SERIAL INTERFACE INDUSTRIAL SCADA SYSTEM

Mr Tariku Sinshaw and Mr. Heruye Mulugeta, College of Technology, Department of Electrical and Computer Engineering, Debremarkos University, Ethiopia.

ABSTRACT

Life track on earth has been changing since the innovation and expansion of digital computing system. Our day to day activates without the help of this devices is unthinkable. Every field is conducted with the help of these devices such as communication, trade transaction, power generation, transportation, industries and manufacturing etc.

Controllers and robotic arms have been playing enormous role for industries and manufacturing sectors. As Process Controlling is a critical issue in interior industries system, companies spent a lot of budget for innovation and implementation of modern technology.

Despite the fact that SCADA system is one of controlling and monitoring mechanism, Most Ethiopian factories use the Old way of controlling mechanism. Old method mostly depends on electro mechanical relay system and analog measurement methods. Therefore it has its own draw backs regarding on power loss, time management and also environmental pollution.

In this paper, we studied the optimization of factories interior system by using serial interface SCADA system that is dedicated to liquid and detergent factories.

The proposed system enables computerized controlling and monitoring of the different parts of factory chambers inside personal computer. In addition, varieties of measurements are taken and stored inside the data base for further analysis and investigation. Different types of sensors assembled on the machinery can detect every physical phenomenon under the factory working environment such as liquid level, Current, and Voltage, Power, Temperature, flow rate of liquid, pressure, position of manipulators and actuators etc. Then the detected data by the sensors send to the computer HMI software by the help of data interpreter or SCADA hard device using serial communication protocol. Then the received data will be stored inside the HMI database after monitored different meters gauges,

After the user installed the HMI software inside personal computer, the software will start communicating with the SCADA hardware device through serial communication protocol. HMI contain GUI representation of the factory chamber sub components like tankers, mixer, filer etc. also contain different display meters and chart, power system lines, toggle switch. Therefore the user can activate specific devices which are connected under the system power installation by sending a control command form HMI to the SCADA hardware through a serial port. Then the SCADA hardware sends signal to the control board in order to activate actuators, either on or off after executing the incoming command data from the computer, so that they will do the required tasks. The user can also monitor the current status of every chamber sub components by reclining sensor measured data from SCADA hardware. Installed sensors in different parts of the factory chambers detect physical environment and sends signal to SCADA hardware. The detected signals will be analyzed and interpreted by the SCADA hardware and the measured data will be stored

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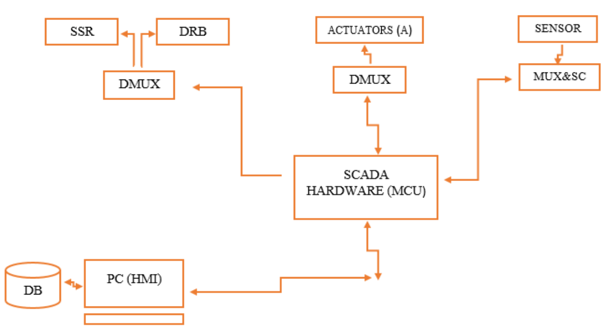
to the database for further analysis and investigation.

INTRODUCTION

It is true that, researches and projects focusing on industries have a goal to create safe, effective, robust working environment inside the factories. In addition, they have also a goal to increase productivity by reducing waste materials releasing from interior system and hence, they have significant role in environmental protection.

Optimization in Industrial control system is a complex task. Because every system have to sense the activities in the environment and may take a response with in low delays like what a human being would do. SCADA system is capable of replacing Human activities in need of continuous supervision. Therefore, SCADA system is capable to make decision based on incoming sensor data. In this paper we propose four approaches; the first approach is developing HIM software using c#.net, the second approach is to take sensor data from the environment to HMI software through SCADA hardware. The third approach is sending control data to hardware from HMI. The fourth approach is integrating the third and second approaches together and to create self-controlling capability of system.

PROJECT DESIGN IMPLIMENTATION

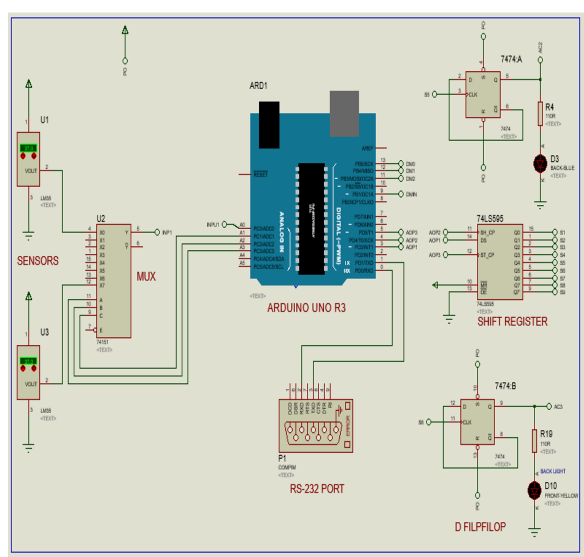


An act of Designing of such kind of system Involves conducting a lot of studies from Programing up to design of analog and digital electronics. Therefore, the design and implementation of this complete system is discussed below.

