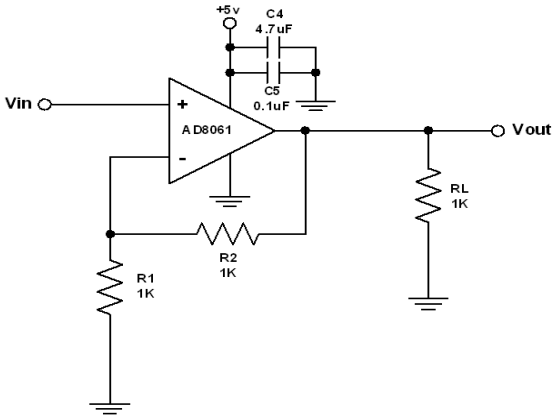

Fig. 4: Serial Buffer circuit [14]

It is most important to understand the nature of buffer to avoid errors later while writing codes. There exists a buffer between the two events of sending and reading the data. Say a sensor is streaming back data to your program, more frequently than your program reads it. Then the data is stored to a list which we call a buffer. One writes data into it and other reads it, may be with different speeds. Buffers are of finite length.

Initially the buffer is empty. As new data values come in they get added to the bottom of the list (most recent data). If your program reads a value from the buffer, it starts at the top of the list (oldest data). Once you read a byte of data, it is no longer in the buffer. The data in the second position on the list moves up to the top position As soon as the buffer is full and more data is sent, the oldest data gets discarded to make space for new data. [11][12]

V. SERIAL COMMUNICATION BETWEEN MATLAB AND ARDUINO

We have to connect the Arduino board to the PC. Each serial port on the PC is labeled COM1, COM2 etc. The Arduino will be given a COM Port Number. Figure it out by following these steps:

1) Right click on "My Computer icon" and select Manage.
2) Select Device Manager in the tree view you will see on the left side in the new window opened.
3) Find and select Ports (COM& LPT) in the center panel.
4) Find lists of all the ports attached to the computer.
5) Figure out the one you are concerned with. Refresh the window. [11]

First Serial port object has to be created. Serial port object is just a name given to that serial port so that can be used it in later commands.

```
>> s = serial ('COM1');
Serial Port Object: Serial-COM1
Communication Settings
Port: COM1
Baud Rate: 9600
Terminator: 'LF'
Communication State
Status: closed
Record Status: o_
```


Read/Write State
Transfer Status: idle
Bytes Available: 0
Values Received: 0
Values Sent: 0 [11]

VI. PNEUMATIC CIRCUIT

Figure 5 shows an electropneumatic circuit diagram developed in Automsim Studio software. In the circuit two cylinders are there among which one is double acting and another is a single acting spring return. Valves also used to control them. One is double acting solenoid operated valve (5/2) and the second is single solenoid spring return (3/2) valve.

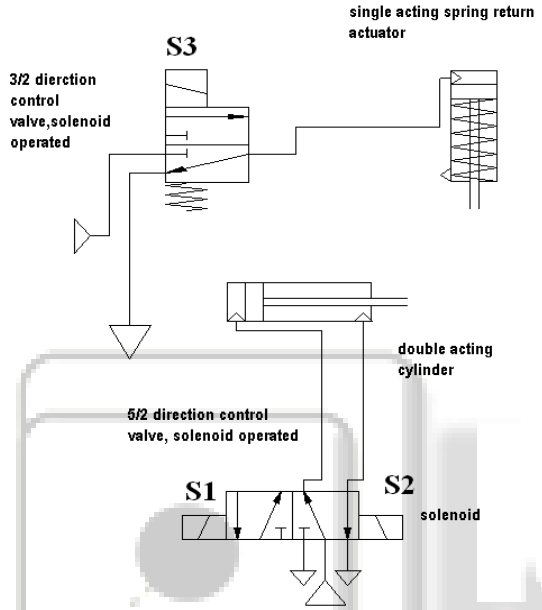

Fig. 5: ElectroPneumatic circuit using Automsim Premium [9]

The circuit shown in figure 5 is used to achieve following position step diagram. Below figure shows position step diagram to be achieved.

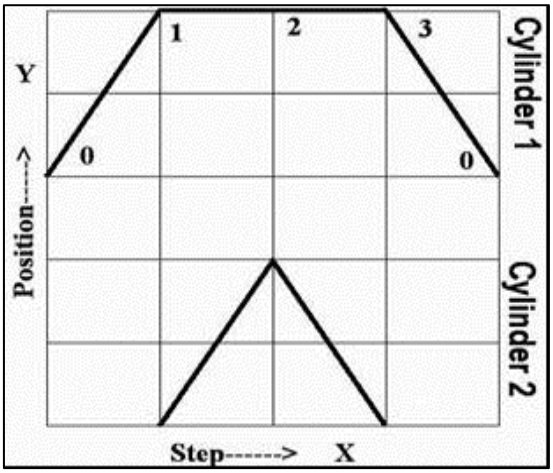

Fig. 6: Position Step diagram [9]

In figure 6 position step diagram is shown. Understanding of this diagram will be in this fashion. When cylinder 1 goes forward (Point 0 to 1 in the figure 6) and gets its extreme position cylinder 2 should go forward (Point 1 to 2). But immediately should get retracted (Point 2 to 3). At the same time cylinder 1 should get retracted (Point 3 to 0).

