



# Development of Graphical User Interface (GUI) for High Temperature Vacuum Furnace by Implementing Modbus Protocol Using LabVIEW

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**ABSTRACT:** The Project requires development of Graphical User Interface (GUI) and implementation of Modbus Protocol in LabVIEW for control and operation of high temperature vacuum furnace system. The high temperature vacuum furnace system can heat materials, specifically metals to a very high temperature to carryout processes like brazing, sintering, and heat treatment with high consistency and low contamination. The GUI is developed for controlling and monitoring of devices like sensors (temperature, pressure, water flow etc.), valves, pumps, data loggers, PID controllers etc of the furnace system.

The communication is based on Modbus protocol which is an open protocol is used for transmitting information over serial lines between devices of furnace system.

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a graphical programming environment. It is a powerful and versatile instrumentation software for measurement automation.

**KEYWORDS:** Graphical User Interface (GUI), LabVIEW, Modbus Protocol, RS-485

## I.INTRODUCTION

The objective of this work is the designing of Graphical User Interface (GUI) for control, operation and supervision of high temperature vacuum furnace. Vacuum furnaces are actually used for high temperature processing which are fully controlled in oxygen-free environment. Inside the furnace is called the hot zone and the hot zone which is placed inside a water-cooled vessel. Also this system provides very high consistency and also very low contamination for several processes like annealing, brazing, sintering and other heating processes. So vacuum furnace is the device which is used for heat treatment.

Here, in our case the furnace is completely under manual operations and many of the steps have to be followed before the actual operation of the furnace starts, which include,

1. Switch ON the chiller or the cooler switch, on the other hand it will alarm with low water pressure.
2. Turn the Power Switch ON, check the state of each switch (the guide book / manual will provide the heating mode. If those instructions are correct then, time to switch on the main power.)Now the furnace can be opened to the sample.
3. There should be some evacuation procedure. At first all the valves should be closed and then start the mechanical pump to run normally and then, it is opened to the low vacuum disc valve. For high vacuum, first open the disc yan and then the diffusion pump suction portion, then open it to diffusion pump for some set time and then close the disc valve and at the same time also open the main valve.
4. Make the heating procedures for the vacuum furnace. If there is some kind of system which facilitates the operation of the furnace automatically in accordance with the requirements, and can be operated within a control room itself without going to the actual location where the furnace is located would be idea. So here I am introducing the idea of controlling and monitoring the entire processing of a high temperature vacuum furnace placed at a distant place and that too will be complete automatically.



After following all these steps for the operation makes it more labour utility as well as time consuming. So in order to make the processing of vacuum furnace easier we will automate the entire process using LabVIEW with the implementation of Modbus protocol.

### II.16-BIT CRC CALCULATION

The CRC (Cyclic Redundancy Check) is actually for the serial communication between the slave devices and the master, a request from the master and a response from the slaves are required. So for making them communicate each other serially we are implementing Modbus Protocol. For each request/response packet corresponding CRC value should be appended to make the packet complete. Here we are using 16-bit CRC Calculation for the entire process. The characteristics and the algorithm of CRC being investigated and also a pipeline algorithm to achieve this are introduced. The Modbus protocol in RTU mode, with 16-bit CRC, is developed based on LabVIEW, by creating the corresponding codes. The developed programmes in LabVIEW were verified in the serial communication system consisting of all the slave devices.

### III. MODBUS RTU

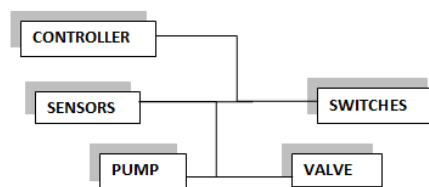


Fig. 1 Block of Modbus connections

In the Fig 1, it shows the basic block diagram connection of Modbus. It is defined as a master/slave protocol in which master will write the data to slave device’s register and read data from slave’s register. Commonly used Modbus protocol is RTU RS-485. Data are transmitted as 8 bits (1byte), one bit at a time. Modbus RTU network can connect 1 master and one or more slaves. Each slave has a unique 8 bit device address and packet send by master includes the address of the particular slave. The slave must respond only if its address is recognized and must respond within a certain time period and otherwise master will call it ‘no response’ error. Exchange of data consists of (1) Request from the Master and (2) Response from the Slave.