SCADA HARDWARE

The Arduino micro controller used as SCADA hardware collaborated with other digital and analog electronics circuit. The microcontroller has two functions. The first one is converting incoming sensor data into compatible format that the computer or HIM can understand and send it to serial communication protocol which established with HMI. Its second function is converting control commands coming from HMI for specific final element and then sends it to different branch. Therefore the hardware acts like a bridge by creating link between HMI and other hardware branch.

Arduino Uno is a development kit which Contain atmega328P microcontroller chip inside. The unique feature of Arduino is the fact that it can upload a generated hex file to the microcontroller memory without requiring other external device. The other feature is for serial communication protocol, the hardware



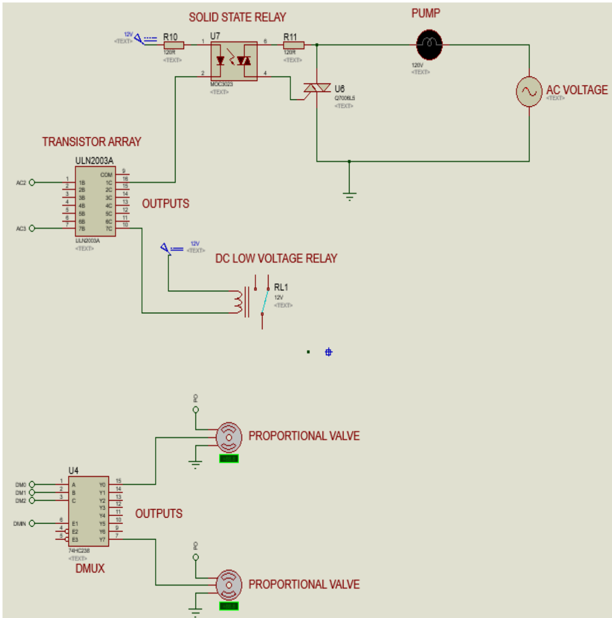


Figure 1.1 circuit, and block diagram

also contains built in USB port. Arduino has open source code development software which Uses edited version of C++ programming.

The other hardware part is digital output expander circuit which contains 8 bit serial to parallel shit register with D flip-flop. As the MCU is designed for general purpose, it contains limited output pins. This makes it difficult to control many devices directly from the hardware. Hence, to increase the number of output pins, we have to add expander responsible for converting incoming serial data form hard ware to parallel data. Then it will be stored to single bit storage device like D flip flop. The 74HC595 shift register can turn on up to 8 outputs. This means it adds additional outputs to a microcontroller. Now we can control even more output devices by cascading more chip together. Secondly, shift registers work in an arithmetical way in which bits (which represents outputs) can be shifted bit by bit. It works really well for a lot of arithmetical processes. Therefore by sending serial data from the microcontroller, we can expand the output pins because the shift register can change in coming serial data in to parallel data. If serial data 00000001 is sent form MCU on shift register pin 15 will turn on.

On side of input section, the sensor signal feed to analog multiplexer after conditioning. This device used for bundling many sensor inputs signal data in one output. Therefore, the MCU can read single sensor data from many sensor inputs by generating and sending continuously channel selector bits to the multiplexer. Since other interface circuits like transistor array and solid state relay uses to drive high current load, this project is used. The MCU output pins has low current driving capacity and which used to isolating digital circuits from the rest power circuit ,and this is helpful to protect the digital system from unwanted Nosie generated from ac load and dc relays.

HMI (Human Machine Interface)

This is second sub component of the system. It permits the user to interact to real world.

The software contains GUI representation of every factory sub chamber with different Meters, Gauges, and Graphs etc. Therefore the user can monitor and control every factory chambers from a single computer. C#.net and other interface plate forms have been used to

