A Project Report on

RELIABILITY IMPROVEMENT OF RADIAL DISTRIBUTION SYSTEM USING SMART GRID TECHONOLGY

Submitted for partial fulfillment of the requirements for the award of the degree

of

BACHELOR OF TECHNOLOGY

IN

COMPUTER SCIENCE & ENGINEERING

BY

G. ROJASRI	16911A05K6
K. MADHURI	16911A05L6
T. SHRESTARAO	16911A05P3
V. ALEKYA	16911A05P5

Under the Esteemed Guidance of

S. DIVYA
ASSISTANT PROFESSOR

Department of Computer Science & Engineering

VIDYA JYOTHI INSTITUTE OF TECHNOLOGY

(An Autonomous Institution)

(Approved by AICTE, New Delhi & Affiliated to JNTUH, Hyderabad)

Aziz Nagar Gate, C.B. Post, Hyderabad-500075

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DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

CERTIFICATE

This is to certify that the project report titled "**RELIABILITY IMPROVEMENT OF RADIAL DISTRIBUTION SYSTEM USING SMART GRID TECHONOLGY**" is being submitted by **G.ROJASRI(16911A05K6), K.MADHURI(16911A05L6), T.SHRESTARAO(16911A05P3), V.ALEKYA(16911A05P5)** in partial fulfillment for the award of the Degree of Bachelor of Technology in **Computer Science & Engineering,** is a record of bonafide work carried out by him/her under my guidance and supervision. These results embodied in this project report have not been submitted to any other University or Institute for the award of any degree of diploma.

Internal Guide

S. Divya

Assistant Professor

Head of Department

Dr. B. Vijaya Kumar

Professor

Head of the Department
Computer Science and Engineering
VJIT, Hyderabad-500075.

External Examiner

DECLARATION

This is to certify that the work reported in the present project entitled as "**RELIABILITY IMPROVEMENT OF RADIAL DISTRIBUTION SYSTEM USING SMART GRID TECHNOLOGY**" submitted for the degree of Bachelor of Technology in Computer Science & Engineering is original and has been done by us this work is not copied and submitted anywhere for the award of any degree.

Date:

Place: Hyderabad

G. ROJASRI	**(16911A05K6)**
K. MADHURI	**(16911A05L6)**
T. SHRESTA	**(16911A05P3)**
V. ALEKYA	**(16911A05P5)**

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G. ROJASRI (16911A05K6)
K. MADHURI (16911A05L6)
T. SHRESTA (16911A05P3)
V. ALEKYA (16911A05P5)

ABSTRACT

The primary function of a power system is to supply its customers with electrical energy as economically as possible with acceptable reliability and quality. Power system reliability is defined as the ability of the system to satisfy the customer demand.

A smart grid is an electrical grid which includes a variety of operational and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficient resources. Electronic power conditioning and control of the production and distribution of electricity are important aspects of the smart grid.

Smart grid incorporates communication and control technologies to provide more efficient and reliable electricity to customers. The infrastructure of such power system will allow the customers to generate and store electricity, and use that in case of an outage or disconnection from the utility. Therefore, the outage of power from the utility side does not necessarily result in loss of electricity.

The objective of this project is to improve the reliability using smart grid. The reliability indices will be calculated for the practical distribution system with and without the smart grid technology using MATLAB. Further the objective of the project is to prove that the reliability of the network can be improved using smart grid technology.

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CHAPTER 1

INTRODUCTION

Chapter provides a brief introduction of Smart Grid and explains the importance of tomation in the electrical distribution system. It also highlights how reliability can be improved using smart grid technology of the feeders. Furthermore, it also emphasizes the ongoing ways improve reliability of the feeders through smart technology and how such automation should be ne in order to be of the most benefit.

1 Important characteristics of smart grid technology

In distribution automation, remotely operated disconnecting switches are used for the quick storation of power supply to the loads which are under un-faulted sections of the feeder. Smart d technology includes the application of distribution automation and digital controls to the stribution system and this can lead to have much more faster restoration of the power supply in stribution systems. Some of the important characteristics of smart grid technology are

- Distribution automation
- Increase in use of digital control and information technology with real time availability
- Deployment of smart meters and phase measurement units
- Inclusion of demand side response and demand side management technologies
- Integration of renewable and energy storage facilities
- Smart appliances and customer devices at the customer's premises
- Dynamic optimization relating to the grid operability
- Advanced, composite and high temperature superconductors are used
- Energy storage, batteries, flywheels and switched mode power supply technologies are used.

1.2 Smart Grid and Present Situation of the Distribution System

In the traditional distribution system, whenever there is power outage, the trouble call system is used to detect it. In other words, when a fault occurs and customers experience power outages, they report the power outage to the power utility company.

Smart Grid is defined as an electricity network that can intelligently integrate the behavior and action of all users connected to it through communication

1. for radical improvement of the power system to minimize power outages.

2. To enable and operate all generations and storage options

3. To enable new product services and markets

4. To optimize asset utilization and operate efficiently

5. To selfheal disturbances

1.3 Difference between a smart grid and a conventional grid

When comparing a future smart grid to a conventional grid, the conventional grid is usually described as a grid with large conventional power plants feeding power to the transmission grid.

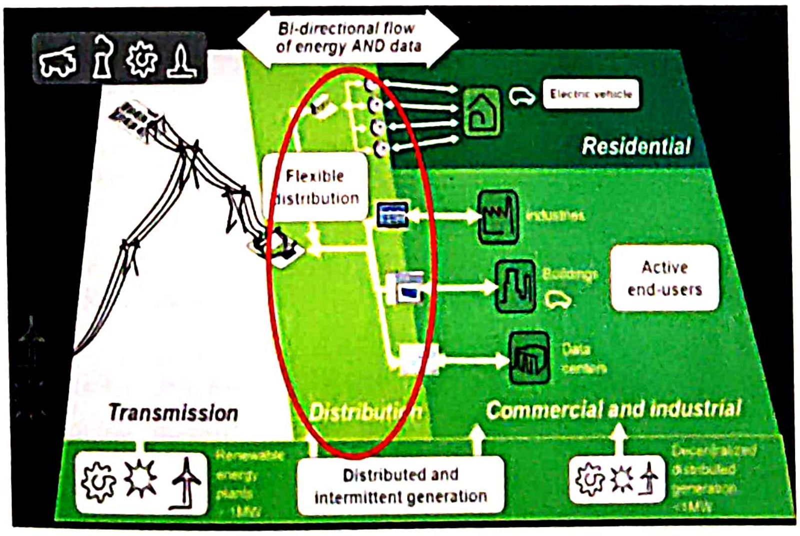

Fig. 1.1 The smart grid concept

Table 1.1: The differences between conventional and smart grid distribution system

S. No.	Conventional Distribution Systems	Smart Grid Distribution System
1	Radial topology	Network topology
2	Electromechanical controls	Digital controls
3	Built for centralized generation	Accommodates distributed generation
4	Manual restoration	Self-healing
5	Few /no sensors are used	Advanced sensors are used throughout the system for monitoring.
6	Emergency decisions are taken by committee and by phone	Decision support systems and predictive reliability is used
7	Limited or no price information	Full price information
8	Limited control over power flows	Full control over power flows
9	It is not a self-monitoring/blind system	It is a self-monitoring system
10	One way communication	Two way communication
11	Prone to failures and blackouts	Adaptive protection and islanding is possible
12	Equipment's are checked and controlled manually	Equipment's are checked and controlled remotely
13	Few customers choice	Many customers choice
14	Manual operated disconnecting switches are used	High rated power electronic switches are used

CHAPTER 2

FEEDER AUTOMATION

This chapter explains the idea of feeder automation and the important role of automation in the distribution system in order to improve system reliability. The automation process is elaborated with the help of an example to understand the quick healing process to power interruption in order to provide a reliable, efficient supply to meet demands.

2.1 Types of Feeders

1. Radial distribution system
2. Ring main distribution system
3. Interconnected system

2.1.1 Radial Electrical Power Distribution System

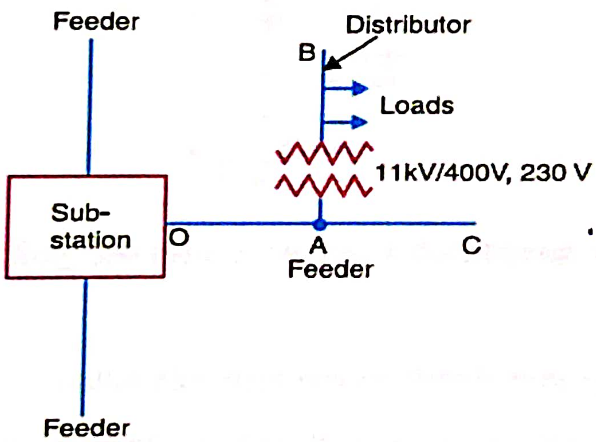

Fig. 2.1 Radial electrical power distribution system

Radial electrical power distribution system has one major drawback that in case of any feeder failure, the associated consumers would not get any power as there was no alternative path to feed the transformer

Advantages

- Its initial cost is minimum.
- It is the simplest distribution system.

Disadvantages

- The end of the distributor nearest to the feeding end would be heavily loaded.
- The consumers are dependent of single feeder and distributor. Therefore, when a fault occurs on the feeder or distributor, the supply is cut off to all the consumers who are on the side of the fault away from the substation.
- The consumers at the far end distributor would be subjected to serious voltage fluctuations because of changing the load on the distributor.

2.1.2 Ring Main Electrical Power Distribution System

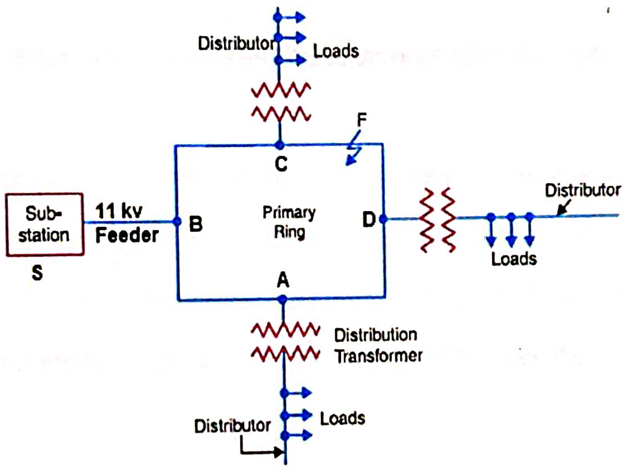

Fig. 2.2 Ring main electrical power distribution system

The drawback of radial electrical power distribution system can be overcome by introducing a ring main electrical power distribution system. Here one ring network of distributors is fed by more than one feeder.

