RESEARCH ARTICLE OPEN ACCESS

Implementation of an Embedded Pressure Control Process

Oparanwata Chidi Cosmas
Electrical and Electronic Engineering Department
Petroleum Training Institute (PTI), Effurun
Delta State, Nigeria.
oparanwatachidi@yahoo.com

--************************----------------------------------

Abstract:
This article presents the implementation of an embedded pressure-control and measurement system. This research shows the importance of using a microcontroller in pressure control as compared to older methods. The reliability of the system as measurement and control of pressure is performed automatically with minimal error with accuracy. It saves cost since more than one function is performed by a single microcontroller and seeks to showcase efficient and modern means of pressure measurement and control.

Keywords — **Embedded, Measurement, Pressure control, automatic control.**

--************************----------------------------------

I. INTRODUCTION

To obtain desired result of product from a process plant, various variables must be measured and controlled. These include level, temperature, pressure and flow rate etc. But in the case of this project, emphasis is on pressure measurement and control. Pressure is probably one of the most commonly measured variables in the power plant or in a process rig. It includes the measurement of steam pressure; feed water pressure, condenser pressure, lubricating oil pressure and many more. Pressure is actually the measurement of force acting per unit area of a surface.

The project "Microcontroller based pressure control rig" is designed to operate using a Microcontroller to control the pressure in a process rig. Over a long period of time, pressure measurement has been carried out by the use of pressure transducers. These transducers convert pressure into physical motion that operates a mechanism over a graduated scale. These transducers include: Bourdon tube, strain gauge and differential capacitance sensors. They only help in the measurement of pressure but cannot control it. This has been a great challenge, since an external device is now required to control the pressure, thereby increasing cost. Due to extensive research and advancement in technology, new devices have been developed that can function as to measure as well as control pressure. These devices are called "Microcontroller" or "Programmable Logic Controllers (PLC)".

A PLC (Programmable Logic Controller) is a digitally operating electronic device that uses a programmable memory for internal storage of instruction for implementing specific functions such as logic, sequencing, timing, counting through digital and analogue input/output modules. PLCs are used in many machines, in many industries. PLCs are designed for multiple arrangements of digital and analogue input and outputs extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact.

A microcontroller is a microprocessor (logic controller) on a single integrated circuit containing a processor core, internal input and output memory (RAM, ROM, and Ports) and programmable input/output peripherals. A microcontroller is used in instrumentation system such as in a process plant to automatically measure and control process variables such as pressure, temperature, level, and flow rate. It is a transducer which converts one standardized instrumentation signal into another standardized instrumentation signal and compares it with a desired (programmed) value, and gives out an output so as to cause the process variable to comply with the set point.

This project employs a Microcontroller instead of a PLC since it is more cost-effective and customizable, and can still effectively perform the function the PLC would perform in the project.

A. Aims And Objectives

The goal and objectives of this project includes:

a) To provide a more efficient way of carrying out measurement and control of pressure in a plant.

b) To provide a means of measurement at a more reduced cost..

c) To provide a safer means of carrying out measurement and control of pressure in a section of a plant associated with multiple hazards.

B. Applications of Automatic Change Over Switch

This project on completion, can find application in:

I. A water supply system.

II. Petroleum and petroleum product transportation through pipes.

III. Steam-turbine power generation plant.

IV. Hydro-turbine power generating plant

C. Significance of Study

The project is aimed to show the importance of using a microcontroller in pressure control as compared to older methods. Such importance includes:

1. The reliability of the system as measurement and control of pressure is performed automatically with minimal error.
2. The accuracy of the system to pressure measurement and control.
3. It also tends to save cost since more than one function is performed by a single major component of the project i.e. microcontroller.
4. The project also seeks to showcase efficient and modern means of pressure measurement and control.

