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Distributed Power Systems Automation using SCADA System

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Abstract: Electricity plays a vital role in both day to day life of people and the economic development of a nation. Though the demand and generation of electric power have kept on increasing at comet's pace, maintaining systems' reliability has been an issue we are struggling with today. To ensure a sustainable supply of electricity and energy security, the efficient management of the electricity distribution network through the use of intelligent devices that can monitor and control power flows in real time has become necessary. In order to bring efficiency and sustainability in the electricity distribution sector, automation of the same using SCADA system is mentioned in this paper; wherein components of the SCADA systems, its operating principle, advantages, disadvantages and other applications are also explained. The overall objective of this paper is to ensure 24*7 stable supply of electricity to all consumers, reduce losses and equipment failure rate, and increase the efficiency of the systems through automation of distributed power systems using SCADA system.

Keywords: Distribution Systems, SCADA, RTU, RMU, FRTU, Master Controller.

I. INTRODUCTION

Power systems constitute an indispensable part in the development of a nation through which various services and manufacturing sectors work round the clock towards our betterment. Modern day cities in our country house various business houses which collectively contribute towards the GDP of our nation. A day without electricity has the potential to create enough unrest and chaos in our modern day society. Apart from this, there are various emergency services that must be continuously supplied power like hospitals where the lives of many patients are at stake. Maintaining national security is an issue of utmost importance which also requires monitoring and transfer of highly confidential data.

These services are possible with the availability of a sustained, reliable and good quality of the electric power supply. Nevertheless, electric power distribution networks are susceptible to interruptions caused by a variety of reasons such as adverse weather conditions, equipment failure, accidents, etc. Electric utilities must meet the increasing demand for reliable power distribution while coping with decreasing tolerance for disruptions and outages. More than ever, utilities are squeezed to do more with less and recognize the need to improve the efficiency of their power generation and distribution systems.

The Electricity Distribution Companies (EDC) normally identify the faulty section of the network and restore the power supply using their own resources which are mostly based on classical methods and techniques. Fortunately, many areas of the existing electrical distribution system can be improved through automation. This allows faster confirmation of correct equipment operation and detection of unexpected equipment operations, as well as increased accuracy of fault location and analysis. Furthermore, by automating the distribution system now, utilities will be ready to meet the challenges of integrating intermittent supply sources like solar, wind and other Distributed Energy Resources (DERs).

Automating electrical distribution systems by implementing a Supervisory Control And Data Acquisition (SCADA) system is one of the most cost-effective solutions for improving reliability, increasing utilization and cutting costs. SCADA systems are widely used for supervisory control and data acquisition of diverse kind of processes.

The main objective of this work is to show the need for the automation for EDC on their distribution networks and the importance of using a computer-based system towards sustainable development of their services.

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II. COMPONENTS OF SCADA SYSTEM

2.1 Remote Terminal Unit (RTU)

RTU is the heart of the SCADA system. A Remote Terminal Unit (RTU) is a microprocessor controlled electronic device that interfaces objects in the physical world to a distributed control system or SCADA (Supervisory Control And Data Acquisition) system by transmitting telemetry data to a master system, and by using messages from the master supervisory system to control connected objects. RTU functions collecting and processing the digits status inputs, analog inputs and transmitting to master stations. Receiving and processing digital and analog control commands from master stations. Acting as data concentrator for acquiring data from slave RTUs and exercising supervisory control on lave RTUs using IEC60870-5-101 and 60870-5-104 protocol. RTU consists of a multifunction transducer (MFT) which has versatile capabilities for electrical parameter monitoring and communication. It measures all sought of electrical parameters including Voltage, Current, PF, Power, and Energy and gives it to RTU comport from where it is transmitted to Master controller through a modem. MFT meter is fitted in the breaker panel.

Fig 1.Remote Terminal Unit (RTU)

There are two relays deliver digital input and output signals to and from the Master controller.

