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Design and Implementation of Smart Fault Detection System for Industrial Power House using PLC and SCADA

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ABSTRACT

This paper presents the use of SCADA (Supervisory Control and Data Acquisition) and PLC (Programmable Logic Controller) for fault detection in an industrial generation system along with test bench facility. This project is of immense importance on industrial scale as it ensures the safety of all the equipment used in the process. To prevent an industry from a bigger loss it is a one-time investment that is conventionally used. This system will provide online monitoring in control room of the generation system. This system will automatically detect the generation faults in field and these faults will be monitored on SCADA. If the system detects any kind of fault it will automatically shut down the generator. The generator can be switched on from petrol to gas using SCADA and can control and manage the distribution load with the help of our HMI. The system will detect the fault with the help of sensors which are installed on the generator then sensors will send the signal to PLC further monitored on SCADA. This project is not only limited to industrial use but it can also be used for domestic and commercial purposes.

Keywords: PLC, SCADA, Industrial Generation, Fault Detection

I. INTRODUCTION

Fault Detection System is very important in industries; it is one-time investment and can be very beneficial in preventing the accidents and saving human lives as well as economic loss. Many accidents have taken place due to fire that erupted as a result of generation failure that was not detected at the right time. Inorder to prevent any such disaster; steps should be taken by the industries to keep their power houses secure.

This paper provides a model for an automated smart power house which can detect faults and can manage distribution load. It also provides a real time monitoring of a power house and distribution load with the help of SCADA. The model was developed and tested by a prototype in which a generator was used and certain faults generated to test the efficiency of the model developed.

To develop a prototype model two PLC's on the concept of master and slave were used, Simens S7-300 and Trilogy FMD-1616 were the PLC's used .Siemens S7-300 worked on +ve 24v logic while Trilogy worked on –ve 24 v logic, so a relay module was to used to interconnect these two PLC's. Smoke, fire, carbon monoxide, gas leakage sensors were employed .Current sensor were used to detect the over current and mange distribution load and oxygen sensor was used to make the generation system efficient and green by monitoring the proportion of oxygen is measured with the help oxygen sensor which is installed at the exhaust of the generator.

Conventionally detecting any fault at distribution side was a hectic job as it consumed man power, lot of effort, time and cost. The model presented in this paper, on the other hand minimizes the human involvement, time, cost and effort. With the help of current sensor, over current can be detected in any distribution line and if the over current is detected, the power house will stop

automatically. Inorder to prevent any kind of loss, whether it is of human lives or any economic loss; some ranges of current are defined that shows low, medium and high output current. Plc was used to make the model automated and SCADA screens were used for the real time monitoring of the system.

II. METHODS AND MATERIAL

A. PLC AND SCADA

Programmable Logic Controller is a controller used for industrial manufacturing and automation processes. PLC consists of internal relay, timers, and close loop controllers. PLC can be programmed in different ways but Ladder programming is the most preferable. PLC is a computer which can be used for real time monitoring of the devices such that it can receive and send data via inputs and outputs. Before PLC's relays, timers were used in industries but due to the development of modern technology they were replaced by the PLC which has fast response as compared to them. PLC can be easily be modified by increasing the number of inputs and outputs. In this model we used two PLC's on a concept of master and slave, the first PLC is Siemens S7-300 and the other one is Trilogy FMD 1616.Inputs and Outputs of Siemens S7-300 can be easily increased by increasing the number of racks.

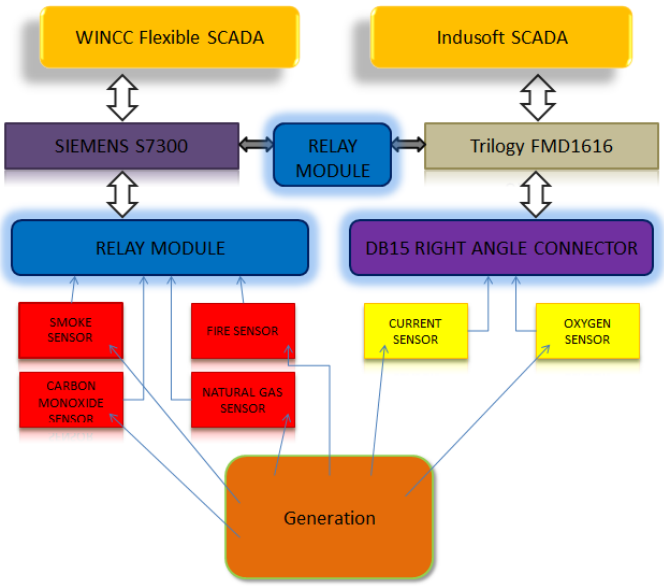
SCADA

SCADA is abbreviation of Supervisory Control and Data Acquisition. It is a graphical interface which allows the person to interact with different devices installed anywhere in the industry. With the help of SCADA we can monitor the whole system live and we can collect information of our system. With the help of SCADA any system can easily be maintained, monitored and controlled.

