

CHAPTER 42

Learning Objectives

- Introduction
- Need Based Energy Management (NBEM)
- Advantages of NBEM
- Automated System
- Sectionalizing Switches
- Remote Terminal Units (RTU's)
- Data Acquisition System (DAS)
- Communication Interface
- Radio Communication
- Machine Interface
- A Typical SCADA System
- Load Management in DMS
- Automated Distribution System
- Substation Automation
- Control System
- Protective System
- Feeder Automation
- Distribution Equipment
- Automation Equipment
- Consumer Side Automation
- Energy Auditing
- Reduced Line Loss
- Power Quality
- Deferred Capital Expenses
- Energy Cost Reduction
- Optimal Energy Use

DISTRIBUTION AUTOMATION



An automated electric distribution system ensures that the power is transmitted efficiently and without interruptions. Faults in transmission are identified and rectified with minimum human intervention

42.1. Introduction

The power industry may seem to lack competition. This thought arises because each power company operates in a geographic region not served by other companies. Favorable electric rates are a compelling factor in the location of an industry, although this factor is much less important in times when costs are rising rapidly and rates charged for power are uncertain than in periods of stable economic conditions. Regulation of rates by State Electricity Boards, however, places constant pressure on companies to achieve maximum economy and earn a reasonable profit in the face of advancing costs of production.

Power shortage in India is endemic. Despite heavy investments in the power sector and additional power generation every year, there appears to be no chance of the shortage syndrome easing-up in the near future. Barring one or two small States with hydro-potential, all other States and Union Territories have perpetual power deficits. There seems to be no respite from these crippling deficits as seen from the figures that are being published from time to time.

In power sector, it has almost become a ritual to insistently clamor for more generation. This school of thought which is predominant majority, believes in classical concept of load management which emphasizes continuous and copious supply of energy to all sectors of consumers at all times. This ideal proposition could be achieved, only if unlimited resources at our command are available. But in actual practice, these resources are not only limited but scarce. These scarce resources are to be distributed throughout the country uniformly and called for immediate attention. A demand based energy management would therefore only result in shortage syndrome repeating itself endlessly since the ever-growing 'demand' could never be met fully and satisfactorily. A better alternative would be to replace the Demand Based Energy Management with a Need Based one.

42.2. Need Based Energy Management (NBEM)

In power sector, there is a distinct difference between 'demand' and 'need'. Consumers of electric power could be classified into five broad categories: the industrial users, agricultural sector, commercial organizations, domestic consumers and essential services. Industrial users could be further sub-divided as shift based industries and continuous process industries. Agricultural sector would include irrigation tubewells and rural industries. Out of these several groups and sub-groups, only three - viz - continuous process industries, domestic consumers and essential services need power round the clock, others may demand power for 24 hours of the day, but they don't need it.

A Need Based Energy Management would :

- (i) Identify the needs of various consumers
- (ii) Forecast the generation requirement based on the need
- (iii) Plan power generation as per forecast
- (iv) Laydown a suitable transmission and distribution network
- (v) Regulate distribution as per need
- (vi) Monitor matching of need with supply

The greatest bugbear of NBEM is distribution network. Consumers cannot be supplied power as per their need since the distribution network is not designed for that purpose. Present day power distribution network is full of constraints and is clumsy to the core. The ills of the system are many – poor reliability, high line losses, low voltage profiles, overloading of transformers, poor maintenance, absence of conservation measures, stealing of power, haphazard layouts, whimsical load connections, inadequate clearances etc. With a single feeder connected to all types of consumers, there is no load discipline and the distribution network is exposed to several malpractices and distortions. Generation of power also suffers and as a result, engineers incharge of power generation in state electricity boards are not enthusiastic about optimizing power generation because they feel that their efforts are wasted due to the chaotic and sub-optimal distribution system. So if power problem is to be solved, distribution holds the key.

Figure 42.1 shows utility system with SCADA (Supervisory Control and Data Acquisition) and Distribution Automation.

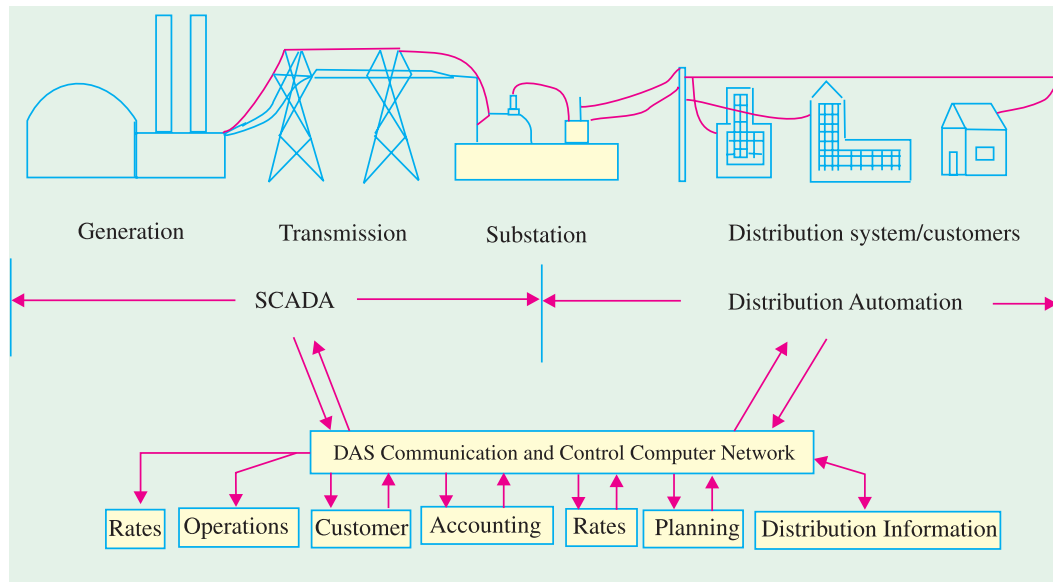


Fig. 42.1 Utility systems with SCADA and Distribution Automation

42.2.1. Advantages of NBEM

The distinct advantages of NBEM are:

