

AUTOMATION OF POWER DISTRIBUTION USING SCADA

ABSTRACT

In every substation certain measurements, supervision, control, operation and protection functions are necessary. Traditionally these functions were performed manually by system operator from control rooms. With the progress in digital electronics data processing data communication and microprocessors, a host of new devices and systems are being introduced for power system automation.

Power Distribution Automation function is to deliver electricity in a stable and efficient manner to consumers. Power utilities are adopting computer aided monitoring, control and management of electric power distribution system to provide better services to consumers. The demand of reduced outage rates (both quality and duration) has led most electric companies to reconfigure their distribution networks. Distribution automation systems provide utilities the ability to optimize the operations of distribution systems and directly improve reliability.

The focus of electric R&D activities worldwide is to automate electric power distribution system, utilizing recent advancement in the area of IT and data communication system. SCADA is a based programmable and distributed supervisory control and data acquisition system. This is the latest trend in power system protection and control.

INTRODUCTION

The distribution automation system is based on integrated technology, which involves collecting data and analyzing information to make control decisions, implementing the appropriate control decision in the field and also verifying that desired result is achieved. Adding targeted distribution automation capabilities can be especially economical when they are an extension of existing investments in SCADA and in system operations.

Traditionally, the protective system comprising of relays and circuit breaker were almost independent control systems for tap changer control, voltage control, data logging, and data monitoring and routine operations. Before 1985, the protective functions were segregated from control functions.

With traditional electromechanical relays and earlier generation of hard-wired static relays, the functions of protection systems were limited to sensing faults and abnormal condition, giving alarm, tripping circuit breaker, auto enclosing of circuit breakers. Data logging and some control and supervision functions were manually performed by system operated from control rooms. In traditional substation controls the three functions i.e., protection, control and monitoring were not integrated fully.

In modern automatic SCADA systems, the functions are interlinked by means of digital processing devices and power line carrier/radio communication links. Every power/substation has a control room the relay and protection panels and control panels and man machine interface (MMI) installed in the control room.

With the development of programmable digital systems i.e, microprocessor based SCADA systems, the entire supervisory functions, control functions, protective functions can be combined. The main function of distribution SCADA is to control and supervision of distribution of power to various consumers with minimum outage and minimum loss.

NEED FOR DISTRIBUTION AUTOMATION:

Due to lack of information at the base station (33kv substation) on the loading and health status of the 11kv/415v transformer with associated feeders is one of the primary causes of inefficient power distribution. Due to absence of monitoring, overloading occurs which results in low voltage at the customer end and increases the risk of frequent breakdown of transformers and feeders. In fact, the transformer breakdown rate in India is as high around 20% in contrast to less than 2% in some advanced countries.

In the absence of switches at different points in the distribution network, it is not possible to isolate certain loads for load shedding as and when required. The only option available in the present distribution network is the circuit breaker (one each for every main 11kv feeder) at the 33kv substation. However, these circuit breakers are actually provided as a means of protection to completely isolate the downstream networks in the event of a fault. Using this as a tool for load management is not desirable, as it disconnects the power supply to a very large segment of consumers. Clearly, there is a need to put in place a system that can achieve a finer resolution in load management.

In the event of a fault in any feeder section downward stream, The circuit breaker at the 33kv substation trips (opens). As a result there is a blackout over a large section of the distribution network. If the fault feeder segment could be precisely identified, it would be possible to substantially reduce the blackout area, by re-routing the power to the healthy feeder segments through the operation of switches placed at strategic location in various feeder segments.