D. Scope of Project

The scope of the project covers the following areas:

- pressure transmitters and pressure transducers
- pressure process measurement
- microcontrollers i.e. embedded system programming
- reservoirs
- compressors and compressor drives
- discrete components

The project was design to automatically control the pressure in a reservoir containing pressurized air/gas, by turning off the compressor when the pressure in the reservoir exceeds the set high point value and turning on the compressor when the pressure falls below the set low point value. The scope of the design was kept concise and simple by not introducing unnecessary complexity.

II. METHODOLOGY

Top-down methodology was adopted in this research work. The pressure control process was subdivided into units as contained in the circuit diagram.

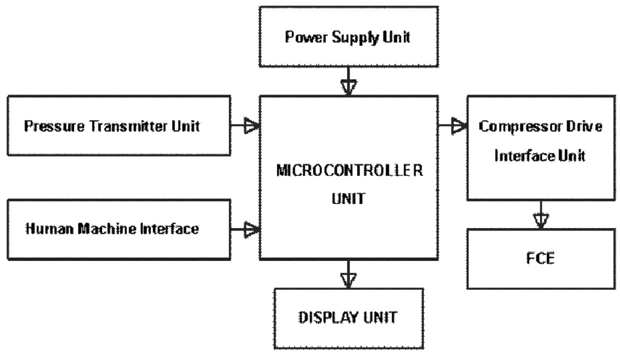


Fig: 1: A block diagram of an embedded Pressure Control process

Power Supply Unit

This unit converts the 220v AC to 5V DC required by the circuit.

It was implemented with the following components:

- 220V/12V step down transformer
- Bridge Diode
- Capacitor
- Voltage regulator

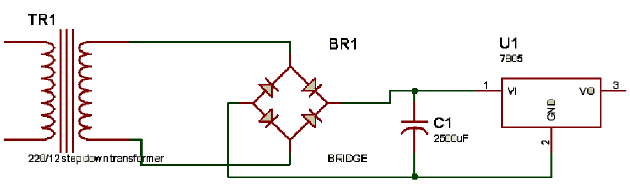


Fig: 2: regulated Power supply unit

A. *Pressure Transmitter*

This block contains element that measures the pressure of the process and convert it into a standardized instrumentation signal that can be usable by the digital microcontroller i.e. 4mA to 20mA.

This is the pressure sensor unit. It senses the pressure and outputs a signal that is proportional to the pressure been measured.

Requirement of the Pressure Transmitter unit

- it should be able to measure the specified pressure range of the design i.e. 1 to 10bars
- its output signal should be easily interfaced with a microcontroller
- less biasing components
- easy to handle in the case of installation
- Cost and availability.

Selection of the Pressure Transmitter unit

The 2 wire pressure transmitter from Rosemount Corporation was selected. Below are some of its features:

- power range from 12V to 30V DC
- Pressure range is 1 to 300PSI
- 4mA to 20mA output signal on two wire
- biased with a 250 ohms resistor to convert the voltage to 1 – 5V
- Portable in size for easy installation.

The pressure transmitter is strategically fitted at the top of the fabricated cylindrical reservoir that contains the pressurized air to be controlled for this design. The output terminal of the pressure transmitter is connected to one of the Analogue to digital converter input pin of the microcontroller. Below is the interface between the pressure transmitter unit and the microcontroller

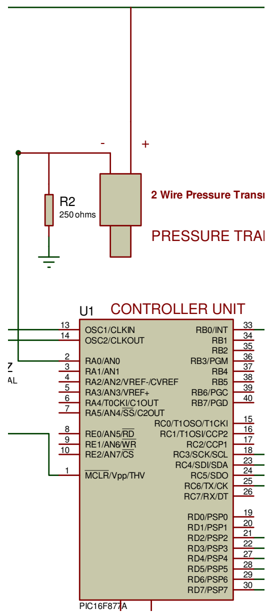


Fig: 3: Pressure transmitter interfaced with microcontroller

B. Microcontroller

This is the unit performs the logic of the entire system. it receives the signal from the pressure sensor through its embedded Analogue to digital converter, it also receives the set point from the user, compares it with the desired value and directly Influences the process plant. The microcontroller also controls the final control element (FCE) which is the compressor.