- (1) It ensures high reliability of supply to consumers meeting the specific demand effectively for periods of actual requirements.
- (2) The system losses can be substantially reduced since line and equipment does not get overloaded at any point of time.
- (3) The voltage profile at all levels is improved thus safeguarding the customer's equipment from losing their efficiency and performance at low voltage.
- (4) The scheme facilitates the adoption of energy conservation schemes and energy audit policy.
- (5) Power cuts are reduced and quality of power improves leading to better industrial and agricultural health and productivity.

42.3. Conventional Distribution Network

The power system network, which generally concerns (or which is in close proximity of) the common man, is the distribution network of 11 KV lines or feeders downstream of the 33 KV substation. Each 11 KV feeder, which emanates from the 33 KV substation branches further into several subsidiary 11 KV feeders to carry power close to the load points, where it is further step-down to either 230 V or 415 V.

The present structure of the distribution feeders doesn't support quick fault detection, isolation of faulty region and restoration of supply to the maximum outage area, which is healthy. 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 11 KV feeder) at the 33 KV substation. However, these circuit breakers are actually provided as a means of protection to completely isolate the downstream network 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 on any feeder section downstream, the circuit breaker at the 33 KV substation trips (opens). As a result, there is a blackout over a large section of the distribution network. If the faulty 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 sectionalizing switches, placed at strategic locations in various feeder segments.

Thus, lack of information at the base station (33 KV sub-station) of the loading and health status of the 11 KV/ 415 V distribution transformers and associated feeders is one primary cause of inefficient power distribution. Also, due to absence of monitoring, overloading occurs, which results in low voltage at the customer end and increases the risk of frequent breakdowns of transformers and feeders.

42.4. Automated System

The inefficient operation of the conventional distribution system can be mainly attributed to the frequent occurrence of faults and the uncertainty in detecting them. To enhance the electrical power distribution reliability, sectionalizing switches are provided along the way of primary feeders. Thus, by adding fault detecting relays to the sectionalizing switches along with circuit breaker and protective relays at the distribution substations, the system is capable to determine fault sections. To reduce the service disruption area in case of power failure, normally open (NO) sectionalizing switches called as route (tie) switches are used for supply restoration process. The operation of these switches is controlled from the control center through the Remote Terminal Units (RTU'S).

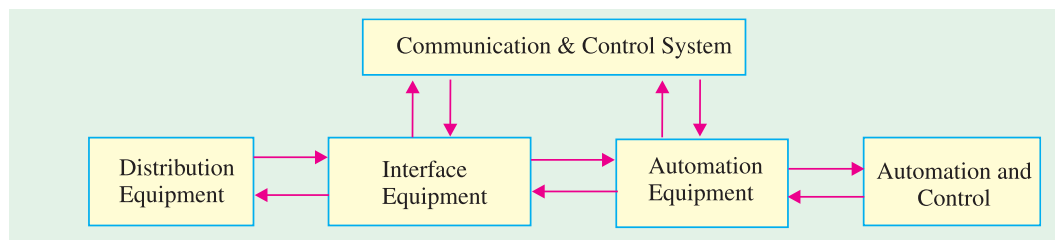


Fig. 42.2. Interconnection of distribution, control and communication system.

In distribution automation (DA) system, the various quantities (*e.g.*, voltage, current, switch status, temperature and oil level, etc.) are recorded in the field at the distribution transformers and feeders, using a data acquisition device called Remote Terminal Unit. These quantities are transmitted on-line to the base station through a communication media. The acquired data is processed at the base station for display at multiple computers through a Graphic user interface (GUI). In the event of a system quantity crossing a pre-defined threshold, an alarm is generated for operator intervention. Any control action, for opening or closing of the switch or circuit breaker, is initiated by the operator and transmitted from the 33 KV base station through the communication channel to the remote terminal unit associated with the corresponding switch or CB. The desired switching takes place and the action is acknowledged back to the operator.

Interconnection of distribution, control and communication system is shown in Figure 42.2.

All the above mentioned functions of data collection, data transmission, data monitoring, data processing, man-machine interface, etc. are realized using an integrated distribution SCADA (Supervisory Control And Data Acquisition) system.

The implementation of SCADA system in the electric utility involves the installation of following units :

1. Sectionalizing Switches
2. Remote Terminal Unit
3. Data Acquisition System
4. Communication Interface
5. Control Computer

42.5. Sectionalizing Switches

These sectionalizing switches are basically either air-brake switches or Load Break Switches (LBS) or Moulded Case Circuit Breaker (MCCB). These are remotely operable switches designed specifically for 11 KV and 415 V feeders. However, switches of appropriate rating corresponding to the rated feeder current can also be chosen.

