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Split Range Control for Mobile Room Heating System

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Abstract : Modeling of Temperature control in various systems on a field is one of the most common problems in industrial environment. In home heating systems also this comes into existence. First Principle modeling of Temperature Control Process is done with so much of assumption. In this paper Split Range Controller is attempted for Room Temperature Control which is one of the classic example of a Non Linear System. Room Temperature is taken as the input data and the output voltage to the fan is controlled for this temperature control process. The Input Temperature is measured using a J Type Thermocouple using Analog input port on DAQ cards. While the Output voltage is generated for two individual 12v Dc fans (Suction & Discharge) using Analog output port on DAQ cards. The collected data is processed in a Split Range Controller in virtual instrumentation environment. We have analyzed the setup model of Temperature Control Process practically using Lab View environment which gives the results almost identical to the simulation results of the process. The Split Range Controller is used here to Control the Temperature of the output system using the inputs and the outputs available. This will produce a gradual control of room temperature under cold conditions and will be mobile so that it can be utilized for single room alone.

Keywords : Process control; nonlinear dynamics; nonlinear rocess control; Temperature control process; Split Range Controller, virtual instrumentation.

1. INTRODUCTION

A home heating system provides warmth to the total interiors of a home from one portion to multiple portions. When its combined with other systems in order to control the building interior temperature, the whole system may be either Heating, Ventilation, Air Conditioning or a combination of all of them. This home heating system has been used from ancient Rome and Greece. This system is been done by either conduction or by convection systems. Right from ancient civilizations the home heating systems are usually central heating systems where the heater or a combustion system is stationary at one part of the home and heat liberated from that chamber warms up the whole room or interior of that home. In United States the furnace efficiency is regulated by minimum AFUE (Annual Fuel Utilization Efficiency). If the AFUE values are higher, then efficiency of the furnace or boiler is more. Later warm air stoves were used instead of heating furnaces. And again those stoves were replaced by hot water tube systems and steam systems. These water or steam heating systems included various components so like fuel supply, boiler, heat exchangers, pump, radiators, reheaters, etc. This in turn increased the space occupied by that system. In recent days electric heaters and heat pumps were used to warm up or maintain heat in the interiors of homes. Beyond these all there were underfloor heating systems, geo thermal heating systems, open therms, oil heaters, etc.

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2. TYPES OF HOME HEATING SYSTEMS

There are various types of home heating systems available all over the world in the temperature and Polar Regions of the world as mentioned above. Some of those are explained below.

Central Heat Furnace : Most of the North American households depend on a central furnace to provide heat to their homes. A furnace kept at a stationary point works by blowing heated air through ducts in the home that deliver the warm air to rooms throughout the house through air registers & grills. This is also known as ducted warm-air or forced warm-air distribution system. Here fuel is burnt and this transforms heat to air through heat exchanger systems which in turn connected with furnace fans which circulate air to the rooms. Here about 30% of fuel efficiency is wasted in exhaust. Nowadays best furnaces have 90% efficiencies.

Boiler systems : Boilers are kind of water heaters which distribute the heat in hot water through radiators or other devices in rooms throughout the house. The cold water then returns to the boiler to get reheated. Hot water systems are usually known as hydronic systems. Residential boilers mostly use natural gas or heating oil for fuel. Steam boilers are most common during the earlier 90's.

Heat Pumps : Heat pumps are two-way air conditioners which during summer works as an air conditioner by moving heat from the relatively cool indoors to the relatively warm outside & during winters works as the heat pump which scavenges heat from the cold outdoors with the help of electrical systems and discharges that heat to the inside of the house. These are forced warm air delivery systems.

Gas-Fired Space Heaters : Gas-fired heating includes wall-mounted, free-standing, and floor furnaces, which are characterized by their lack of ductwork & relatively small heat output. As they lack ducts, they are most useful for warming a single room. When heating of several rooms is required, either the doors between rooms must be left open or another heating method is essential. Better systems use sealed combustion air systems for better heating.

Unvented Gas-Fired Heaters : These are similar to GFSH but lack ventilation systems. They also include wall-mounted, free-standing, and floor furnaces, but which are not connected to chimneys. This can be used only near windows along with oxygen depletion sensors. However this system has been banned in most parts of United States for its hazardous effects.

