

## Chapter 3

### Distribution Automation System

#### 3-1 Introduction:-

The word Automation means doing the particular task automatically in a sequence with faster operation rate. This requires the use of microprocessor together with communication network and some relevant software programming. The application of automation in distribution power system level can be define as automatically monitoring, protecting and controlling switching operations through intelligent electronic devices to locate and isolate the fault and then restore the service. Now days due to advancement in the communication technology, distribution automation system (DAS) is not just a remote control and operation of substation and feeder equipment but it results into a highly reliable, self-healing power system that responds rapidly to real-time events with appropriate actions. Hence, automation does not just replace manual procedures; it permits the power system to operate in best optimal way, based on accurate information provided in a timely manner to the decision-making applications and devices. Distribution Automation Systems have been defined by the Institute of Electrical and Electronic Engineers (IEEE) as systems that enable an electric utility to monitor, coordinate, and operate distribution components in a real- time mode from remote locations.

There are several reasons to use (DAS). Until now, the electric power industry has made remarkable progress in both quantity and quality of supplying electrical power. But, it is expected that the social demand for better services would be requested. Now, distribution automation has to address enhancements in efficiency as well as reliability and quality of power distribution. Today (DAS) are more concerned about improving reliability to achieve the required performance and improving power quality.

Adding more capabilities for distribution automation system by extend the existing (supervisory control and data acquisition) SCADA and communicate the infrastructure is required. The success or failure of an automation program depends on proper selection of communication's equipments to integrate data into the control room. With the latest high speed communication technology, there has never been a better time to extend the automation beyond the substation. Distribution automation ensures providing effective management minute by minute and continuous operation of a distribution system. It represents a tool to achieve a maximum utilization of the utility and to provide the highest quality of service to customers. Obviously, both the utility and customers are beneficiaries of successful distribution automation.

Power system engineering has working for years designing a wide range of distribution automation applications and systems, such as applications that include automatic sectionalizing and SCADA controlled switching.[4]

### 3-2 Distribution Management System (DMS):-

Distribution automation system offers an integrated distribution management system (DMS). The functions of DMS are shown in figure (3-1).

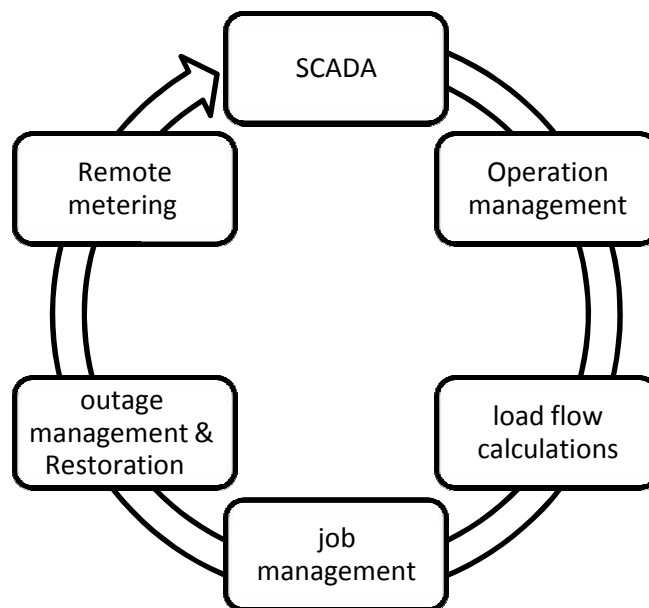


Fig (3-1) Function of DMS

- **SCADA** involves collecting and analyzing information to take decisions, implementation the appropriate decisions and then verifying that the desired results are achieved.
- **Operation management** supports the analysis of distribution network and present state of the network.
- **Load flow calculations** estimate voltage levels and power flows at each feeder.
- **Job management** makes switching order handling easier on work protection and ensures the safety of repair crew on duty.
- **Outage management and service restoration** facilitates to reduce outage time there by increasing the reliability of the supply.
- **Remote metering** provides the appropriate selection of energy registers where time of use rates are in effect, thus improving energy metering services to be more accurate and more frequent.