Generally, 11 KV Vacuum break line sectionalizers are installed away from the substation and on the pole. A fault-indicating device is provided for location of fault at any section. To avoid opening of switches due to transient voltage drop or any other mal-operation, generally, 1.5 - 3 seconds delay is provided. Benefits obtained from installing these sectionalizing switches include :

1. Immediate isolation with indication of faulty section
2. Immediate restoration of supply to the healthy section
3. No down time for transient faults
4. Improvement of revenue due to lesser outage of section and low down time
5. Requires less man-power in the system and
6. Better Reliability of power supply

42.6. Remote Terminal Units (RTU's)

A typical SCADA system consists of remote terminal units, to record and check, measured values and meter readings, before transmitting them to control station and in the opposite direction, to transmit commands, set point values and other signals to the switchgear and actuator.

The functions of RTU's can be given as following :

- (a) Acquisition of information such as measured values, signals, meter readings, etc.
- (b) Transmit commands or instructions (binary plus type or continuous), set points, control variables, etc. including their monitoring as a function of time.
- (c) Recognition of changes in signal input states plus time data allocation and sequential recording of events by the master control station.
- (d) Processing of information transmitted to and from the telecommunication equipment such as data compression, coding and protection.
- (e) Communication with master control station.

A typical architecture RTU interfacing is shown in Fig 42.3.

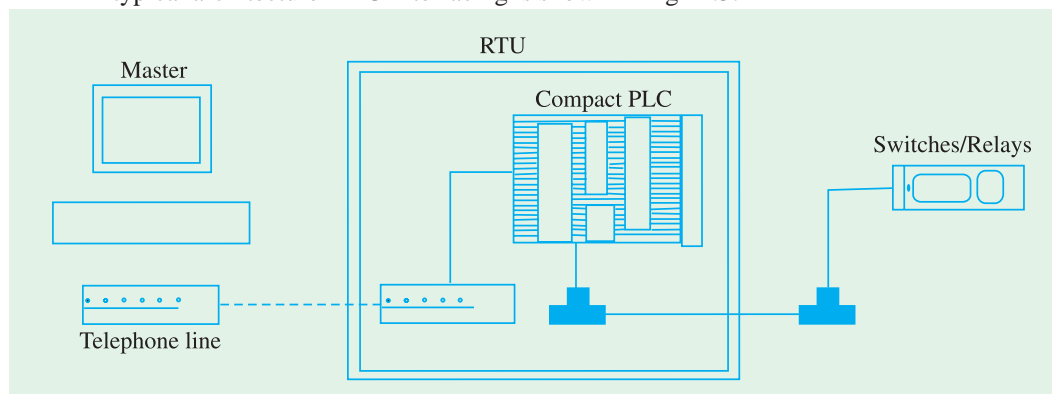


Fig. 42.3. Typical Architecture of RTU Interfacing

42.7. Data Acquisition System (DAS)

The data regarding the complete network consists of electrical and mechanical variables, on / off states, analog quantities, digital quantities, changes of state, sequence of events, time of occurrence

and several other data, which the control room operators will like to know.

Data is acquired by means of current transformers (CTs), potential transformers (PTs), transducers and other forms of collecting information. Transducers convert the data into electrical form to enable easy measurement and transmission. Data may be collected at low level or high level. Then it is amplified in signal amplifier and conditioned in data signal conditioner. The data is transmitted from the process location to the control room and from the control room to the control center.

The large number of electrical, mechanical and other data are scanned at required interval, recorded and displayed as per the requirement. Some of the data is converted from analog to digital form through A/D (Analogue to Digital) converters.

The data loggers perform the following functions :

1. Input Scanning
2. Signal Amplification and A/D Conversion
3. Display, Recording and Processing

The input scanner is generally a multi-way device, which selects input signals at regular periodic intervals in a sequence decided by the rate of change of input data. Slow varying quantities are scanned with a lower period of time-intervals. Output of scanner is given to A/D converter. Digital signals are obtained through DSP by micro-controllers or the control computer. This acquired signal can be displayed, recorded and processed for appropriate actions to be performed later.

42.8. Communication Interface

A good data communication system to transmit the control commands and data between Distribution Control Centre (DCC) and a large number of device remotely located on the distribution network is a pre-requisite for the good performance of Distribution Automation System (DAS). The communication requirements of each DAS is unique, depending upon the Distribution Automation functions selected for the implementation. A wide range of communication technologies are available to perform the tasks of DAS. The choice of communication technology also has a big impact on the cost of DAS.

RTU's communicate with the control room through a communication interface, which could be any of the following :

(a) Power line carrier communication (PLCC) :

Each end of the transmission line is provided with identical carrier equipment in the frequency range of 30 to 500 kHz. The high frequency signals are transmitted through power lines. The carrier current equipment comprises the coupling capacitor and the tuning circuit.

(b) Fibre optics data communication :

Application of fibre optic communication is presently in infant stage and has a vast scope due to freedom from electromagnetic interference and enormous data handling capacity of a single pair of optical fibre. The information is exchanged in the form of digitised light signals transmitted through optical fibres.

Fibre optics, with its explicit downward cost trend in terms of product as well as installation and maintenance costs has become a widely accepted choice, as it offers both technical and commercial advantages over conventional systems that use metallic cables and radio links. The communication basically consists of a transmitter and a receiver for information signals coming from the user's device which is connected through copper wire to the switching center or exchange, where it is changed into a digital signal like 1s or 0 s for easy handling. The signal is then transferred to the transmitter. In the transmitter, the information signal which is electrical, drives an optical source : Laser or a light emitting diode (LED), which in turn, optically modulates the information signal,

which gets coupled into the optical fibre. The receiver located at the other side of the link detects the original signal and demodulates or converts back the optical signal to the original information signal (Electrical). The signal is then connected through copper wires to the switching device or exchange for selection and connection to the proper user or user device. This has advantage of high data rate (9600 bits and much more) and immunity from noise.