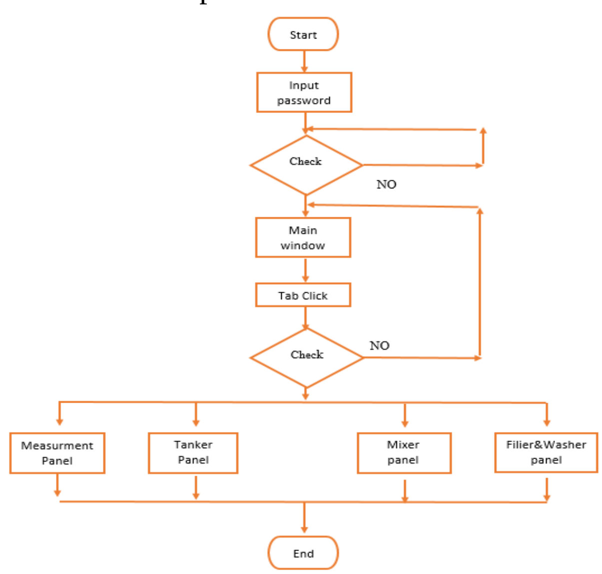


Figure 1.3 flow chart for HMI

develop the software.
Behind the GUI different code fragment written uses for serial communication protocol, system status animation, Data base communication, Process control.
In our context, the Supervisory control and Data Acquisition design belongs to liquid and detergent processing factory. In the past era as technology was not advanced, many industrial organizations were facing problems to perform their task in efficient way. Hence we try to solve this problem.
The factory has five working stations; these are tanker station, mixer station, bottle feeder station, filler station and packaging station. Therefore, in order to produce a single product, those chambers must be functionally working together in an integrated manner.

Inside tanker station, there are two tankers for the purpose of storing liquids that are supposed to be processed. After being stored there, they are delivered in a constant flow to a mixer station. Inside this station, liquids mixed together based on the desired ratio and stored to system reservoir and later added to filler tanker.
Parallel to this process, bottle feeder makes plastic or glass container ready and delivers them to the next chamber.
The filler station is responsible for filling ready bottles by adding liquid. Finally packaging station produced the final result by packing filled bottles properly. Hence, it is based on the above mentioned procedures that the SCADA system is designed.
Based on the above work flow the HMI was developed. The unique feature of our application software is that, the user can interact with HMI using Amharic language, any graphical displays, tenders and notice will use Amharic. The software also contains the option to turn the language to English.
Moreover, the system has password protection feature, so that the user must input user and password correctly in order to enter in to the main window panel.
The window panel contains four sub control panel. The first one is default panel which is the power panel. It contains power installation of the factories described schematically model, based on that the user can change the breaker position in order to control loads which is connected under the installation. GDI (graphical Drawing interface) used for making power line.

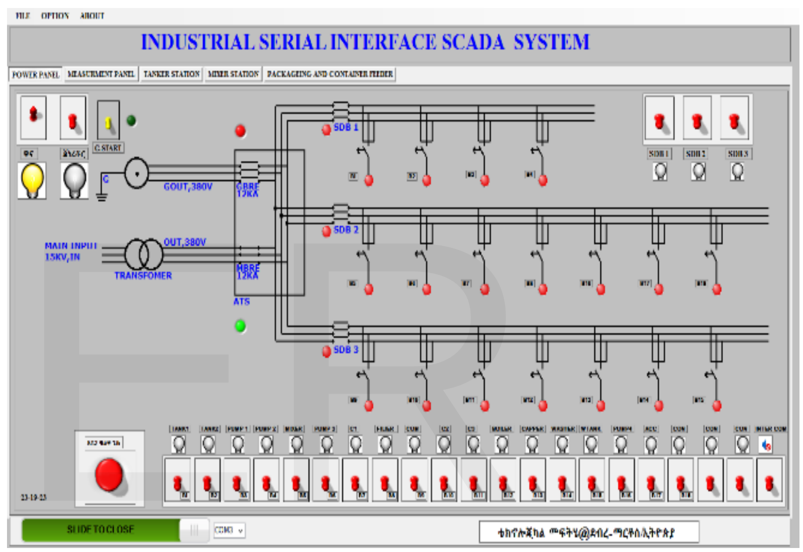


Figure 1.4 power control panel

The next one is power measurement panel. This panel contains variety of Gauges built in responsible for monitoring the incoming power measured data sent from SCADA hardware such as voltage, current, active power, apparent power, behind GUI there is different code fragment dedicated for calculating other parameters such as reactive power, power factor also contain power factor improvement algorithm. Based on those power measurements, the system tries to correct system total power factor in case when the system is running under low power factor. The software calculates the capacitor size to achieve the desired power factor amount and send command to SCADA hardware to have the right capacitor size from the capacitor banks to the system. In Addition, power is measured in every hour and stored inside the data base for further analysis and investigation.