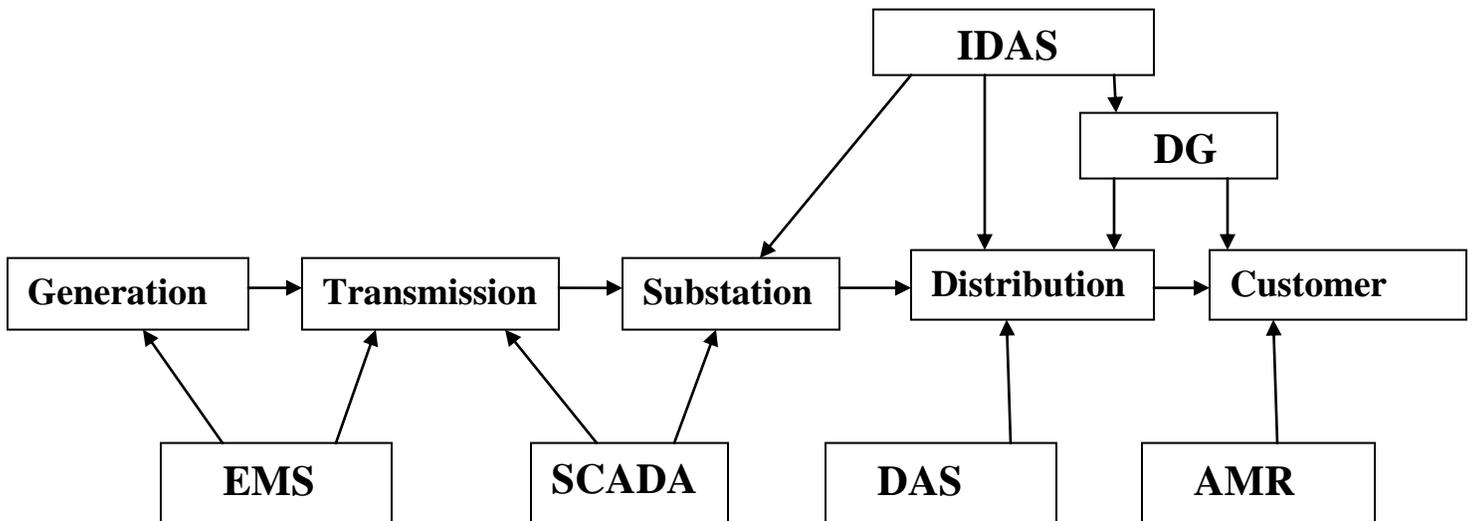
Currently the scope of Power System Automation in India has been limited to SCADA system automation up to the transmission level. However as the fig.1 given below indicate, the substations contribute only 1% of the outages.

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substations	Primary distribution circuits	Secondary distribution circuits
Less than 1% of outages	44% of outages	55% of outages
Contribute 5% to reliability	Contribute 87% to reliability	Contribute 8% to reliability

Fig.1

Hence the need for protection of the system beyond the substation becomes very important. As such the fledgling field of DAS in India will become extremely critical in the coming years.



Intelligent Distribution Automation System

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SCADA:

SCADA is an acronym for supervisory control and data acquisition system. It consists of one or more computers with appropriate applications software (Master Stations) connected by communications system (wire, radio, power line carrier or fiber optics) to a number of remote terminal units (RTUs) placed at various locations to collect data and for remote control and to perform intelligent autonomous (local) control of a system and report results back to the remote master(s). The required control actions are then conveyed back to the process. The concept of SCADA forms the basis of the DA system.

SCADA Process classified into 3 parts.

Input:

Analog: Continuous Electrical Signals

Ex. Active Power (MW), Reactive Power (MVAR), Voltage (KV), Frequency (Hz).etc..

Digital: Switching Signals High (1) or Low (0) Signal

Ex. Breaker Close (high) or Open (low), Isolator Closed (high) or Open (low).

Process:

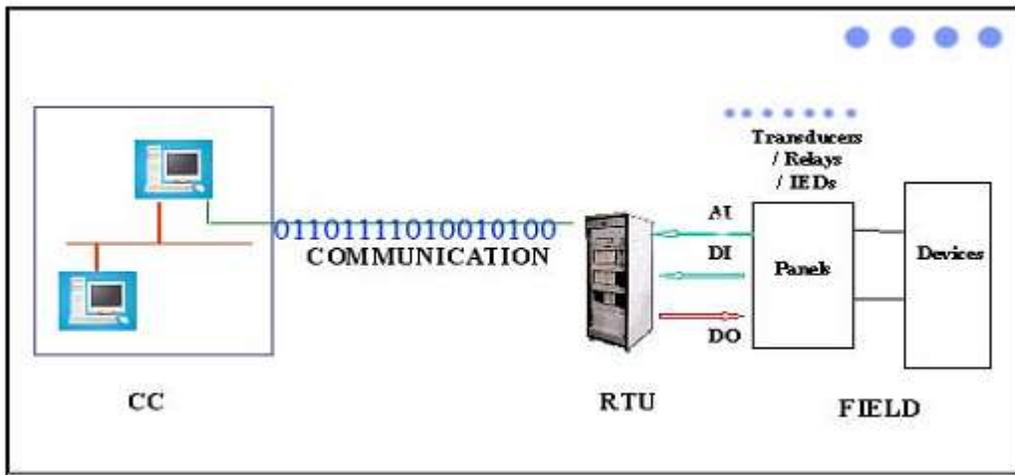
- The signals are converted into digital format
- Implement protocol between Master and Slave
- It operates with Real Time Operating System (RTO)

Output:

- The results are exposed with user friendly environment
- Through displays can be possible to control the substation and generating station.