1. Contact multiplying relay (CMR) for digital input signals.

2. Heavy duty relay (HDR) for output signals.

2.2 Ring Main Unit (RMU)

RMU is a compact, enclosed and sealed type of Switchgear used for medium voltage power distribution. It is a complete Switchgear in itself. A complete Switchgear means, assembly of required switching devices, protection device as well as the metering device. It is mainly implied in RING DISTRIBUTION NETWORK. The incomer feeder is protected via, either Vacuum Circuit Breaker or SF_6 Circuit Breaker with associated Disconnect Switch and Earth Switch.

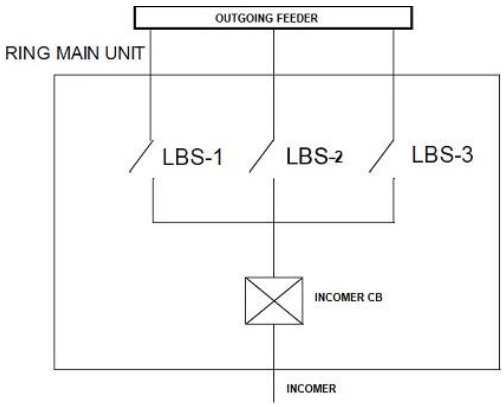

Fig 2.Ring Main Unit (RMU)

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Outgoing feeder comprises of Load Break Switches with associated Disconnect Switch and Earth Switch. Provision for cable connection is provided in an outgoing feeder. The Load Break Switch is nothing but an isolator having the capability of breaking the circuit during on load condition.

Current Transformer of a suitable ratio (as demanded by the user) is installed in the incomer feeder. The secondary of this CT is connected to a self-powered relay for necessary protection.

A self-powered protection device is also mounted on the Ring Main Unit, RMU. This relay is microprocessor based Numerical Relay with the user interface. This relay provides limited protection such as Over Current and Earth Fault protection.

In a distribution system, RMU is widely used as it is a complete package and only needs installation and cable connection. Everything else is within the package. This greatly reduces the commissioning time.

2.3 Feeder Remote Terminal Unit (FRTU)

Feeder Remote Terminal Unit (FRTU) is an intelligent electronic device designed for use in feeder automation. The device acquires data from the feeders (like RMUs, distribution transformers, etc.) & transfers it to the main Control Station.

FRTU is similar to RTU, only it is used on the consumer side to transfer data from consumer substation to control center. FRTU is highly modular, featuring flexibility to interchange its I/O modules which provide an advantage of easy maintenance & upgradation.

Fig 3.Feeder Remote Terminal Unit (FRTU)

The FRTU is ideally suited to Distribution Automation where it can monitor ground mounted RMUs as well as offering a cost-effective solution for extensible MV/LV switchgear applications and LV feeder monitoring. FRTU is always used with RMU unit and they are mounted on the same station.

2.4 Fault Passage Indicator

When reliable and fast indication of the failure section is needed after a short circuit, the fault detectors are a must-have. Fault passage indicator is used to detect short circuit failures or phase-to-earth faults in electric power distribution networks. It is based on the principle Ir+Iy+Ib=0. It consists of an LED which glows when a fault occurs and a communication circuit which alerts the control system.

Fig 4.Feeder Remote Terminal Unit (FRTU)

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A fault passage indicator consists of a sensor and an indicator. The sensor will be a core balance current transformer (CBCT) coil. These are spilled open type CT, which are fitted on the RMU unit of open ring type network.

WORKING PRINCIPLE: when there is a fault at a point on feeder the current flows in reverse direction from the point of fault. This triggers the FPI as the CBCT is unbalanced due to reverse current. FPI is to be used in DMS (Distribution management system) system along with RMU unit.

2.5 Master controller

The master station gathers data from the various RTUs and generally provide an operator interface for display of information and control of the remote sites. In large telemetry systems, sub-master sites gather information from remote sites and act as a relay back to the control master station.

Fig 5.Master controller

Master controller is on Distribution management center DMS.

III.HOW SCADA WORKS

3.1 For data acquisition:

In case of data analysis/ acquiring data of field equipment, the digital input signals from the field are given to CMR from where the signals come to digital input card on RTU. Then RTU transmits these digital signals to master controller through the router. In this way, the signals are transmitted to the master controller through SCADA.