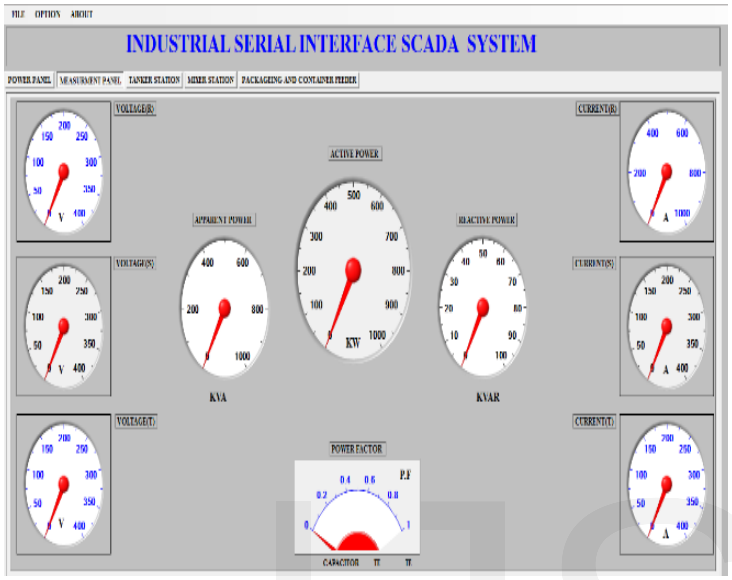


Figure 1.5 power measurement panel

The third panel is the tanker panel. This section contains two tankers for the purpose of storing two different liquids. Therefore with the aim of controlling tankers liquid level and temperature, the system contains controller and pumps independently. Hence, the process of filling liquids in to the tankers can be operated using two modes, either manual or automatically by changing the position mode selector switch fitted in GUI.

In the first mode which is “Manual Operation”, the user can fill the tanker manually by observing the status of the tanker on GUI (level animation display) done by adjusting knob.

In the second mode which is “Automatic Operation” can be done by using (PI) process controller algorithm of the system. For the purpose of doing it, the software will receive level data from SCADA hardware and then compare it to set point value to find the error. Then it will be multiplied by the gain and the result will be sent to SCADA hardware in order to manipulate the inlet valve (proportional controller). At the same time, errors are saved inside memory continuously for few seconds then multiply by the gain to add to the output (proportional + integral). This iteration will continue until the error is removed.

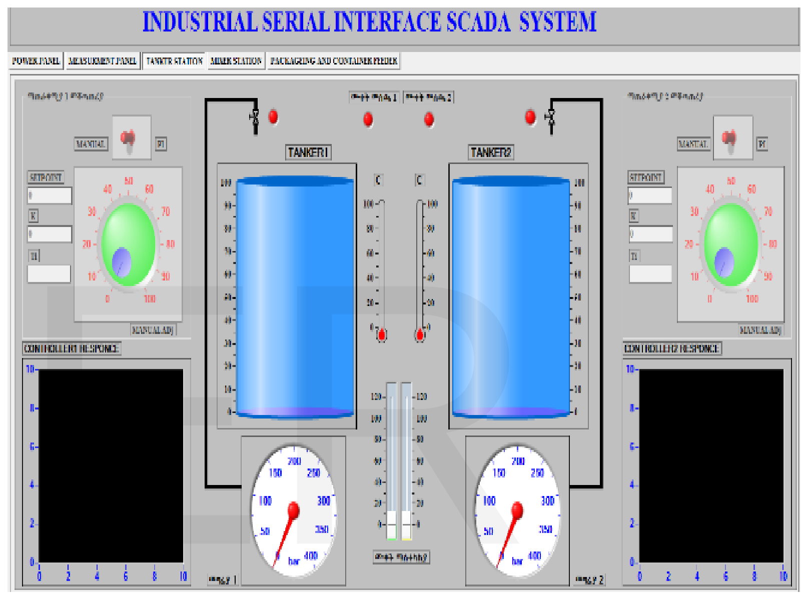


Figure 1.6 Tanker panel

This panel contains graphical representation of mixer and specifically tanker part of the filler machine. Two liquids which are stored in tanker station need to be mixed together in to one solution so that the mixer part performs this task automatically. But before the mixing starts, for the first round the user is expected to set mixture ratio. Later based on settled ratio two inlet valves will get its own position then liquids start to flow in to the mixer tanker. When the liquid reaches maximum level point, both inlet valves will be automatically shut down and the bleeder starts to rotate.

After liquids are appropriately mixed together, mixer tanker outlet valve will open and drain the mixed liquid to system reservoir; at this point one cycle will be completed. Further, the system reset itself to the starting point while the mixed liquid completely drained out from tanker. This iteration will continue until either power switch off or system fault occurs. If fault occurs inside the system, the software will announce the user to correct the error based on status text displayed on software notice textbox. There is electric liquid pump between system reservoir and filler tanker which is dedicated to load mixed liquid from system reservoir to filler tanker. This process has also its own PI Controller and manual filling method which is the same as the tanker section.