Electric Space Heaters : These are plug-in electric heaters which are inexpensive to buy, but are costly for usage. They are resistive heaters which has "oil-filled" and "quartz-infrared" heaters. They convert electric current from the wall socket directly into heat. However it consumes more electricity for this heat generation and thereby makes it costly for usage.

Wood-Burning and Pellet Stoves : Pollutants from wood burning have been a problem in environmental issues. Pellet stoves are less polluting than wood stoves and gives greater convenience, temperature control, and indoor air quality.

Fireplaces : Gas fireplaces are nowadays a part of room's décor, providing a warm glow, but not an effective heat source. They rely on air drawn from the room into the fireplace for combustion and dilution, the fireplace will lose more heat than it provides, if more warm air is drawn through the unit. If the room is sealed with glass doors combustion will not take place efficiently and needs proper exhaust systems and pollution control.

3. MOBILE ROOM HEATING SYSTEM

In this paper, we have designed a Mobile room Heating System using Split range Control. Here we have constructed a wooden box along with a heating element inside it. This paper deals about an air ventilation (Suction and Discharge) system which is being performed by a 12v DC Fan. By using LabVIEW Graphical user interface or virtual instrumentation, the design of the controller is built in Front Panel and block diagram of the LabVIEW. The LabVIEW has its own built in Data Acquisition System which is very much useful in acquiring data for feedback and also controlling the room temperature.

By using this DAQ, We can acquire signal from Thermocouple and generate an output voltage to the fan. In this process a literalizing is required to drive a 12v DC fan. This circuit consists of a ST100 Transistor for linearization. It act as a switch between DAQ and 12v supply. The hardware model consists of two suction fans and one discharge fan for constant and smooth output air regulation inside the room.

This setup is easy to build and also small in size thereby makes it easy to transfer the setup from one place to another place in no time. The main objective of this paper is to make a room heating system which can be controlled automatically by a split range controller so that we can have three different temperature regulating points (set point, Medium, Hot) for temperature maintenance in the room. The block diagram of the above setup is clearly shown below with the inter connections and circuit flow.

The temperature measurements are acquired as data samples in LabVIEW through DAQ 6009 which is shown below.

