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Design and development of system to control, synchronize and coordinate multiple high-performance microvalves

The innate nature of humans to manipulate and thereby control forces of nature has traditionally stirred efforts aimed at the development of modern technology. With that view in mind, this thesis details the design of a mechanism which would aid the performance of physical tasks in a number of industries. More specifically, the development of a system to control, synchronize and coordinate multiple high performance microvalves wirelessly is proposed in this study. The goal of this article is to perform a system which can control microvalves by sending a specific command from a Graphical User Interface. This controller allows the controlling ON and OFF switching of the devices wirelessly. The development system plays a crucial role in the oil and gas industry. Quite recently, considerable attention has been paid to automatic functions and its growth potential appears unlimited. It will be extremely efficient to provide automatic functions to optimize system performance. Some limitations to control pressure or flow automatically can be used to balance requirement conditions which ensure that flow or pressure will not exceed a desired rate. An implication of these findings helps to reduce energy consumption and therefore minimize the risk of noise.
Key words: control system, wireless communication, microvalves.

Б. Ишанова

Микроклапандарды сәйкестендіру және басқару жүйесі

Бұл мақалада микроклапандарды қашықтықтан сәйкестендіру және басқару жүйесі ұсынылған. Бұл технология газ және мұнай саласында сұйық заттың мөлшері мен қысымын бақылауда қолданылады. Микроклапандарды мониторинг жасау және ыңғайлы басқару үшін Java бағдарламасында графикалық интерфейс құрастырылған, ол клапандарды арнайы командалармен бақылайды. Бұл жобада сымсыз мәлімет алмасу технологиясы қолданылады. Оның өз күшіне енуі үшін жүйеде қабылдап-жібергіш модуль қолданылады, оның көмегімен қашықтықтан басқару мүмкіншілігі пайда болады. Жүйенің жұмыс жасау принципі графикалық интерфейстен жіберу кешені арқылы микроклапандарды басқаратын тізбектегі қабылдағышқа жіберіледі. Өз кезегінде басқаратын тізбектегі микробақылаушы қабылдау модулінен ақпаратты оқып құрылғыны байланыстырады.
Түйін сөздер: басқару жүйесі, сымсыз байланыс, микроклапан.

Б. Ишанова

Система управления и координирования микроклапанов

В данной статье представлена система управления и координирования микроклапанов на расстоянии. Разработанная технология используется для контроля давления и потока жидкости в нефтяной и газовой отрасли. Для удобного управления и мониторинга микроклапанов был разработан графический интерфейс в программе Java, который позволяет контролировать клапаны с помощью специальных команд. В данном проекте используется технология беспроводной передачи данных. Для ее реализации в системе был использован приемно-передающий модуль, при помощи которого появляется возможность дистанционного управления.

Принцип работы системы заключается в том, что команды с графического интерфейса отправляются через передающий комплекс в приемник, находящийся внутри цепи управления микроклапанами. В свою очередь, микроконтроллер, находящийся внутри цепи, считывает информацию с приемного модуля и координирует устройства.
Ключевые слова: система управления, беспроводное соединение, микроклапан.

Introduction

This project is therefore organized in a manner where firstly the design for the system to control microvalves has been detailed in three parts. The first part pertains to the design of the graphical user interface (GUI). To create this part of project, several programs have been studied and analyzed. Besides this, the second part discusses the design of a circuit for controlling multiple microvalves. The studies cover a specific application of microvalves that can be met the designing parameter of a process service. Finally, the third part aims to control microvalves wirelessly. For this reason, modern wireless technologies, which are RF and GSM communication, were studied and applied to the completion of a circuit of transmitter-receiver antenna.

Figure 1 summarizes the performed system in details, which was developed in a sequence of steps:

1) design GUI;

2) design circuit to control microvalve (LED and LCD);

3) design the wireless communications between GUI and control circuit;

Following this, the data from the GUI is transferred to the transmitting antenna (Tx) circuit which is connected to the PC through serial port. After that, microcontroller from Tx circuit was programmed to transmit the signal to the receiver (Rx) antenna circuit, where this information is extracted and utilized to control the devices inside the external entity. In our case, external circuit was performed in a set of LCD module and 8 LEDs which were connected to the ports of microcontroller. The microcontroller from Rx antenna circuit was also programmed to read the receiver code.