Advantages

- The system is more reliable since each distributor is fed via two feeders. In the event of a fault on any section of the feeder, the continuity of supply can be maintained. For an instant, suppose fault occurs at any point F of section CD of the feeder, then section CD of the feeder can be isolated for repairs and at the same time continuity of supply is maintained to all the consumers.

2.1.3 Interconnected Electrical Power Distribution System

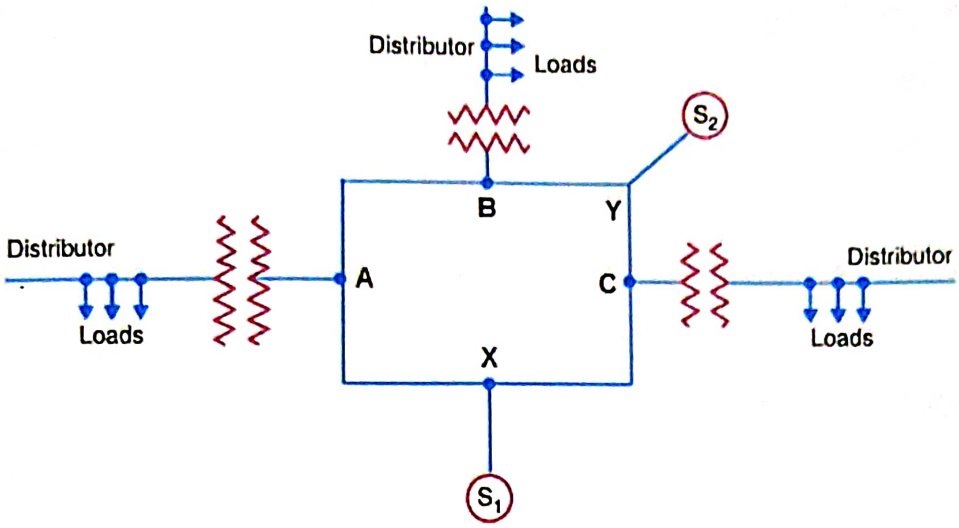

Fig. 2.3 Interconnected electrical power distribution system

When a ring main feeder is energized by two or more substations or generating stations, it is called as an interconnected distribution system. This system ensures reliability in an event of transmission failure. Also, any area fed from one generating stations during peak load hours can be fed from the other generating station or substation for meeting power requirements from increased load.

Advantages

- It increases the reliability of supply.
- During overload hours, the area fed from one generating station can be fed from other generating station. Thus it reduces the reserved plant capacity, improves the service reliability and increases the load factor and efficiency of the system.

Disadvantages

- Expensive tie line
- Expensive circuit breaker
- Synchronizing problem
- Metering and instrumentation

2.2 Objective of Feeder Automation

Feeder Automation generally refers to automation of the task that has to be done in a repetitive fashion over a period of time. In other words, automation refers to distance supervision and control of substation equipment and feeder switches continuously in order to avoid power outages.

The power companies are implementing numerous ways of improving reliabilityTherefore, concisely, the main objectives of feeder automation include but are not limited to

- Decrease the number of customer outages and duration of customer outages.
- Instantaneous fault detection, isolation and service restoration.
- Transformer and feeder load balancing.

2.3 Automation in Distribution Feeder Reconfiguration

In the radial distribution system, the fault current always flows from source to fault location. Therefore, in the properly coordinated automatic distribution system, the fault will be cleared by the nearest protecting devices. After the fault has been isolated, the system will reconfigure in order to restore power to its customers. The reconfiguration is done with the help of automatic and manual switches. The study mainly focuses on a two stage reconfiguration where a limited number of customers are restored quickly using automatic switches and the remaining customers are restored later using manual switching.

System reconfiguration usually takes place in two phases, upstream and downstream restoration. In the upstream restoration after the circuit breaker clears the fault, the fault is located and the nearest upstream switch is opened. This will restore power to all upstream customers.

In the downstream restoration, after the upstream reclosing switch is opened, the downstream sectionalizing switch close to the fault location is opened. This will allow the normally open switch to close, restoring service to downstream customers.

CHAPTER 3

POWER SYSTEM PROTECTION

Power system protection is the backbone and effective way to improve reliability of the distribution system. This section describes various protection devices used for radial line protection. Proper coordination between these protecting devices must be assured in order to reduce the number of customer interruptions during a fault which will improve reliability of the distribution system.

3.1 Protective Devices

Different types of protection devices like reclosers, relays, switchgears and automatic sectionalizers are used in overhead line protection of the electrical distribution system.

3.2 High Voltage Circuit Breakers

High voltage circuit breakers usually interrupt high fault currents. The insulating mediums that are usually used in the circuit breakers are vacuum, SF6 (sulfur hexafluoride gas) and oil.

3.3 Switchgears

Switchgear is a combination of fuses or circuit breakers which have a tendency to isolate a fault and de-energize the circuit. Once a faulted current has been broken, switchgears can be opened or closed manually until the faulted segment is repaired. The switchgears should have the ability to quench the arc created during opening of the circuit, but Switchgears have no ability to change the number of interruptions experienced by utility customers.

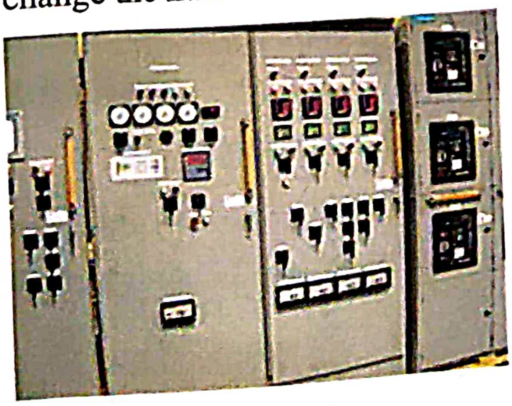

Fig. 3.1 Switch gear

Fig. 3.2 High voltage switch gear installation

3.4 Automatic Sectionalizers

Automatic sectionalizers automatically de-energize a faulted section so that no faulted line sections can be safely energized. It helps to overcome the coordination problems of other protection devices like fuse and reclosers near substations. When the fault current exceeds the pre-set value, the sectionalizers will open instantaneously in order to isolate the fault to restore power back to un faulted line segment customers. This also helps to save the fuse from blowing which is also known as a "fuse saving" scheme.

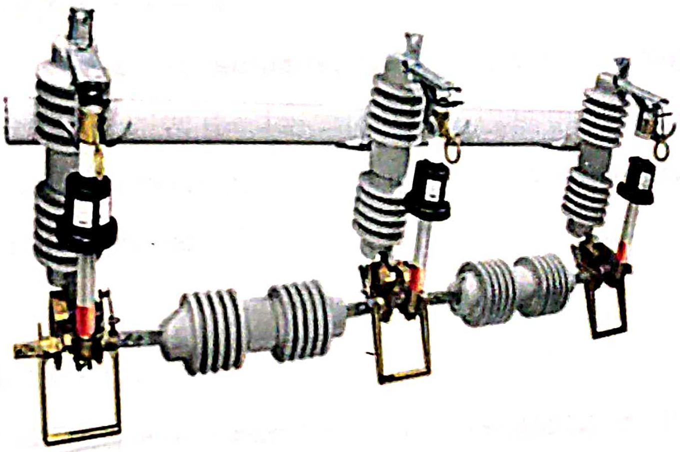

Fig. 3.3 Automatic Sectionalizers

3.5 Disconnect Switches

Disconnect switches provide a means for ensuring a circuit is completely de-energized for service, maintaining maximum safety for personnel. Available UL 98, UL 508, and UL 1008 rated switches in fused or non-fused configurations supply reliable disconnecting operations for even the most demanding applications, up to 600A.

3.6 Fuse

A fuse is an electrical safety device that operates to provide over current protection of an electrical circuit. Its essential component is a metal wire or strip that melts when too much current flows through it, thereby interrupting the current.

CHAPTER 4

SMART GRID

A smart grid is an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users

4.1 Modernization opportunities

Since the early 21st century, opportunities to take advantage of improvements in electronic communication technology to resolve the limitations and costs of the electrical grid have become apparent. Technological limitations on metering no longer force peak power prices to be averaged out and passed on to all consumers equally.

4.2 Definition of "Smart Grid"

The first official definition of Smart Grid was provided by the Energy Independence and Security Act of 2007 (EISA-2007), which was approved by the Congress in January 2007, and signed to law by President George W. Bush in December 2007. Title XIII of this bill provides a description, with ten characteristics, that can be considered a definition for Smart Grid, as follows:

"It is the policy of the United States to support the modernization of the Nation's electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure that can meet future demand growth and to achieve each of the following, which together characterize a Smart Grid:

1. Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.
2. Dynamic optimization of grid operations and resources, with full cyber-security.
3. Deployment and integration of distributed resources and generation, including renewable resources.
4. Development and incorporation of demand response, demand-side resources, and energy-efficiency resources.

5. Deployment of 'smart' technologies (real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices) for metering, communications concerning grid operations and status, and distribution automation.

6. Integration of 'smart' appliances and consumer devices.

7. Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal storage air conditioning.

8. Provision to consumers of timely information and control options.

9. Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.

1.3 Early technological innovations

Smart grid technologies emerged from earlier attempts at using electronic control, metering, and monitoring. In the 1980s, automatic meter reading was used for monitoring loads from large customers, and evolved into the Advanced Metering Infrastructure of the 1990s, whose meters could store how electricity was used at different times of the day.[11] Smart meters add continuous communications so that monitoring can be done in real time, and can be used as a gateway to demand response-aware devices and "smart sockets" in the home.

Monitoring and synchronization of wide area networks were revolutionized in the early 1990s when the Bonneville Power Administration expanded its smart grid research with prototype sensors that are capable of very rapid analysis of anomalies in electricity quality over very large geographic areas. The culmination of this work was the first operational Wide Area Measurement System (WAMS) in 2000. Other countries are rapidly integrating this technology — China started having a comprehensive national WAMS when the past 5-year economic plan completed in 2012.

4.4 Features of the smart grid

The smart grid represents the full suite of current and proposed responses to the challenges of electricity supply. Because of the diverse range of factors there are numerous competing taxonomies and no agreement on a universal definition. Nevertheless, one possible categorization is given here.