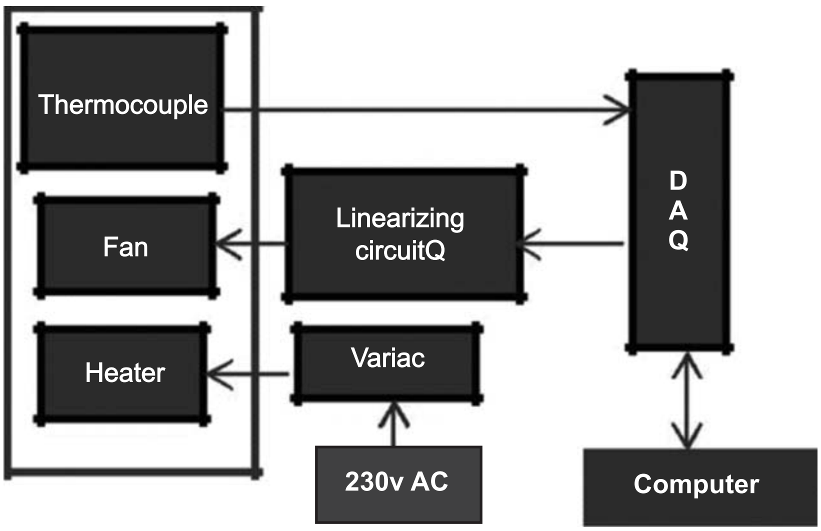

Figure 1 : Block diagram of MHS

4. PROCESS AND MEASUREMENTS

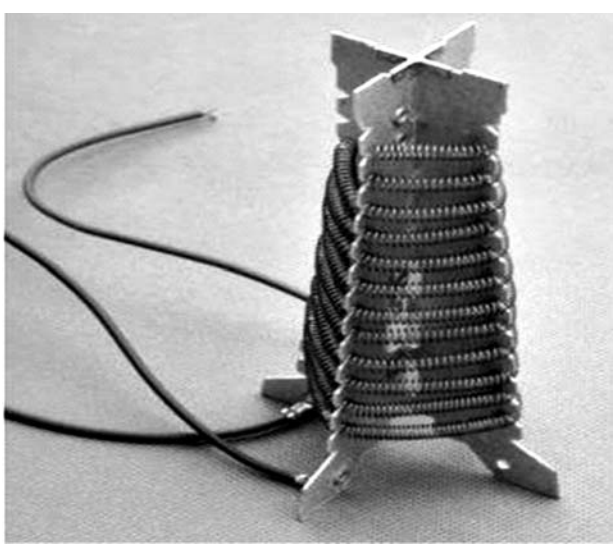

Figure 2 : Resistive Heating Filament

The setup consists of a heating element which is insulated inside a hollow wooden box and is supplied with a regulated input. The input air drawing is done at the backside of the wooden box with the help of two 12V DC fans which suck in the air to be regulated out. One 12V DC fan is provided at the front side of the box to push out the hot air from the wooden chamber to the room. Measurements are thermocouple as the hot air flow is regulated and the temperature raise is gradual. The temperature measurements made by thermocouple provide a better alternative for data acquisition through LabVIEW. The heating element is a small resistive element which draws only little current when compared to large electric heaters and the element used is shown below.

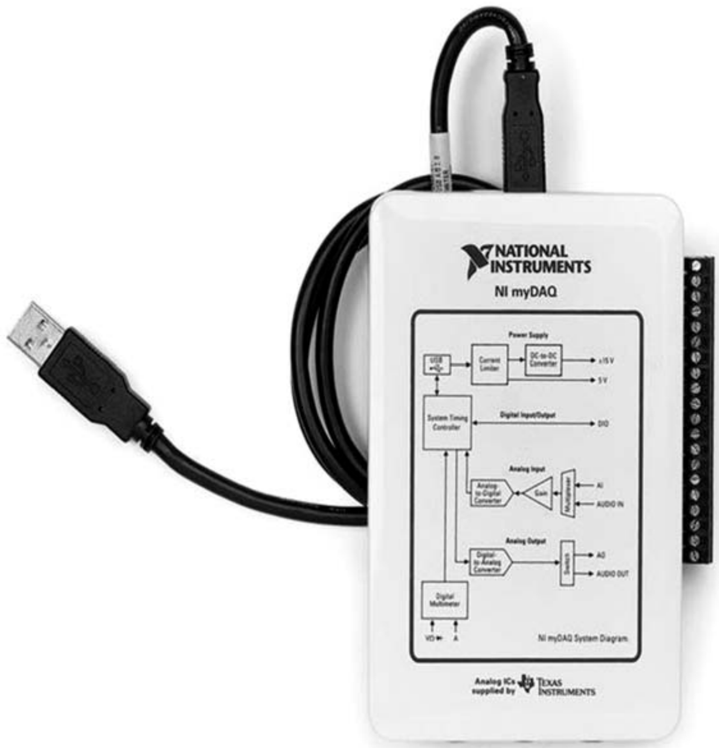

Figure 3 : Hardware structure of DAQ card

The measured temperature data of input and output is consequently compared to provide the feedback of room temperature. The thermocouple used here is a J type thermocouple for which the cold junction compensation is provided internally through LabVIEW environment. The thermocouple has a better interfacing with DAQ cards and does not require any interfacing units for data acquisition. The voltage output measurement and some types of thermocouples which can be used for this measurement are shown below.

$$V = \int_{T_{ref}}^{T_{sense}} (S_{+}(T) - S\_(T))\,dT,$$

Table 1

List of Various thermocouples which can be used for this room heating measurements

Type	*Material*	*Output Range*	*Temperature Range*	
			Wide	*Narrow*
E	Chromyl –Constantan	68 µV/°C	−50 °C to + 740 °C	−110 °C to + 140 °C
J	Iron –Constantan	50 µV/°C	(770 °C)[8]	(−40 °C to + 750 °C
K	Chromel –Alumel	41 µV/°C	−200 °C to + 1350 °C	800 °C – 1050 °C

5. MOBILE HOME HEATING SETUP

The mobile home heating setup with the wooden box and voltage regulator is shown below.

The complete setup is shown below under working conditions which is being interfaced with DAQ along with virtual instrumentation.