The main hardware requirements were two Arduino Uno microcontroller boards, two USB B type cables , eight LEDs, eight resistors, Liquid Cristal Display (LCD) module, RF module (Tx and Rx) and GSM modem.

Figure 2 represents a design of Transmitter antenna circuit . This part of system is performed in set of Arduino Uno microcontroller and transmitter.

Receiver antenna circuit is performed in a way where Rx module was connecting to the control circuit. This case was depicted in the following figure, which was performed as receiver antenna part.

1. Graphical User Interface

As it was mentioned earlier the first part of the project was created Graphical User Interface (GUI) in Java program. Graphical User Interface allows to control valves, using on-off command. This means that valves can be closed and opened to control pressure or liquid flow.

Modern programs use a graphical user interface to communicate with the user. This means that the programs display window on the screen, which consists of different types of GUI components [1]. According to analysis which I have done during project, Java program was used to create GUI in this project.

Each GUI program has a top-level container, which is presented as a main window. Top-level container is defined as graphical component which can be displayed independently as separate window on the screen [1]. Components at the top level can contain inner classes (figure 4).

GUI is performed in a manner where the main window consists of three buttons with labels which are “individual control valves”, “ multiple control valves” and “ current status”, and combo box with button “connect” (figure 5).

For the reason that the aim of GUI in this project was to control valves that were external circuit, serial communication method was declared before starting to design GUI components to cooperate with other program. Following that, Combo box was used to choose available items from drop- down list [15]. In this project combo box was created in a manner to be able to choose one of the several available COM ports which allows GUI to connect to the external circuit through Button “connect” (figure 6).

The main page contains three buttons and thee labels as well, which are “individual control valves”, “multiple control valves” and “current status”. Buttons b1, b2 and b3 are able to open the inner windows. For example , when button b1 is pressed, the window of Individual control valves opens. The same methods were used for other two buttons.

2. “Individual control valves”

Further step was to design the first inner window of GUI as “Individual control valves”. The goal of this page implied to control eight valves using switch on/off function. To realize the control function, sixteen buttons were created, eight of them were “on” and others were “off” (figure 7). What is more, you can see a timer , which is able to reset all microvalves after 60 second.

LCD module in control circuit was programmed to monitor the action. It was able to display the last event which was happened in the system. Each