In conventional distribution system the abnormal conditions are detected manually which costs lots of time and money to both consumers and power industry. In order to maintain high service quality and reliability and minimize loss in revenues, automation is required, automation may be applied to the power distribution system so that problems on distribution network may be detected and operated upon so as to minimize the outage time.[4]

### **3-3 Supervisory Control and Data Acquisition system (SCADA):-**

The equipments (either fixed wired or/and programmable), which are used for distribution automation, include:

- (i) Data collection equipment.
- (ii) Data transmission (telemetry) equipment.
- (iii) Data monitoring equipment.
- (iv) Data processing equipment.
- (v) Man-machine interface.

All the above equipments are integrated through distribution SCADA system.

Distribution SCADA involves collecting and analyzing information to take decisions and then implementing them and finally verifying whether desired results are achieved.[4]

There are four major components of electrical SCADA systems:

- (i) Master station.
- (ii) Communication network.
- (iii) Remote Terminal Unit (RTU).
- (iv) Human Machine Interface (HMI).

### **3-2-1 Master station:**

The SCADA master station provides electrical operators with facilities to remotely monitor and control electrical plant of the traction supply network. In telecommunication, a master station is a station that controls or coordinates the activities of other stations in the system.

In a data network, the control station may designate a master station to ensure data transfer to one or more slave stations. Such a master station controls one or more data links of the data communications network at any given instant. The assignment of master status to a given station is temporary and is controlled by control station according to the procedures set forth in the operational protocol. Master status is normally conferred upon a station so that it may transmit a message, but a station need not have a message to send to be designated the master station.

In basic mode link control, the master station is a data station that has accepted an invitation to ensure a data transfer to one or more slave station. At a given instant, there can be only one master station on a data link.

In data transmission, a master station can be set to not wait for a reply from a slave station after transmitting each message or transmission block. In this case the station is said to be in continuous operation.[4]

### **3-2-2 communication network:**

A supervisory (computer) system, gathering (acquiring) data on the process and sending commands (control) to the SCADA system by the communication network.

The communication network connects the SCADA master station with all of the RTUs located in the substations. Data may be moved using a copper, fiber optic or radio frequency communication system. Multiple units may share communication lines.[4]

### **3-2-3 Remote Terminal Unit (RTUs):**

The RTUs interface to the electrical plant within a substation and monitor the status of the plant via digital and analogue inputs. This data is transferred to the master station when requested by the master station. The RTUs also provide for control outputs to switch plant such as circuit breakers and tap changers. In newer RTUs, serial links are provided to interface into intelligent electronic devices (IEDs) such as electrical protection relays.

RTU always connect to sensors in the process and convert sensor signals to digital data. They have telemetry hardware capable of sending digital data to the supervisory system as well as receiving digital commands from the supervisory system. Its architecture comprises of a CPU, volatile memory and nonvolatile memory for processing and storing programs and data. It communicates with other devices via either serial ports or an onboard modem with I/O interfaces. It has a power supply with a backup battery surge protection against spikes real time clock and a watchdog timer to ensure that it restarts when operating in the sleep mode.[4]

### **3-2-4 Human Machine Interface (HMI):**

Apparatus or device which presents processed data to a human operator, and through this, the human operator monitors and interacts

with the process. The HMI is a client that requests data from a data acquisition server or in most installations the HMI is the graphical user interface for the operator, collects all data from external devices, creates reports, performs alarming, sends notifications, etc.[4]

The main system components can be shown in the block diagram in figure (3-2):



Fig (3-2) the main system components

### **3-4 SCADA Operation:-**

A SCADA system for a power distribution application is a typically a personal computer based (PC) software package. Data is collected from the electrical distribution system, with most of the data originating at substations. Depending on its size and complexity, a substation will have a varying number of controllers and operator interface points.

In a typical configuration, a substation is controlled and monitored in real time by a programmable logic controller (PLC) and by certain specialized devices such as circuit breakers and power monitors. Data from the PLC and the devices is then transmitted to a PC-based SCADA node located at the substation.

One or more PCs are located at various centralized control and monitoring points. The links between the substation PCs and the central station PCs are generally Ethernet-based and are implemented via the internet, an internet and/or some version of cloud computing.

In addition to data collecting, SCADA systems typically allow commands to be issued from central control and monitoring points to substations. If desired and as circumstances allows these commands can enable full remote control.[4]

### **3-5 Distribution automation system (DAS) Classifications:-**

The distribution automation can be broadly classified as:

- (i) Substation automation.
- (ii) Feeder automation.
- (iii) Consumer side automation.