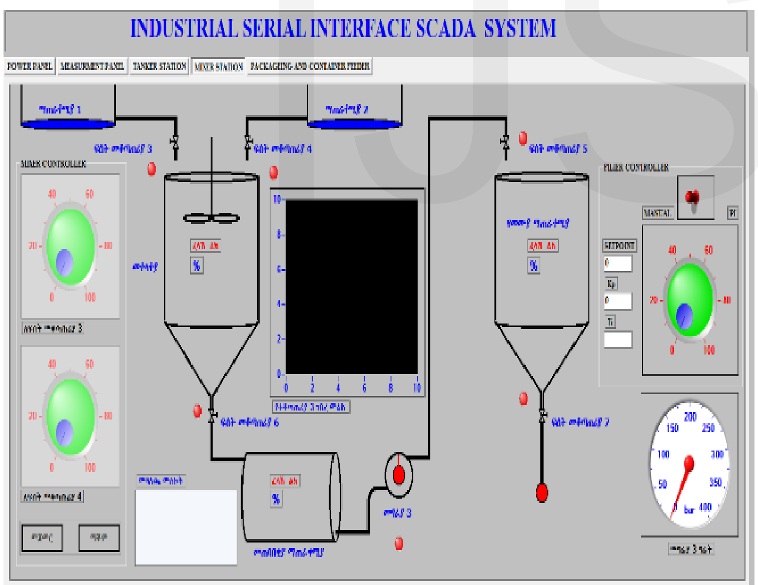


Figure 1.7 mixer panel

filler panel contains three different sub systems in one GUI panel. The first is bottle washer dedicated for cleaning or washing liquid containers which are supposed to be filled inside the filler section. The process of cleaning containers will be done by using steam and water. The bottle washer starts spinning and picks the container if it is available. And then conveyor one will start spraying hot steam inside the container after flip the position. And then, the process of adding pressured water takes place as the water used by the mechanical container tilting mechanism start to drain out of the container. After that, the container will be transferred to the filler section passing through conveyor 2.

Steam generator and water tanker are available in washer section. Since both of them use water as primary input material, one water pump is used for the purpose of filing the devices with water. Behind the GUI the HMI contains code fragment dedicated for maneging water pump to do

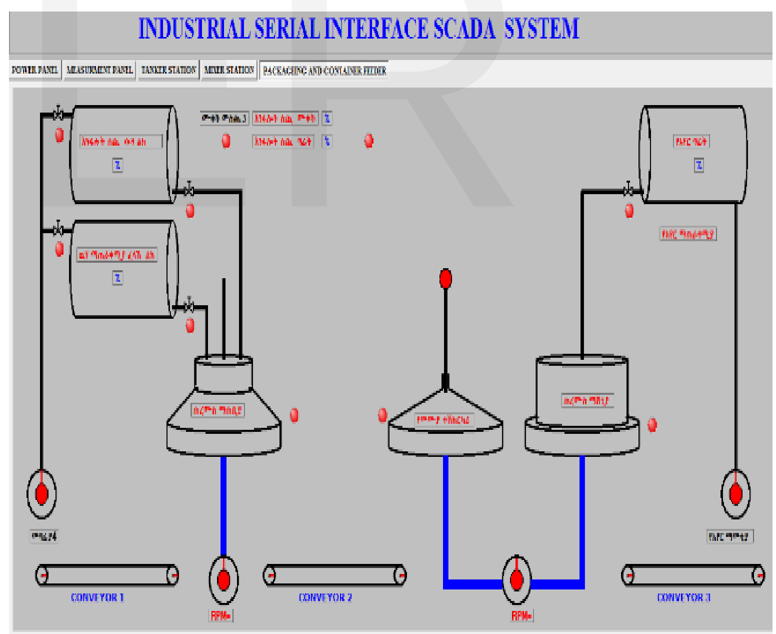


Figure 1.8 bottle washer and flier

effectively based on the incoming level sensor data. And also it contains on/off controller for regulating temperature, stem pressure and pneumatics air pressure. When container reach the final point at conveyor2 proximity sensor detect the Object and send signal to system controller, then filler pick the container and it starts to add liquid inside until the level reachs on the desired point. And Then it will transfer to capper machine. Finally, the container sealed. Notice that all sub section discussed above spin with constant and equal speed.

RESULTS

This section will describe the result and pragmatic outcome of the study which was implemented by developing appropriate protype and model. After completely designing HMI software and protype, the first thing we have tried to do in this project is sending serial data through computer serial port in to the SCADA hard ware in order to control loads which are connected under the system and we can control light bulbs directly form HMI by changing toggle switch position.

