1.1 THE POWER SYSTEM AS A CRITICAL INFRASTRUCTURE

The energy is produced by the electric power systems, which are having critical infrastructure, whose service is vital to the economy and growth of the nation. Providing the continuous uninterrupted supply of power, to meet the load demand is a complex technical challenge. It involves the coordination effect and maintaining the harmony among the three components of power system i.e., generation, transmission and the load distribution. This means that the real-time estimation of the state condition together with the control and coordination of generating units is aimed, at delivering of power to the loads in secured manner.

A power system is said to be reliable when the system demand conditions are met from the generator with an acceptable continuity of supply availability at the contractual frequency and voltage margins. This can be further classified into adequacy and security. The Adequacy is the ability of the power system to generate sufficient power and to meet the load demand at any instant of time, whereas the security is the ability of the system to cope with any abnormal disturbances caused by shunt faults or series faults resulting into the system components outage. Generally, from the practical consideration "N-1" criteria will be followed while planning the power system [1-3]. The "N-1"criterion expresses the ability of the transmission to lose the linkage without causing an overload failure elsewhere.

From the grid operation point of view, the following requirements are to be ensured for the reliable system operation:

1. A balance between the real power generation and demand should always be maintained.

2. Appropriate reactive power compensation should be provided for maintaining the system voltages within the operational limits (+5% to – 10%) as per Indian Electricity Grid Code (IEGC).

3. The power flows in the transmission lines and transformers should be limited not to exceed their thermal limits [4].

4. The power system should return to the stability within reasonable time following any contingency.

5. The power system should be equipped for meeting the emergencies.

A reliable operation and control of power system is very complex and poses a technical challenge. In the real-time system operation, the power system network will be subjected to various types of faults like Phase-Phase, Phase-Earth, double line – ground, three phase and open circuit faults. If preventive actions are not taken, the system travels from the normal to alert, emergency and in extremes states depending on the type of contingency. Hence, it is found essential that there should be an equipment which detects the faults, and abnormal stress in power system components and actuates, immediate tripping for isolation of the equipments which it protects. The protection relays detect the faults and abnormal states in power system and prevents the hazard currents, over/under voltages from damaging the equipment such as lines, transformers, bus-bars, circuit breakers and generators. Possible failure in the main protection is covered by the backup protection.

The power system operation and maintenance is a major concern worldwide. Due to the electricity act 2003, in India, and the implementation of power sector reforms in this new era of deregulation, the power systems are being operated at the oscillating limits, exceeding their maximum laudability. In addition, due to the severe right of way issues, and other environmental constraints, the transmission network expansion is at a low pace, in providing either the evacuation facilities to the upcoming generators, or, in delivering required powers to loads, which are at a very high growth rate. As a result, the power systems are more vulnerable to the severe disturbances. Such contingencies arising due to the outage of certain critical elements may result in cascade failures, leading to large scale blackout. The power systems world wide have experienced a number of critical failures. The uncontrolled cascade failures lead to blackouts and cause the tremendous impact on the social economics. The investigations in the sequence of events of the cascade failures for the large scale blackouts is seeking to understand how and why the cascade failures always spread to the system disintegration as it did. The protection relays have played a significant role in creation and propagation of the uncontrolled cascade failures in leading to system disintegration [5, 6].

The cascade failures started regularly with protection relays operated by overload, at depressed voltage and caused the load transfer to the parallel circuits. The load transfer may cause further tripping of lines and voltage drop by further abnormal overloadings. The system voltage collapse may be initiated due to insufficient supplementation of reactive power. This uncontrolled cascade failures would ultimately violate the entire system integrity, leading to blackout.

1.11 Structural Reforms of the Power System

Traditionally, the power industry is a vertically integrated single utility, and a monopoly in its service area. It normally is owned by the government, a cooperative of consumers, or privately. As the single electricity service provider, the industry is also obligated to provide electricity to all customers in the service area.

With the deregulation, vertically integrated power utilities were split into generation, transmission, and distribution service providers to form a competitive electricity market. In the deregulated market, the economic decision making mechanism, responds to a decentralized process. Each participant aims at profit maximization. Unlike that of the regulated environment, the recovery of the investment in a new plan is not guaranteed in a deregulated environment. Consequently, risk management has become a critical part of the electricity business in a market environment.