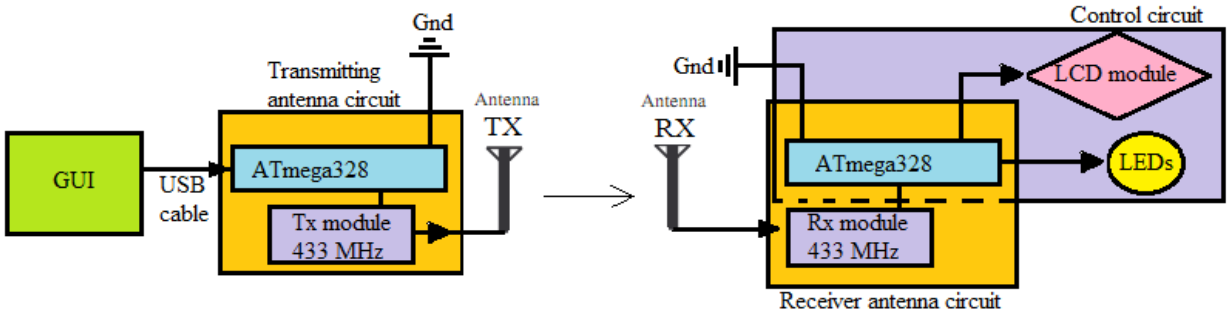

Figure 1 – Block diagram of the control system

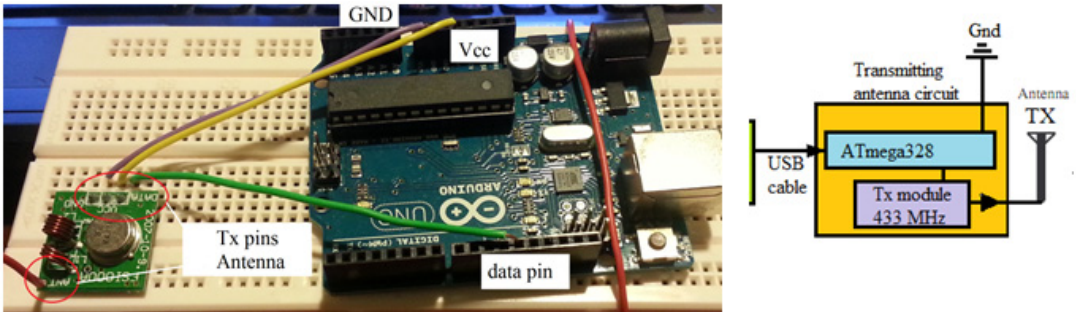

Figure 2 – Transmitter antenna circuit

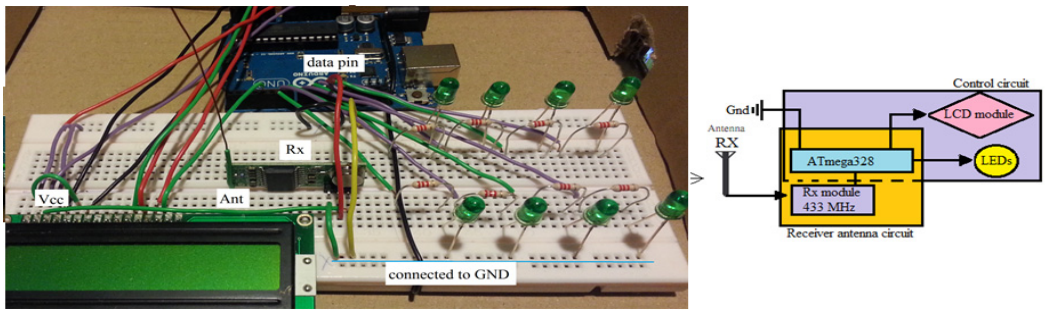

Figure 3 – Receiver antenna circuit

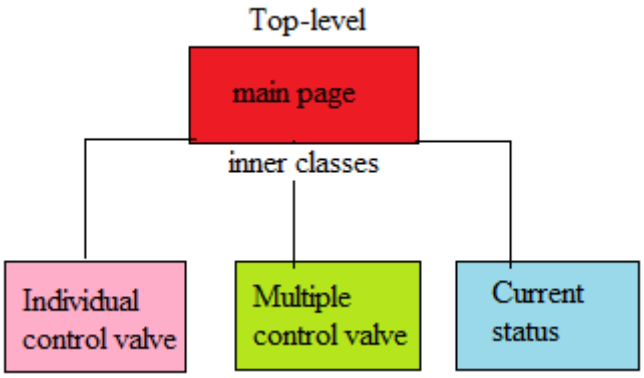

Figure 4 – Top-level containers

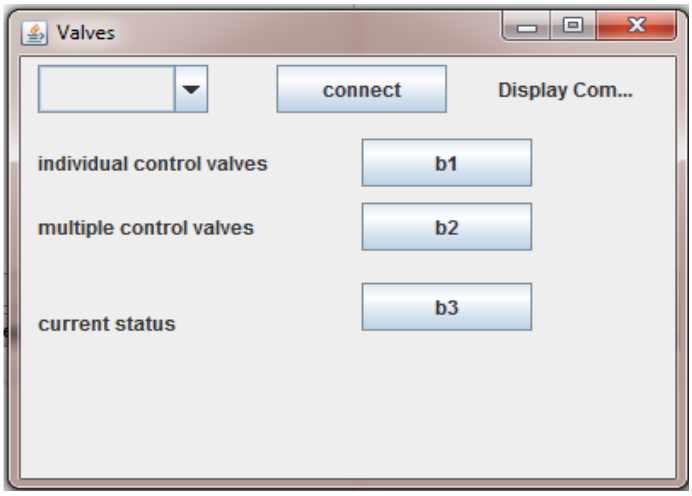

Figure 5 – Main window

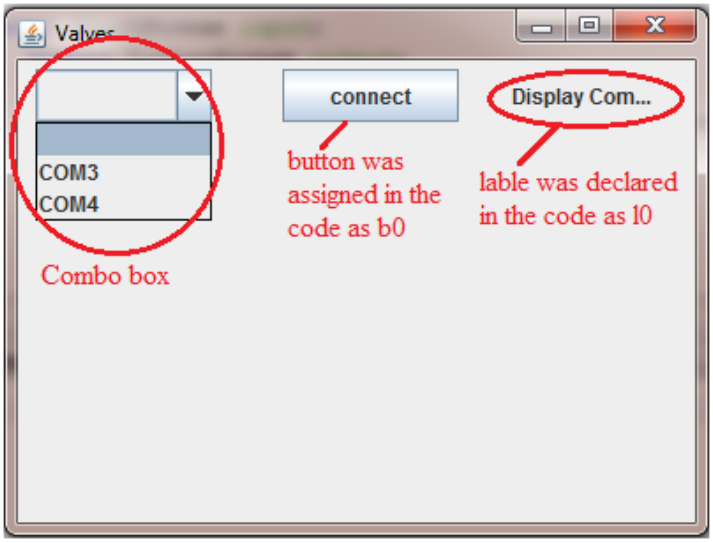

Figure 6 – Combo Box Design

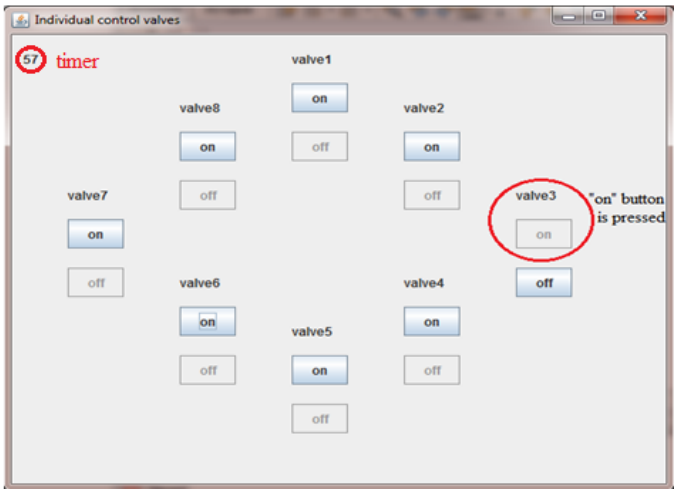

Figure 7 – Individual control valves

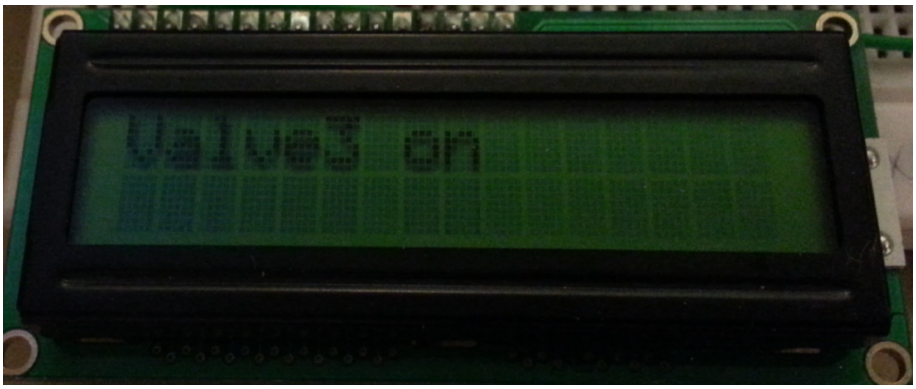

Figure 8 – LCD module

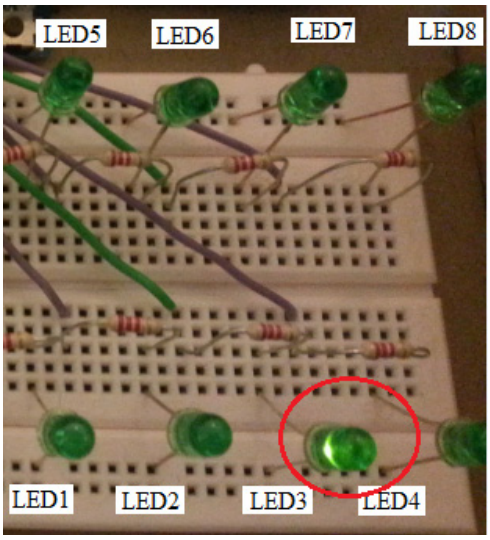

Figure 9 – LED3 is turned on

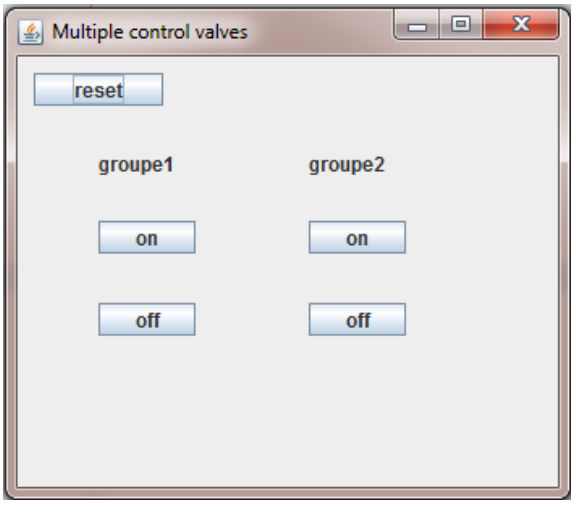

Figure 10 – Multiple control valves

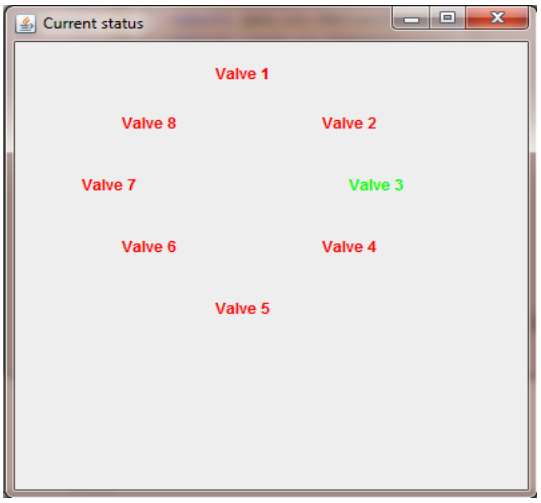

Figure 11 – Current status of LED3

button in the interface was assigned an unique code, which was able microcontroller read the command and run the circuit to control microvalves. From figure 8 it can be observed that Valve 3 was turned on. The “on” status of valves was displayed in the beginning of the first line.