Monitoring and Controlling

Using this test bench the operator/supervisor/manager can constantly monitor the faults occurring in generator which is installed in power house. The model provides us opportunity to control the generator using SCADA screen; user can give command to start/stop the generator using SCADA screen. This paper presents the automated model for fault detection so whenever it detects any fault it will shut down the generator to prevent any kind of loss.

B. Block Diagram



The block diagram consists of:

1. Generation:

Synchronous Generator which is mechanically coupled with engine.

2. Smoke Sensor

Smoke detector is used to detect the smoke and it is installed on generation unit.In normal state when there is no smoke than it will give 0v at output.

3. Flame Sensor

It is used to detect the flame. In normal state when there is no flame or fire is detected it will give 5v at output.

4. Carbon Monoxide

In generation due to burning of fuel different harmful gases are produced. Carbon monoxide is one of them so; whenever it is produced this sensor will detect it and give 5v at output when CO is detected.

5. Natural Gas

A generator was used which had both options whether to run on petrol or gas.So if any gas leakage occurs it will detect it and sends 5v at output.

6. Current Sensor

Current transformers are the sensors that are used to measure the alternating current. We used RS 321 which can measure up to 30Ampere.

7. Oxygen Sensor

To make the system smart and efficient, an oxygen sensor at the exhaust of the generator was installed to continuously monitor the concentration of oxygen. Oxygen will be produced when incomplete combustion takes place.

8. Relay Module

PLC's operate on 24v and the outputs of sensors are 5v so to connect the PLC and sensor used relays.

9. PLC (Siemens S7-300)

Smoke, flame, carbon monoxide and natural gas sensors are connected to Siemens S7-300 through relay module. Generator can start /stop and the fuel options from gas to fuel using this PLC can be changed.

10. PLC (Trilogy FMD-1616)

Current and oxygen are analog sensors and they are connected to Trilogy PLC using DB-15 connector. Trends of oxygen and current sensor can also be monitored using this PLC.

11. SCADA Screen

It shows the status of sensors, generator and give live monitoring of all the process occurring at the field.

C. Methodology

Output of a generator passes through a current sensor such that whenever load increases the current also changes and we can easily monitor the load current. Oxygen sensor is installed on exhaust of the generator to monitor the concentration of the oxygen. In this the system is made green, efficient and environment friendly. Smoke, flame, carbon monoxide and natural gas sensor is installed on generator for safety purposes. Generator ignition switch, Start/Stop switch and fuel conversion switch are connected to the PLC with the help of relays. We are using two PLC's first PLC which is Siemens is Master and second PLC which is Trilogy is Slave. Trilogy plc will only monitor the analog sensors which are current and oxygen which will give data to Siemens (Master) plc with the help of this relay module. These are interconnected with the help of relays as shown in figure (a).

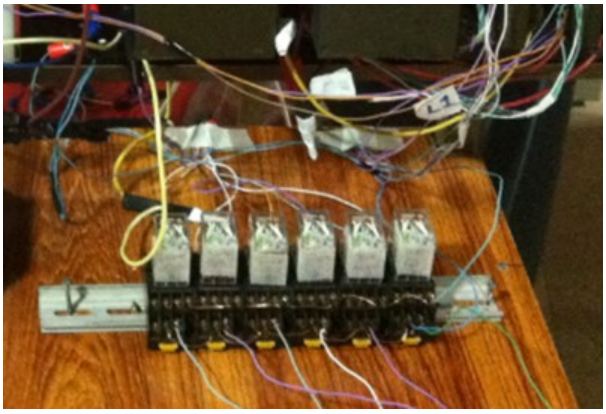


Figure (a)

In this paper a test bench or prototype model to produce the dummy faults is presented to check the working, safety and reliability of the system. Test bench is shown in figure (b) and Figure (c).