The power systems were originally operated as small entities matching the generation with load demand. Then the inter-state power transfer concept has come and facilitating the connectivity between two or more states together with the power exchanges between them. Then the concept of regional transmission system evolved and the operation were carried out within the regional boundaries. The later developments initiated the inter-regional corridor developments and resulted into the inter-regional power system operation. As of now, except southern region, all the other regions of Eastern, Western, Northern and Northeastern regions are operated in synchronous mode forming the new grid. Only, the Southern region is operating in asynchronous mode, for want of the development of bulk inter regional corridors between the Southern grid and new grid. As per the proposals it is expected that, by 2014, all the regional grids will be interconnected forming the National grid. This is how the grid expansion and development is progressing in India. The Andhra Pradesh state utility is the major constituent of the Southern grid and with this size of the power system, the complexity is increased in maintenance of the grid, in safe and secure manner, and also to meet the larger power demand situations.

1.12 Uncertainties in a Power System

Uncertainties existed in power systems from the beginning of the power industry. Uncertainties from demand and generator availability have been studied in reliability assessment for decades. However, with the deregulation and other new initiatives happening in the power industry, the level of uncertainty has been increasing dramatically. For example, in a deregulated environment, although generation planning is considered in the overall planning process, it is difficult for the transmission planner to access accurate information concerning generation expansion. Transmission planning is no longer coordinated with generation planning by a single planner. Future generation capacities and system load flow patterns also become more uncertain.

Uncertainties in Power Systems are related to:

- system load
- bidding behaviors of generators
- availability of generators, transmission lines, and other system facilities
- installation/closure/replacement of other transmission facilities
- market rules and government policies

1.13 Load Modeling Issues

A model with the appropriate structure and parameters, usually has good performance when fitting the available data. Even if a model with good generalization capability has been obtained, cross validation is still needed. It is worth noting that both research and engineering practice in system modeling are still facing many challenges.

1.14 Situational Awareness

Many studies of major blackouts concluded that a lack of situational awareness is one of the key factors that resulted in the wide spread power system outages. The lack of situational awareness was comprised of a number of factors such as deficiencies in operator training, lack of coordination and ineffective communication, and inadequate tools for system reliability assessment. As a result, operators and coordinators were unable to visualize the security and reliability status of the overall power system following some disturbance events.

1.2 THREATS TO POWER SYSTEM SECURITY

1.21 Overall Security Problem

Based on the Security level of power system, its operating states are classified into Normal State, Alert State, Emergency State, In Extremis state [7] as shown in the Fig.1.1.

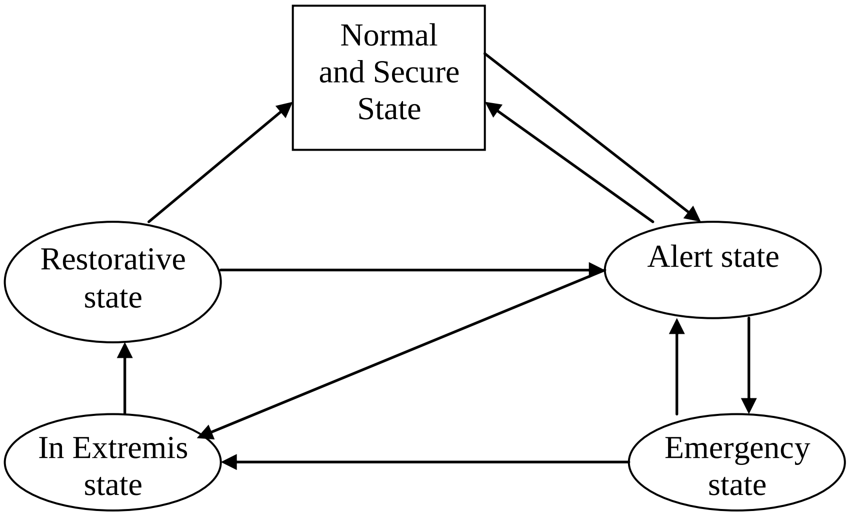

Fig. 1.1: The probable operating states of power system in security analysis

Normal State: In normal state, the power balance between generation and load is satisfied and no equipment is overloaded. All the voltages are within limits. In addition, the system has sufficient security margin to withstand any of the credible contingencies.