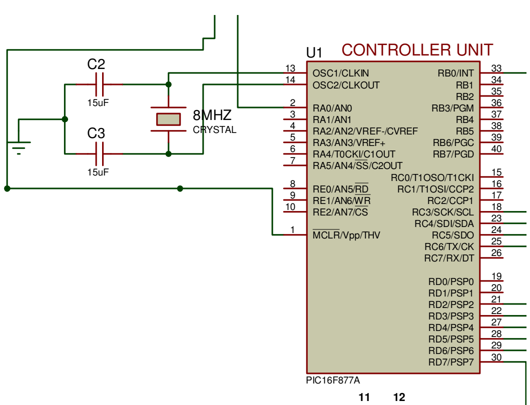


Fig: 4: Microcontroller Unit

C. Compressor Drive Interface Unit

This unit enables the microcontroller to control the FCE i.e. the compressor, it consists of a transistor, relay, resistor and a diode.

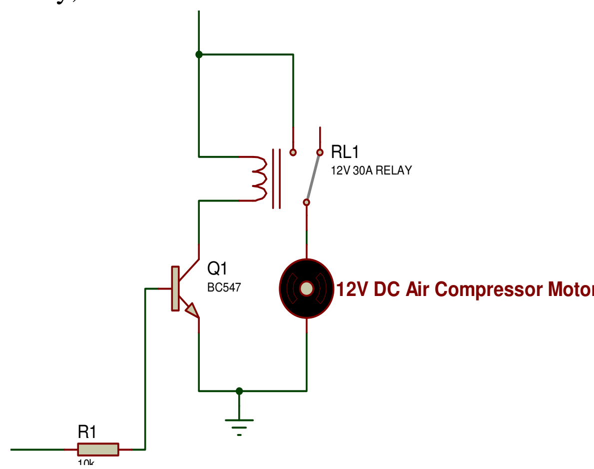


Fig: 5: Compressor driver interface unit

D. Display Unit

This indicates the various outputs of the microcontroller in a digital form that can easily be comprehended by the observer. It displays the set point, process variable and the current status of the entire system.

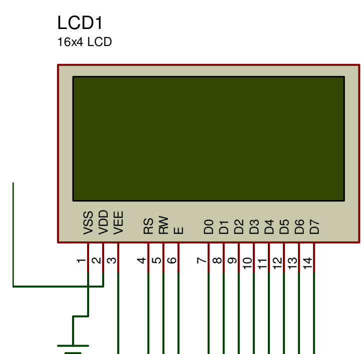


Fig: 6: Display Unit

E. Human Machine Interface Unit (HMI)

This unit enables the User to input data into the system representing the SET High and low pressure limit.

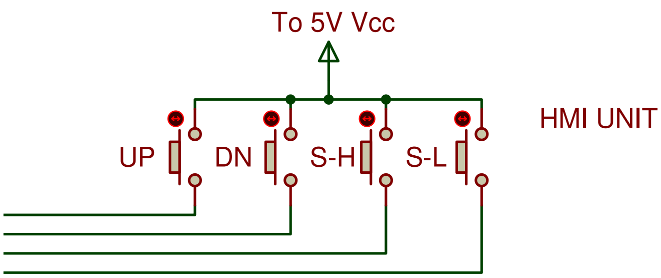


Fig: 7: HMI Unit

F. Final Control Element

This unit represents the 12V DC Compressor, fitted on a reservoir that contains the pressurized gas/air to be controlled.

Flow Chart

The flow chart gives a graphical representation of the sequence of program. Execution. The flow chart for the system is given in figure below.