At the same time, when the receiver antenna circuit got an assigned code to turn on Valve3, microcontroller run LEDs part in control circuit . The unique code was extracted by microcontroller from receiver antenna circuit and generated the LEDs part according to the receiving data. Figure 8 represents that LED3 was lighted on.

3. “Multiple control valves

The goal of “multiple control valves” was to manage a group of valves simultaneously. From figure 10 it can be observed that this type of page contained two labels which were “group1” and “group2” and five buttons, where two of them “on” and two “off” and one “reset”. “ Reset” function is turn off all microvalves at the same time

4. “Current status”

“Current status” window was able to monitor the status of valves. As this type of window contained eight labels of valves (figure 10) and allows control the current status of each microvalves.

“Current status” is a window in a Graphical User Interface, which displays the status of valves. As follows from the figure shown above, the word “valve3” was assigned as green color to indicate the “on” status. Red color was assigned as “off” status. Such cases are depicted in the figure 10.

Conclusion

In conclusion, this report discusses several aspects of the wireless technology and the proposed utilization of this technology for a system to control, coordinate and synchronize multiple high-performance microvalves.

Considerably more work will need to be done in transmission part of this project. The project covers only RF and GSM types of communication which are not enough satisfied to modern conception. Now it becomes necessary to control devices in a very large distance, a reasonable approach to tackle this issue could be to use satellite communication. However this type of transmission is very expensive, but it would be able to extend this technic to the global industry. Oil and gas are the most important branches in the world -wide industry. Satellite communication can be used to develop targeted interventions aimed in all-round development and growth of oil and gas industry of the world in general.

References

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