Other station signals and transformer signals are also interfaced to the master controller by RTU.

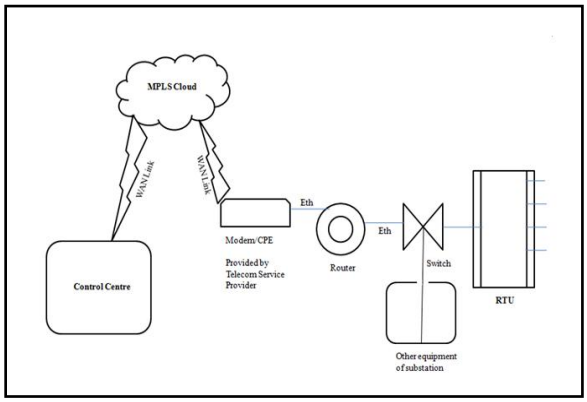

Fig 6.Block diagram of the SCADA system

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3.2 For supervisory control:

In case of controlling the field equipment through the DMS control center, the digital output signals are given from master controller to RTU through communication.

These signals arrive on digital output card on RTU and from where it goes to station equipment through heavy duty relay HDR. All paragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified.

IV. ADVANTAGES OF SCADA SYSTEM

1. Real-Time Monitoring & Control

2. Faster Identification & Restoration of faults, a supply of Quality power, Improve Reliability

3. Reduction in AT&C Losses

4. Quick decision making during interruptions as the entire information is available at one central location.

5. Better assistance to field staff in localizing faulty section by utilizing FPI's at DMS Stations.

6. Reduction in time for fault identification and restoration.

7. Increased safety standards

8. Automatic load shedding schemes based on real-time data.

9. Historical database for network analysis, planning, and design.

V. DISADVANTAGES OF SCADA SYSTEM

1. SCADA system is complex in terms of hardware units and dependent modules.

2. As the system is complex, it requires skilled operators, analysts, and programmers to maintain SCADA system.

3. Installation costs are higher.

4. The system increases unemployment rates.

VI. APPLICATIONS OF SCADA SYSTEM

SCADA can be used to manage any kind of equipment. Typically, SCADA systems are used to automate complex industrial processes where human control is difficult. For example in systems where there are more control factors unable to be managed by operators in a control center. SCADA systems are widely used for control in the following domains:

1. **Electric power generation, transmission and distribution:**

Electric utilities use SCADA systems to detect current flow and line voltage, to monitor the operation of circuit breakers, and to take sections of the power grid online or offline.

2. **Water and sewage**:

State and municipal water utilities use SCADA to monitor and regulate water flow, reservoir levels, pipe pressure, and other factors.

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3. **Buildings, facilities and environments:**

Facility managers use SCADA to control HVAC refrigeration units, lighting, and entry systems.

4. **Manufacturing:**

SCADA systems manage parts inventories for just-in-time manufacturing, regulate industrial automation and robots, and monitor process and quality control.

5. **Mass transit**:

Transit authorities use SCADA to regulate electricity to subways, trams, and trolleybuses; to automate traffic signals for rail systems; to track and locate trains and buses; and to control railroad crossing gates.

6. **Traffic signals**:

SCADA regulates traffic lights, controls traffic flow and detects out-of-order signals.

VII. CONCLUSION

SCADA is a system for acquiring and controlling the numerous devices placed on an electrical grid. SCADA/DMS is used to measure the voltage, current, active power, reactive power, power factor, etc., acquiring the status of switches, protection relays and faults of Feeder Terminal Unit (FTU), and controlling switches and relays from the control center. Typically, a Remote Terminal Unit (RTU) acts as an intermediate device between the control center and Intelligent Electronic Devices (IEDs) on the grid. The communication requirements for SCADA are very stringent.

Distribution Automation involves employing automation elements at various places on the electricity grid such as Ring Main Units (RMUs), distribution transformers, reclosers, etc. This centralized monitoring and control of the distribution networks improve the reliability and efficiency of the electrical network.

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