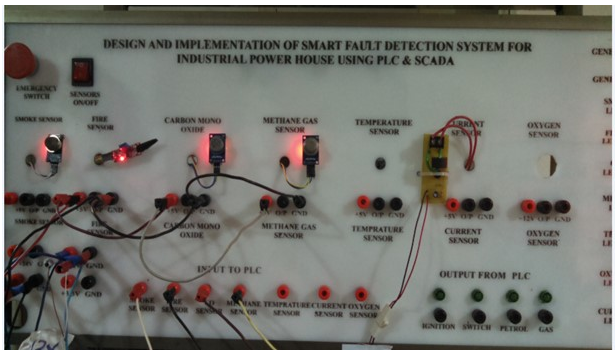


Figure (b)

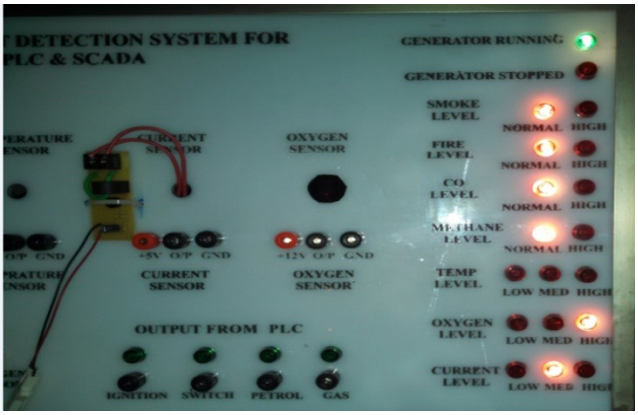
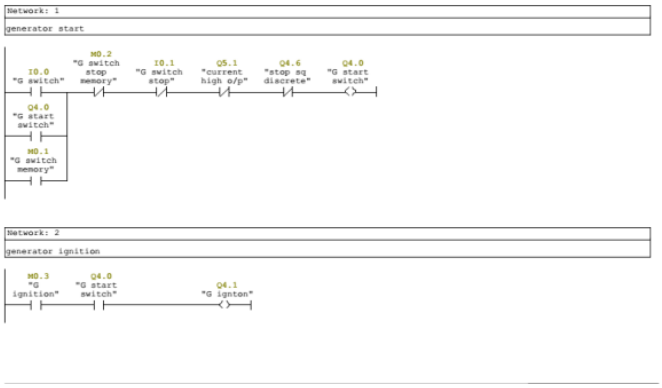
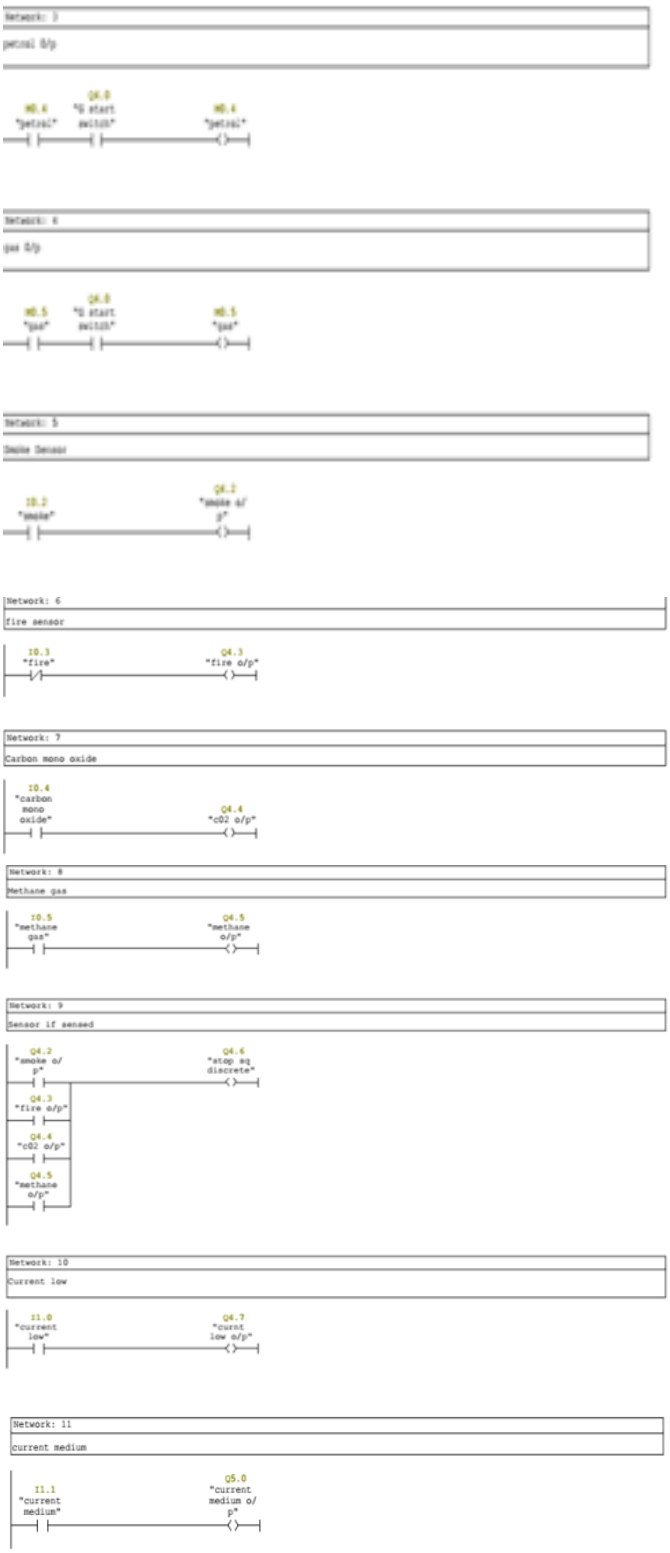