Alert state: Under this state, the power balance between generation and load is still met. No equipment is overloaded. No voltage is out of its limits. However, when a severe contingency occurs, the system will either have overloaded equipments or have voltage violations.

Emergency state: The power balance between generation and load is still satisfied. However, either overloaded or voltage violations happen in emergency state. If suitable corrective control actions are taken, the state can still be restored to normal state or at least alert state.

In Extremis State: Under this state, the power balance between generation and load is lost. Voltage violation may happen and some equipment is overloaded. There are cascading outages. Load shedding may be taken, to save as much of the system as possible.

Restorative State: Under this state, the operator performs control actions to restore all system loads. Depending on different cases, the system can reach either normal or alert state.

1.22 Security Assessment Levels

Security Monitoring: Using measurements provided by the supervisory control and data acquisition system (SCADA) and state estimation, identify whether the system is in normal state or not.

Security Analysis: Security analysis is used to check the system's ability to withstand disturbances. If the system is in the normal state, contingency analysis is used to test the security of the system. If one or more operation constraints is violated in the contingency analysis, the system is insecure. Otherwise, it is secure [8].

Security Margin Determination: For a given operating condition, the determination of a security margin using some selected variables is used to assess the security level of a system. These margins are particularly needed in market environment. In this case, operators know how much load increase can be acceptable before the system becomes insecure.

1.23 Power System Stability

Power system stability is the ability of an electric power system, for a given initial operating condition, to regain a state of operating equilibrium after being subjected to a physical disturbance, with most system variables bounded, so that practically the entire system remains intact.

The overall stability problem is divided into three main categories:

Rotor Angle Stability: Refers to the ability of synchronous machines to remain in synchronism after being subjected to a disturbance. Rotor angle stability is further divided into two subcategories; a small signal (or small disturbance) rotor angle stability and transient (or large disturbance) rotor angle stability. The small signal rotor angle stability concerns the stability of the system equilibrium point (or steady-state point). Small signal rotor angle instability may appear in two forms: (a) as an aperiodic (non-oscillatory) increase of the rotor angle due to lack of synchronizing torque, or (b) rotor oscillations of increasing amplitude due to lack of sufficient damping torque. Transient rotor angle stability concerns the ability of system to maintain synchronism when subjected to a severe disturbance. The instability is usually in form of a periodic angular separation due to insufficient synchronizing torque, manifesting as first swing instability[7].

Frequency Stability: Relates to the ability of a power system to maintain steady frequency following a severe system disturbances resulting in a significant imbalance between generation and load[7].

Voltage Stability: Refers to the ability of a power system to maintain steady voltages at all buses in the system after being subjected to a disturbance from a given initial operating condition [9]. Voltage stability is dependent on the system ability to restore equilibrium between load demand and supply. Voltage instability may appear in progressive fall or rise of voltages at some buses. In relation to voltage stability, the term voltage collapse is commonly used. It is described as the process by which a sequence of events accompanying voltage instability leads to abnormally low voltages in a significant part of the power system or to a blackout.

It is common, that the operating conditions are normal and in compliance with system operating policies, prior to the ensuing events that lead to a blackout. Major system blackouts are most of the time, initiated by a single severe disturbance (loss of generator or a tripping of a critical line) or even a multiple related events, such as a fault, and a subsequent relay maloperation. Following the initiating event, a proper automatic or operator remedial control actions could ensure a stable operation of the system. If proper operational planning criteria are followed, most systems are designed in such way that the system stability is maintained for such single outages. The system might, however, enter an emergency state if the severity of the disturbance is great, particularly during peak load hours. The normal operating state can be restored by applying a system readjustment, such as generation shifting and increase of spinning power reserve. The time frame for such system readjustment is usually in tens of minutes.

If proper automatic control actions or operator intervention are not taken following a severe disturbance, the system may enter a state of severe emergency where it can be exposed to further failures and cascading outages. The system can also enter this state, if a second severe disturbance occurs when remedial actions have not ensured stable operation, following the initial disturbance and before the system readjustment has been carried out.