Each data packet weather request or response includes,

1. Device Address / Slave Address
2. Function Code
3. Register Number
4. Register Count
5. Data
6. Checksum ( CRC or LRC )

In Fig 2, it shows the typical Modbus RTU Frame or the packet of the entire information to be sent.

Address	Function code	Data 1	Data 2	.....	Data N	CRC low	CRC high
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Fig. 2 Modbus RTU Frame



**IV.SERIAL COMMUNICATION**

It is through the serial communication we have transferred the information between processing equipment and peripherals. In serial communication, data is within the kind of binary pulses, which implies as logic high or 5volts and logic zero or 0volts. This communication method takes many forms depending upon the kind of transmission mode and data transfer. The transmission modes could also be either Simplex, half duplex or full duplex and also there'll be a source/sender and destination/receiver for every transmission. While communicating serially, certain set of rules we need to obey in order to make this possible and they include the 1. Baud Rate which is the speed of transmitting data from transmitter to receiver and the value ranges are 4800/9600, 2. Framing which is the percentage of data bits that we are sending from the host device, 3. Synchronization which helps the receiver to detect the beginning and end of the transferred information, 4. Error Control which detects the errors present in the data transferred. And thereby we can make the serial communication possible. In the below Fig 3, it shows the complete communication block diagram of the host and the peripheral devices.