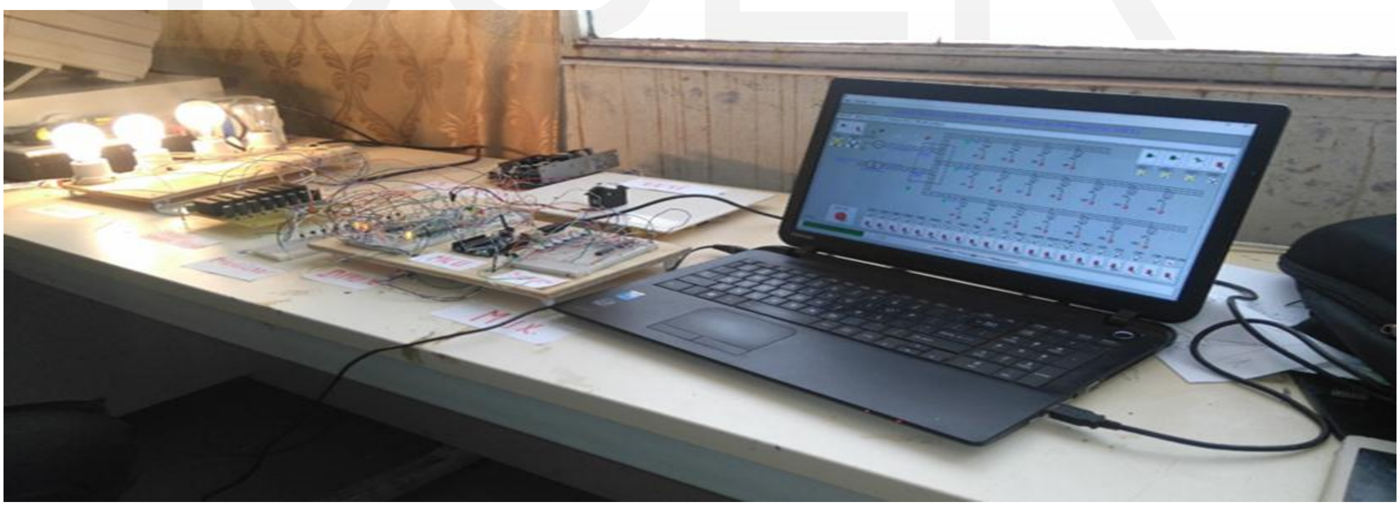
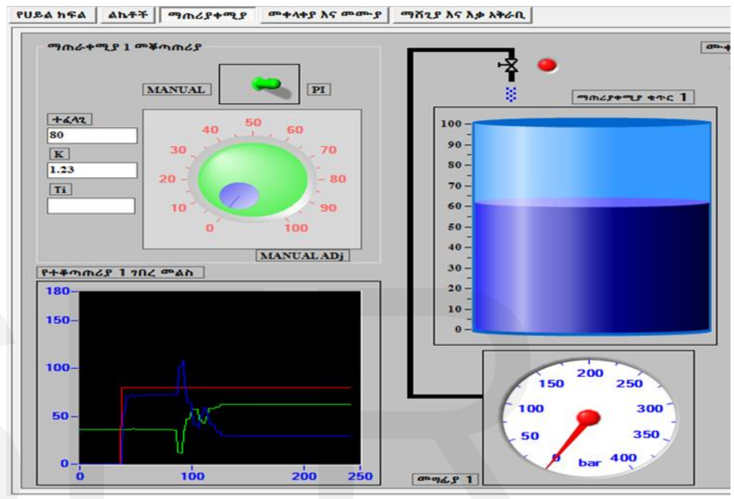


Figure 1.9 protype over view

The next step was sending sensor data from hardware to the software. It is only 200ms that our system takes to perform the above task. In the meantime, the system database store or update sensor data.

The third step is enabling the system autonomous feature. Meaning, the system, based on the incoming sensor data, has to take a decision of controlling the process, without human interference.

The figure below shows one of our controller responses under tanker section to maintain tankers level at desire point using PI controller.



2.0 Tanker controller response

The forth task we did is configuring the data base which belongs for storing real time measured data. We created Microsoft access database which has equal attributes with the number measurement that need to be stored for further analysis. We also have tried to link it with HMI software using C# program

HMI search engine by using working date as a primary key in to engine textbox. The figure below shows our sample stored and retrieved data's form database.

What we did in task sixth is trying to facilitatee self-automated mixer and washer filler machines. Every working environment in real operation time would be represented in the form of code .Before going to write the pseudo code, the first cycle is filling mixer tanker. We need to take consideration, It is own level data and in let valve position. After

