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Design and Implementation of IoT Based Substation Automation for the Unit Service Switchgear in a Thermal Power Station

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ABSTRACT: The main aim of this project is to retrofit the existing analog based LT change over system into digitally controlled substation automation with IoT based technology to maintain un – interrupted power supply to the Unit Service Switchgear in a thermal power station at 415 V level with fail proof digital mechanism to diagnosis and online monitor the change in electrical parameters of the system. This retrofit allows the engineers to trouble shoot the cause of failure easily when the system mal-operates and allows putting back the system in quick time compared to the old system, since IoT enabled android mobile App also available the operator can able to control the operation remotely.

KEYWORDS: Unit Service Switchgear, Node-RED, Raspberry pi microcomputer, INA219Power sensors, Relays, Blynk and Internet of Things.

I. INTRODUCTION

Thermal power plant plays an important role in power generation network. In India, most of our power generation is obtained from coal based thermal power plants only. In a thermal power plant, there are number of electrical equipments used for various systems. They are operated various voltage levels such as 11 KV, 6.6 KV and 415 V etc. and controlled from relevant switchgear control rooms. Among all the switchgears, the Unit Service Switchgear is most important one because it handling the vital pumps such as Auxiliary Oil pumps, Lube oil pumps and Auxiliary Cooling water pumps and valves etc. Unit service switchgear has two separated buses named as unit service switchgear A and unit service switchgear B feed from two 6.6 KV / 433 V unit service transformers and interconnected with a Bus coupler. Normally, both buses are operating separately. When any one of the bus voltage goes to low level the healthy bus is extended through the bus coupler by automatically in auto mode or by manually in manual mode after satisfying relevant conditions. In the present system analog voltage and current values are used to operate the relays and complicated wiring circuits are used to operate the incomer and bus coupler breakers. The under voltage sensing of the relay is based on the analog VT input obtained from 415 V / 110 V voltage transformer and breaker trip or close commands are also given by electromechanical trip relays. Time taken for these operations is in order of few seconds. In addition to that, if any faults occur in this system it may taken few hours to few days to identify the fault and rectify it depending upon the fault type. Online monitoring and fault recording are not possible in this system. The generation loss is in order of lakhs if the change over scheme is not working properly.

So, we propose an embedded system using microcomputer and IoT sensors to monitor the bus voltages and current of the unit service switchgear continuously. The above data are constantly updated to the server using IOT. Based on the data's obtained from the sensors the controlling system controls the system to maintain uninterrupted supply to the pumps and valves if any abnormalities arise in the switchgear system. This system will help us to identify problems before any catastrophic failure, thus resulting in a hassle free operation of unit service switchgear. In addition to that, we can easily identify the faults and recover the supply at anywhere at any time with the help of smart mobile by mobile based IoT using blynk server.

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II. EXISTING SYSTEM

The existing system is working on auto and manual modes. In auto mode, change over occurs based on the analog voltage input which is given by a 415 V / 110 V Voltage Transformer and electromechanical relays with complicated control circuit. Manual change over are done by relevant switchgear operators or generator operators either local manual mode by TNC switch or remote manual mode by semaphore switch.

DISADVANTAGES OF EXISTING SYSTEM:

1. This system uses analog sensors to deduct the loss of voltage. Because of analog method and static relay mechanism, the relay contacts got struck often and lead to mal operation of the system.
2. If the system mal operates then it will be very difficult to trouble shoot the cause of the problem and this leads to loss generation.

III. PROPOSED USS AUTOMATION SYSTEM

The system proposed in this paper focuses on autonomously monitoring the current and voltage level of the unit service switchgear with the help of IoT sensors and microcomputer. The main aim of this project is to design and implementation of a low cost IoT based online wireless monitoring and controlling of a unit service switchgear in a thermal power plant to maintain un- interrupted power generation. In order to reduce the cost of the system, IBM open source graphical wiring tool (Node-RED) is used as the main controlling software. Windows/Linux HMI based substation automation for LT Change auto/manual change over with online monitoring using IoT technology of the electrical parameters of the system. In addition to that the event and disturbance are also recorded with time samples.