#### **3-5-1 Substation automation:-**

Substation automation is cutting edge technology in electrical engineering. It means having an intelligent, interactive power distribution network including:

- Increase performance and reliability of electrical protection.
- Advanced disturbance and event recording capabilities, aiding in detailed electrical faults analysis.
- Display the real time substation information in a control center.
- Increasing integrity and safety of electrical power network including advanced interlocking functions.
- Remote switching and advanced supervisory control.
- Advanced automation functions like intelligent load shedding.[4]

#### **3-5-2 Feeder automation:-**

Automated the fault diagnosis and supply restoration process significantly reduces the duration of service interruptions. The key objective behind automating the service restoration process is to restore supply to maximum loads in out of service zones. This is achieved by the reconfiguring the network such that the constraints of the system are not violated. Providing timely restoration of supply to outage areas of the feeder enhances the value of service to customers and retains the revenue for the power industry.

The system data consisting of the status signals and electrical analog quantities are obtained using a suitable data acquisition system and processed by the control computer for the typical functions of the fault detection, isolation and

network reconfiguration for supply restoration. The equipments normally required in feeder automation are:

**- Distribution equipment:**

This includes transformers, breakers, load break switches and motor operators, power re closures, voltage regulators, capacitors banks etc.

**-Interface equipment:**

Interface equipment is required for the purpose of data acquisition and control. Potential transformers, current transformers, watt, var meter and voltage transducers, relays are some examples.

**-Automation equipment:**

Automation equipment includes a DAS, communication equipment, substation remote terminal units (RTUs) and distribution feeder RTU, current-to-voltage converters, etc.[4]

**3-5-3 Consumer side automation:-**

Consumer side automation is very important for a distribution company as almost 80% of all the losses are taking place on distribution side alone. It is needed to evaluate the performance of specific area in the distribution system and judge the overall losses.[4]

**3-6 Distribution automation system implementation:**

Distribution substation and feeder automation also referred to as Primary Distribution automation. Different functions of Primary Automation Technique are listed below.

**- Transformer Load Balancing:** Transformer load balance monitoring provides remote access to near real-time information concerning the overall operation of the distribution system. This information can be used on a daily basis to verify the effects of other down line events such as capacitor switching, residential load control, and Recloser operations. It is also useful on a periodic basis to fine tune the efficiency of the Utility's power distribution configuration.



- **Voltage Regulation:** This feature of DAS offers utility personnel the ability to reduce line voltage during peak demand times by remotely taking control of the Load Tap Changer.

- **Fault Isolation and Sectionalizing:** Remote monitoring of the recloser operation to the melting of a fuse link, utilities can detect the fault very fast and can take quick action to clear that fault. Even during the outage of the power supplies distribution automation devices on that line can report the data remotely. By correlating the last voltage or current measured before an outage from several points along the distribution system, an indication of the nature of the fault as well as its approximate location can be obtained.

- **Remote Interconnect Switching:** Distribution automation systems can be deployed to drive remotely interconnected switches that separate different portion of the utility distribution feeders. By the use of remote interconnect switching utilities can manipulate their distribution system to provide the most efficient configuration and also will able to remotely restore power to as many consumers as possible during the time of multiple faults.

- **Capacitor Bank Switching:** It is most commonly deployed automation technique in a distribution network. The most cost effective capacitor control configuration is to install a number of one-way receivers at the capacitor locations for positive control and to monitor the aggregate effects of the capacitor switching at the substation low voltage level bus. Utilities with capacitor bank switching facilities can operate with reduced losses and as a result with higher efficiency.

- **Voltage Monitoring:** By monitoring the feeder voltage remotely utility personal gets advance notification about the line voltage drop due to high usage. Also recorded data of feeder voltages will give snapshot of the actual usage patterns.

Consumer location is the most challenging application area for the distribution automation system as large numbers of installation points are required and all the points should be economically viable.

- **Load Management:** Load management is achieved by local appliance control. It consists of a utility activated relay that interrupts the power consumed by non-critical loads such as water heaters, air conditioners, electrical heaters, pool pumps, etc.

- **Automatic Meter Reading (AMR):** For utilities, AMR is one of the cost effective way to read the residential kilowatt-hour meters. The AMR device can be initially programmed to report back to the utility based on a schedule or some pre-set usage level. Modern AMR devices incorporate the capability of remote reconfiguration of operating parameters and schedules.