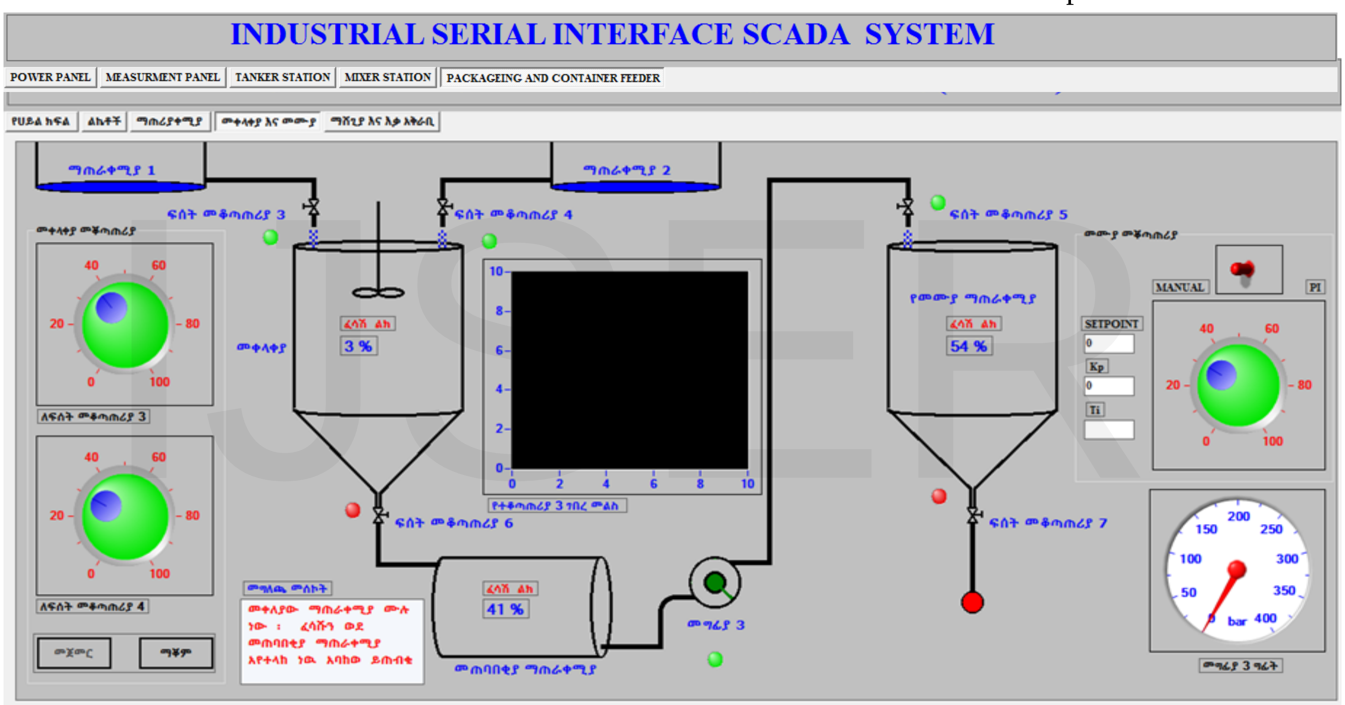


Figure 2.1 mixer station operations

By inserting necessarily namespace and references in to the pseudo C# code after configuring the database successfully crossing data. We created the time function in order to store and update a measured data to the database in every 200 millisecond continuously until the system aborts communicating to SCADA hardware. Finally we can store and retrieve stored data from

mixing the liquids, we need to take reservoir level data, mixer out let value position for the purpose of draining the system reservoir out.

The third step is loading liquid mixture to filler tanker through pump 3. To perform this, task reservoir level needs for pump protection, Filler tanker inlet valve position and filler system controller type. Based on the above pre request we tried to write the code. After a long

time of continues improvement we can achieve
control system showing tenders effectively.