When the system is in the state of a severe emergency, a system blackout can occur due to many different instability mechanisms. For the simplest cases, the initial disturbance causes redistribution of power flow resulting in increased loading on other lines. The actions of On Load Tap Changer (OLTC)-transformer, thermostats and other load regulation devices tend to gradually restore load which causes further loading and eventually overloading of critical transmission lines. This can lead to a process of cascading line outages, which at some point causes the system to be prone to dynamic performance issues. The increase in the impedance between the load and generation, as transmission lines trip, can lead to a number of stability problems.

The above unstable phenomena can lead to partitioning of the system into smaller islands with a large imbalance between load and generation. Eventually, a point of no return is reached when a rapid chain reaction of load and generation tripping occurs and finally leading to the system blackout.

When the system is in the state of severe emergency, voltage instability can as well be the driving mechanism in the evolution of a system blackout. Voltage instability has been considered to be the main driving mechanism in many actual system blackouts.

1.3 EMERGENCY CONTROL

Typical representatives of emergency control, in today’s power systems are:

- Protection based systems:
    - ❖ Under frequency load shedding (UFLS) schemes
    - ❖ Under voltage load shedding (UVLS) schemes
    - ❖ System Protection Schemes (SPS)

Emergency control measures may include:

- Tripping of generators
- Fast generation reduction through fast-valving or water diversion
- Fast HVDC power transfer control
- Load shedding
- Controlled opening of interconnection to neighboring systems to prevent spreading of frequency problems
- Controlled islanding of local system into separate areas with matching generation and load
- Insertion of a braking resistor

1.31 Common Practice

The main challenge in emergency control is the urgency. i.e., with in short interval of time the control actions to be applied. Since, historically high performance communication system and control decision logic could not be met, the emergency control strategy relies on devices reacting to their local measurements based on their setting determined offline by simulations of assumed dangerous scenarios.

Under frequency load shedding (UFLS) schemes, Local devices used for UFLS schemes are UFLS relays. UFLS schemes and relays might be sorted in various categories, but their functionality is essentially the same. They are usually triggered when frequency drops to a predefined level and/or with a predefined rate of change. Their action is disconnection of the load in several steps from the feeders they supervise [10]. However, their effectiveness is strongly dependent on their careful tuning based on the previous studies, since there is no on-line coordination between them.

Under voltage load shedding (UVLS) schemes, under voltage load shedding relays are a conventional local solution to prevent voltage instability [11]. The criterion for triggering the load shedding action is, a predefined voltage level, in the supervised node.

The emergency control measures to be adopted for enhancing the transient stability are [12]:

1. **High Speed Fault Clearing:** Longer fault duration leads to more kinetic energy that could be observed by the generator which may lead to the system instability. Therefore, a fast clearance of fault can certainly help to improve the stability following the severe contingency by adopting fast acting relays.

2. **Reduction of Transmission System Reactance:** The series inductive reactance reduction is an important method to enhance the transient stability of the system, since its reduction increases the post fault synchronizing power transfer.

3. **Fast Valving:** The process of the fast valving involves the control of acceleration power (which drives the generator shaft), following the recognition of the severe transmission fault, which results in a reduction by rapid closing and opening of the steam valves, in a prescribed manner.

4. **Generator Tripping:** Since the rejection of generation at certain locations in the system can reduce the power to be transferred in the critical lines, it can play a very important role in the transient stability enhancement

5. **High Speed Excitation System:** A rapid but temporary increase of generator excitation causes increases in the generator internal voltage. This in turn, results in an increase of generator's capability to provide more reactive power, which can enhance the transient stability following a fault.

6. **Load Shedding**: Following the severe fault, some generator units or transmission lines could be uncontrollably tripped. Generator units tripping directly, affects the load generation balance, while transmission line tripping effects this indirectly. In case of load generation imbalance, the system frequency gets affected. If load is higher than the generation, the frequency decreases and the frequency decline directly leads to a system collapse. Thus, it is essential to maintain the load generation balance. To curtail the frequency faults, certain load relief measures are to be taken care with the frequency threshold i.e., when frequency touches the frequency threshold it trips the certain amount of loads.