- **Demand Side Management (DSM):** An extension of automatic meter reading technology is the DSM application using Real Time Pricing. This application includes the functionality of monitoring the power usage during specific periods of the day as well as the control functionality of notifying the customer of the change of periods and the new rate for that period. For some utilities, this option is not cost effective.

- **Quality of Service Monitoring:** Quality of service is different things to different utilities. The most comprehensive definition includes monitoring power outages and its duration, the track record of power disturbances (such as voltage blinks and harmonics), and monitoring voltage wave-form distortions.[5]

The typical power transmission and distribution automation is shown in figure (3-3):

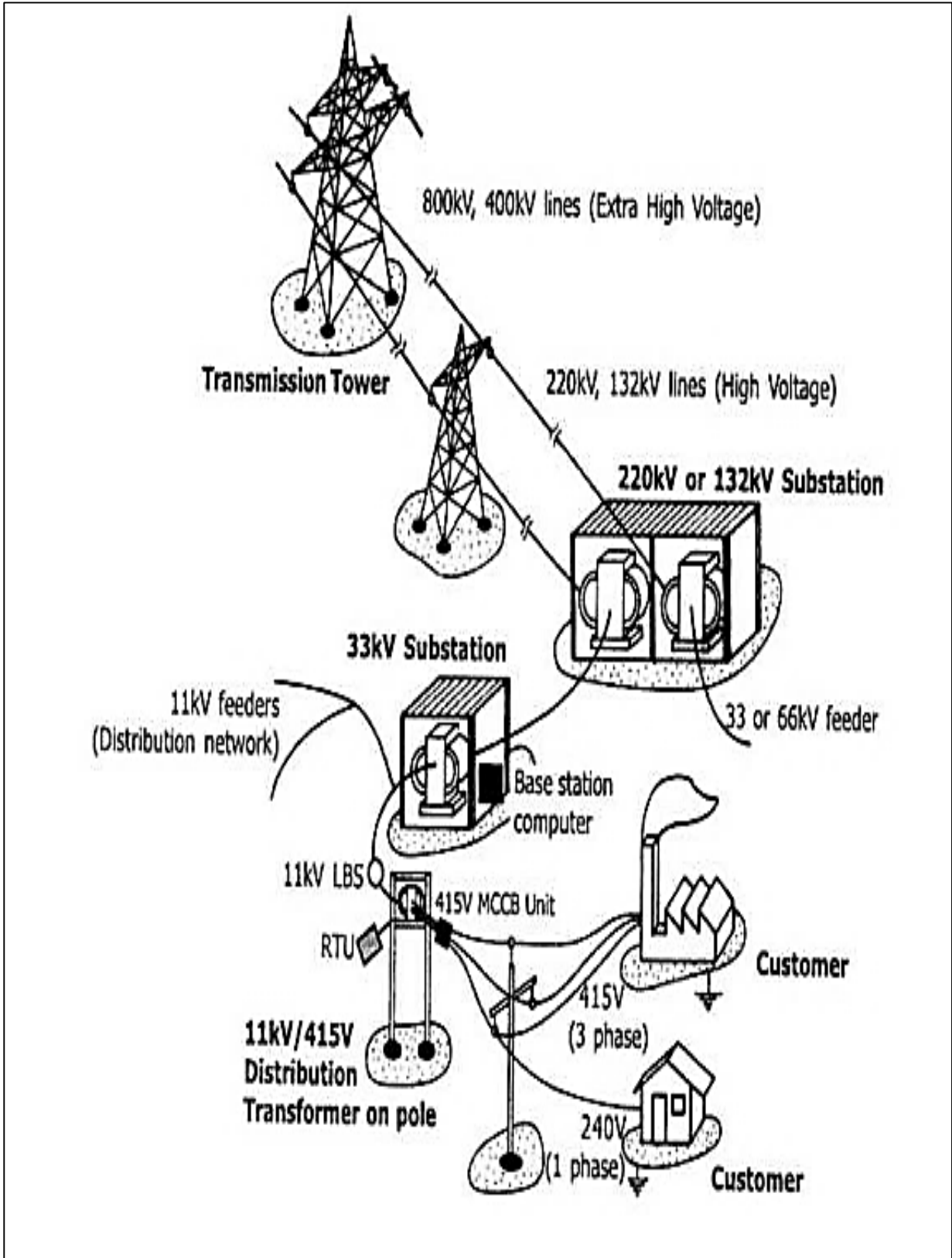


Fig (3-3) The typical power transmission and distribution automation