January 2012

PRECISION FLOW SIMULATOR USING AMR7

TUSHAR GOPAL CHAVAN

Instrumentation and control, Vishwakarma Institute of Technology Pune, India,
chavantushar@hotmail.com

P.V. POL

Instrumentation and control, Vishwakarma Institute of Technology, Pune, India, hi_pol@yahoo.co.in

Follow this and additional works at: <https://www.interscience.in/ijica>

Part of the [Aerospace Engineering Commons](#), and the [Mechanical Engineering Commons](#)

Recommended Citation

CHAVAN, TUSHAR GOPAL and POL, P.V. (2012) "PRECISION FLOW SIMULATOR USING AMR7,"
International Journal of Instrumentation Control and Automation: Vol. 1 : Iss. 4 , Article 17.

DOI: 10.47893/IJICA.2012.1057

Available at: <https://www.interscience.in/ijica/vol1/iss4/17>

This Article is brought to you for free and open access by the Interscience Journals at Interscience Research Network. It has been accepted for inclusion in International Journal of Instrumentation Control and Automation by an authorized editor of Interscience Research Network. For more information, please contact sritampatnaik@gmail.com.

PRECISION FLOW SIMULATOR USING ARM7

TUSHAR GOPAL CHAVAN¹ & P.V.POL²

Instrumentation and control, Vishwakarma Institute of Technology Pune, India

E-mail chavantushar@hotmail.com, E-mail hi_pol@yahoo.co.in

Abstract—Flow plays very important role in petroleum refineries. Flow measurement is quantification of bulk fluid movement. Flow simulator along with flow computer can control the flow through the different flow streams in the industries. Flow algorithm is stored in the flow computer, depending upon requirement the set point is given to the flow computer. Flow computer gives control signals for the flow simulator. Depending upon the control signals from flow simulator, flow computer adjust the opening and closing of the valve. Ultimately based upon opening and closing of the valve, the flow through the streams can be controlled according to the requirement. Using this type of flow simulator we can also check the flow computers to detect the malfunctioning in their operation.

Keywords—Flow computer, Flow meters, ARM7

I. INTRODUCTION

Flow can be measured in a variety of ways. Positive-displacement flow meters accumulate a fixed volume of fluid and then count the number of times the volume is filled to measure flow. Other flow measurement methods rely on forces produced by the flowing stream as it overcomes a known constriction, to indirectly calculate flow. Flow may be measured by measuring the velocity of fluid over a known area.

Flow computers are programmed to measure and control the flow of liquid hydrocarbons. These liquids include Crude Oil, Refined products, Lubricating Oils, and Light Hydrocarbons. Other products can also be measured when physical characteristics such as density and thermal coefficient of expansion are known. Flow computers are ideal for oil well testing, Net Oil Computations (NOC), Leased Asset Custody Transfer skids and many other applications in oil production at the wellhead.

Flow meters which are generally used to measure the flow of the fluid works on the different principles such as differential pressure, positive displacement, velocity, mass etc. meters can be mainly classified as below

A. Differential pressure:

These flow meters are based on principle of Bernoulli's equation. Differential pressure flowmeters introduce a constriction in the pipe that creates a pressure drop across the flowmeter. e.g. orifice plate, Venturi tube, flow nozzle, pitot tube etc.

B. Positive displacement:

A positive displacement meter is a type of flow meter that requires the fluid being measured to mechanically displace components in the meter in order for any fluid flow to occur. Positive displacement (PD) flowmeters make volumetric flow measurements taking finite increments or volumes of the fluid. With appropriate pressure and temperature

compensation, the mass flow rate can be accurately determined. e.g. Reciprocating piston, Nutating disk, Rotary vane etc.

C. Velocity:

In these kind of flow meters depending upon velocity of fluid through the stream, equivalent number of electrical pulses gets generated. Number of pulses or in other words, frequency of pulses directly proportional to the flow through the stream. e.g. Turbine, vortex shading etc.

D. Mass:

The mass flow meter measures the mass per unit time (e.g., kilograms per second) flowing through the device. Volumetric flow rate is the mass flow rate divided by the fluid density. e.g. Coriolis, thermal etc.

In the current study of flow simulator Vertex and Turbine flow meters are used since they provide electric pulses which are necessary to drive flow computer. Here LPC2148 (ARM7) is used as main controller for building the flow simulator.

II. BASIC IDEA BEHIND FLOW SIMULATOR

Flow computer can control the flow depending upon the algorithm which is feed in the computer. Digital valve logic (refer table 1) is used to control the flow. The flow computer produces the control signals (based upon digital valve logic). Frequency of the pulses gets vary according to the control signal which is being received from flow computer. In response to this frequency flow computer can control the flow of the stream.

Basic logic which is used to build flow simulator is to increase or to decrease or to maintain the frequency of pulses which are generated from the flow simulator. The first and most important thing in this setup is to load the flow algorithm in the flow computer. Using this technique flow can be controlled

very precisely, which is most challenging and important thing in case of petroleum refineries.

Valve logic:

There are basically two control valve logics

A. Analog valve logic:

In this type of logic 4-20ma signal works as control signal to the valve

B. Digital valve logic:

In this type of control Combination of 0's and 1's can be used as control signal to the valve as shown below:

Table 1: Digital valve logic

S1	S2	Output frequency
1	1	Increase frequency
1	0	Maintain frequency
0	0	Decrease frequency

Figure 1. Graph of Frequency of pulses (in Hz) Vs Flow (in m3/s)

In figure 1 dotted line shows the set point given by user. Initially there is no flow, shown by point 'o' on the graph. As we have to achieve the set point frequency of pulse train should be increased so as to proceed towards the set point. To acknowledge the microcontroller whether to increase or decrease the frequency of pulse train status signals 's1' and 's2' are used. 's1' and 's2' are nothing but meter output signals from IO card of the flow computer. According to status of 's1' and 's2' microcontroller decides whether to increase or decrease the output frequency as shown in table 1.