The SCADA system consists

- ✓ Control centre equipment
- ✓ Application software
- ✓ Distribution management software
- ✓ Communication system
- ✓ RTUs for field data acquisition
- ✓ UPS, etc.



A Typical SCADA System Architecture

A SCADA system can be implemented with hardware and software components that constitute a whole system. Using SCADA system the various application programs that implemented in power systems are fault location, load balancing, load shedding, etc. Now a detailed description of hardware components, software components are given below.

1. HARDWARE COMPONENTS:

The components of a SCADA system are field instrumentation, remote stations, Communication Network (CN) and Central Monitoring Station (CMS).

a) Field instrumentation:

Field instrumentation generally comprises sensors, transmitters and actuators that are directly interfaced to the plant or equipment and generate the analog and digital signals that will be monitor by the remote station. Signals are also conditioned to make sure they are compatible with the inputs/outputs of the Remote Terminal Unit (RTU) or a Programmable Logic Controller (PLC) at the remote Station. It also refers to the devices that are connected to the equipment or machines being controlled and monitored by the

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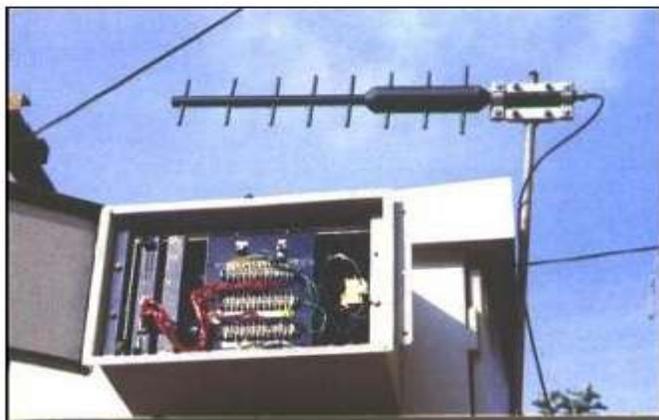
SCADA system. These are sensors for monitoring certain parameters and actuators for controlling certain modules of the system.

b) Remote Terminal Unit (RTUs):

The remote station is installed at the remote plant with equipment being monitored and controlled by the central host computer. This can be a RTU or PLC. Field instrumentation, connected to the plant or equipment being monitored and controlled, is interfaced to the remote station to allow process manipulation at a remote site. It is also used to gather data from the equipment and transfer it to the central SCADA system.

An RTU is a microprocessor controlled device used to interface the various power system components and their operation to the DCC. It gathers local information and transmits it to the DCC and also accepts commands and logging requests sent to it by the DCC. Hence the DCC can control and monitor the distribution networks by interfacing with the various RTUs. It has a capability to exchange the information with intelligent electronic devices (IEDs) such as IED meter and IED relays.