Figure 4 : Hardware setup of MHS

Figure 5 : Complete Hardware setup of MHS

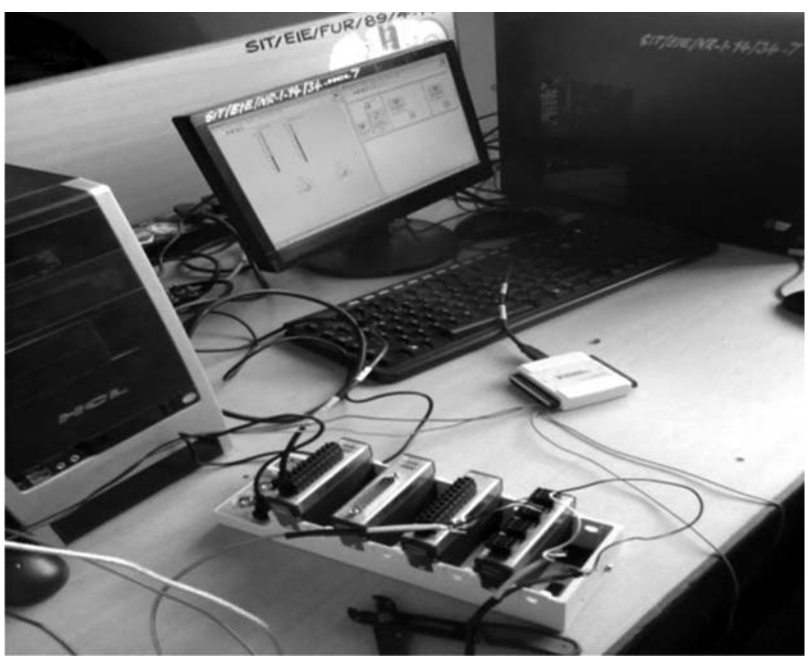

Figure 6 : Hardware setup of MHS interfaced with

6. SPLIT RANGE CONTROL

In a split range control, output of the controller is split and sent to two or more manipulated variables for controlling various output devices. Most of the split range applications, the controller adjusts the opening of one of the valves when its output is in the range of 0 to 50% and the other valve when its output is in the range of 50% to 100%. Split range control is used when we need to control more than one parameter using a single control. The flow diagram of split range control for a temperature process is given below with reference from http://instrumentationtools.com/

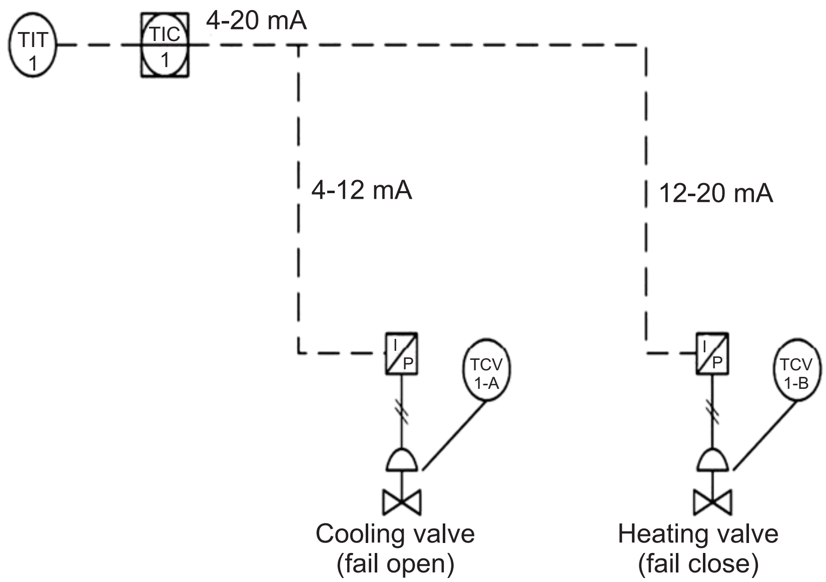

Figure 7: Flow diagram of temperature process using SRC

Here in the above diagram the cooling valve and heating valve both are being controlled simultaneously by a single controller. Likewise in our paper also the inlet suction fans and exhaust outlet fan are being controlled by a single controller. The control is being done by comparing the room temperature and exhaust outlet air temperature. These data are being acquired using DAQ cards which is being interfaced with the computer through virtual instrumentation or by LabVIEW software environment.