The working of flow simulator can be described in short as follows:

A) Starting from point 0 on the graph, the aim is to achieve the set point. For this S1=S2=1 is given to microcontroller, so that frequency of pulse train is increased as shown by line AB on the graph.

B) From the graph that it's clear that we crossed the set point limit, since practically it is very difficult to stop and maintain the frequency exactly at the set point. So to achieve the set point we have to decrease the pulse train frequency which is done by applying

S1=S2=0, shown by line BC on above graph. When S1=S2=0 pulse train frequency at the output of the microcontroller gets decreased.

C) As we reached the set point we have to maintain that set point for finite time interval, this can be achieved by applying S1=1 and S2=0, as shown by line CD.

D) To make the flow off S1=S2=0 is applied, so that to make the flow off as shown by line DE in the graph.

Figure 2. Flow chart

A) At starting microcontroller first get the status of its input ports.

B) If status of input port is 1 1 then microcontroller goes to the interrupt service routine, after execution of which output frequency gets increases.

C) If status of input port is 0 0 then microcontroller goes to interrupt service routine, after execution of which output frequency gets decreases.

D) If status of input port is 1 0 then microcontroller goes to interrupt service routine, after execution of which the output frequency which is present at the output port gets lock.

III. ARM7 (LPC2148) BASED SYSTEM

ARM 7 (LPC2148) is used as main controller for building the precision flow simulator. Timer mode of ARM along with PWM mode is used to generate frequency according to requirement. Separate ISR (Interrupt Service Routine) are made for increasing, decreasing and to maintain the frequency so as to satisfy the digital valve logic. Using timer mode and PWM mode in ARM, the frequency and the time for which the frequency should stay at the output can be adjusted precisely.

The relation between output frequency and flow through the pipe can be given by simple formula as below,

$$f_o = K \times F$$

Where, K=flow meter constant

F=flow of liquid through the pipe (in m3/sec)

Fo=Output pulse train frequency (in Hz)

Depending upon type of flow meter the value of 'k' changes,therefore output pulse train frequency is directly proportional to the flow liquid though the pipe.

IV.EXPERIMENTATION

Fix the mode in which we want to use the flow meter e.g.Turbine flow meter,Vertex flow meter etc.Suppose you have selected the vertex mode then flow computer will take the necessary data required to control the flow.The data should contain the some relation between the flow and the frequency which should be generated so as to provide necessary control action.The data for vertex flow meter is shown in table 2 as:

Nominal pipe size(Inches)	Internal diameter(Inches)	Crossectional area(ft ²)	Nominal pulse rate(hz/ft/s)
1/2	0.57	0.0018	19.1
1	1.01	0.0056	10.8
2	2.01	0.022	5.59
4	3.69	0.074	3

Table2:Relation between flow and pulse rate for vertex flow meter

The frequency which we want at the output of the ARM based flow simulator ranges from 0 Hz to 10KHz.Flow computer gives response to the incoming pulse frequency from simulator and decides opening and closing of the control valve attached to the pipeline, ultimately flow through the pipe gets adjusted.

A. Experimental Study

Figure3.ARM based Flow simulator

Figure above shows ARM based flow simulator.Switches are used for checking the basic working of the flow simulator,switches can be bypassed while actual interfacing of the flow simulator with the flow computer.Here LCD display is used to show switch position(control signal status) and current output frequency of the simulator.Using RS

232 we can modify the program which is flashed in the ARM chip.By flashing we can change the count by which the frequency should increase or decrease on acknowledge of status signals at the input port of the ARM.Also we can change the time delay for which we want particular frequency count at the output of the ARM.

Figure4:Signal conditioning circuit

As flow computer is going to acknowledge the pulses having magnitude 5V or 12V depending upon requirement,but the magnitude of the output pulse from ARM has magnitude of 3.3V max.To make interfacing of flow computer with flow simulator we have to make output signal of the ARM either 5V or 12V.Which can be accomplish by constructing just simple signal conditioning circuit as shown in figure4.

B.Results

Figure5:Nature of output using DSO

The screenshot shown in figure5 is an intermediate reading for the frequency of 405 Hz. Tektronix DSO is used to analyze the nature of the simulator output. It is found that flow simulator gives exact square wave of different frequency as per requirement. Resolution of the square wave can be adjusted as per requirement.

C. Conclusion

The precision flow simulator designed using ARM7 can be efficiently used to check malfunctioning of flow computer at intermediate stage. Also this flow simulator along with flow computer is alternative option for the flow meter since once we set the flow computer to work for respected flow meter, it can behave as particular flow meter for which operation is being set.

ACKNOWLEDGMENT

We would like to thank Emerson Innovation Centre officials for giving their valuable time and innovative ideas to make this device. special thanks to Mr. Bimal Shah (Technical Leader, Remote automation Solutions Emerson Innovation Centre).

REFERENCES

- [1] American Petroleum Institute (API) — Manual of Petroleum Measurement Standards (MPMS), Chapter 21 – Flow Measurement Using Electronic Metering Systems
- [2] Stark, Stephen T. — Testing, Maintenance, and Operation of Electronic Flow Computers for the industry.
- [3] Emerson Innovation centre, Hinjewadi, pune