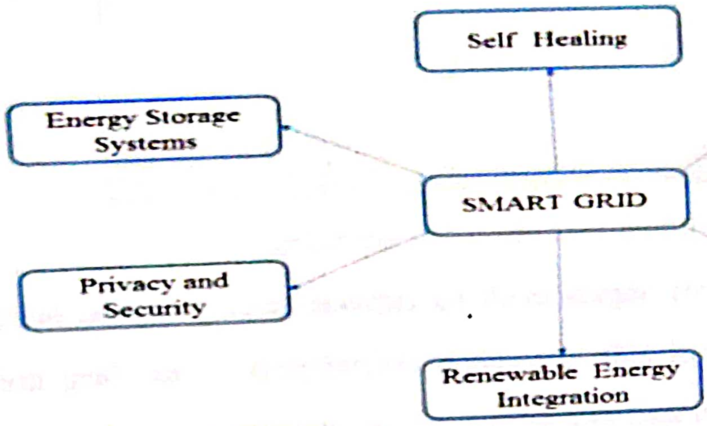

Fig. 4.1 Smart Grid features

4.5 Reliability

The smart grid makes use of technologies such as state estimation that improve fault detection and allow self-healing of the network without the intervention of technicians. This will ensure more reliable supply of electricity, and reduced vulnerability to natural disasters or attack.

Although multiple routes are touted as a feature of the smart grid, the old grid also featured multiple routes. Initial power lines in the grid were built using a radial model, later connectivity was guaranteed via multiple routes, referred to as a network structure. However, this created a new problem: if the current flow or related effects across the network exceed the limits of any particular network element, it could fail, and the current would be shunted to other network elements, which eventually may fail also, causing a domino effect. See power outage

4.6 Hierarchical Levels of reliability in power system

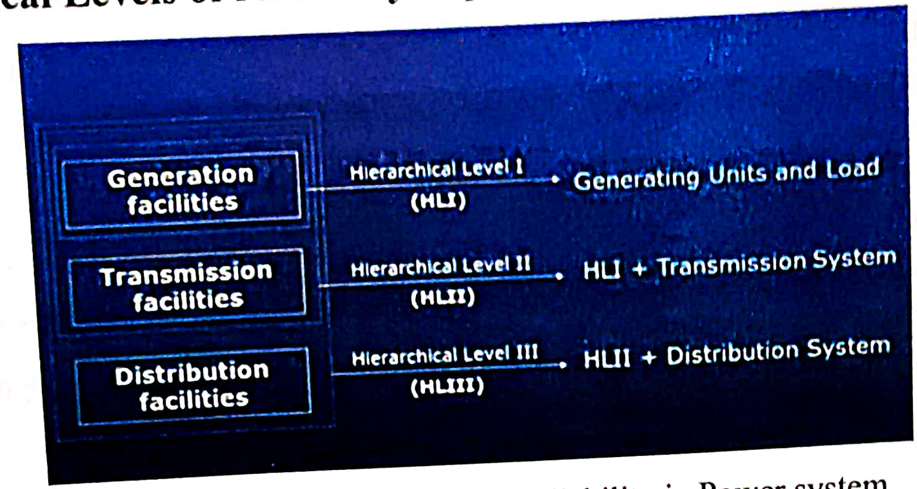

Fig. 4.2 Hierarchical Levels of Reliability in Power system

The electrical power system consists of three major components: generation, a high voltage transmission grid, and a distribution system. In this it is considered that above three major components as three hierarchical levels, among this first two levels it is assumed that generation and transmission are 100% reliable.

4.7 Flexibility in network topology

Next-generation transmission and distribution infrastructure will be better able to handle possible bi-direction energy flows, allowing for distributed generation such as from photovoltaic panels on building roofs, but also the use of fuel cells, charging to/from the batteries of electric cars, wind turbines, pumped hydroelectric power, and other sources.

Classic grids were designed for one-way flow of electricity, but if a local subnetwork generates more power than it is consuming, the reverse flow can raise safety and reliability issues. A smart grid aims to manage these situations.

4.8 Smart Grid Efficiency

Numerous contributions to overall improvement of the efficiency of energy infrastructure are anticipated from the deployment of smart grid technology, in particular including demand-side management, for example turning off air conditioners during short-term spikes in electricity price, reducing the voltage when possible on distribution lines through Voltage/VAR Optimization (VVO) leading to lower power prices.

4.9 Load adjustment/Load balancing

A smart grid may warn all individual television sets, or another larger customer, to reduce the load temporarily (to allow time to start up a larger generator) or continuously (in the case of limited resources). Using mathematical prediction algorithms it is possible to predict how many standby generators need to be used, to reach a certain failure rate. In the traditional grid, the failure rate can only be reduced at the cost of more standby generators. In a smart grid, the load reduction by even a small portion of the clients may eliminate the problem.

4.10 Peak curtailment/leveling and time of use pricing

To reduce demand during the high cost peak usage periods, communications and metering technologies inform smart devices in the home and business when energy demand is high and track how much electricity is used and when it is used. It also gives utility companies the ability to reduce consumption by communicating to devices directly in order to prevent system overloads.

4.11 Sustainability

The improved flexibility of the smart grid permits greater penetration of highly variable renewable energy sources such as solar power and wind power, even without the addition of energy storage. Current network infrastructure is not built to allow for many distributed feed-in points, and typically even if some feed-in is allowed at the local (distribution) level; the transmission-level infrastructure cannot accommodate it.

4.12 Market-enabling

The smart grid allows for systematic communication between suppliers (their energy price) and consumers (their willingness-to-pay), and permits both the suppliers and the consumers to be more flexible and sophisticated in their operational strategies. Only the critical loads will need to pay the peak energy prices, and consumers will be able to be more strategic in when they use energy.

4.13 Demand response supports

Demand response support allows generators and loads to interact in an automated fashion in real time, coordinating demand to flatten spikes. Eliminating the fraction of demand that occurs in these spikes eliminates the cost of adding reserve generators, cuts wear and tear and extends the life of equipment, and allows users to cut their energy bills by telling low priority devices to use energy only when it is cheapest.

Currently, power grid systems have varying degrees of communication within control systems for their high-value assets, such as in generating plants, transmission lines, substations and major energy users .

4.14 Platform for advanced services

As with other industries, use of robust two-way communications, advanced sensors, and distributed computing technology will improve the efficiency, reliability and safety of power delivery and use. It also opens up the potential for entirely new services or improvements on existing ones, such as fire monitoring and alarms that can shut off power, make phone calls to emergency services, etc.

4.15 Provision megabits, control power with kilobits, sell the rest

The amount of data required to perform monitoring and switching one's appliances off automatically is very small compared with that already reaching even remote homes to support voice, security, and Internet and TV services. Many smart grid bandwidth upgrades are paid for by over-provisioning to also support consumer services, and subsidizing the communications with energy-related services or subsidizing the energy-related services, such as higher rates during peak hours, with communications.

4.16 Smart Grid Technology

- Integrated communications: Areas for improvement include: substation automation, demand response, distribution automation, supervisory control and data acquisition (SCADA
- Sensing and measurement: core duties are evaluating congestion and grid stabilityTechnologies include, advanced microprocessor meters (smart meter) and meter reading equipment
- Three technology categories for advanced control methods are, distributed intelligent agents (control systems), analytical tools (software algorithms and high-speed computers), and operational applications (SCADA, substation automation, demand response, etc.).

4.17. Communication techniques for smart grid

Wireless mesh is used in small business operation and remote areas for affordable connections. GSM is Global System for Mobile communication is used to transfer data and voice services. GSM is a cellular technology that connected mobile phone with the cellular network. Cellular network communication Cellular networks are also be a good option for communication between far nodes for utility purpose. Cellular networks are used to build a dedicated path for communication infrastructure to enable smart meter deployment over a wide area. Different cellular networks technologies such as 2G, 2.5G, 3G, 4G, 5G WiMAX and LTE used to share data between smart meter and the utility data center.

CHAPTER 5
RELIABILITY EVALUATION OF FEEDER

5.1 Introduction

Reliability is a probability of a device or a system performing its function adequately, for the period of time intended, under the operating conditions intended IEEE[5]. Reliability can be calculated by using few indices. They are load indices, customer indices, energy indices.

The purpose of this project is to include distribution systems that contain the main elements found in practical systems but which are sufficiently small that they can be easily analyzed using hand calculations. The project contains all the basic data needed to perform continuity analyses together with limited load flow data so that some design studies containing load flow solutions are also possible.