(c) Radio communication :

Radio communication utilizes frequency bands between 85 MHz to 13 GHz, Point to point radio links, Multi terminal radio communication facility, Limited area radio scheme, Mobile radio sets, Emergency radio communication etc. are the types of radio communication facilities used in electrical power systems.

(d) Public telephone communication :

Dial-up and dedicated leased telephone lines are often used for Distribution Automation. The dial-up lines are suitable for infrequent data transmission. The leased line are suitable for continuous communication but are expensive. The reliability of communication varies greatly and is dependent upon the telephone company. Telephone communication service through packet switching network, cellular radio are viable and may have the advantages of providing services in other-wise inaccessible places.

(e) Satellite communication :

A satellite communication system using very small aperture terminal (VSAT) is suitable for DAS. VSAT is a point to multi-point star network like TDMA. It consists of one single Hub and number of remote Personal Earth Stations (PES). The communication between transponder and Hub is TDM access and between Hub and PES is TDMA access. The communication system between Hub remote PES is through two separate radio links. The link from remote PES to Hub is called inroute and from Hub to the remote PES is called as outroute. No end user transmission either originates or terminates at the satellite. In India extended 'C' band with up link in the 6.15/ 6.815 and down link in the 4.09/ 4.59 KHz range is used. Fig. 42.4 shows schematic diagram of VSAT network.



Nowadays even telephone connections are via wireless systems. The figure shows the transmission tower from where radio waves can be transmitted to other stations and satellites

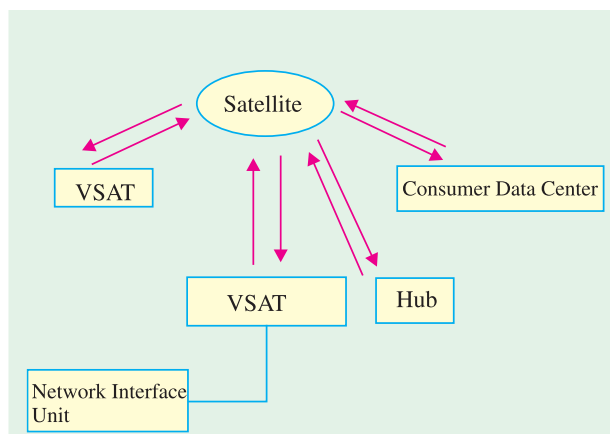
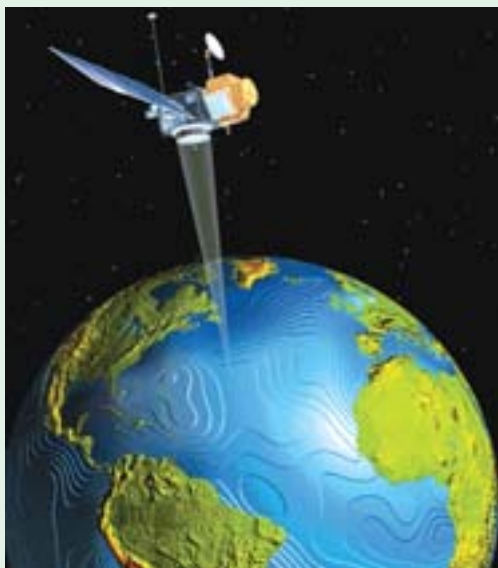


Fig. 42.4 Schematic diagram of VSAT network



A satellite helps to develop instant communication links with the stations spread across the globe

(f) Polling scheme :

SCADA systems intended for electric system operations almost universally use a polling scheme between the central master and individual RTUs.

The master station controls all activities and RTUs respond only to polling requests. Fig. 42.5 illustrates the most common communication arrangement. Multiple two or four wire telephone grade circuits radiate from the master. The media for these circuits may be leased telephone circuits from a common carrier, private microwave, fibre optic cable systems, two-way cable TV, power line carrier, or even satellite. Polling and command requests and RTU responses are time multiplexed on each circuit. Each circuit terminating at the master station is independently serviced on an asynchronous basis by the master station. The most commonly used information rates is 1200 bits/sec. using asynchronous byte-oriented message formats.

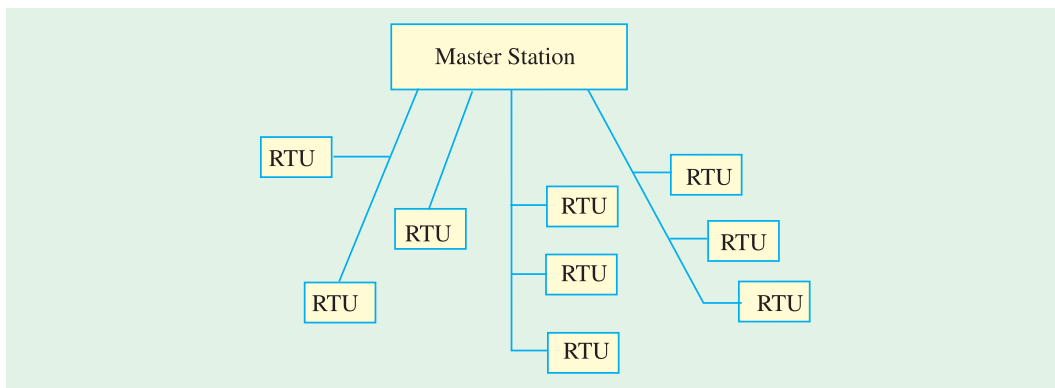


Fig. 42.5. Typical multidrop communication system

42.9. Distribution SCADA

Distribution SCADA involves collecting and analyzing information to take decisions, implementing the appropriate decisions and then verifying whether the desired results are achieved. Fig 42.6 gives flow diagram of the SCADA functions.