RTU on the pole top



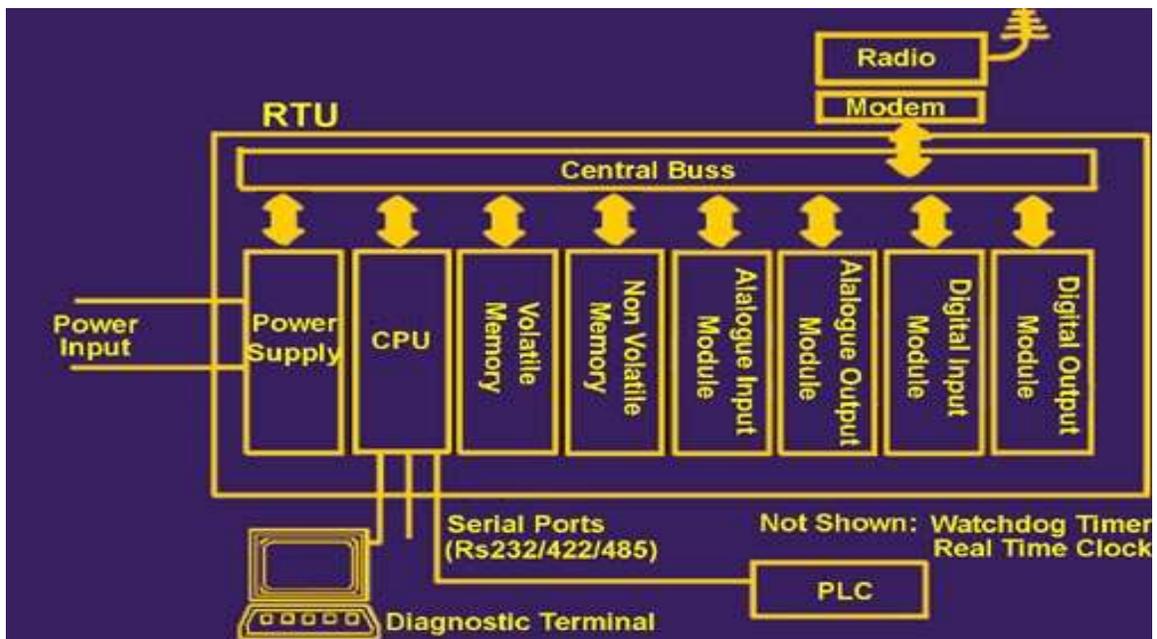
Commercially the RTU must be capable of performing the following functions:

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1. Collecting, Processing and transmitting status changes, analog values and accumulator values.
2. Receiving and processing digital and analog commands from the Master station(s).
3. Supporting data transmission rates from 50 to 9600 bits per second.
4. Supporting up to 6 communication ports and multiple concurrent protocols, including the IEC 870-5-101 protocol.

The RTU hardware must be capable of supporting communication with multiple master stations, a local maintenance interface, and a local logger. As such, an RTU must have at least 4 communication ports.

- 2 ports, communication to DCC.
- 1 port, local logger or printer facility.
- 1 port, maintenance terminal.



Typical RTU Hardware Structure

c) Communication Network:

The Communication Network (CN) refers to the communication equipment needed to transfer and from different sites. The medium used can be cable, telephone, radio, and fiber optic or satellite communication system. The fiber Optic System is currently preferable to the other media because of the following factors:

- Simplified Installation
- Immunity from EM interface
- Reliability and high Bandwidth
- Availability of Direct Metallic Contacts for devices in the same region
- Two way communication unlike that provided by radio.
- Break in a fiber cable will not cause a loss of data.