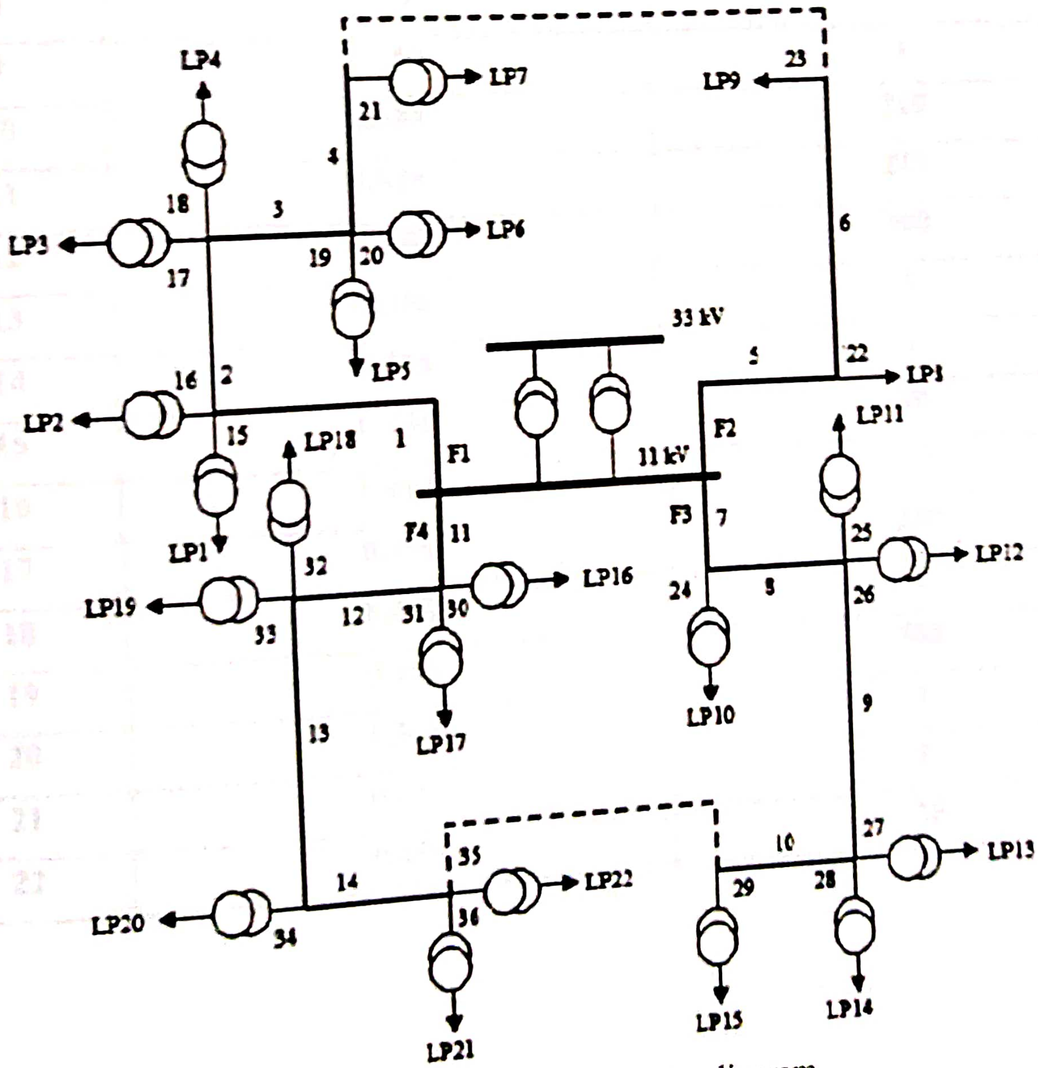

Fig. 5.1 RBTS BUS 2 Line diagram

Table 5.1: Load Data

Load point	Average Load per Load point	Number of customer per Load point
1	0.535	210
2	0.535	1
3	0.535	210
4	0.566	1
5	0.566	1
6	0.454	10
7	0.454	10
8	1.00	1
9	1.150	1
10	0.535	210
11	0.535	210
12	0.450	200
13	0.566	1
14	0.566	1
15	0.454	10
16	0.454	10
17	0.450	200
18	0.450	1
19	0.450	200
20	0.566	1
21	0.566	1
22	0.454	10

5.2 Description of the distribution network

The RBTS has 5 load bus bars (BUS2-BUS6). Two of these bus bars (BUS2 and BUS4) were selected and distribution networks designed for each. BUS2 has generation associated with it and BUS4 does not. This permits the effects and differences caused by the generation and transmission system on the overall load point indices to be seen. The peak loads defined in the RBTS for different customer types are shown in Table 5.2.

Table 5.2: Peak Loads in the RBTS for bus 2

Customer type	Peak loads, Mw (bus 2)
Residential	7.25
Small user	3.50
Government/institutions	5.55
Commercial	3.70
TOTAL	20.00

Table 5.3: Feeder Types and Lengths

Feeder length	Lengths Km	Feeder section numbers
1	0.60	2, 6, 10, 14, 17, 21, 25, 28, 30, 34
2	0.75	1, 4, 7, 9, 12, 16, 19, 22, 24, 27, 29, 32, 35
3	0.80	3, 5, 8, 11, 13, 15, 18, 20, 23, 26, 31, 33, 36

5.3 Customer and loading data

The defined average load assumes that this will be the variations through the day and through the year.

Table 5.4: Customer data

Number of load points	Load points	Customer Type	Load level per Load point		Number of customers
			Average	Peak	
5	1-3, 10, 11	Residential	0.535	0.8668	210
4	12, 17-19	Residential	0.450	0.7291	200
1	8	Small users	1.00	1.6279	1
1	9	Small users	1.15	1.8721	1
6	4, 5, 13, 20, 21	Govt/inst	0.566	0.9167	1
5	6, 7, 15, 16, 22	Commercial	0.454	0.7500	10
Total	22		12.291	20.00	1908

Table 5.5: Loading Data

Feeder number	Load points	Feeder load (MW)		Number of customers
		Average	Peak	
F1	1 to 7	3.645	5.934	652
F2	8,9	2.15	3.500	2
F3	10 to 15	3.106	5.057	632
F4	16 to 22	3.390	5.509	622
TOTAL	22	12.291	20.00	1908

5.4 System data

The reliability data assumed for the 33kV and 11kV system components is shown in Table 5.6 This includes sufficient data to perform the basic analyses included in this paper together with more complex analyses such as effect of weather on the 33kV overhead line system, temporary failures, maintenance effects, etc. The fuses and disconnects are assumed to be 100% reliable. Table 5.6 also includes other required or useful data including 33kV circuit lengths and transformer ratings. The latter permit loading levels and supply restrictions to be taken into account if desired. It is assumed that the circuits themselves do not introduce any restrictions.

Table 5.6: Reliability and System Data

Components	Λp	λa	Λr	λ"	R	rp	r"	re	S
Transformers:									
33/11	0.0150	0.0150	0.050	1.0		15	120	0.083	1.0
	0.0150	0.0150			200	10			1.0
Lines:									
33	0.0460	0.0460	0.060	0.5	8		8	0.083	2.0
11	0.0650	0.0650			5				1.0

Where,

λp = permanent (total) failure rate (f/yr)

λa = active failure rate (f/yr)

λr = temporary failure rate (f/yr)

λ"= maintenance outage rate (out/yr)

r = repair time (hr)

rp = replacement time by a spare (hr)

r" = maintenance outage time (hr

rc = Recloser time (hr)

s = switching time (hr)

5.5 Reliability results

Several case studies are performed on the llkv feeders. These centres on the inclusion or not of disconnects in the main feeders, fuses in each lateral and an alternative back-fed supply. The effect of replacing a failed low voltage transformer with a spare instead of repairing it is also evaluated. Finally in all cases the effect of constructing the llkv system with overhead lines and alternatively with underground cables is also assessed. The base case assumes the system with disconnects, with fuses, with alternative supply and repairing transformers. The individual load points indices (λ, r, U) are shown in Table 5 for BUS2 respectively.

5.6 Reliability indices

Reliability indices are simply statistical aggregations of reliability data of well defined loads, equipment and power users. The electrical distribution system is basically analyzed based on its reliability and reliability can be evaluated using reliability indices.

In the distribution system, the reliability is basically represented by load based indices and overall system based indices.

5.7 Load Based Indices

Load based indices are conventional indices which typically represent the data of each connected individual customer. The load point indices used in this thesis are represented below.

- **Average failure rate, λ (f/yr)**

$$\lambda i = \lambda 1 + \lambda 2 + \lambda 3 + \ldots\ldots\ldots + \lambda m = \sum_{j=1}^{n} \lambda j \qquad \ldots\ldots\ldots\ldots\ldots\ldots(5.1)$$

Where,

n = total number of customers at load point i

λj = average failure rate of loads at point i

λi = average failure rate of load point i

- **Average outage time, r (hr)**

$$r_i = (r_{i1}\lambda_1 + r_{i2}\lambda_2 + \ldots\ldots r_{im}\lambda_m)/\lambda_i = \sum_{j=1}^{n} \lambda_j \frac{r_{i,j}\lambda_j}{\lambda_i}$$

……………(5.2)

Where,

n = total number of feeders at load point i

rij = average outage time of feeder j due to failure of segment i

λi = average failure rate of each segment i

- **Average annual outage time, U (hr/yr)**

$$U_i = r_i \lambda_i$$ ………………(5.3)

Where,

Ui= average annual outage time

5.8 System based indices

System based indices are most widely used indices by utility companies for the reliability improvement targets. In other words, system based indices often serve as benchmarks for reliability improvement. The main advantage of system based indices is that it treats all type of customers equally despite its size. Some commonly used system indices are described below.

- **System Average Interruption Frequency Index**

System Average Interruption Frequency Index (SAIFI) represents the total number of sustained interruptions in a system over a year. It is the ratio of the total mean failure rate of each element and the total customers served in the system. Total mean failure rate for an element is the total number of interruptions that a customer on that segment is expected to experience in a year. SAIFI can be reduced by reducing the number of sustained interruptions.

$$\text{SAIFI} = \frac{\sum_{i=1}^{n} \lambda_i N_i}{N}$$ ……….(5.4)

Where,

n = total number of load points

λi= average failure rate of each segment i

Ni= Number of customer interrupted

N = Total number of customers served

- **System Average Interruption Duration Index**

System Average Interruption Duration Index (SAIDI) is the annual outage duration an average customer will experience over a year. The sum of the annual outage duration represents the total number of annual customer hours interrupted due to all possible faults. SAIDI can be reduced by reducing the number of interruptions or by reducing the duration of interruptions.

$$SAIDI = \frac{\sum_{i=1}^{n} UiNi}{N} = \frac{\sum customers\ minutes\ interrupted(CMI)}{Number\ of\ customers\ served}$$

.... (5.5)

Where,

n= total number of load points

Ui = average annual outage rate of component i

Ni = number of customers disconnected

N = Total number of customer served

- **Customer Average Interruption Duration Index**

Customer Average Interruption Duration Index (CAIDI) is the measure of the average time to restore service to customers per interruption. CAIDI can be improved by increasing the number of momentary interruptions or decreasing the duration of sustained interruptions. Due to this, CAIDI might not be that useful to describe reliability as compared to SAIDI and SAIFI. Customer Average Interruption Duration Index is calculated as

$$CAIDI = \frac{Sum\ of\ all\ customers\ interruption\ durations}{Total\ number\ of\ customer\ interruptions} = \frac{SAIDI}{SAIFI}$$

.... (5.6)

- **Average Service Availability Index**

Average Service Availability Index (ASAI) provides the same information as SAIDI and represents the customer weighted availability of system over a year. Usually ASAI has a value of more than 0.999.

$$ASAI = \frac{\sum_{j=1}^{N}(Ni*8760)-\sum_{i=1}^{N} UiNi}{\sum_{i=1}^{N}(Ni*8760)}$$

..................(5.7)

Where,

Ui = average annual outage rate of component i

Ni = number of customers disconnected

N = Total number of customer served

- **Average Service Unavailability Index**

Average Service Unavailability Index (ASUI) provides the same information as SAIDI and represents the customer weighted unavailability of system over a year. Usually ASUI has a value of more than 0.999.

$$ASUI = \frac{Total\ no\ of\ customers\ hours\ not\ available}{Total\ no\ of\ customers\ hours\ demanded}$$

..................(5.8)

ASUI = 1-ASAI

- **Energy Not Supplied**

Energy Not Supplied (ENS) provides the information about the energy not supplied by the system.

$$ENS = \sum La(i)Ui$$

..................(5.9)

where,

La(i)= average load connected to the load point i

- **Average Energy Not Supplied**

Average Energy Not Supplied (AENS) provides the information about the average energy not supplied by the system.

$$AENS = \frac{Total\ energy\ not\ supplied}{Total\ no\ of\ customers\ served} = \frac{\sum La(i)Ui}{\sum Ni}$$

..................(5.10)

5.9 Case Studies

It deals with three cases and comparing them the case which is reliable is found

1. Without automation
2. With automation
3. With smart Grid

For these three cases the major difference is switching time which is considered as:

Case 1: For Without Automation - 1 hour

Case 2: For With Automation - 0.6 seconds

Case 3: For Smart Grid - 0.1 seconds

The above cases are divided in to 4 Sub cases (A, B, C, D) according to the Components connected, repairing and replacement of Equipment as shown below,

- Case a : Using alternative supply, fuses, disconnects, repair of transformers
- Case b : No disconnects, no fuses, no alternative supply
- Case c : No disconnects-fuses-no alternative supply
- Case d : Disconnects-no fuses-alternative supply

For the RBTS system the load point indices and system performance indices are calculated for the above cases using the formulae discussed in the chapter 5 from formulae 5.1 to 5.10. The results are shown below for the individual cases.