7. RESULTS AND DISCUSSION

Figure 8 : Complete setup of MHS interfaced with

The setpoint for room temperature was fixed as 30 °C and the tolerance value was set as ± 1.5 °C. When the set point reached both the suction fans get switched to a minimum running condition and only the front exhaust fan bring out the hot air from the box to the external room conditions. The temperature of the outside room which is 32 to 34 °C is termed as medium condition for which the front exhaust fan and back suction fan one will be operating. When the room temperature range is between 34 to 39 °C it is termed as hot condition, and at that time the front exhaust fan gets switched to minimum operating condition and both the back suction fans operate at a higher speed condition. So that this can be keep the temperature of the box at a steady state condition.

The complete realtime working picture and the output conditions of front panel is shown below for different operating conditions.

The front panel diagram of the process is shown below at initial starting condition.

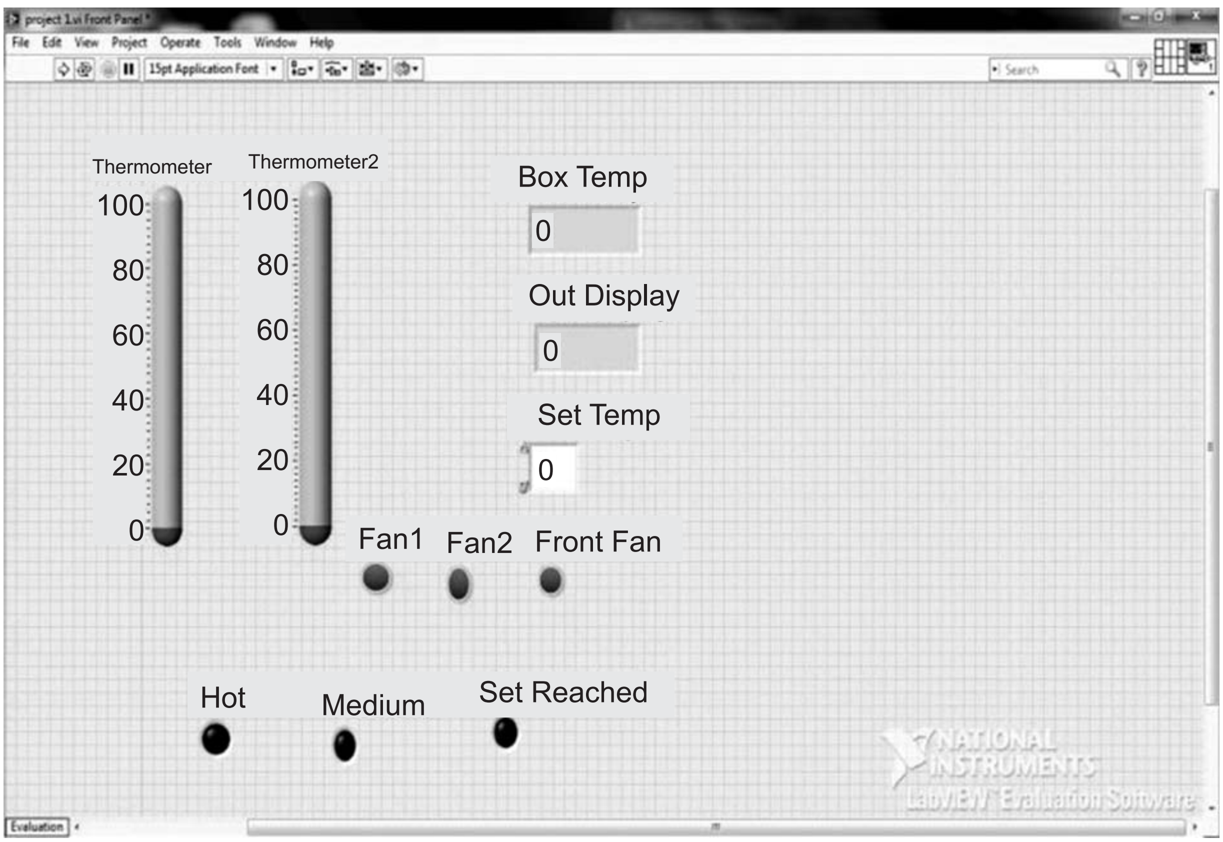

Figure 9 : Front Panel of MHC setup in VI

The front panel during operating condition is shown below when the operating temperature reaches the setpoint value. At that condition the front exhaust fan alone gets triggered and starts to provide a constant hot air.