IV. METHODOLOGY

This system consisted of three main blocks namely the monitoring block (voltage and current sensors), the control system (microcomputer and relays) and the communication block (ADC convertor, WIFI module and IoT platform). The current and voltage sensors are monitoring the bus side current and voltage of the unit service switchgear A and B as well as the incomer and bus coupler breaker status. All sensors are interfaced with the microcomputer unit. This Wi-Fi enabled microcomputer can be easily connected to personal computers by using web HMI to monitoring the parameters remotely. The low voltage setting details and the logics build for change over scheme are fed into the microcomputer. And all the digital values obtained from the sensors are fed into the microcomputer for further processing. The microcomputer analyses all the values with the set values. If any abnormalities arise, the microcomputer alerts the maintenance engineer and automatically controls the breakers to restore the unit service switchgear normal condition in auto mode. These controls can be done by the maintenance engineer in manual mode. The microcomputer is programmed using Node-RED software to perform all the above tasks based on the requirement of the concern maintenance engineer. All the data are uploaded on to cloud using WiFi modules instantly and continuously. So, the maintenance engineer can easily monitor and control everything at everywhere through his personal computer by using NodeRED or his mobile by using Blynk server with the help of Internet of Things.

ADVANTAGES OF PROPOSED SYSTEM:

3. Accurate change over with minimum time is possible in the event of low voltage.
4. Sequence of events and disturbance handling are monitored at anywhere and recorded data can be obtained at any time.
5. Reduce time of equipments.
6. Reduces loss of generation.
7. Easy trouble shoots.

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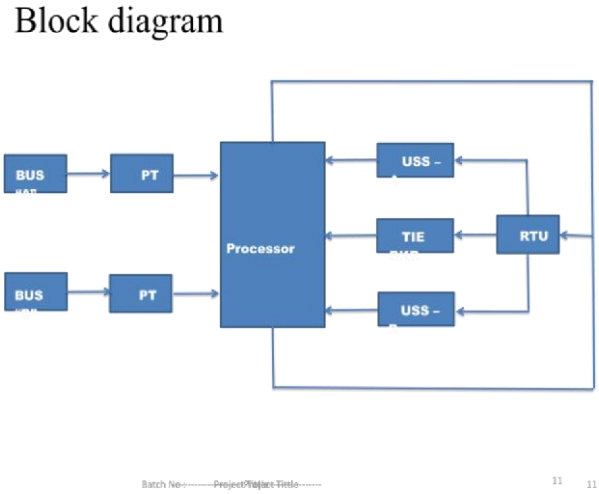

Fig.1 Block diagram representation of prototype of USS automation.

V. HARDWARE COMPONENTS

Micro Controller: In this project raspberry pi is used as micro controller. A Raspberry Pi is a general-purpose computer, usually with a Linux operating system, and the ability to run multiple programs. It is a mini computer with Raspbian OS.Itcan run multiple programs at a time. It requires complex taskslike installing libraries and software for interfacing sensors andother components. Raspberry Pi can be easily connected to theinternet using Ethernet port and USB Wi-Fi dongles. Raspberry Pi did not have storage on board. It provides an SD card port. Raspberry Pi has 4 USB ports to connect different devices. The processor used is from ARM family. The Recommended programming language is python but C, C++, Python, ruby are pre-installed. The raspberry pi analysis the input voltages, current and logics and execute the change over if necessary.

Transformer: In this prototype USS automation system, 2 nos. 230/0-9V steps down transformers were used to form unit service switchgear A and B. It consists of two windings and works on the principle of mutual induction. The output voltage of the PT was 9 Volts.

Current & Voltage Sensors: The INA219 was used as sensors in this system. It is a current shunt and power monitor with an I2C- or SMBUS- compatible interface. The INA219 senses across shunts on buses that can vary from 0 to 26 V. The operating voltage of these sensors is 3 to 5 V and they measure DC parameters only. Hence the secondary voltage of the transformer (09 volts) is converted into DC with the help of bridge diode and then it was reduced to 5 volts by DC-DC buck convertor and filter circuit. These 5 volts were used in this prototype model of DT monitoring.

Relay: A relay is an electrical switch that uses an electromagnet to move the switch from Off to On position instead of a person moving the switch. It takes a relatively small amount of power to turn on a relay but the relay can control something that draw much more power.

Buck DC/DC Converters: The buck converter is a very simple type of DC-DC converter that produces an output voltage that is less than its input. The buck converter is so named because the inductor always “bucks” or acts against the input voltage. The output voltage of an ideal buck converter is equal to the product of the switching duty cycle and the supply voltage. In this project, two number DC-DC buck convertors are used to matching the bus voltage of USS A and B.