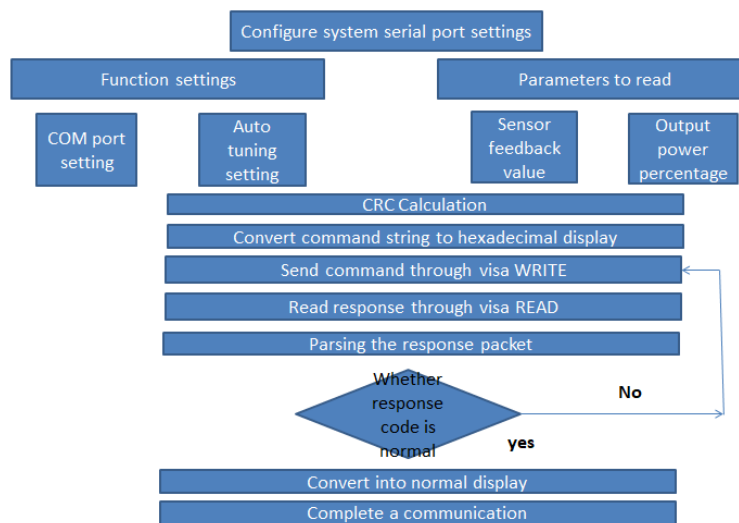


Fig. 3 Communication Flow Chart

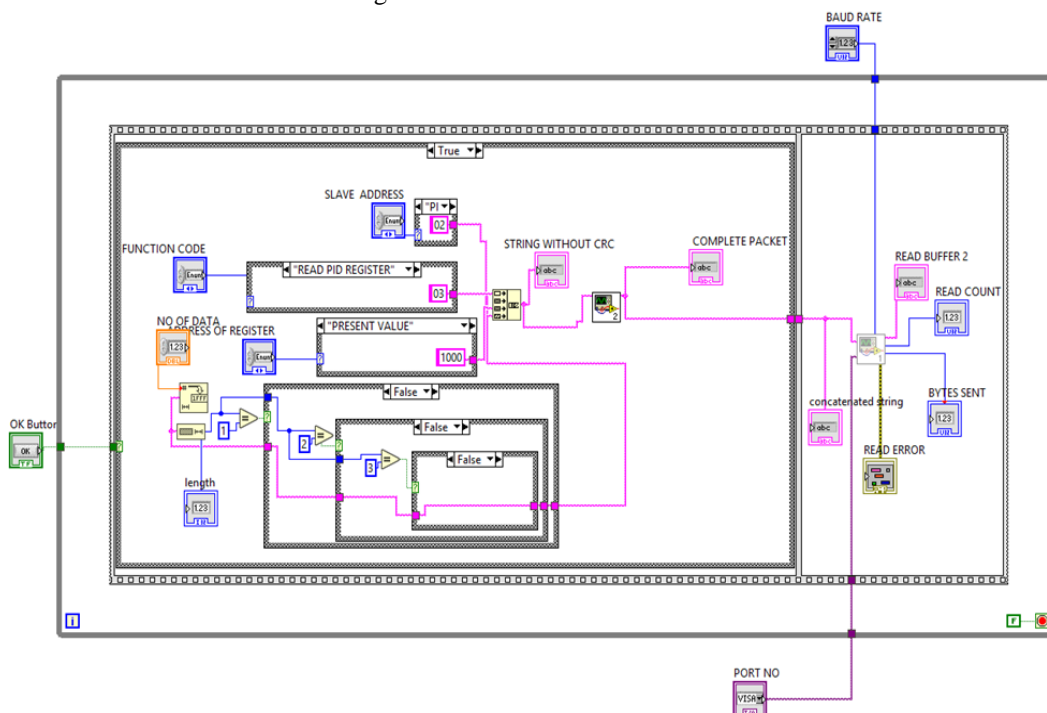


Fig. 4 Serial communication between slave devices Block diagram LabVIEW



In Fig 4, the system serial communication is shown in the LabVIEW block diagram and in the Fig 5, the front panel in LabVIEW corresponding to the blockdiagram LabVIEW is shown.

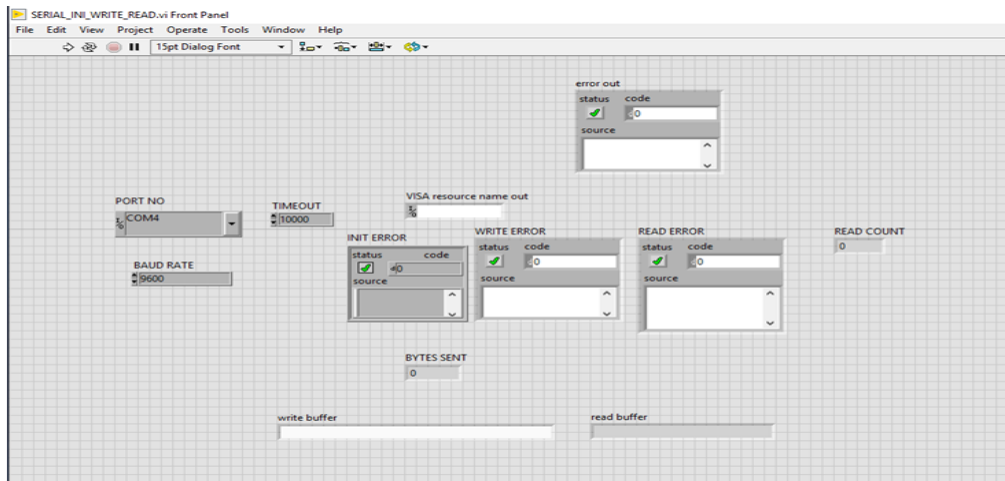


Fig. 5 Serial communication between slave devices Front Panel LabVIEW

### V. RESULT AND DISCUSSION

In the below Fig 6, the temperature variation of the furnace obtained by using the K-type thermocouple against the corresponding voltage is plotted.

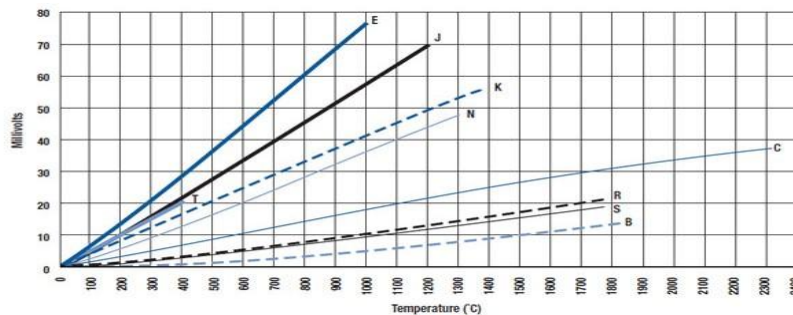


Fig. 6 Thermocouple voltage plotted against temperature

In the fig 7, it can be see that the sample simulation of the furnace has been done and the corresponding PID controller graph has been plotted and also in Fig 8, the temperature controlling of the vacuum furnace corresponding to the changes has been plotted.