5.10 Results

The load point indices for all 22 load points are calculated for all 3 cases without automation, with automation and smart grid.

Table 5.7: The load point indices for RBTS system without Automation, with automation and smart grid

The load point indices for all 22 load points are calculated using formulae 5.1 to 5.3.

From the table 5.7 it is observed that outage time (r) is reduced from without automation to automation and further decreased using smart grid.

	Load points	Λ	R			U		
			With out automation	With automation	Smart grid	With out automation	With automation	Smart grid
1	1	0.239	14.94	14.72	14.430	3.575	3.521	3.4524
	2	0.252	14.43	14.21	13.944	3.64	3.586	3.5174
	3	0.252	14.431	14.2147	13.944	3.64	3.586	3.5174
	4	0.239	14.94	14.72	14.430	3.575	3.521	3.4524
	5	0.252	14.43	14.21	13.944	3.64	3.586	3.5174
	6	0.243	14.55	14.33	14.060	3.824	3.569	3.5011
	7	0.252	14.28	14.04	13.754	3.601	3.543	3.4692
2	8	0.1397	3.883	3.772093	3.6325	0.54275	0.52715	0.5076
	9	0.1397	3.605	3.465116	3.2906	0.50375	0.48425	0.4598
3	10	0.2425	14.756	14.52619	14.238	3.57850	3.52260	3.4527
	11	0.2522	14.431	14.214668	13.944	3.640250	3.585650	3.5174
	12	0.2555	14.31115	14.09746	13.830	3.65650	3.60190	3.5336
	13	0.2522	14.22498	13.98791	13.691	3.588250	3.528450	3.4537
	14	0.2555	14.10763	13.87358	13.581	3.60450	3.54470	3.4699
	15	0.2425	14.7567	14.52619	14.238	3.57850	3.52260	3.4527
4	16	0.252	14.43	14.21	13.944	3.64025	3.58565	3.5175
	17	0.2425	14.8103	14.58515	14.300	3.592	3.537	3.4686
	18	0.243	14.76	14.53	14238	3.579	3.523	3.4527
	19	0.256	14.26	14.04	13.776	3.644	3.588	3.52
	20	0.256	14.26	14.04	13.768	3.644	3.588	3.5177
	21	0.252	14.22	13.99	13.691	3.588	3.528	3.4537
	22	0.256	14.11	13.87	13.581	3.605	3.545	3.4699

The System performance indices are calculated for the 3 cases without automation, with automation and smart grid. The results are

Table 5.8: The system performance indices for RBTS system without Automation

	SAIFI	SAIDI	CAIDI	ASAI	ASUI	ENS	AENS
Case a: using disconnects - fuses-alternative supply– repair of transformers							
feeder 1	0.2479	3.61836	145906	0.999587	0.00041305	13.1720	0.02020
feeder 2	0.1395	0.5225	3.744186	0.99994	0.000059	1.12203	0.56101
feeder 3	0.2498	3.62375	14.50143	0.999586	0.000414	11.2031	0.01772
feeder 4	0.2470	3.60511	14.5907	0.999588	0.000412	12.248	0.01969
System	**0.2482**	**3.61259**	**14.5515**	**0.99959**	**0.00041**	**37.7457**	**0.01978**
Case b: no disconnects-no fuses-no alternative supply– repair of transformers							
feeder 1	0.625	23.6	37.76	0.997360	0.00269406	86.022	0.13193
feeder 2	0.1917	0.95875	5	0.999891	0.00010944	2.06131	1.03065
feeder 3	0.558	20.34	36.45165	0.997678	0.002322	63.1760	0.09996
feeder 4	0.625	23.6	37.76	0.997306	0.002694	80.004	0.12862
System	**0.6023**	**22.4964**	**37.3476**	**0.99743**	**0.00257**	**231.263**	**0.12121**
Case c: no disconnects - fuses - no alternative supply– repair of transformers							
feeder1	0.2479	4.16496	16.49488	0.99952	0.00047545	15.1799	0.02328
feeder 2	0.1397	0.69875	5	0.9992	7.98E-05	1.50231	0.75115
feeder 3	0.2498	4.17448	16.70517	0.999523	0.000477	12.9707	0.02052
feeder 4	0.2470	4.16041	16.8816	0.999525	0.000475	14.1714	0.02278
System	**0.2482**	**4.16299**	**16.772**	**0.99952**	**0.00048**	**43.4851**	**0.02297**
Case d: using disconnects - fuses- alternative supply- replacement of transformers							
feeder1	0.2479	0.76867	3.0984	0.999912	8.77E-05	2.7881	0.00427
Feeder2	0.1397	0.5057	3.61860	0.999942	5.77E-05	1.08403	0.50201
Feeder3	0.2498	0.77758	3.0964	0.999912	0.83E-05	2.35109	0.00372
Feeder4	0.2470	0.755111	3.05611	0.999914	8.62E-05	2.58686	0.00415
System	**0.2482**	**0.76557**	**3.08437**	**0.99991**	**8.70E-05**	**8.84383**	**0.00464**

Table 5.9: The system performance indices for RBTS system with Automation.

	SAIFI	SAIDI	CAIDI	ASAI	ASUI	ENS	AENS
Case a: using disconnects - fuses-alternative supply– repair of transformers							
feeder 1	0.247993	3.56370	14.3701	0.999593	0.0004068	12.971	0.01989
feeder 2	0.13975	0.5057	3.61860	0.999942	5.7728E-0	1.08403	0.54201
feeder 3	0.24989	3.65868	14.6412	0.999582	0.000418	11.1713	0.01767
feeder 4	0.247082	3.54958	14.3659	0.999595	0.000405	12.0560	0.01938
System	**0.24821**	**3.58736**	**14.4529**	**0.99959**	**0.00041**	**37.2827**	**0.01954**
Case b: no disconnects-no fuses-no alternative supply– repair of transformers							
feeder 1	0.62	23.6	37.76	0.997306	0.0026940	86.022	0.13193
feeder 2	0.19175	0.95875	5	0.999891	8.0001094	2.06131	1.03065
feeder 3	0.558	20.34	36.4516	0.997678	0.002322	63.1760	0.09996
feeder 4	0.625	23.6	37.76	0.997306	0.002694	80.004	0.12862
System	**0.60235**	**22.4964**	**37.3476**	**0.99743**	**0.00257**	**231.263**	**0.12122**
Case c: no disconnects - fuses - no alternative supply– repair of transformers							
feeder1	0.247993	4.164965	16.79468	0.999525	0.00047545	15.1799	0.02328
feeder 2	0.13975	0.69875	5	0.99992	7.98E-05	1.50231	0.75115
feeder 3	0.24989	4.174448	16.70517	0.999523	0.000477	12.9707	0.02052
feeder 4	0.247082	3.917968	15.85693	0.999553	0.000447	13.8321	0.02223
System	**0.24821**	**4.08395**	**16.4536**	**0.99953**	**0.00047**	**43.4851**	**0.02279**
Case d: using disconnects - fuses- alternative supply- replacement of transformers							
feeder1	0.535	0.71370	2.87793	0.99991	8.1474E-0	2.58302	0.00396
Feeder2	0.13975	0.5057	3.61860	0.99994	5.7728E-0	1.08403	0.54201
Feeder3	0.24989	0.71868	2.87602	0.99991	8.2000E-0	2.17433	0.00344
Feeder4	0.247082	0.69959	2.83142	0.99992	7.9900E-0	2.39494	0.00385
System	**0.24821**	**0.71054**	**2.86264**	**0.99992**	**8.1000E-0**	**8.23634**	**0.00432**

Table 5.10: The system performance indices for RBTS system with Smart grid.

	SAIFI	SAIDI	CAIDI	ASAI	ASUI	ENS	AENS
Case a: using disconnects-fuses-alternative supply – repair of transformers							
feeder1	0.24799	3.49538	14.0947	0.9996	0.0004	12.7203	0.01951
Feeder2	0.13975	0.48376	3.46163	0.99994	5.5E-05	1.03651	0.51825
Feeder3	0.24895	3.49985	14.0056	0.9996	0.0004	10.8055	0.0171
Feeder4	0.24708	3.4809	14.088	0.9996	0.0004	11.8167	0.019
System	**0.24821**	**3.48898**	**14.0565**	**0.9996**	**0.00039**	**36.3789815**	**0.01906**
Case b: no disconnects-no fuses-no alternative supply– repair of transformers							
feeder1	0.62500	23.6	37.76	0.99731	0.00269	86.022	0.13194
Feeder2	0.19175	0.95875	5	0.99989	0.00011	2.06131	1.03066
Feeder3	0.558	20.34	36.4516	0.99768	0.00232	63.176	0.09996
Feeder4	0.625	23.6	37.76	0.99731	0.00269	80.004	0.12862
System	**0.60235**	**22.4964**	**37.3475**	**0.99743**	**0.00256**	**231.263352**	**0.12120**
Case c: no disconnects- fuses-no alternative supply– repair of transformers							
feeder1	0.24799	4.16497	16.7947	0.99952	0.00048	15.1799	0.02328
Feeder2	0.13975	0.69875	5	0.99992	8E-05	1.50231	0.75116
Feeder3	0.24989	4.17445	16.7052	0.99952	0.00048	12.9708	0.02052
Feeder4	0.24708	3.91797	15.8569	0.99955	0.00045	13.8321	0.02224
System	**0.24821**	**4.08395**	**16.4535**	**0.99953**	**0.00046**	**43.48514**	**0.02279**
Case d: using disconnects-no fuses-alternative supply – replacement of transformers							
feeder1	0.625	21.5240	34.4385	0.99754	0.0024	78.43493	0.12029
Feeder2	0.19175	0.52877	2.75762	0.99994	6.04E-0	1.136866	0.56843
Feeder3	0.558	19.6654	35.2426	0.99775	0.00224	61.01073	0.09653
Feeder4	0.24708	3.4809	14.0880	0.99960	0.00039	11.8167	0.01899
System	**0.47915**	**15.0044**	**31.3144**	**0.99829**	**0.00171**	**152.399234**	**0.07987**

From the above results concluded that in the individual sub cases, the CASE A and CASE D are better cases. By comparing the these two cases the CASE D is not economical, because in this case the replacement transformer should be done rather than repair of transformer.