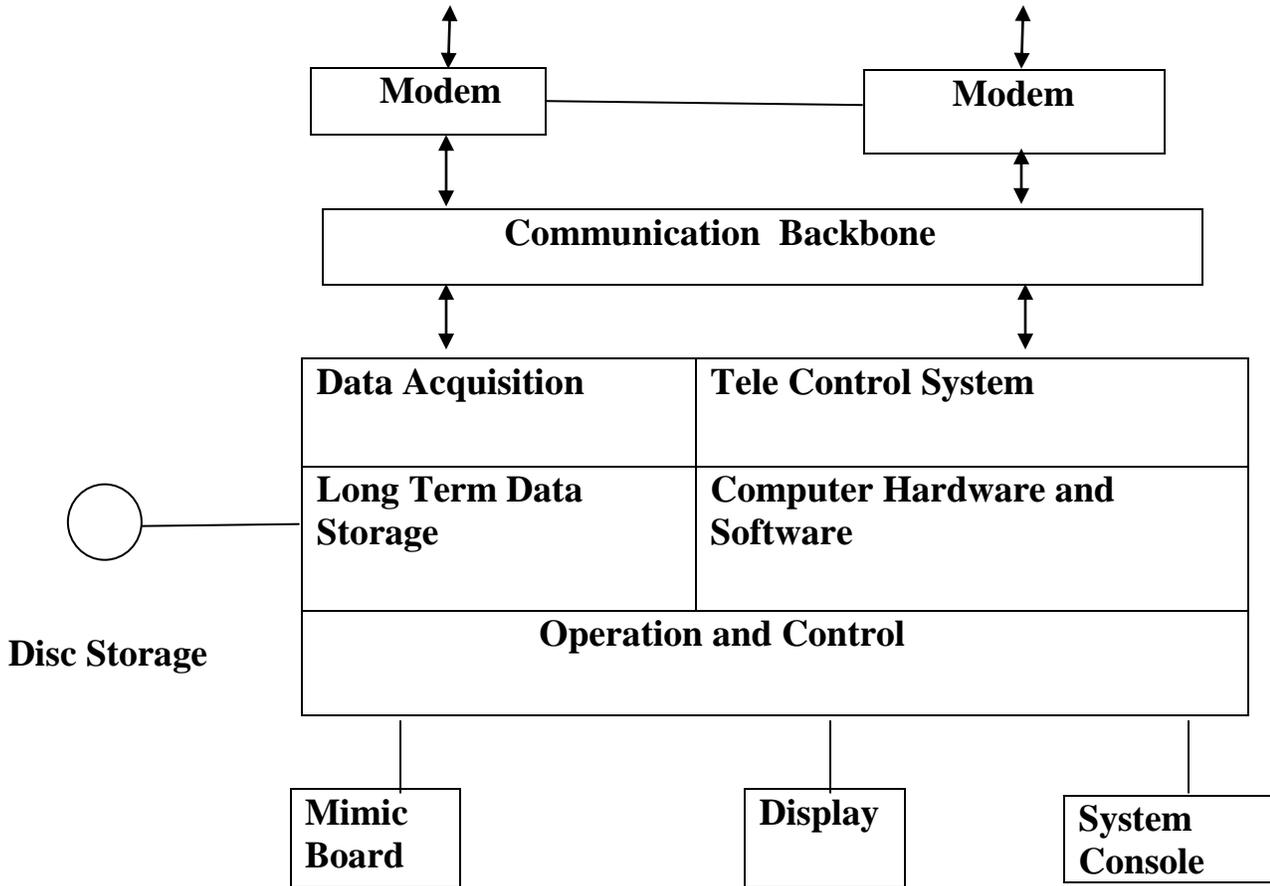
CENTRAL MONITORING STATION:

It is also called as distribution control center (DCC).The Central Monitoring Station (CMS) function is collecting information gathered by the remote stations and generating necessary action for any event that is detected. It also has storage media for storing the data, Visual Display Units (VDUs) for displaying the data to the operators and to issue control commands and communication interfaces.

The CMS can have a single computer configuration or it can be networked to workstations to facilitate sharing of information from the SCADA system. It uses a Man Machine Interface (MMI) to monitor various types of data needed for the operation. A MMI program runs on the CMS computer. A mimic diagram of the whole plant or process can be displayed on screen for easier identification with the real system.

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Each I/O point of the remote units can be displayed with corresponding graphical representation and the present I/O reading. Set-up parameters such as trip values, limits, etc. are entered on this program and downloaded to the corresponding remote units for updating of their operating parameters.



Distribution Control Centre

There are two typical network configurations for the SCADA systems. They are the point-to-point and the point-to-multipoint configurations. The point-to-point configuration is the simplest one device is designated as the master unit to several slave units. The master is usually the main host and is located in the control room, while the slaves are the remote units. Each slave is assigned a unique address or identification

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number set-up for a telemetry system. Here data is exchanged between two stations. One station can be set up as the master and the other as the slave.

The point-to-multipoint configuration is where one device is designated as the master unit to several slave units. The master is usually the main host and is located in the control room, while the slaves are the remote units. Each slave is assigned a unique address or identification number

SOFTWARE COMPONENTS:

a) Data Acquisition and Processing:

This is done by Master Distribution Automation Software. This serves as a data collector from the devices to our SCADA system and presents it as a processed data to the user. Data acquisition can be done in multiple scan rates and uses different protocols. The data can be fetched as a whole or as a group and also report by exception. Data processing means conversion of fetched data into engineering conversions, zero suppression, reasonability check, and calculation subsystem. So, user can use this processed data for future purposes.

b) Control:

This is done by Engineering Analysis Software. Users are allocated to groups, which have defined read/write access privileges to the process parameters in the system and often also to specific product functionality. The allocated users can have the access to the devices, which are to be controlled. Control can be single or group, open or closed loop control. The execution of control can be executed at selective places, can be immediately executed, can be executed at required time etc.

c) Man machine interface:

The products support multiple screens, which can contain combinations of synoptic diagrams and text. Standard windows editing facilities are provided: zooming, re-sizing, scrolling etc. On-line configuration and customization of the MMI is possible for users with the appropriate privileges. Links can be created between display pages to navigate from one view to another.

d) Logging and Archiving:

The terms logging and archiving are often used to describe the same facility. However, logging can be thought of as medium-term storage of data on disk, whereas archiving is long-term storage of data either on disk or on another permanent storage medium. The logging of user actions is in general performed together with either a user ID or station ID.

e) Automated mapping and facilities management (AM/FM):

SCADA systems can be made use to have GUI system. GUI system can be used to have maps, graphical representation of the required area. Using SCADA these maps can be layered, zoomed, scrolled and planned.