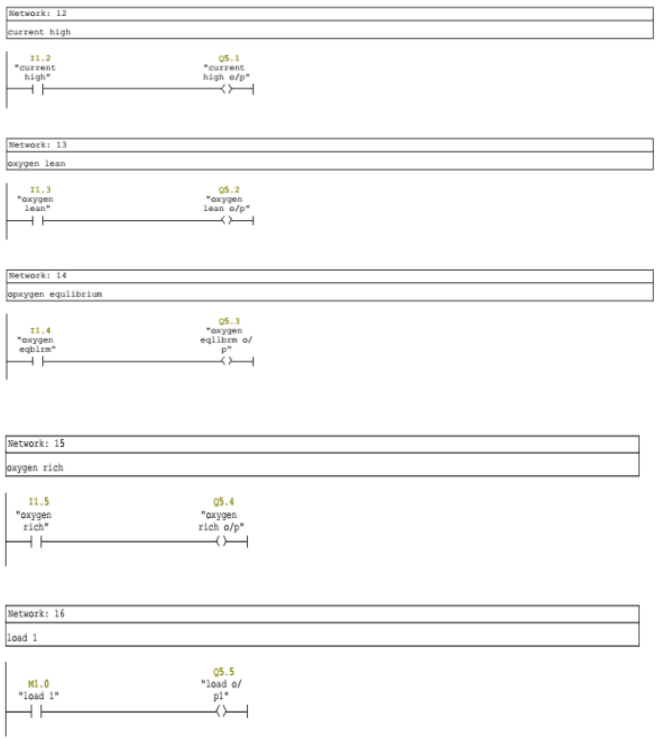
Figure (c)

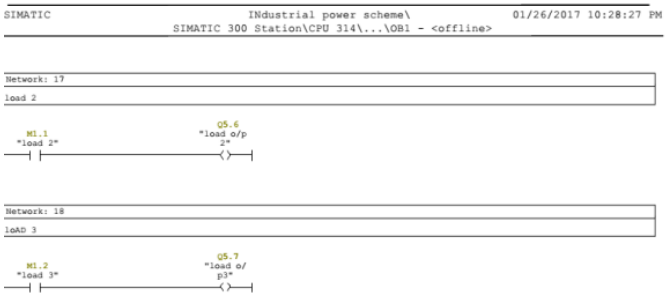
a. Ladder Diagram (Programming)