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Bridge Rectifier:ABridgerectifierisanAlternatingCurrent(AC)toDirectCurrent(DC)converterthat rectifies mains AC input to DC output. Bridge Rectifiers are widely used in power supplies that provide necessary DC voltage for the electronic components or devices. They can be constructed with four or more diodes or any other controlled solid state switches. The operating voltage of these sensors is 3 to 5 V and they measure DC parameters only. Hence the secondary voltage of the transformer (09 volts) is converted into DC with the help of bridge diode.

Loads: In this project, LED lamps with 5 V and 1.2 W were used as connected loads of switchgear end.

VI. SOFTWARE USED

Node-RED: Node-RED is a flow-based development tool developed originally by IBM for wiring together hardware devices, APIs and online services as part of the Internet of Things. **Node-Red**in its simplest form is an open source visual editor for wiring the internet of things produced by IBM.

Blynk: Blynk Server is an Open-Source Netty based Java Server, responsible for forwarding messages between Blynk mobile application and various micro controller boards and SBCs. Blynk is an Internet of Things platform aimed to simplify building mobile and web applications for the Internet of Thing**s. Blynk** is a Platform with IOS and Android apps to control Arduino, Raspberry Pi and the likes over the Internet. It's a digital dashboard where you can build a graphic interface for your project by simply dragging and dropping widgets.

Javascript: Java Script often abbreviated as JS, is a highlevel, interpreted programming language. It is a language which is also characterized asdynamic, weakly typed, prototype based and multi-paradigm.

VII. HARDWARE

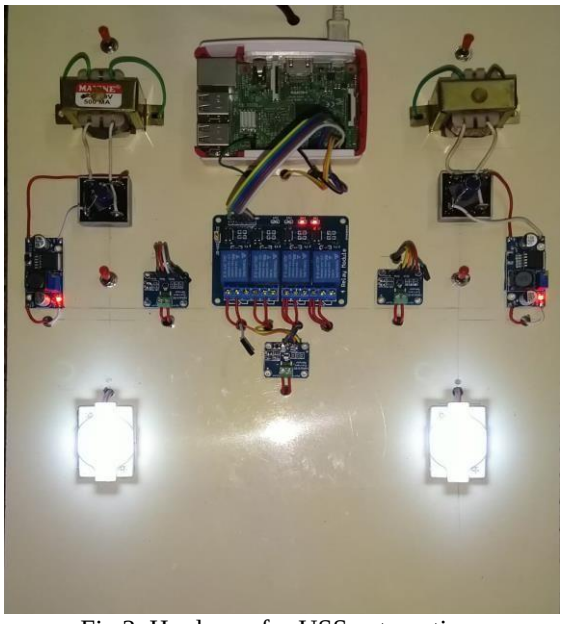

Fig.2. Hardware for USS automation.

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VIII. RESULTS AND DISCUSSION

The prototype model of this project is implemented on hardware and finally it gave results as follows.

1. Smooth and fast auto Changeover was obtained when low voltage is sensing any one of the switchgear.
2. Sequence of operations and faults were recorded continuously.
3. All the operations were checked in manual and auto mode via PC and smart mobile phone.

The Node-RED dashboard for this project is as follows.

A. CONTROL WINDOW

Fig.3. Control window of USS change over

B. TRENDING WINDOW OF USS A & B

Fig.4. Trending window of USS A & B

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C. TRENDING WINDOW OF BUS COUPLER

Fig.5. Trending window of bus coupler

D. CPU MONITORING

Fig.6. CPU monitoring

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Fig.7. Control Window

E. MOBILE WINDOW

Fig. 8. Bus coupler window

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Fig. 9. USS A monitoring

Fig. 10. USS B monitoring

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The prototype hardware model of the above project was tested in a two separate single phase 230/0-9 V transformers with two connected loads and the system worked perfectly. Auto and manual change over operations done perfectly. It gave the alert messages and disturbance records at every instant of time

VIII.CONCLUTION

This paper developed an automated system based on the concept of Internet of Things (IoT) that continuously monitored the important parameters like current and voltage of Unit service switchgear. It successfully monitored and controlled the breakers and carried out the change over during low voltage occurs at any one of the switchgear. It gave the alert messages and recorded everything at every instant of time. The proposed system can always be improvised and taken forward to generation network of any dimension.

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