Data acquisition in an electric utility SCADA system concentrates on the power system performance quantities like bus line volts, transformer currents, real and reactive power flow, C.B. status (circuit breaker status), isolator status and secondary quantities such as transformer temperature, insulating gas pressure, tank oil levels, flow levels etc. Often transformer tap positions, usual positions or other multiple position quantities are also transmitted in analog format.

The usual reason for installing supervisory control is to provide the system with sufficient information and control to operate the power system or some part of it in a safe, secure and economic manner.

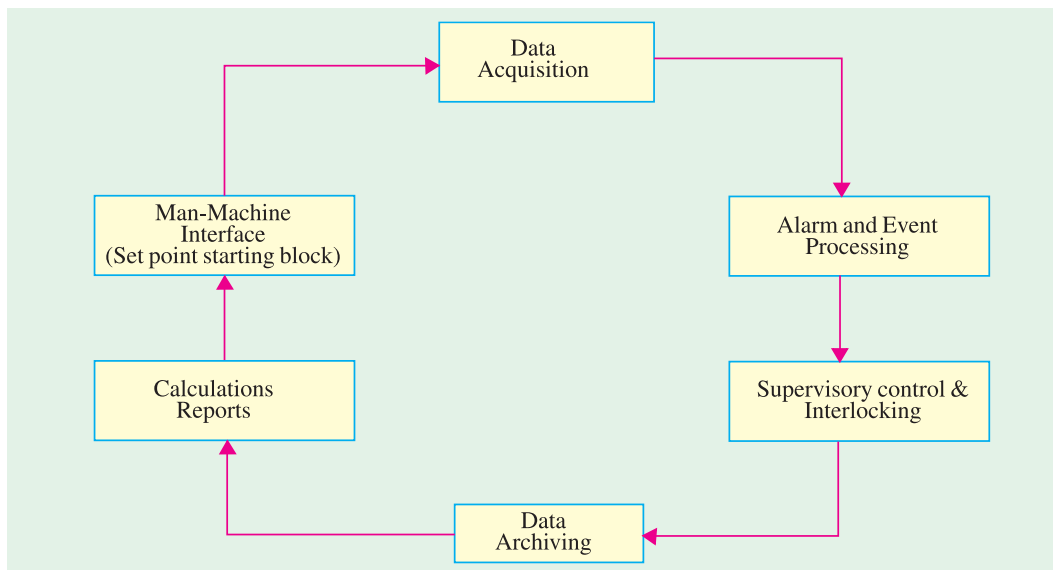


Fig. 42.6. SCADA functions

42.10. Man – Machine Interface

The implementation of SCADA system in an electric utility requires the installation of remote terminal units. RTU's are designed to acquire data and transfer the same to the master station through a communication link. They collect data from transducers, transmitters, connect input from equipment/ instruments, meter readings etc., performs analogue/ digital conversions, check data scaling and corrections (typically at I/O levels) performs preprocessing tasks and send/ receive messages from/ to master stations via interfaces. Fig 42.7 shows the flow diagram for man-machine interface.

Man-Machine Interface (MMI) is the interface between man and technology for control of the technical process. The computer system at master control centre or central control room integrates with RTU over the communication link with its transmission protocol, acquires the remote substation or distribution transformer/ feeder data and transfers the same to the computer system for man-machine interface.

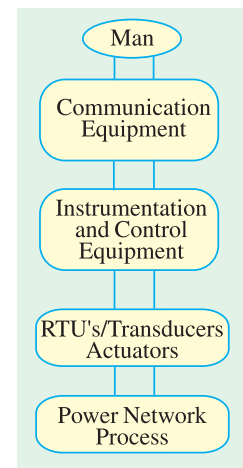


Fig. 42.7. Man - Machine Interface

42.11. A Typical SCADA System

A typical SCADA system may therefore comprises hardware and the software.

The hardware may include :

1. User friendly man-machine interface
2. Work station
3. Service having a particular function
4. Communication sub system
5. RTU's

All the above components communicate with each other through a local area network (LAN) with internationally standardised protocols. A flexible redundancy is provided, assigning hot standby server to any server fulfilling time critical functions.

A software must offer the following features :

1. Use of high level programming language
2. Modular structure with clear and standardised interfaces between software modules and the database
3. Inter module communication only via a 'soft bus' independent of their computer residency
4. Easy addition of further application programs
5. Comfortable on-line diagnostics, development tools and file editors.

Artificial Intelligence (AI) plays a pivotal role in the development of software, rule based experts systems, logic based systems like fuzzy logic, neural networks etc. fall under this category. Few applications of the recent times are stated on the next page :

1. Application of expert system to power system restoration using flow control rules, energisation rules, line switching rules, load shedding rules, voltage correction rules etc.
2. Knowledge-based expert systems for fault location and diagnosis on electric power distribution feeders.
3. Fuzzy based logic for reconfiguration of distribution networks.