VII. RELAY CIRCUIT

The output generated by the Arduino to be given to relay unit. For an example two pneumatic cylinders are required to be controlled in figure 5. But Arduino will give signal to the solenoid. Hence first need to control solenoids (S1, S2 and S3) and then solenoids will control the cylinders. There are three solenoids in the figure 5. Hence three relays are required to fulfill the requirement (Each having 1 NO & 1 NC contact). Outputs can be taken at pin number 6, 7, 8. Figure 7 shows the relay circuit which has been developed for the problem under consideration. [9]

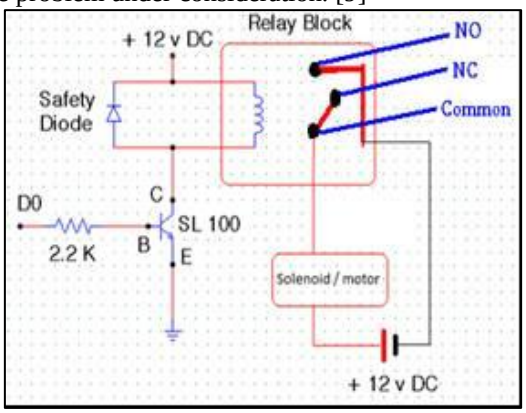

Fig. 7: Relay circuit [2]

According to figure 7, if bit D0=1, transistor is activated. Then current passes through the relay coil making the contact becomes closed and solenoid is actuated. The pneumatic cylinder is actuated in this way. [2]

VIII. FUTURE SCOPE

A. *GUI Feature Can Be Added For More Sophistication:*

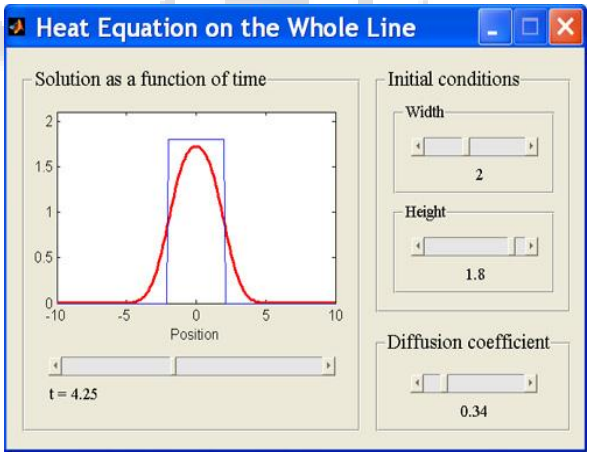

Fig. 8: Matlab GUI example [13]

B. *System Can Be Converted Into The Wireless System Using Xbee:*

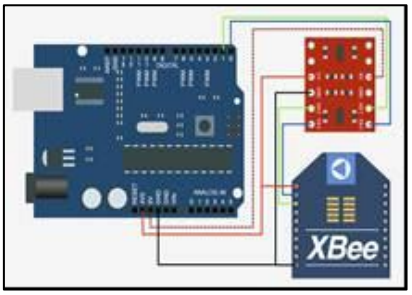

Fig. 9: Arduino Xbee Wireless Modem [10]

C. All The Parameters Of The System Also Can Be Monitored Using Some Sensors And Some Serial Displays:

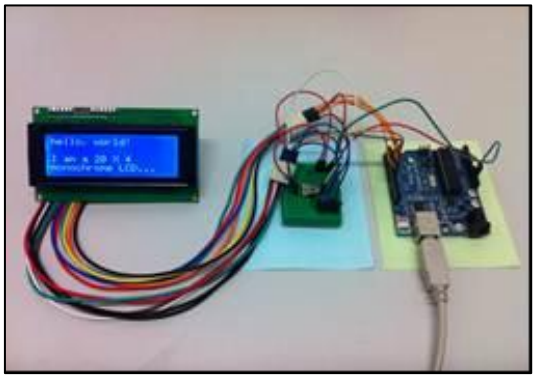

Fig. 10: Arduino Serial LCD display [8]

IX. ADVANTAGES

This technology or way of serial (digital) communication between computer and pneumatic system makes whole system flexible. It also increases the reliability and accuracy of the system. It is very much user friendly and easy to operate. System's monitoring also can be done using these. System is cheaper and not much complex to implement.

X. APPLICATIONS

This technology can be used in pharmaceutical industries, power plant, manufacturing industries. It also can be used in hydro testing, scissor lift, pneumatic pushing systems, pneumatic conveyor, hydraulic/ pneumatic motors and in many more.

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