Siemens's Programming

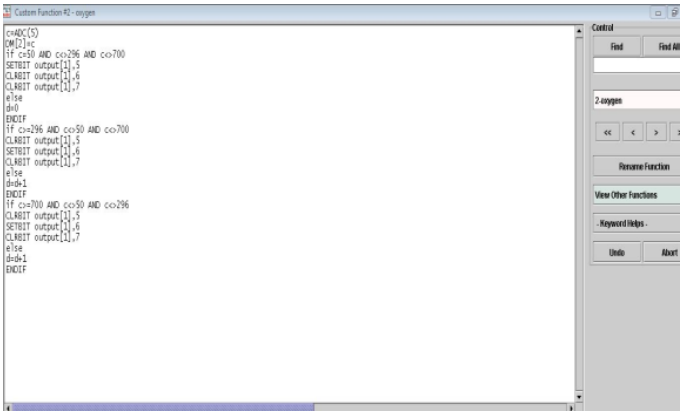


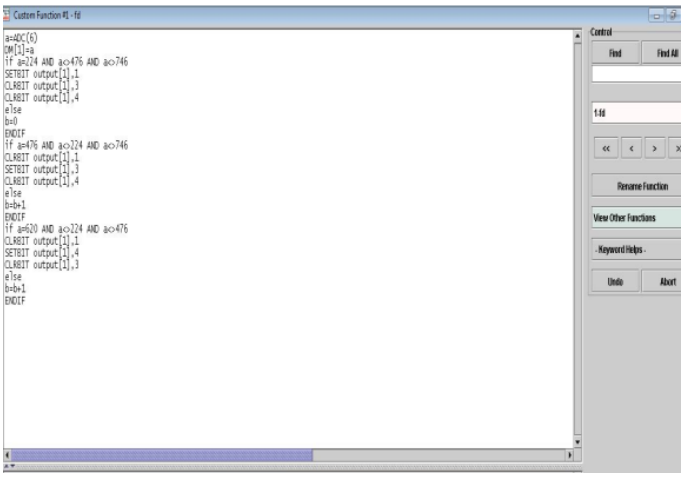






Trilogy's Programming





b. SCADA Screen

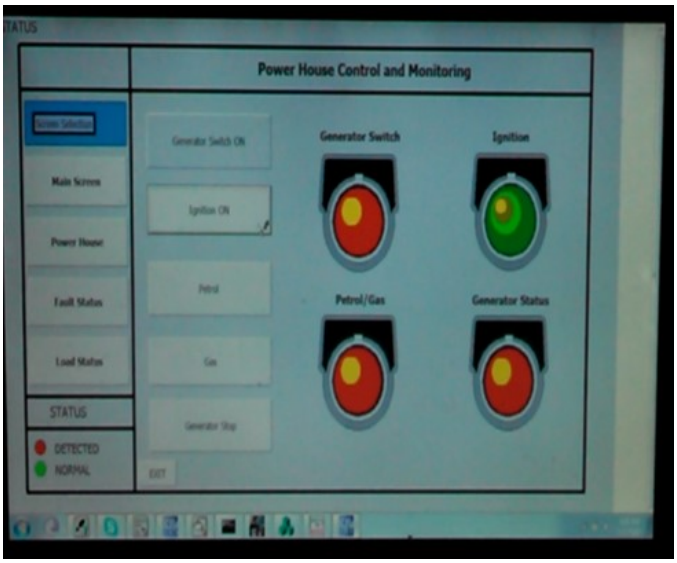


Figure (d) shows when generator starts running the ignition button is released, it works just like an ignition of a car works.

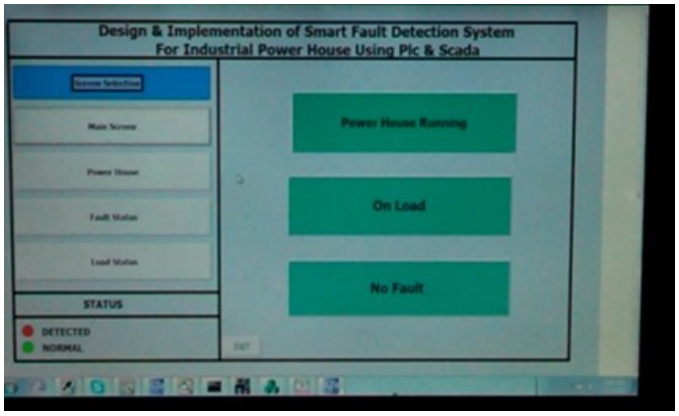


Figure (e) shows the Main Screen of the SCADA, this is showing that the Power House is running, a load is connected; consuming energy and no fault is detected at the moment.

Figure (f) is showing the Fault Status Screen. Also status of Generator is shown side by side.