The application of model based expert system results in an intelligent power distribution system with learning self organizing and diagnostic capabilities. In addition, it advises the control center operations in cases of emergency. Distribution automated systems can therefore be operated in two operational modes: Online and Off-line. The Online operation permits faulty equipment identification, restoration planning, network maintenance scheduling and emergency operations. The Off-line simulator mode allows the user to verify the validity of acquired knowledge by setting an imaginary fault on the system and provides a convenient way of training the inexperienced operator.

42.12. Distribution Automation

Distribution Automation functions provide a means to more effectively manage minute by minute continuous operation of a distribution system. Distribution Automation provides a tool to achieve a maximum utilization of the utility's physical plant and to provide the highest quality of service to its customers. Obviously, both the utility and its customers are beneficiaries of successful Distribution Automation.

Distribution Automation systems are modular, hence they may be implemented in stages, commencing from a modest degree of capability and complexity and growing as necessary to achieve tangible and intangible economic benefits. For example, a utility may start with a limited capability SCADA System for sub station monitoring and control, extend this to the feeders and finally implement a complete integration of automation functions. Systems implemented in this fashion must be designed to accommodate future expansion.

Distribution Automation System offers an integrated 'Distributed Management System' (DMS). The functions of DMS are shown in Fig 42.8. As in any other SCADA system, Distribution SCADA involves

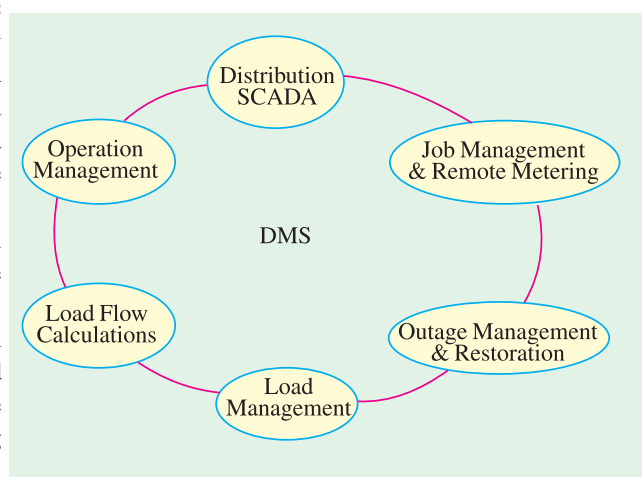


Fig. 42.8. Functions of distributed management system

collecting and analyzing information to take decisions, implementing the appropriate decisions and then verifying that the desired results are achieved. Operation management supports the analysis of distribution network. It models the load profile to present state of the network. Load flow calculations estimate voltage levels and power flows at each feeder. Job management makes switching order handling easier and work protection tagging ensures the safety of repair crew on duty. Outage management and service restoration facilitates to reduce outage time thereby increasing the reliability of the supply. Remote metering provides for 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.

42.13. Load Management in DMS

This involves controlling system loads by remote control of individual customer loads. Control includes suppressing or biasing automatic control of cyclic loads, as well as load switching. Load Management can also be effected by inducing customers to suppress loads during utility selected daily periods by means of time-of-day rate incentives. Distribution Automation provides the control and monitoring ability required for both the load management scenarios -viz - direct control of customers loads and the monitoring necessary to verify that programmed levels are achieved. Execution of load management provides several possible benefits to the utility and its customers. Maximum utilization of the existing distribution system can lead to deferrals of capital expenditure. This is achieved by :

- (i) Shaping the daily (or monthly, annual) load characteristic by suppressing loads at peak times and encouraging energy consumption at off-peak times.
- (ii) Minimizing the requirement for more costly generation or power purchases by suppressing loads.
- (iii) Relieving the consequences of significant loss of generation or similar emergency situations by suppressing load.
- (iv) Reducing cold load pick-up during re-energization of circuits using devices with cold load pick-up features.

The effectiveness of direct control of customer loads is obviously enhanced by selecting the larger and more significant customer loads. These include electric space and water heating, air conditioning, washing machines, dryers and others of comparable magnitude.

More sophisticated customer's activated load management strategies are under study, taking advantage of the capabilities of Distribution Automation and of customers installed load control PC. With such an arrangement, the utility could vary rates throughout the day, reflecting actual generation costs and any system supply capability constraints and broadcast this information to all customer's PC. Each PC could then control its loads to conform to a customer selected cost bias. This is sometimes called as 'spot pricing'.

42.14. Automated Distribution System

In the 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 the distribution network may be detected and operated upon so as to minimize the outage time.

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

1. Data collection equipment
2. Data transmission (telemetry) equipment

3. Data monitoring equipment
4. Data processing equipment
5. 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 .

The implementation of SCADA system in the electric utility involves the installation of following units :

(a) Data acquisition unit : The basic variables (data) required for control, monitoring and protection include current, voltage, frequency, time, power factor, reactive power and real power. The data may be tapped in analog or digital form as required. For data collection purpose CT's and PT's are used. Transducers may be needed to convert the data into electrical form to enable easy measurement and transmission .The data is amplified in signal amplifier and conditioned in data signal conditioner. The data is then transmitted from the process location to the transmission room. In the control room data processing and data logging are performed which includes input scanning at required intervals, recording, programming and display by microprocessor, PLC, PC etc.