The front panel during operating condition of 32 to 34 °C is shown below when the operating temperature reaches the medium value. At that condition the front exhaust fan and one of the suction fan gets triggered and starts to provide a constant hot air flow. Here the medium condition gets enabled and is indicated.

The front panel during operating condition of 34 to 39 °C is shown below when the operating temperature reaches the hot value. At that condition the front exhaust fan and both the suction fans gets triggered and starts to provide a constant hot air flow. Here the hot condition gets enabled and is being indicated.

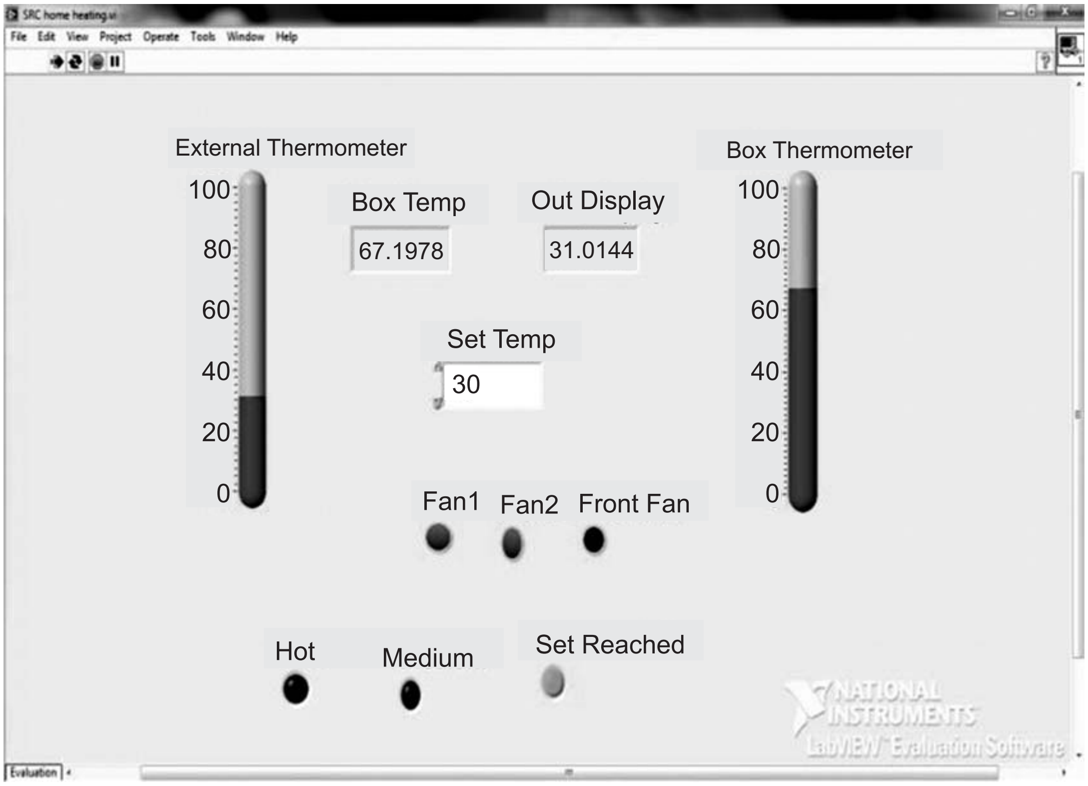

Figure 10 : Front Panel of MHC setup in VI for setpoint condition

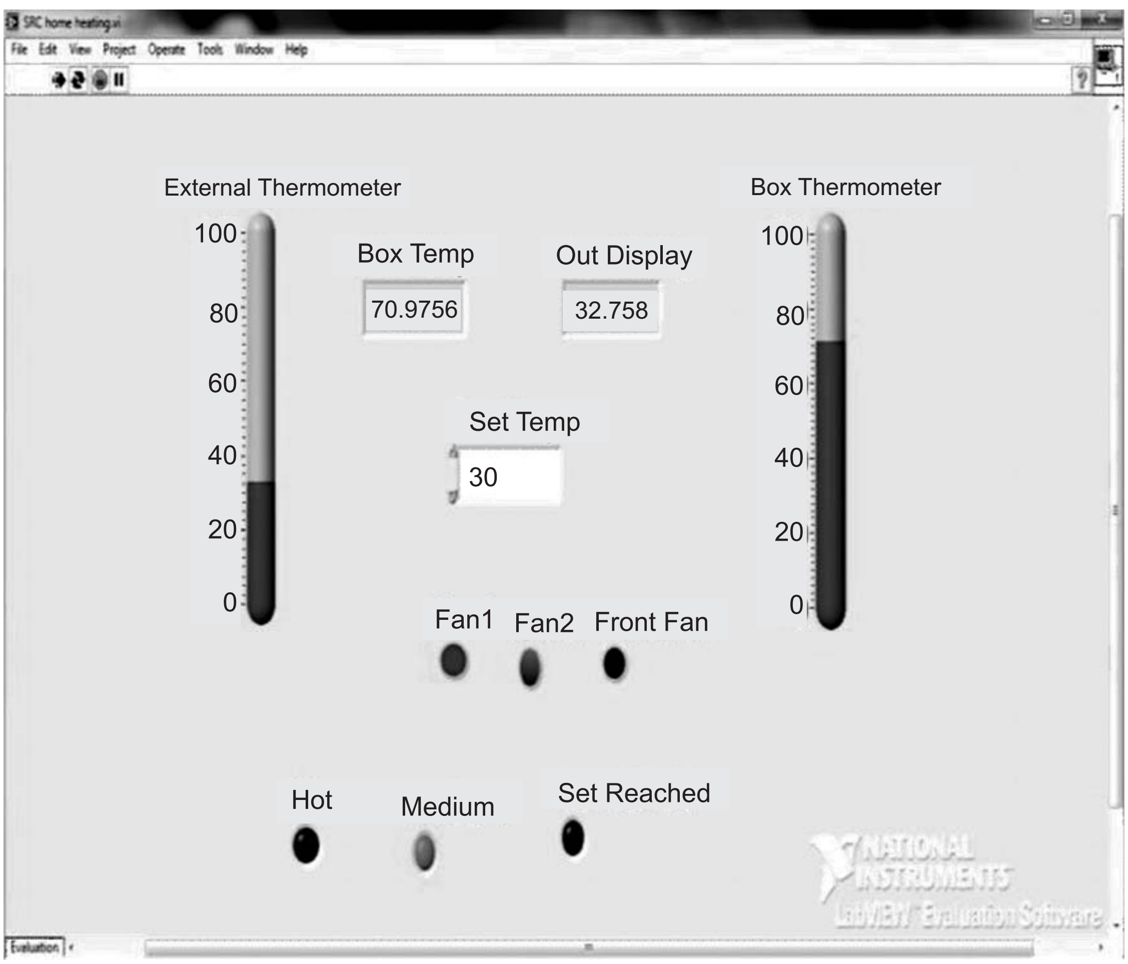

Figure 11 : Front Panel of MHC setup in VI for medium condition

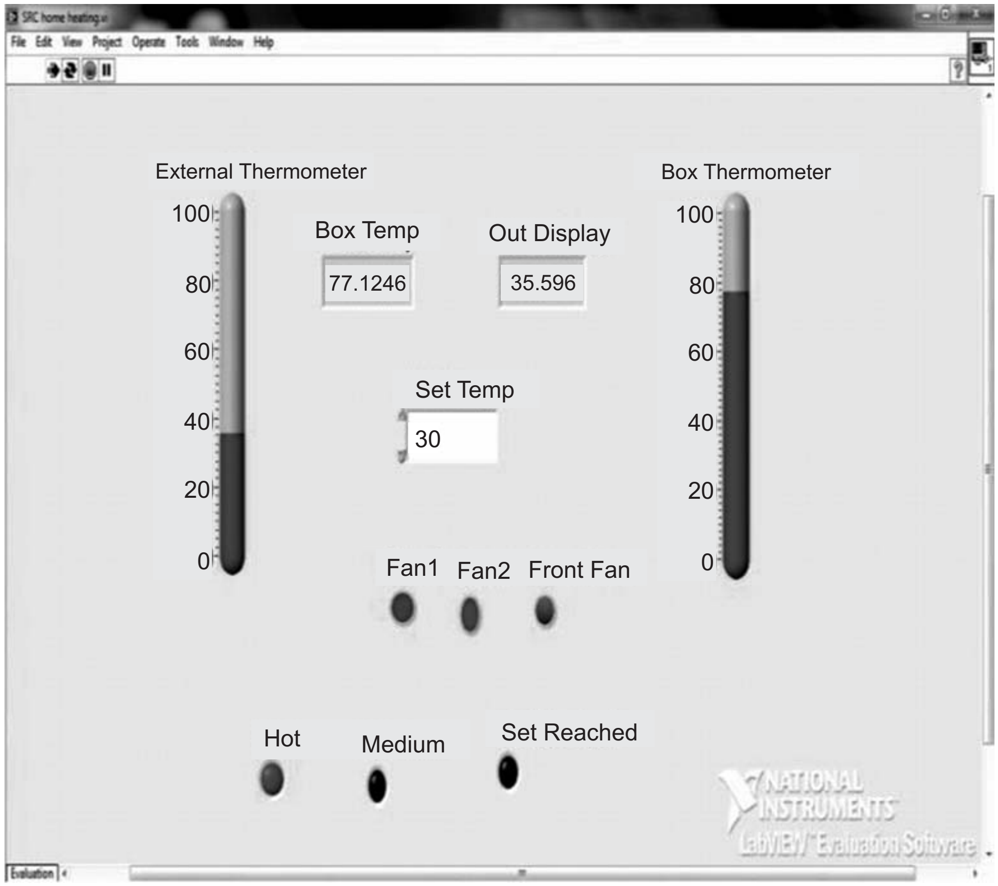

Figure 12 : Front Panel of MHC setup in VI for hot

8. CONCLUSION AND FUTURE SCOPE