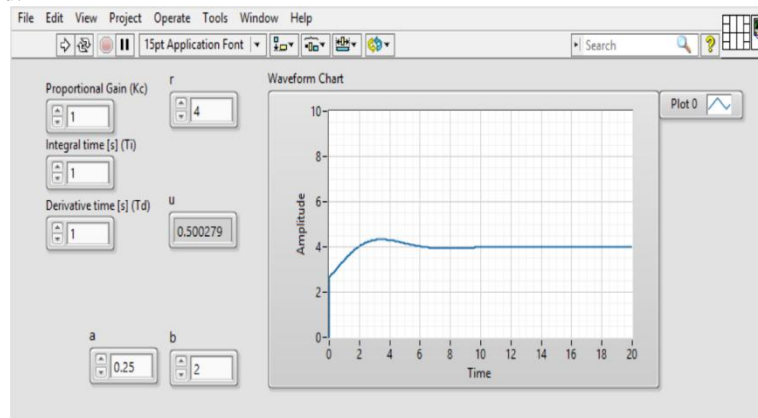


Fig. 7 Simulation Example of furnace with PID controller in LabVIEW Front panel

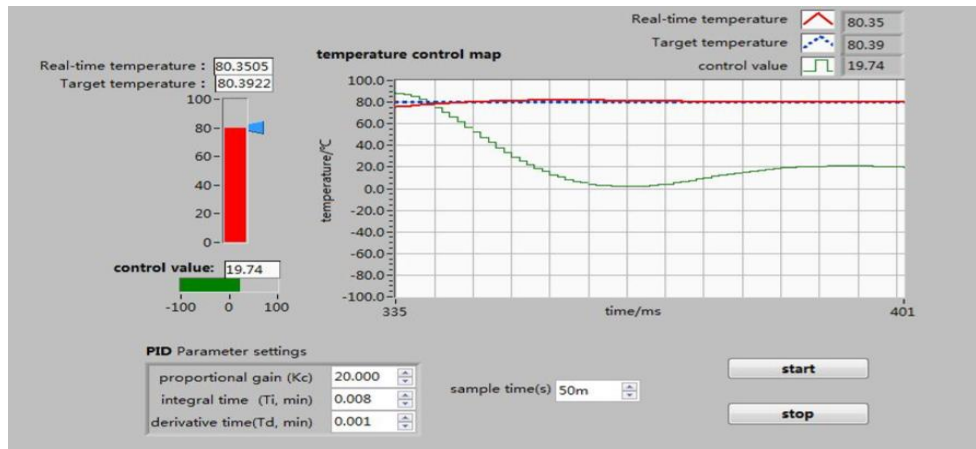


Fig. 8 Temperature control based on PID of vacuum furnace

## VI.CONCLUSION

The development of GUI for implementation of Modbus protocol, and interfacing of DSP based controller, PID controller, multi-function meters using LabVIEW has been done. This would help control the furnace temperature, and monitor the heater voltage and current, mains three phase input voltages and currents.

After the implementation of this, the solution allows to control and monitor the processes by means of an interface capable of extracting information. This application enable the storage of information entering the system and it will automatically analyses- in real time- the correct process operation, enabling comparison with previous data in order to come up with possible improvements. The system has benefits such as, it will require less labour-intensive, and requires less skill of operation. Also it could meet the requirement of producing automation, saving energy as well as reducing environmental pollution because of its definite control effects and performance.

It has got improved control technology and optimized control strategy of vacuum furnace. Since the existing furnace system is under manual controlling it has got some disadvantages such as it requires labour, time consuming, less accurate, etc and by the implementation of our system it has got its complete operation as automatic, less time requirement, storage of performance data in order to correct quality problems, automatic control and monitoring remotely from a distant, and most importantly it will make the operators job easier by having graphical statistics presented in real time.

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