III. RESULTS AND DISCUSSION

Figure (e) shows when the flame and smoke is detected the SCADA indicated it using the indication lamps. Also the Generator is turned off, as it can be seen from the lamps

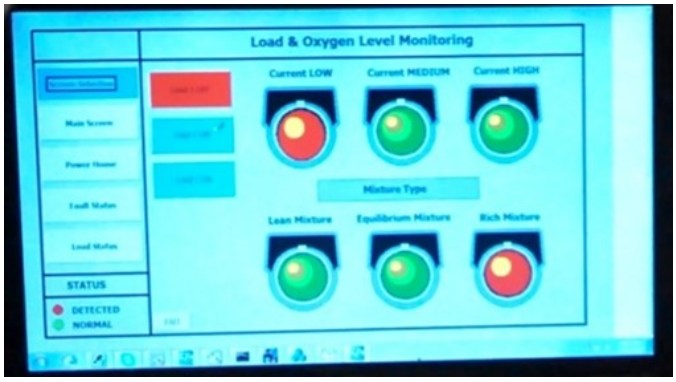


Figure (f) shows the only a single load is on i.e current low indication is on.And at this time Oxygen concentration is Rich

Figure (h) shows that 2nd load is on which is indicated by current medium lamp.

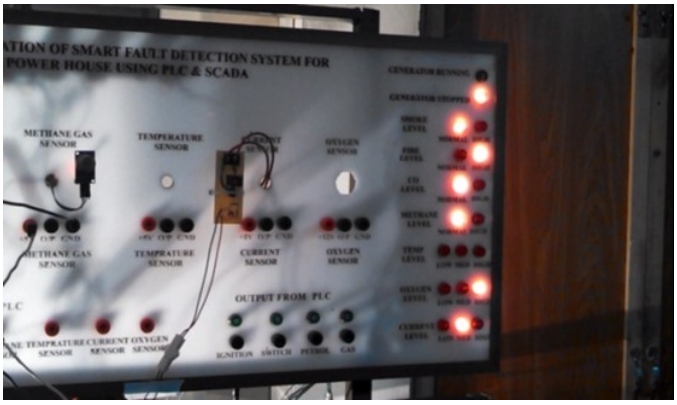


Figure (h) showing the indication of the detected flame as well as the indication that the Generator is turned off.

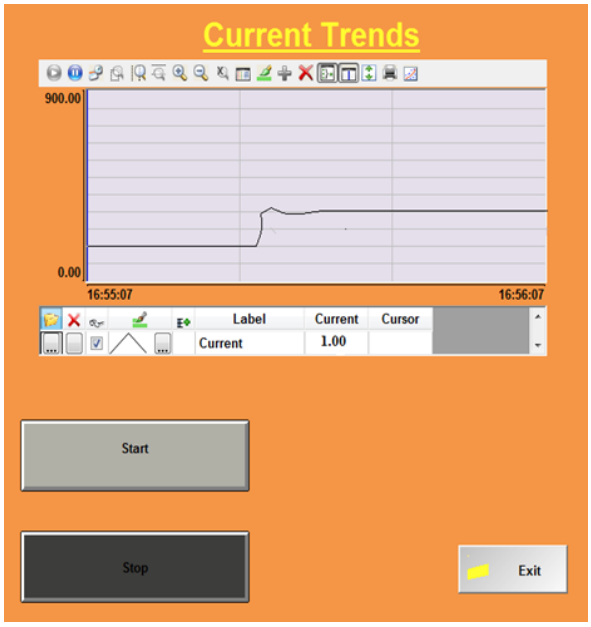


Figure (i) shows when no load is on is the graph is zero, when load one is on the graph of current rises from zero to some peak.

Figure (j) shows the equilibrium mixture of the oxygen. This shows the generator is running efficiently.

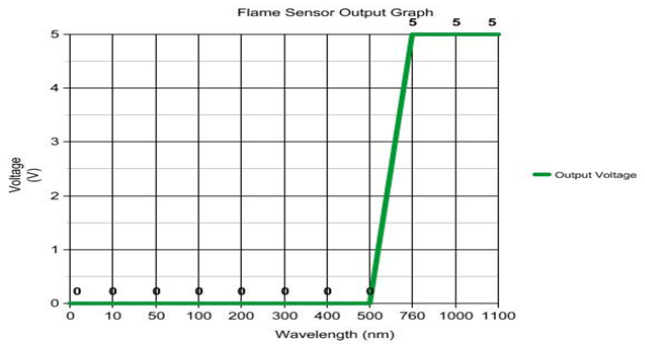


Figure (k) shows the output of flame sensor. When it detects the flame it will give 5v at output.

Above mentioned figures shows us that when this system detects any fault the generation system is shut down and this system is constantly measuring the current and proportion of the oxygen to make system smart and efficient.

IV. CONCLUSION

The proposed paper presents the solution for detection of faults at industrial power house, this system can be easily maintained and ladder language can be easily understood by any one. It also provides real-time monitoring of the equipment. With the help of SCADA screen you can start/stop and monitor the generation system.

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