In this paper split range control has been implemented for a mobile home heating system and the simulations and practical results have come very well. The interfacing with virtual instrumentation has provided an additional advantage of data acquisition and also efficient control of the system. In this paper the input current drawn by the resistive element is very less and also the heat liberated is more efficient for constant room heating. In future other control algorithms can be implemented for optimized functioning of the system. Adaptive control and intelligent control algorithms would show better results for effective operations.

9. REFERENCES

1. M. Naghedolfeizi, S. Arora, and S. Garcia, "Survey of LabVIEW technologies for building Web/Internet-enabled experimental setups," Proceedings of the 2002 ASEE Annual Conference and Exposition, June 16-19, 2002 Montreal, CA.
2. N. Swain, J. Anderson, M. Swain, and R. Korrapati, "State-space analysis of linear, time-invariant control systems using virtual instruments," Proceedings of the 2001 ASEE Annual Conference Proceedings, June 2001, Albuquerque, NM.
3. L. Sokoloff, "LabVIEW implementation of ON/OFF controller," Proceedings of the 1999 ASEE Annual Conference Proceedings, June 1999, Charlotte, NC.
4. R. Bachnak and C. Steidley, "An interdisciplinary laboratory for computer science and engineering technology," Journal of Computing in Small Colleges, Vol. 17, No. 5, April 2002, pp. 186-192.
5. K. Resendez and R. Bachnak, "LabVIEW programming for internet-based measurements," Journal of Computing in Smakk Colleges, Vol. 18, No. 4, April 2003, pp. 79-85.
6. V.van doren, "Fundamentals of self-tuning control",control engineering.volume 54, No 5, july 2007.
7. V.van Doren,"Applications of self tuning control,"contol engineering.volume 54, No 9, july 2007.
8. Ajith.B.Singh, A.Anie Selva Jothi, S.Kaushik, ―Model identifi cation and model reference adaptive control implementation for a hybrid tank system‖, International Journal of Emerging trends in Engineering and Development, Vol 1, Issue 3, ISSN: 2249-6149, November 2011.