APPLICATION PROGRAMS:

The various application programs that can be implemented using SCADA systems are clearly explained here. The following are the applications that can be used for remote monitoring, control, safety, efficient utilization of resources etc.

a) Fault location, isolation and Service Restoration:

This function determines alternate paths for restoring service to the affected load points due to a fault on a section of the feeder considering current loading conditions. Most of the rural feeders do not have an alternate supply for service restoration. In urban areas, many alternate paths are available to a feeder; therefore, this function will

be more effective. To implement this function, load switches or sectionalizers are needed at selected feeder locations. Earlier, sectionalizers were air-break switches without any remote-control features. All such switches should be replaced with remotely controllable switches.

b) Maintaining good voltage profile:

This function controls the capacitor banks and voltage regulators to provide a good voltage profile in the distribution feeders. An appropriate schedule for switching on/off of capacitor banks and raise/lower voltage regulator taps was based on the feeders' reactive load curves in order to get good voltage profiles and reduce energy losses.

c) Load Balancing:

This function distributes the system total load among the available transformers and the feeders in proportion to their capacities. As explained above, there was a need to replace the existing switches with remotely controllable switches in order to reconfigure the network for load balancing.

d) Load Control: Load Management Function is divided into three categories:

- During summer there is usually a generation shortage. Therefore, loads need to be shed for long durations. A restriction and control schedule is worked out based on which of the loads at different substations are shed on a rotation basis.

- **Emergency Based Load Shedding:** During emergencies, the utility needs to shed some load to keep up the balance between generation and demand. Instructions are sent to respective substations to shed load. Based on the amount of relief requested, the operator would select some loads and shed them. This function will help to identify loads to be shed considering their priority, time when they were last shed and the duration of the last interruption to ensure that only the required amount of load shedding is done.

e) Remote metering:

The function of remote metering is to read data from the meters and to provide information to the operator of the consumption patterns of the high-value HV customers. Its main feature is to provide a multiple tariff to the customers to encourage them to shift their loads from peak times to off-peak times. This function also provides meter-tampering detection.

f) Fuse of call operations:

This consumer-aid application function responds to complaints from consumers. It has the following features: Accepts interruption/restoration data from the operator, identifies the interruption source whenever possible and gives information on the outage effects to the operator, displays status of energized/de-energized status of the consumer. This function will improve the response time to the consumer complaints.

g) Energy accounting:

This function helps in arriving at the system's load patterns, which helps in planning expansion. It also helps in detecting abnormal energy consumption patterns of the consumers and identifying high-loss areas. Processing the data obtained by the remote metering function and the data obtained from the substation does this.

IMPLEMENTATION:

SCADA system to automate power for Hyderabad & Secunderabad and streamline APCPDCL electrical distribution network .APCPDCL (Andhra Pradesh Central Power Distribution Company Ltd) commissioned a state of the art SCADA (Supervisory Control & Data Acquisition) system supplied by ABB India to monitor and control the power distribution network for the twin cities of Hyderabad and Secunderabad.

The system offers operational advantages by integrating distribution automation functionalities like Automatic / Remote meter reading, Load balancing, trouble call management etc. to facilitate effective distribution management.

CONCLUSION:

SCADA plays an important role in power system supervision and remote control systems .SCADA and IED go hand in hand for greatly enhancing substation automation and reducing human intervention. The main motivation for accepting the distribution automation in developing countries such as India is to improve operating efficiency of distribution system. This indicates worldwide interest for distribution automation at present.

Looking at the interest of power utilities for distribution automation, academic institutions are now taking interest to introduce courses and R&D activities in the field of distribution automation in the regular academic curriculum.

The Indian Government too, recognizing the potential of the Distribution Automation technology is creating a panel of vendors for the implementation of SCADA/DMS.