7. **Controlled Islanding:** This method is adopted as final option to prevent the major disturbances in one part propagating to the other parts, leading to the total blackouts. This is associated with the formation of power system network with load generation balance and is built on the theory that losing a part of the system is much better than the losing the whole power system.

Generally, the above mentioned preventive measures from one to six are built in features of preventive measures of the power system utilities. The only issue which drawn the attention of many utilities in the power sector and also as per the recommendations of the recent expert committee, after happening of the major blackout of the new grid on 30th and 31st July, 2012 in India, is to get equipped by each utility with the required island schemes. **Hence, in this thesis the focus is made on this aspect of formation of the island.**

1.4 MOTIVATION AND OBJECTIVES

The main motivation for consideration of the proposed issues in this thesis is, based on the study of how are existing systems of the state utility and, is there any scope for improving the system condition? If so can this be achieved by designing the suitable control schemes for its application in the real-time system frame work.

The objective of the thesis is to design and develop a new methodology to the security schemes, in two different areas of power systems applications, by making use of the IT tool of CYMFLOW module of the CYME international software.

In this thesis, two problems are defined, and the solutions are proposed and implemented in the state transmission utility, which are first of its kind.

1.5 CONTRIBUTIONS OF THIS THESIS

The following steps can be taken to avoid or mitigate the catastrophic failures in power systems

- Avoid or eliminate the failure cause in the first place
- Detect and control failures early
- Reduce the impact/consequence of failure

The first step of eliminating the failure is mostly related to the best maintenance practices of power system equipments like generator transmission lines, transformers and periodically checking of the protection relays thoroughly following the protection coordination. Whereas the second and third steps need the attention of the research scholars and the practicing engineers, where the new technological innovative studies are to be made. Hence, in this work, the above issues will be addressed by focusing into the following objectives.

The thesis focus on the research objectives of finding out the remedial measures and their design, development and implementation in two critical areas of transmission utility security needs.

1. When the power system enters into an emergency state from an alert state, due to the critical contingency, the power flows resulting in abnormal overloading conditions, implying that, the inequality constraints are violated resulting in the total power station outage and causing multiple cascade tripping. To bring the system to normal state, the unique methodology is proposed for design, and development and implementation in real-time system operation.

2. When the power system enters into in extremes state from the emergency state, when the effect of control measures applied is not sufficient, the system undergoes multiple cascade outages which get propagated all across the system, resulting in the total system collapse. To prevent such happenings of total system blackouts and provide restorative power requirements in case of partial blackouts and ensuring the availability of the supply to certain essential loads, the suggested formation of intentional islanding scheme, which is all together in a new dimension is proposed.

1.6 INFORMATION TECHNOLOGY (IT) NEEDS FOR THE POWER SYSTEM SOLUTIONS

The planning, design, and operation of power systems required continuous and comprehensive analysis to evaluate current system performance and to ascertain the effectiveness of alternative plans for system expansion. These studies play an important role in providing a high standard of power system reliability and ensuring the maximum utilization of capital investment.

The computational task of determining power flows and voltage levels resulting from a single operating condition for even a small network is all but insurmountable if performed by manual methods. The need for computational aids in power system engineering led in 1929 to the design of a special-purpose analog computer called an ac network analyzer. The usage of the device made possible, the study of a greater variety of system operating conditions for both present and future system designs. It provided the ability to determine power flows and system voltages during normal and emergency conditions and to study the transient behavior of the system resulting from fault conditions and switching operations. By the middle of 1950s, 50 network analyzers were in operation in the United States and Canada and were indispensable tools to planning, relaying, and operating engineers.

The earliest application of digital computers to power system problems dates back to the late 1940s. However, most of the early applications were limited in scope because of the small capacity of the punched card calculators generally in use at that time. The availability of large-scale digital computers in the middle 1950s provided equipment of sufficient capacity and speed to meet the requirements of major power system problems. In 1957, the America Electric Power Service Corporation completed a large-scale load flow program for the IBM 704 which calculated the voltages and power flows for a specified power system network [13].

The initial application of the load flow program to transmission planning studies proved so successful that all subsequent studies employed the digital computer instead of the network analyzer. The success of this program led to the development of programs for short circuit and transient stability calculations. Today, the computer is an indispensable tool in all phases of power system planning, design, and operation.