Table 5.11: System Performance Indices of Feeders and System for different Configurations.

Case	Configuration	Feeder	SAIFI	SAIDI	CAIDI	ENS	%ASAI
1	Non automated	1	0.2479	3.618	14.59	13.172	99.9587
		2	0.1400	0.520	3.74	1.120	99.9940
		3	0.2498	3.618	14.50	11.203	99.9586
		4	0.2470	3.605	14.59	12.248	99.9588
		system	**0.2480**	**3.613**	**14.55**	**37.746**	**99.9588**
2	Automated	1	0.2479	3.482	14.04	12.688	99.9599
		2	0.1400	0.479	3.420	1.030	99.9945
		3	0.2498	3.486	13.95	10.774	99.9602
		4	0.2470	3.466	14.03	11.758	99.9604
		system	**0.2480**	**3.475**	**14.01**	**36.23**	**99.9603**
3	Smart grid	1	0.2479	3.481	14.04	12.67	99.9601
		2	0.1400	0.475	3.43	1.030	99.9945
		3	0.2498	3.475	13.95	10.76	99.9602
		4	0.2470	3.465	14.03	10.79	99.9604
		system	**0.2480**	**3.457**	**14.00**	**36.20**	**99.9605**

From the results of these 3 cases, concluded that the reliability is improved from case 1 to case 2. The reliability still improved from case 2 to case 3.

CHAPTER 6

SYSTEM DESIGN

6.1 UML DIAGRAMS

UML diagram is a diagram that is designed based on Unified Modeling language with the aim to visually represent the system with roles, actors, anchors etc to understand and maintain the system easily. By using this we can better understand flaws or errors in the system so that we can maintain or alter the system properly. Different types of UML diagrams include:

- Class diagram
- Activity diagram
- Usecase diagram
- Sequence diagram

6.1.1 CLASS DIAGRAM OF RADIAL POWER DISRTIBUTION

Class diagram is a type of UML diagram that provides visually the overview of the architecture in the terms of classes and methods. It shows the relationship with various classes and their dependencies. It is similar to a flow chart in which classes using rectangular boxes. These boxes contain three fields namely name of the class, attributes of the class, methods related to that class.

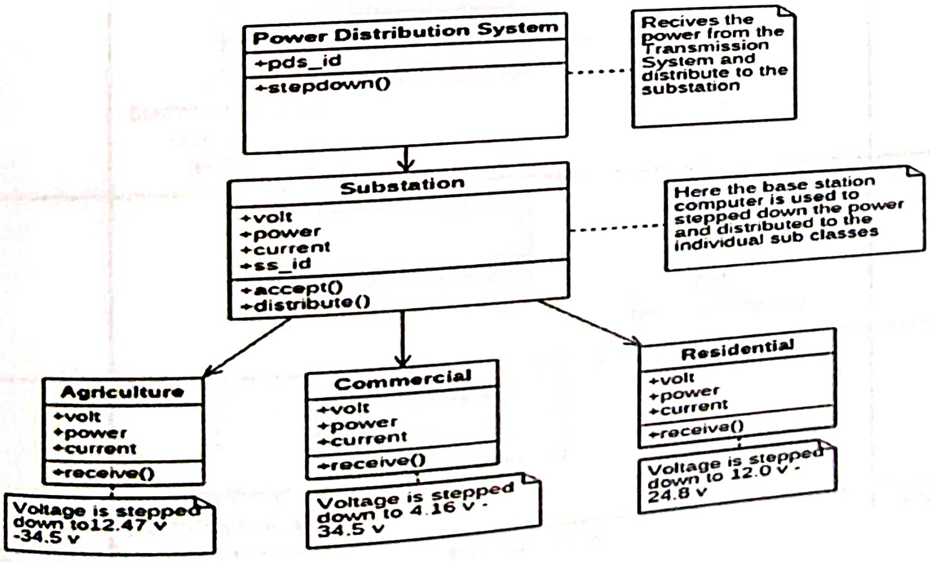

Fig.6.1 class Diagram

6.1.2 USE CASE DIAGRAM OF SMART GRID MONITORING

Use case diagram also represented as behavior diagrams. These diagrams are used to explain the set of actions that system need to e performed in accordance with the external user

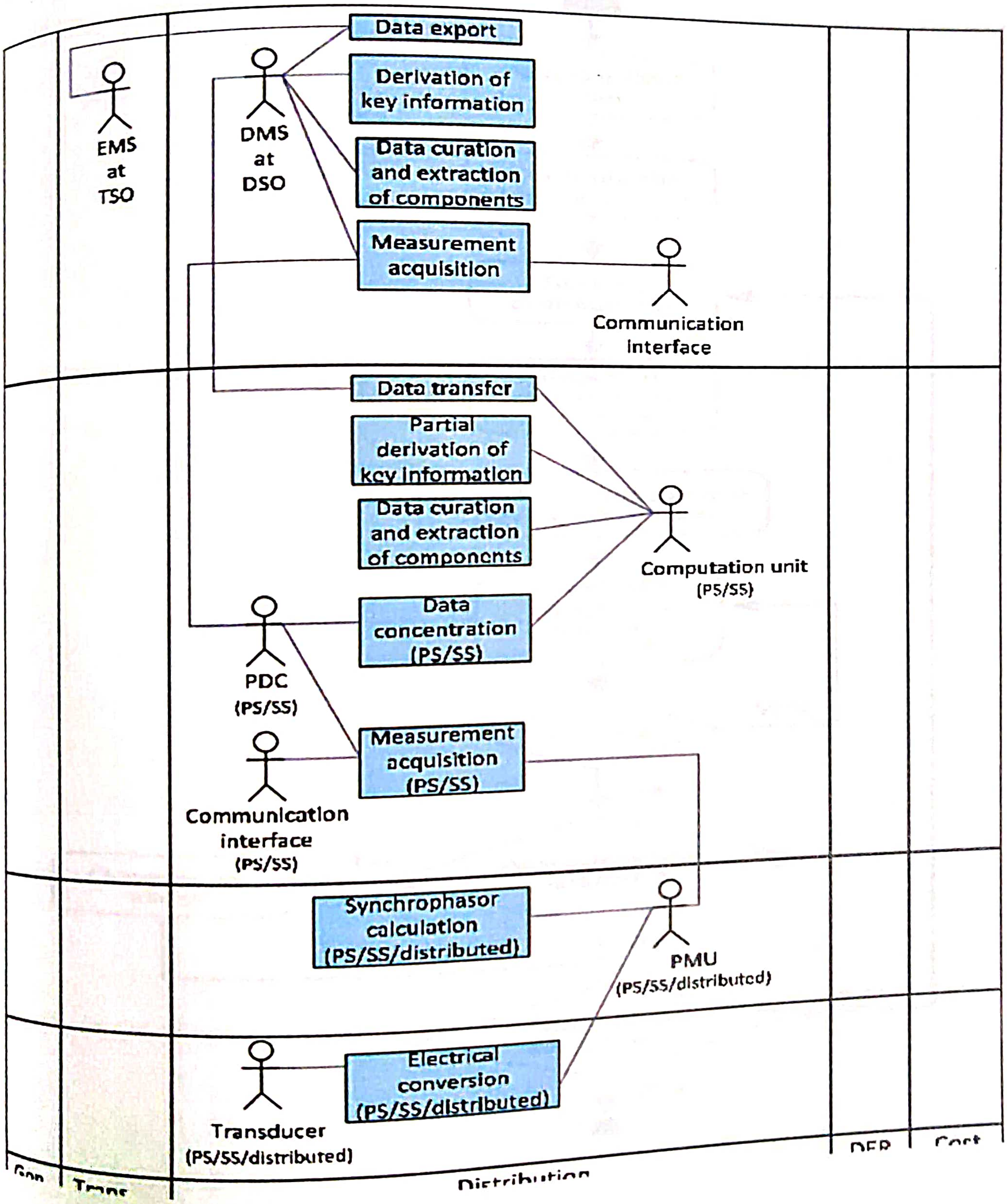

Fig.6.2 Use case Diagrams

6.1.3 ACTIVITY DIAGRAM FOR POWER GENERATION USING RTS

Activity diagram is one of the important UML diagrams, which is used to represent the dynamic aspects of the system. It is basically flow chart to represent the flow of activity from one activity the other.