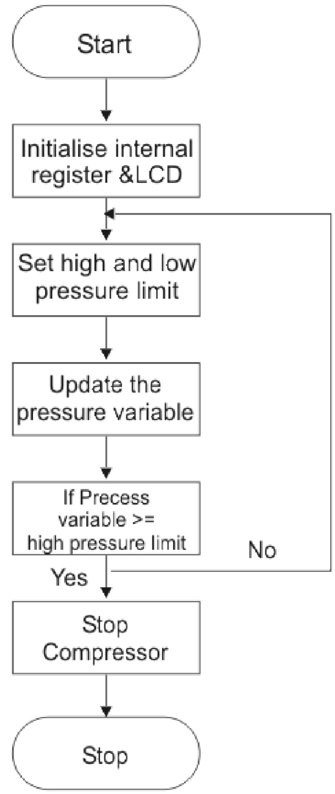


Fig: 8: Flow Chart representation

III. CODING

The coding is done in MPLAB C-Language language. The code contains the instruction of program to direct the affairs of the pressure control rig System. There are five subroutines in the complete code. Each subroutine performs specific function as group of instructions. The subroutine and functions are stated as follows.

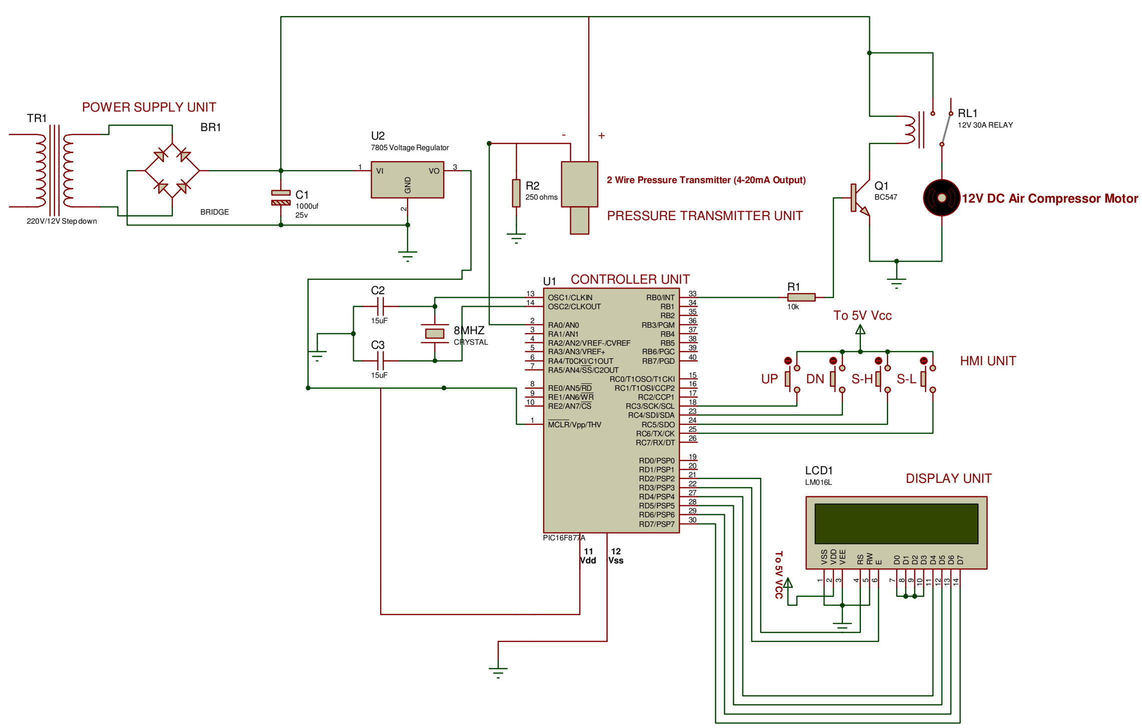
1. **Initialization:** This subroutine initializes the microcontroller including preloading the counters and reference values for the system and the LCD.
2. **Read INPUT:** This subroutine makes the controller to wait for the USER to INPUT DATA, coverts it and after the conversion,

reads the value into its data memory as SET High and Low pressure limit.

3. **READ SENSOR:** This subroutine waits for the pressure transmitter unit to give signal and then converts it to voltage proportional to pressure measured.
4. **COMPARE:** This subroutine enables the microcontroller to perform comparison between the SET High and low pressure limit and the process variable.
5. **Display LCD:** This subroutine enables the microcontroller to display value on the LCD.
6. **DRIVE CONTROL:** This subroutine enables the controller to activate and deactivate the Compressor through the compressor drive control unit.