The formulation of a suitable mathematical model is the first step in the analysis of an electrical network. The model must describe the characteristics of individual network components as well as the relations that govern the interconnection of these elements. A network matrix equation provides a convenient mathematical model for a digital computer solution. The elements of a network matrix depend on the selection of the independent variables, which can be either currents or voltages. Correspondingly, the elements of the network matrix will be impedances or admittances.

The electrical characteristics of the individual network components can be presented conveniently in the form of a primitive network matrix. This matrix, while adequately describing the characteristics of each component, does not provide any information pertaining to the network connections. It is necessary, therefore, to transform the primitive network matrix into a network matrix that describes the performance of the interconnected network.

The form of the network matrix used in the performance equation depends on the frame of reference, namely, bus or loop. In the bus frame of reference the variables are the nodal voltages and nodal currents. The formation of the appropriate network matrix is an integral part of a digital computer program for the solution of power system problems.

A Power System is predominantly in steady-state operation or in a state that could, with sufficient accuracy be regarded as steady-state. In a power system, there are always small load changes, switching actions, and other transients occurring so that in a strict mathematical sense, most of the variables are varying with the time. However, these variations are most of the time so small that an algebraic, i.e. not time-varying model of the power system is justified.

A short circuit in a power system is clearly not a steady-state condition. Such an event can start a variety of different dynamic phenomena in the system, and dynamic models are needed for these studies. However, when it comes to calculate the fault currents in the system, steady-state (static) models with appropriate parameter values can be used. A fault current consists of two components, a transient part, and a steady-state part, but since the transient part can be estimated from the steady-state one, fault current analysis is commonly restricted to the calculation of the steady-state fault currents.

1.7 CYMFLOW SOFTWARE PACKAGE

The Power system analysis packages like CYME international Software, MiPOWER Software, PSS/E Software, Power World Software and ISPA Power Software are available as Power system analysis tools. However, in our study CYME Software is used for carrying out the simulations and determining the Power flows, as this is being adopted globally by many large utilities in Power sector. In our country, this is being adopted by Central Electricity Authority (CEA), Power Grid Corporation of India Limited (PGCIL) and APTRANSCO and many state utilities. The details of CYMFLOW are briefly presented in this section.

- **Key Features of the Program**

CYMFLOW is a PC (Personal Computer) version of load flow program developed and used since 1975, by one of the larger utilities in North America, Hydro Quebec. The program has also been widely used by utilities and consulting firms around the world.

The program is “menu-driven” and designed to minimize user generated errors during the data input and analysis stages. The program exhibits reliable convergence, accurate results and extensive documentation features, which allow the user to avoid continuous reference to the manual.

The Fast Decoupled Load Flow algorithm was chosen for its simplicity and efficiency, along with the savings it provides in computer resources. Special care was taken in providing a “user-friendly” facility for system modifications and/or corrections during case studies.

- **Load Flow Files**

Input and output files requested or generated by the Load Flow program are shown in Fig. 1.2.

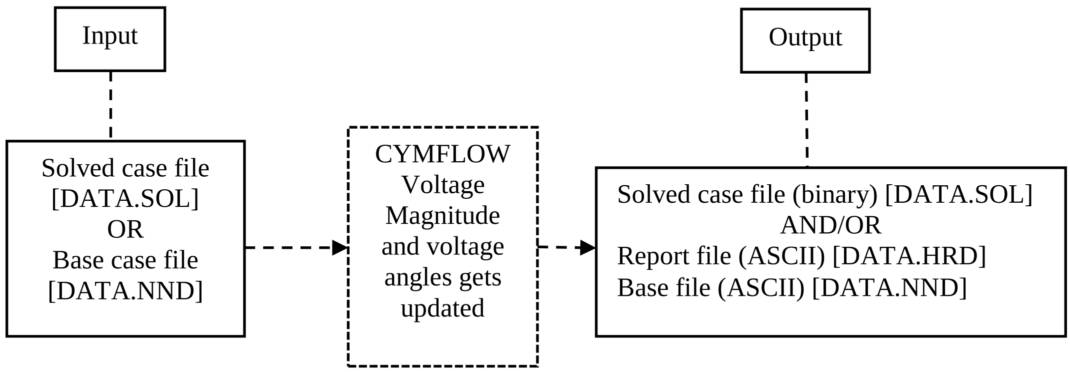

Fig. 1.2: Data File Architecture

- **Input files**

The Load Flow program accepts two type of data files. The NETWORK DATA file (formatted according to the CYMFLOW format). The SOLVED CASE file –produced by the program after a study has been completed.