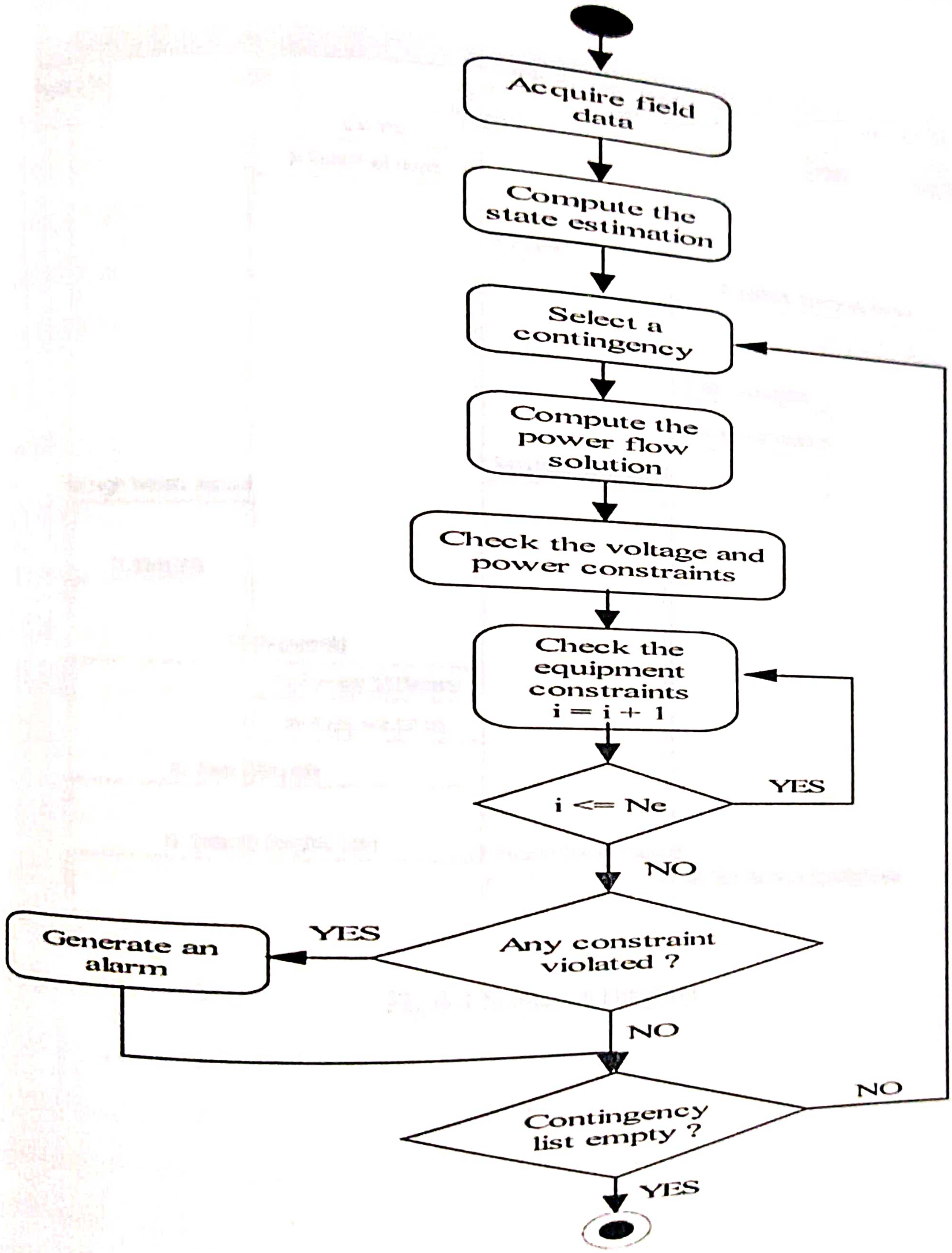

Fig.6.3 Activity Diagram

6.1.4 SEQUENCE DIAGRAM FOR POWER TRANSMISSION

A sequence diagram shows the object interactions arranged in time sequence. It depicts the objects and the classes involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario.

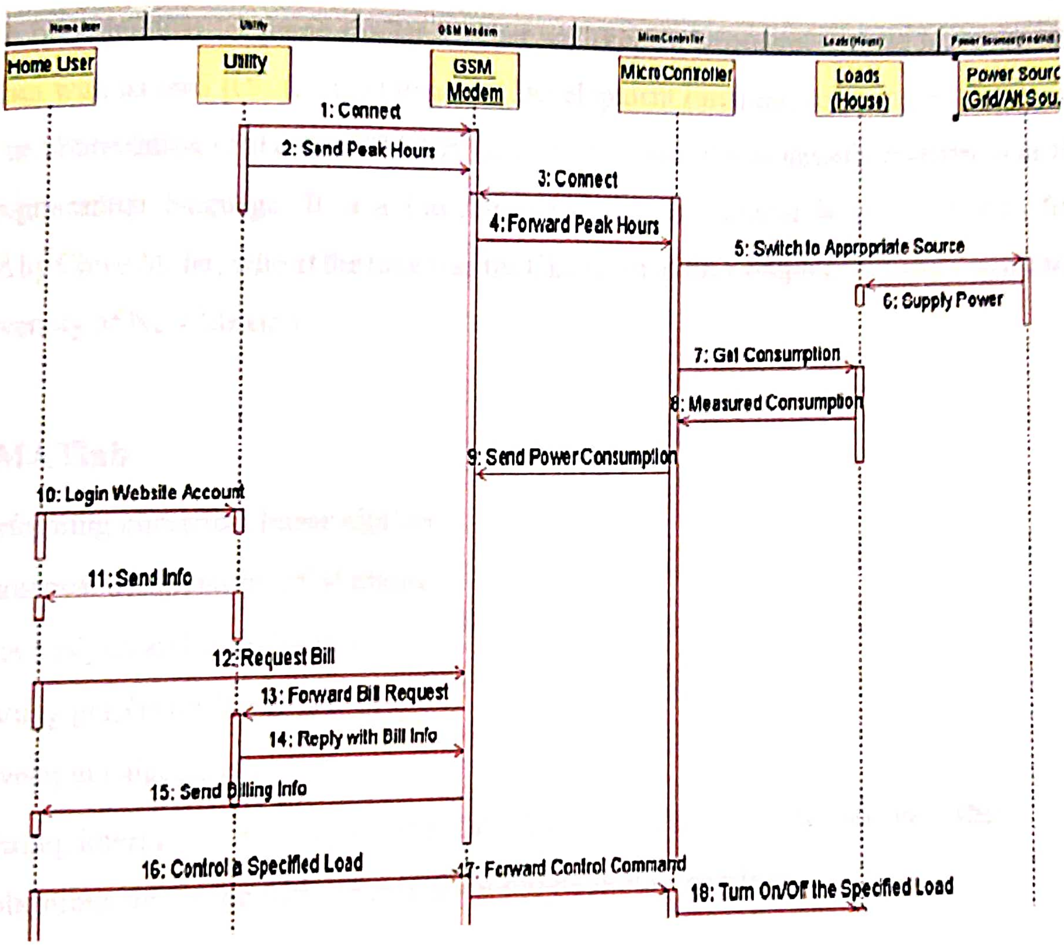

Fig.6.4 Sequence Diagram

CHAPTER 7
SOFTWARE ENVIRONMENT

7.1 Introduction to MATlab

Matlab is a programming language similar to other well-known languages such as Java, C#, etc., which comes with its own IDE (that is Integrated Development Environment) and set of libraries. Matlab is an abbreviation of the term "Matrix Laboratory" since it was initially referred to as the matrix programming language. It is a fourth-generation programming language. It was first discovered by Cleve Moler, who at the time was the Chairman of the Computer Science department at the University of New Mexico.

Uses of MATlab

- Performing numerical linear algebra
- Numerical computation of Matrices
- Data analysis and visualization
- Plotting graphs for larger data sets
- Developing algorithms
- Creating interfaces for the user that is the GUI- Graphical User Interface and other applications that is the API – Application Programming Interface.

7.2 What can you do with MATlab?

Using Matlab you can implement and design different algorithms. You can load data from different sources such as files, databases or the web to analyze your data and visualize it using Matlab visualization application which gives you a wide range of graph plots to choose from. It also makes it easier to work with larger data sets. Matlab as a math product contains mathematical function library that allows you to perform linear algebra and computation of matrices. This also helps to facilitate data analysis. Creating data models, prototype and simulation of data can be achieved. You can also design interfaces for both users as well as other programming applications to make working with Matlab easier.

Advantages

1. It provides the fastest IDE for mathematical computation of matrices and linear algebra.
2. Contains the best mathematical package libraries to provide support for all fields of mathematics, ranging from simple summation to matrix inversion, etc.
3. It provides multi-threading support and garbage collection to facilitate parallel execution of algorithms.
4. Its graphics system (Simulink) includes commands for two-dimensional and three-dimensional data visualization, image processing, graphics presentation and animation providing high-quality visualization of plots and charts.

7.3 Why do we need MATlab

Using MATLAB allows us several advantages over other languages and methods.

1. By using tool boxes one could greatly enhance Matlab's functionalities. For example, Statistics Toolbox facilitates specialized statistical manipulation of data, Excel link lets the data to be written in a format which is readable by Excel.
2. MATLAB considers every single data element as a matrix. For example, an integer would be treated as a matrix of one row and one column. It provides built-in functions for matrix-based operations such as matrix addition, multiplication, inversion, etc.
3. It considerably reduces the size of the code by using Vectorized operations.
4. Simulink – Matlab's graphics system provides optimized output for interaction. Making it easier to plot data and allowing one to customize its size and colour.

CHAPTER 8
SAMPLE CODE

```
clear;
n = [1; 0; 0; 1];
n_sum = sum(n);
length = [0.75 0.60 0.80 0.80];
fault_per_km = 0.065;
lamda = length*fault_per_km;
L = [1  1.15];
lamda_sum = sum(lamda);
%WITHOUT AUTOMATION
%%load 8
without_automation_r_8 = [5 0 0 0; 0 1 0 0;0 0 5 0; 0 0 0 0];
without_automation_u_8 = lamda*without_automation_r_8;
without_automation_u_8sum = sum(without_automation_u_8);
without_automation_r_8sum = without_automation_u_8sum/lamda_sum;
%%load 9
without_automation_r_9 = [1 0 0 0; 0 5 0 0;0 0 0 0; 0 0 0 5];
without_automation_u_9 = lamda*without_automation_r_9;
without_automation_u_9sum = sum(without_automation_u_9);
without_automation_r_9sum = without_automation_u_9sum/lamda_sum;
%load indices calculation
without_automation_u_sum = without_automation_u_8sum + without_automation_u_9sum;
without_automation_r_sum = without_automation_u_sum/lamda_sum;
without_automation_u = [without_automation_u_8sum ; without_automation_u_9sum];
%system indices calculation
customer_num = sum(L);
SAIFI =  (lamda_sum*n_sum)/n_sum;
SAIDI =  without_automation_u_sum/n_sum;
CAIDI = SAIDI/SAIFI;
```

```
ASAI = ((n_sum*8760)-(without_automation_u_sum*n_sum))/(n_sum*8760);
ENS = sum(L*without_automation_u);
disp('USING WITHOUT AUTOMATION');
disp(['lamda ' num2str(lamda)]);
disp(['lamda_sum ' num2str(lamda_sum)]);
disp(['without_automation_u_8sum ' num2str(without_automation_u_8sum)]);
disp(['without_automation_r_8sum ' num2str(without_automation_r_8sum)]);
disp(['without_automation_u_9sum ' num2str(without_automation_u_9sum)]);
disp(['without_automation_r_9sum ' num2str(without_automation_r_9sum)]);
disp(['without_automation_u_sum ' num2str(without_automation_u_sum)]);
disp(['SAIFI ' num2str(SAIFI)]);
disp(['SAIDI ' num2str(SAIDI)]);
disp(['CAIDI ' num2str(CAIDI)]);
disp(['ASAI ' num2str(ASAI)]);
disp(['ENS ' num2str(ENS)]);
%WITH AUTOMATION
%%load 8
with_auomation_r_8 = [5 0 0 0; 0 0.6 0 0;0 0 5 0; 0 0 0 0];
with_auomation_u_8 = lamda*with_auomation_r_8;
with_auomation_u_8sum = sum(with_auomation_u_8);
with_auomation_r_8sum = with_auomation_u_8sum/lamda_sum;
%%load 9
with_auomation_r_9 = [0.6 0 0 0; 0 5 0 0;0 0 0 0; 0 0 0 5];
with_auomation_u_9 = lamda*with_auomation_r_9;
with_auomation_u_9sum = sum(with_auomation_u_9);
with_auomation_r_9sum = with_auomation_u_9sum/lamda_sum;
%load indices calculation
with_auomation_u_sum = with_auomation_u_8sum + with_auomation_u_9sum;
with_auomation_r_sum = with_auomation_u_sum/lamda_sum;
with_auomation_u = [with_auomation_u_8sum ; with_auomation_u_9sum];
%system indices calculation
```

```
SAIFI = (lamda_sum*n_sum)/n_sum;
SAIDI = with_auomation_u_sum/n_sum;
CAIDI = SAIDI/SAIFI;
ASAI = ((n_sum*8760)-(with_auomation_u_sum*n_sum))/(n_sum*8760);
ENS = sum(L*with_auomation_u);
disp('------------------------');
disp('USING WITH AUTOMATION');
disp(['lamda ' num2str(lamda)]);
disp(['lamda_sum ' num2str(lamda_sum)]);
disp(['with_auomation_u_8sum ' num2str(with_auomation_u_8sum)]);
disp(['with_auomation_r_8sum ' num2str(with_auomation_r_8sum)]);
disp(['with_auomation_u_9sum ' num2str(with_auomation_u_9sum)]);
disp(['with_auomation_r_9sum ' num2str(with_auomation_r_9sum)]);
disp(['with_auomation_u_sum ' num2str(with_auomation_u_sum)]);
disp(['SAIFI ' num2str(SAIFI)]);
disp(['SAIDI ' num2str(SAIDI)]);
disp(['CAIDI ' num2str(CAIDI)]);
disp(['ASAI ' num2str(ASAI)]);
disp(['ENS ' num2str(ENS)]);
%SMART GRID:
%%load 8
r_8 = [5 0 0 0; 0 0.1 0 0;0 0 5 0; 0 0 0 0];
u_8 = lamda*r_8;
u_8sum = sum(u_8);
r_8sum = u_8sum/lamda_sum;
%%load 9
r_9 = [0.1 0 0 0; 0 5 0 0;0 0 0 0; 0 0 0 5];
u_9 = lamda*r_9;
u_9sum = sum(u_9);
r_9sum = u_9sum/lamda_sum;
%load indices calculation
```

```
u_sum = u_8sum + u_9sum;
r_sum = u_sum/lamda_sum;
u = [u_8sum ; u_9sum];
%system indices calculation
SAIFI = (lamda_sum*n_sum)/n_sum;
SAIDI = u_sum/n_sum;
CAIDI = SAIDI/SAIFI;
ASAI = ((n_sum*8760)-(u_sum*n_sum))/(n_sum*8760);
ENS = sum(L*u);
disp('------------------------');
disp('USING SMART GRID');
disp(['lamda ' num2str(lamda)]);
disp(['lamda_sum ' num2str(lamda_sum)]);
disp(['u_8sum ' num2str(u_8sum)]);
disp(['r_8sum ' num2str(r_8sum)]);
disp(['u_9sum ' num2str(u_9sum)]);
disp(['r_9sum ' num2str(r_9sum)]);
disp(['u_sum ' num2str(u_sum)]);
disp(['SAIFI ' num2str(SAIFI)]);
disp(['SAIDI ' num2str(SAIDI)]);
disp(['CAIDI ' num2str(CAIDI)]);
disp(['ASAI ' num2str(ASAI)]);
disp(['ENS ' num2str(ENS)]);
```