V. Circuit of Operation

According to the circuit diagram, when the switch is ON, the power supply Unit provides 5v Dc to the Circuit, the microcontroller initializes its internal Registers and configures pin LCD through PIN 22,27,28,29 and 30. Then it display "Pressure control Rig" on the LCD, and waits for the user to input SET High and low pressure limit. When the user inputs high and low limits through the HMI unit, the compressor is activated by making PIN 33 High, which drives the base of the Transistor that energies the relay of the Compressor. When the compressor is Activated, the microcontroller waits for the pressure transmitter unit to signal in form of voltage to PIN 2 which is proportional to the measured pressure, the controller calibrates the data and update the process variable with the value, when the process variable is greater than the high pressure limit, it deactivates the Compressor by making PIN 33 LOW, if the process variable is lesser than the low pressure limit, it activates the Compressor by making PIN 33 HIGH, the entire process is maintained by the microcontroller until



the user cancels the process.

Fig: 9: The prototype system unit

IV. RESULT

The analysis of the results carried using water shows that if the process variable is lesser than low pressure limit, it activates the Compressor and when the process variable is greater than the high pressure limit, it deactivates the Compressor. With this the system controls pressure automatically.

V. CONCLUSIONS

After all necessary procedures which lead to the Design and construction of the Microcontroller based Pressure control RIG has been found to function as intended. However, the re1iability of the project is dependent on the capability of the components used in the design. The various operations of the ICs and other components used in the design were taken into consideration and as such the project is guaranteed to have a high efficiency.

ACKNOWLEDGMENT

A very big thank you to the staffs and students of Electrical and Electronic Engineering Department, PTI, for their support in ensuring the success of the implementation of this research work.

REFERENCES

[1] S. M. Metev and V. P. Veiko, *Laser Assisted Microtechnology*, 2nd ed., R. M. Osgood, Jr., Ed. Berlin, Germany: Springer-Verlag, 1998.

[2] J. Breckling, Ed., *The Analysis of Directional Time Series: Applications to Wind Speed and Direction*, ser. Lecture Notes in Statistics. Berlin, Germany: Springer, 1989, vol. 61.

[3] S. Zhang, C. Zhu, J. K. O. Sin, and P. K. T. Mok, "A novel ultrathin elevated channel low-temperature poly-Si TFT," *IEEE Electron Device Lett.*, vol. 20, pp. 569–571, Nov. 1999.

[4] M. Wegmuller, J. P. von der Weid, P. Oberson, and N. Gisin, "High resolution fiber distributed measurements with coherent OFDR," in *Proc. ECOC'00*, 2000, paper 11.3.4, p. 109.

[5] R. E. Sorace, V. S. Reinhardt, and S. A. Vaughn, "High-speed digital-to-RF converter," U.S. Patent 5 668 842, Sept. 16, 1997.

[6] (2002) The IEEE website. [Online]. Available: http://www.ieee.org/

[7] M. Shell. (2002) IEEEtran homepage on CTAN. [Online]. Available: http://www.ctan.org/tex-archive/macros/latex/contrib/supported/IEEEtran/

[8] *FLEXChip Signal Processor (MC68175/D)*, Motorola, 1996.

[9] "PDCA12-70 data sheet," Opto Speed SA, Mezzovico, Switzerland.

[10] A. Karnik, "Performance of TCP congestion control with rate feedback: TCP/ABR and rate adaptive TCP/IP," M. Eng. thesis, Indian Institute of Science, Bangalore, India, Jan. 1999.

[11] J. Padhye, V. Firoiu, and D. Towsley, "A stochastic model of TCP Reno congestion avoidance and control," Univ. of Massachusetts, Amherst, MA, CMPSCI Tech. Rep. 99-02, 1999.

[12] *Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification*, IEEE Std. 802.11, 1997.