(b) Remote terminal unit (RTU) : RTU is used to record and check signals, measured values and meter readings before transmitting them to control station and in the opposite direction to transmit commands, set point values and other signals to the switchgear and actuator.

(c) Communication unit : A good data communication system to transmit the control command and data between distribution control centre and large number of remotely located devices is a prerequisite for a good performance of DA system. Wide range of communication technologies are available to perform the task of DA system which include public telephone communication (leased or dedicated line), power line carrier communication (PLCC), UHF MARS (ultra high frequency multi address radio system) and VHF Radio, as discussed earlier.

Distribution Automation can be broadly classified as :

1. Substation Automation.
2. Feeder Automation.
3. Consumer side Automation

42.15. Substation Automation

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

1. Increased performance and reliability of electrical protection.
2. Advanced disturbance and event recording capabilities, aiding in detailed electrical fault analysis.
3. Display of real time substation information in a control center.
4. Remote switching and advanced supervisory control.
5. Increased integrity and safety of the electrical power network including advanced interlocking functions.
6. Advanced automation functions like intelligent load-shedding.

42.15.1 Requirements

The general requirements for selecting an automation system while designing a new substation are :

1. The system should be adaptable to any vendor's hardware.
2. It should incorporate distributed architecture to minimize wiring.
3. It should be flexible and easily set up by the user.

4. The substation unit should include a computer to store data and pre-process information.

42.15.2. Functioning

Bus voltages and frequencies, line loading, transformer loading, power factor, real and reactive power flow, temperature, etc. are the basic variables related with substation control and instrumentation. The various supervision, control and protection functions are performed in the substation control room. The relays, protection and control panels are installed in the controlled room. These panels along with PC aids in automatic operation of various circuit breakers, tap changers, autoreclosers, sectionalizing switches and other devices during faults and abnormal conditions. Thus, primary control in substation is of two categories.

1. Normal routine operation by operator's command with the aid of analog and digital control system.
2. Automatic operation by action of protective relays, control systems and PC.

The automated substation functioning can be treated as integration of two subsystems, as discussed below :

(a) Control System : The task of control system in a substation includes data collection, scanning, event reporting and recording; voltage control, power control, frequency control, other automatic and semiautomatic controls etc. The various switching actions like auto reclosing of line circuit breakers, operation of sectionalizing switches, on-load tap changers are performed by remote command from control room. The other sequential operations like load transfer from one bus to another, load shedding etc. are also taken care by control center.

(b) Protective System : The task of protective system includes sensing abnormal condition, annunciation of abnormal condition, alarm, automatic tripping, back-up protection, protective signaling.

The above two systems work in close co-operation with each other. Most of the above functions *i.e.* automatic switching sequences, sequential event recording, compiling of energy and other reports, etc. are integrated in software in the substation computer. This software is of modular design, which facilitates addition of new functions.

The communication between circuit breakers, autoreclosers and sectionalizing switches in the primary and secondary distribution circuits located in the field and the PC in distribution substation control room is through radio telecontrol or fibre optic channel or power line carrier channel as is feasible.

42.16. Feeder Automation

Automating 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 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 typical functions of fault detection, isolation and network reconfiguration for supply restoration. The equipments normally required in Feeder Automation are discussed below :

(a) Distribution equipment :

This includes transformers, breakers, load break switches and motor operators, power reclosures, voltage regulators, capacitor banks etc.

(b) Interface equipment :

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

(c) Automation equipment :

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

42.17. 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 a specific area in the distribution system and judge the overall losses.

42.17.1. Energy Auditing

Energy audit has a very wide range of applications in the electrical systems. It means overall accounting of energy generated, transmitted and distributed. As far as distribution side is concerned energy audit would mean overall accounting of energy supplied to and utilized by the consumers. Energy audit can also be used for rethinking about billing strategy, usefulness of an individual subscriber, loading of a given feeder etc.

Remote metering is used in energy auditing in which the energy used by a consumer is billed from a remote (distant) location without actually going to the place. In remote metering, the concept of TOD (time of day) metering can be introduced wherein the electronic meters at consumer's service entrance point are programmed to read the following meter readings on monthly basis.

1. KW hrs. consumed during calendar month by the consumer during low tariff and high tariff hours.
2. KVA maximum demand by the consumer during the calendar month (based on maximum demand lasting for 30 minutes duration).
3. Low tariff for off peak hour consumption.

These readings are telemetered to the control room for the purpose of monthly billing and cash collection through the various modes of communication available (- viz - Telephonic and wireless communication) depending on the load condition of the consumer. Tampering of energy - meters (if done) is also telemetered for taking action/penalty and disconnection of service.

Thus energy audit, though a very cumbersome and tedious job, can make a non-profitable business of distribution into a highly profitable one.

42.18. Advantages of Distribution Automation

More and more electric utilities are looking to distribution automation as an answer to the three major economic challenges facing the industry : the rising cost of adding generating capacity, increased saturation of existing distribution networks and greater sensitivity to customer service. Therefore, utilities that employ distribution automation expect both cost and service benefits. These benefits accumulate in areas that are related to investments, interruptions and customer service, as well as in areas related to operational cost savings, as given below :

(a) Reduced line loss :

The distribution substation is the electrical hub for the distribution network. A close coordination between the substation equipment, distribution feeders and associated equipment is necessary to increase system reliability. Volt/VAR control is addressed through expert algorithms which monitors and controls substation voltage devices in coordination with down-line voltage devices to reduce line loss and increase line throughput.