CHAPTER 9
SYSTEM TESTING

The main use of testing is to find out errors. Testing is the way toward attempting to find each possible flaw or shortcoming in a work item. It gives a way to deal with check the helpfulness of parts, subassemblies, social occasions just as a finished thing It is the path toward working on programming with the point of ensuring that the Software system satisfies its necessities and customer wants and does not bomb in an unacceptable manner. There are various sorts of test. Each test type keeps an eye on a specific testing need. Testing permits to expel the mistakes and improve the framework execution. There are numerous kinds of tests which enables us to improve our venture execution and to make it mistake free. What's more we likewise have tests which encourage us to check singular modules autonomously and furthermore to check complete framework together according to our convenience.

9.1 Unit testing

Unit testing incorporates the arrangement of analyses that favor that within program basis is working properly, and that program information sources produce significant yields. It checks whether little segments are working appropriately or not. Every single decision branch and inside code stream should be endorsed. It is the attempting of individual programming units of the application .it is done after the completion of an individual unit before fuse. This is an auxiliary attempting, that relies upon learning of its improvement and is prominent. Unit tests perform fundamental tests at section level and test a specific business system, application, or possibly structure plan. Unit tests ensure that all of a thoughtful method for a business technique performs unequivocally to the recorded points of interest and contains obviously portrayed data sources and foreseen results.

A unit test encourages you to discover which part is broken in your application and fixes it quicker.

9.2 Verification and Validation

Testing procedure is a piece of subject alluding to checking and approval of our task. We have to find the framework determinations and we should attempt to meet the details of the client and to fulfil the client, for this reason, we need to check and approve the item and we have to ensure that everything is working appropriately. Check and approval are the two unique things. One is performed to guarantee that the product is working accurately and to implement a particular usefulness and the other is done to guarantee if the client prerequisites are appropriately met or not by the finished result.

Check is progressively similar to 'would we say we are building the item right?' and approval is increasingly similar to 'would we say we are building the correct item?'.

CHAPTER 10

RESULTS AND OUTPUT SCREEN

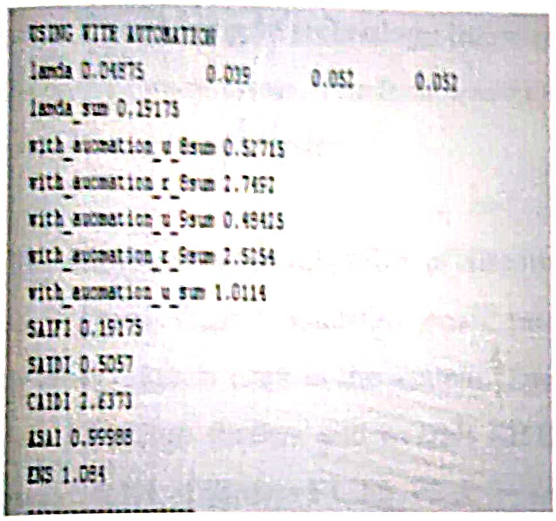

Fig.10.1 with Automation

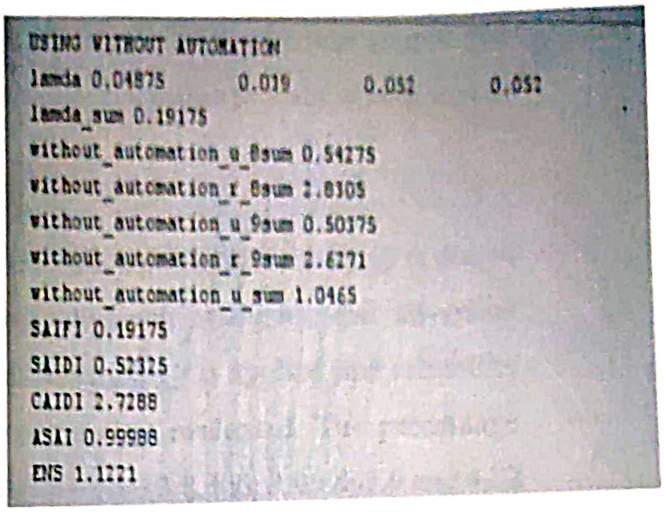

Fig.10.2 without Automation

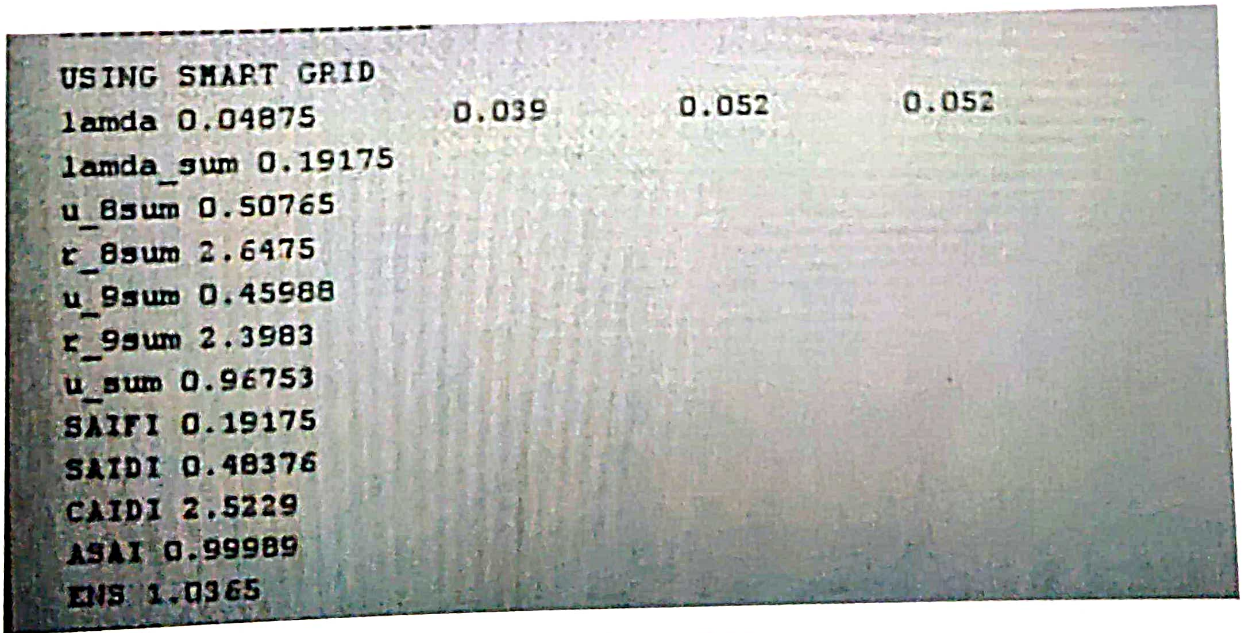

Fig.10.3 Smart Grid

CHAPTER 11

CONCLUSION AND FUTURE ENHANCEMENT

The impact of smart grid technology on the reliability of radial distribution system is investigated. The smart grid technology improves the quality and reliability of power supply and also reduces the power losses. The fault detection, isolation and restoration process is very fast in the smart grid distribution system.

The improvement in reliability of distribution system with smart grid technology is due to advanced sensors, digital controls, smart meters, power electronic switches and advanced communication system used in the system. The smart grid technology is applied and reliability indices of individual feeders and overall RBTS Bus 2 system are evaluated. The percentage reduction in SAIDI of feeders F1, F2, F3 & F4 and overall system are 3.8, 8.6, 3.95 & 3.9 and 4.32 respectively with respect to the corresponding non-automated systems.

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