- **Output Files**

Solved case files contain data saved by the program after a study has been completed. These data files can be used for further power flow studies or utilized as the starting point for contingency analysis, short circuit, or transient stability studies.

The report file contains the solution report and the iteration report.

It is possible to create a base case file (formatted file) from either an input file or from scratch. Modifications on an input (or fresh information to create a file from scratch) are kept in the memory until the current activity is terminated. The user can designate a new name for the file containing the new network data.

- **General Description**

CYME's Power Flow Program determines the line flows, voltage profiles, transformer tap-settings and reactive compensation requirements. The program operated in the interactive and/or batch modes. Full reports can be obtained in the same position.

The key features of the program include:

- Solution of systems with more than one swing bus.
- Solution of isolated networks.
- Control area interchange.
- Generator reactive power limits.
- Assignment of any generator to remote voltage control.
- Control of voltage or reactive power flow through LTC transformers.
- Phase shifter control of real power flow.
- Representation and control of DC lines.

Reports

The Load Flow program generates the following sets of reports:

(1) INPUT-DATA REPORT SET (2) SOLUTION REPORT SET

(1) The INPUT-DATA REPORT SET, includes the title case, bus and area reports (bus identification, voltage, active and reactive load, active and reactive shunt, etc.). The bus report can be obtained by bus or by zone. The area report contains the areas and area-associated zones as well as interchange data.

(2) In the SOLUTION REPORT SET, a transformer report, an abnormal-condition report (voltage violations, overload branches), a bus report (bus voltages, active and reactive load, etc.), a generator report (active and reactive generation), a DC line report, a shunt report (inductive, capacitive and resistive shunt) and a summary report (by bus, area or zone) are the available options. The latter report provides also interchange results as well as the loading of area control generator.

1.8 PROBLEM STATEMENT

In this research work, when the power system encounters the security threat during the critical operating states, the need of suitable protective control schemes necessitated the design of the automatic control protective schemes.

1.81 PROBLEM DEFINITION

1. The widespread cascade failures which occur when the systems are highly loaded due the critical lines outages, emphasized the need for analytically tractable models to understand and quantify the risk of failure, so that the power system is operated in safe mode during the contingency without propagation of failure into the large portion of the network. This means that in the absence of the proposed remedial action, the power station would experience the blackout. These situations are becoming predominant in the majority of the power utilities, especially in the era of deregulation and open access regime, as the generation expansions are coming up without associated transmission system in place. A suitable remedial action scheme is the need of the hour, in the event of critical outages by arming the GRS i.e., Generation Rejection Scheme on the preset arming points.

   In this thesis, a new approach is proposed to design a protection scheme to detect the particular system condition that is known to cause the unusual stress to the power system and take suitable predetermined action to counteract the observed critical condition in a controlled manner.

2. This thesis, also proposes a new adaptive technique of designing, modeling and formation of island for a frequency, below the conventional action of regular defense mechanism, as a last resort for preventing the total blackout, with the probability of accelerating the restoration process.

1.9 ORGANISATION OF THE THESIS

The thesis is organized and presented in six chapters:

Chapter 1: A brief introduction about Power System failures, blackouts and possible causes are presented. The Objectives of the proposed work is outlined.

Chapter 2: A review of relevant literature on the research aspects pertaining to blackouts, SPS and Island Schemes are presented.

Chapter 3: Critical Failures in Power Systems are discussed

Chapter 4: Design of Special Protection Scheme SPS: design, modeling and implementation of SPS in the state utility is presented.

Chapter 5: Proposed Island Scheme: The adapted technique, methodology, modeling details for the state utility is presented. It is also investigated for its applicability by modeling the state power system as a base case and implementing the proposed methodology for formation of the new proposed island scheme, for further justification.

Chapter 6: Conclusion and future scope are presented.