(b) Power quality :

Mitigation equipment is essential to maintain power quality over distribution feeders. The substation RTU in conjunction with power monitoring equipment on the feeders monitors, detects,

and corrects power-related problems before they occur, providing a greater level of customer satisfaction.

(c) Deferred capital expenses :

A preventive maintenance algorithm may be integrated into the system. The resulting ability to schedule maintenance, reduces labour costs, optimizes equipment use and extends equipment life.

(d) Energy cost reduction :

Real-time monitoring of power usage throughout the distribution feeder provides data allowing the end user to track his energy consumption patterns, allocate usage and assign accountability to first line supervisors and daily operating personnel to reduce overall costs.

(e) Optimal energy use :

Real-time control, as part of a fully-integrated, automated power management system, provides the ability to perform calculations to reduce demand charges. It also offers a load-shedding/preservation algorithm to optimize utility and multiple power sources, integrating cost of power into the algorithm.

(f) Economic benefits :

Investment related benefits of distribution automation came from a more effective use of the system. Utilities are able to operate closer to the edge to the physical limits of their systems. Distribution automation makes this possible by providing increased availability of better data for planning, engineering and maintenance. Investment related benefits can be achieved by deferring addition of generation capacity, releasing transmission capacity and deferring the addition, replacement of distribution substation equipment. Features such as voltage/VAR control, data monitoring and logging and load management contribute to capital deferred benefits.

Distribution automation can provide a balance of both quantitative and qualitative benefits in the areas of interruption and customer service by automatically locating feeder faults, decreasing the time required to restore service to unfaulted feeder sections, and reducing costs associated with customer complaints.

(g) Improved reliability :

On the qualitative side, improved reliability adds perceived value for customer and reduce the number of complaints. Distribution automation features that provide interruption and customer service related benefits include load shedding and other automatic control functions.

Lower operating costs are another major benefits of distribution automation. Operating cost reduction are achieved through improved voltage profiles, controlled VAR flow, repairs and maintenance savings, generation fuel savings from reduced substation transformer load losses, reduced feeder primary and distribution transformer losses, load management and reduced spinning reserve requirements. In addition, data acquisition and processing and remote metering functions play a large role in reducing operating costs and should be considered an integral part of any distribution automation system.

Through real time operation, the control computer can locate the faults much faster and control the switches and reclosures to quickly reroute power and minimize the total time-out, thus increasing the system reliability.

(h) Compatibility :

Distribution automation spans many functional and product areas including computer systems, application software, RTUs, communication systems and metering products. No single vendor provides all the pieces. Therefore, in order to be able to supply a utility with a complete and integrated system, it is important for the supplier to have alliances and agreements with other vendors.

An effective distribution automation system combines complementary function and capabilities and require an architecture that is flexible or “open” so that it can accommodate products from different vendors. In addition, a distribution automation system often requires interfaces with existing system in order to allow migration and integration, still monitoring network security.

Tutorial Problem No. 42.1

1. Why we need Transmission System Interconnection? *(Nagpur University, Summer 2004)*
2. Describe different distribution automation methods and their advantages and disadvantages.

OBJECTIVE TESTS – 42

1. Need based energy management is better than demand based energy management
(a) true (b) false
2. Round the clock power is required to
(a) agricultural uses
(b) shift based industries
(c) commercial organisations
(d) essential services
3. Need based energy management would include
(a) plan power generation as per forecast
(b) monitor matching of need with supply
(c) identify the needs of various consumers
(d) all of the above
4. Existing Distribution systems are
(a) properly designed
(b) chaotic
(c) optimally operated
(d) automated
5. Distribution systems are not radial
(a) true (b) false
6. The major aim of distribution automation is to keep minimum area in dark for a minimum time
(a) true (b) false
7. Distribution automation is used for
(a) electrical quantities only
(b) physical quantities only
(c) both of the above
8. Sectionalizing switches are circuit breakers
(a) true (b) false
9. RTU is a -
(a) transmitter (b) receiver
(c) trans-receiver
10. The main problem in implanting Distribution Automation in metros is -
(a) RTUs (b) communication
(c) D.A.S. (d) control computers
11. Distribution SCADA means -
(a) data acquisition
(b) man – machine interface
(c) data archiving
(d) all of the above
12. Now - a - days the trend is towards -
(a) manned substation
(b) unmanned substation
13. Artificial Intelligence plays a pivotal data in distribution automation
(a) true (b) false
14. Distribution Automation means -
(a) substation Automation
(b) feeder Automation
(c) consumer side Automation
(d) all of the above
15. Distribution Automotive system are modular
(a) true (b) false
16. Existing distribution systems are controlled
(a) automatically
(b) manually
17. Distribution Automotive systems operate in real time
(a) true (b) false
18. Until recent years, much of the investment and technical exploitation was done in -
(a) generation
(b) transmission
(c) generation and transmission
(d) distribution
19. Demand supply gap in power sector is expected to grow by - - - - percent every year.
(a) 5 (b) 10
(c) 15 (d) 20
20. Major revenue losses in distribution system occur in -
(a) domestic sector
(b) industrial sector
(c) agricultural sector
(d) commercial sector

ANSWERS

1. (a) 2. (d) 3. (d) 4. (b) 5. (b) 6. (a) 7. (c) 8. (b) 9. (c) 10. (b)
11. (d) 12. (b) 13. (a) 14. (d) 15. (a) 16. (b) 17. (a) 18. (c) 19. (d) 20. (c)