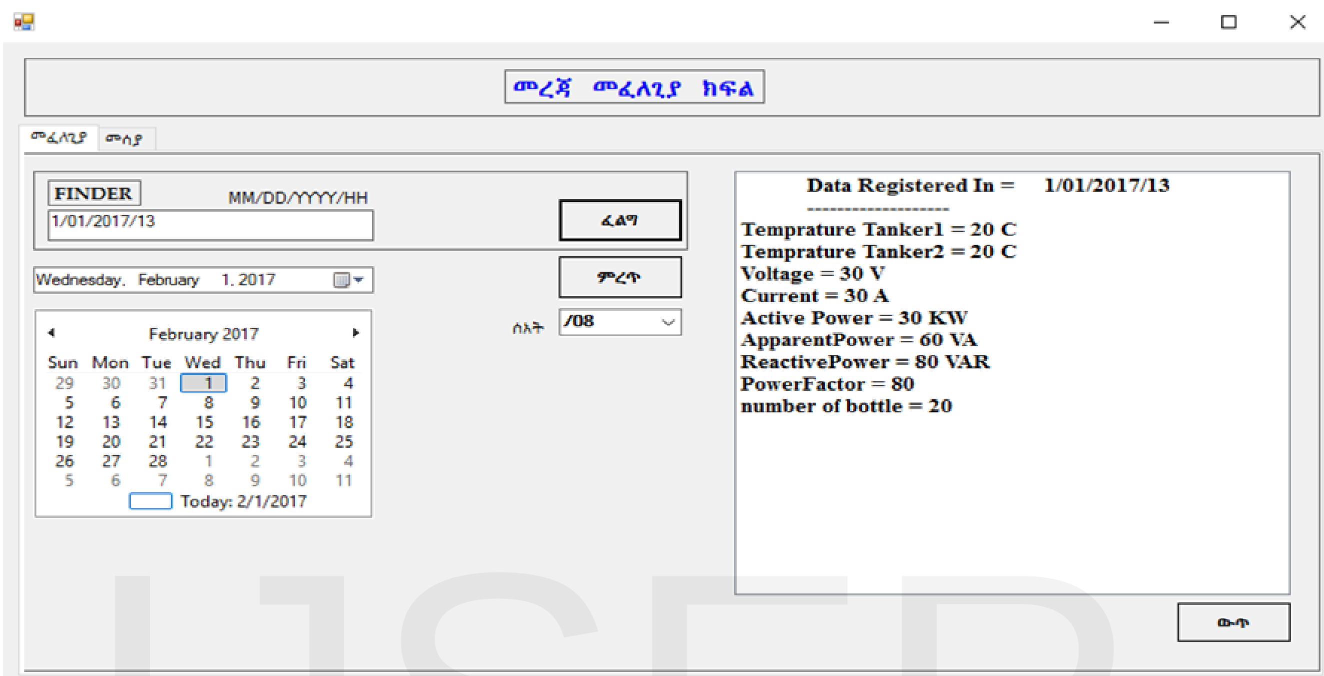


Figure 2.2 stored data at specific day

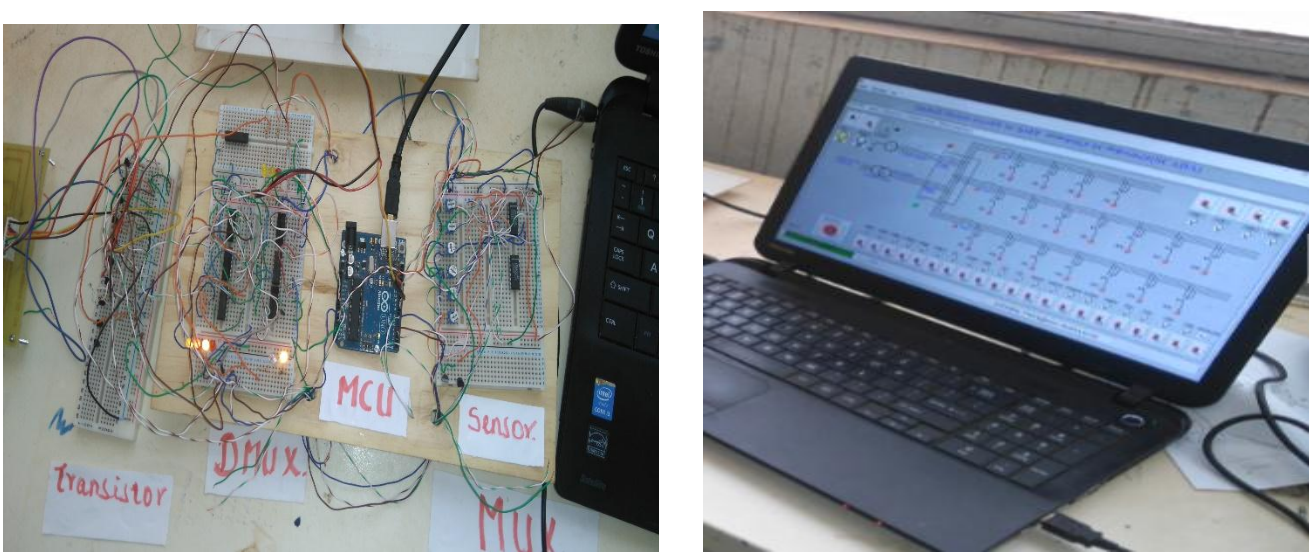


Figure 2.3 partial view of system protype

CONCLUSION

The SCADA system that is designed and prototyped in this project showed the potential of digital controlling systems to increase productivity in the Economy in general and the manufacturing sector in particular. Such automation systems can be installed in liquids and detergent factories for enhancing efficiency by reducing manual involvements during production.

In addition, the proposed system, even though it is specifically developed for liquid processing industries, can also be easily customized for other types of factories specialized in production of different types of materials. The system will have huge potential because the manufacturing sector ,in Ethiopia, is at infant stage and as the existing few factories are dominantly using manual system, Hence, automation systems should be adopted widely in our country and our system will have some contribution to cover this big hole in our development.

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Profile

Mr Tarkiu sinshaw(Msc)
Lecture at debremarkos university
Department of Electrical and Computer Engineering
Email: tareelectr@gmail.com
Tel: (+) 251-930-074749
Ethiopia

Heruye Mulugeta (Bsc)
Technical assistant at Debremarkos University
Department of Electrical and Computer Engineering
Email:- heruyem83@gmail.com.
Tel: (+) 251-913-783978
Ethiopia