CHAPTER 1

INTRODUCTION

Due to ongoing climatic change and other natural disasters, some damage to physical infrastructure is inevitable, but a smart grid with the ability to anticipate, respond to and isolate damage could mitigate the impact and speedy recovery. The power grid should be enhanced to embark upon these challenges. The increase in power demand is outstripping capacity, and the deregulation and the fragmentation of the industry means no single company is in-charge of the infrastructure within a specific region, so there is less incentive for investment in upgrades to improve reliability. Remarkable advances in technology compel the existing system to clutch with large-scale computer and communication systems.

Power flow monitoring is the need of the hour to optimize the power flow in the power starved countries, thereby reducing the carbon emission. In a meshed network a utility has little control over the flow of power. The ability to control power flow is critical, as it very essential in matching the demand with the generation. The utility will directly draw the power from generator and load will not be under control. The ability to control power flow allows the utility to provide the cheapest energy possible. Power flow control also allows the utility to increase overall Available Transfer Capacity (ATC) of the system by avoiding problems of line overload, thus obviating the need to install new power lines on the system. Although lot of compensation techniques with the different Artificial Techniques (AI) has provided solution on a temporary basis, it is the need of the hour to find a solution that should pave the way for reliable, secured and quality power. This can be achieved by implementing the concept of the Internet of Things (IoT).

These intelligent devices added to the network helps in communicating the exact information in the short notice, which helps us in data analytics as well as decision making. The data recorded in blocks are further analysed through AI techniques, which will give the exact compensation level in the correct location.
Compensation on each node will reduce the fault condition at the stage itself, islanding the system from further deprival of voltage.

The Internet of Things (IoT) is expected to grow to 50 billion connected devices by 2020, providing valuable information to consumers, manufacturers and utility providers. Within the IoT, devices across a variety of industries will be interconnected through the Internet and peer-to-peer connections as well as closed networks like those used in the smart grid infrastructure.

But it all starts with a smarter and more connected grid. With the global focus on energy management and conservation, the IoT will extend the connected benefits of the smart grid beyond the distribution, automation and monitoring being done by utility providers. Management systems for in-home and in-building use will help consumers monitor their own usage and adjust behaviours. These systems will eventually regulate automatically by operating during off-peak energy hours and connect to sensors to monitor occupancy, lighting conditions, and more.

1.1. Need for the Study

Load forecasting is vital in optimizing the generation, the same lies with power flow optimization. Flexible AC Transmission Systems (FACTS) controllers are integrated in conventional power system to effectively control power flow, increase transmission line stability limit, and improve the security of transmission systems. The smartness can be achieved by forecasting the real need, analysing the data and thereby injecting or evacuating the power. The smartness can be achieved by embedding low power controllers like Internet of Things (IoT) to monitor and update the real time information regarding the flow rate to the central server which may help in data accumulation, decision making and future big-data analytics.

IoT actually, determines the rate at which the power to be absorbed or injected to the grid, and achieved by adapting D-FACTS devices. The emergence of Flexible AC Transmission Systems or FACTS is a boon to power flow control. FACTS devices are less utilized, because of their complexity and high cost. Distributed
FACTS (D-FACTS) is vital, which promises to be a simpler and cost effective solution to the power flow problem. Distributed Series Reactance (DSR) and Distributed Series Capacitor (DSC) are the two varieties of D-FACTS that can be applied in a meshed network. DSR is applied for series inductive injection while DSC for series capacitive injection. The placement of the D-FACTS units is important in order to maximize controllability of the grid, and to minimize the number of D-FACTS modules required on the system and subsequently to minimize the required capital.

Various optimization through Artificial Intelligence techniques have been analysed to fit this curve, but in particular Particle Swarm Optimization (PSO) has become a useful optimization tool in recent. It has been used in problems such as economic load dispatch, short term load forecasting and also placement and sizing of FACTS devices. Traditional FACTS devices are a lumped solution and can only be applied at one or two locations in a network. D-FACTS on the other hand can be applied to a large number of locations in the same network.

This study compares different optimization technique and checks if we can choose the best solution by optimally locate and place the D-FACTS in a large meshed power network.

1.2. Problem Statement

With an aging infrastructure, the grid is facing severe challenges including recurring black-outs in major industrialized cities around the globe, more than 30 percent electrical energy lost from production to homes in countries like India.

The grid topology needs to adapt and shift from a centralized source to a distributed topology that can absorb different energy sources in a dynamic way. There is a need to track real-time energy consumption and demand to the energy supply: this goes with the deployment of more remote sensing equipment capable of measuring, monitoring and communicating energy data that can be used to implement a self-
healing grid, increase the overall efficiency, and increase the level of self-monitoring and decision making.

Data accumulation is an art to analyse the data from the past, to survive for the current situation and planning for the future with the available resources. Decision making is vital for execution, which is human dependent – varies among individual. An artificial intelligence technique embedded to the system (SMART system) should pave the way for controlled mechanism with the available resources with accuracy and within the shortest available time period with sustainability.

In the simplest terms, building a smart grid means securing the future of energy supply for everyone in a rapidly growing population with a limited power production capacity. A smart grid reduces the losses, increases efficiency, optimizes the energy demand distribution and also makes large-scale renewable energy such as solar and wind deployments a reality.

The connected smart grid provides a communication network that will connect all the different energy-related equipment of the future. From the transmission and distribution power infrastructure, electrical, meters to home and building automation, addressing global smart grid challenges and building system solutions to connect grid devices briefly explained in Figure 1.1
Figure 1.1 Self-Healing Power System
1.3. Objective of the Study

This study mainly focuses on the identification of a methodology for the congested power system to decongest itself during the emergency situation. In simpler words comparing various Artificial Intelligence techniques and identify the best suitable technique which paves the way for self-healing grid.

The main objectives of the study are:

- To develop an efficient, simple reliable, accurate and fast optimization algorithm for solving OPF with FACTS controllers.
- To compare the Artificial Intelligence techniques for power optimization.
- To develop a methodology to optimize the power flow thereby the power system self-heals in response to criticality, material failures and other destabilizers.
- To study and propose a SMART grid system that should feature all this facility for self-healing.

1.4. Methodology of the study

The main objective of this study is to minimize the loss thereby reducing the overall cost incurred in power loss due to real power loss and thereby balancing the reactive power flow by installing D-FACTS devices in the grid system. Rather than increasing the Generation or installation of more and more Distribution transformers, we can still increase the efficiency of Power system by increasing the reactive component which plays a vital role in voltage boosting. The objective of the D-FACTS placement problem is to determine the locations and sizes of the D-FACTS so that the power loss is minimized and annual savings are maximized. This can be achieved through Self-healing schemes in the context of power distribution systems have the objective of performing fault location, isolation
and service restoration in an automated fashion, i.e., without (or with limited) distributed systems operation and repair crew intervention.

1.5. Limitations of the study.

Smart Grid evaluation through Internet of Things is in research level or in conception, which when embedded to this existing system can go miles after revamping the existing system, whereas this study revolves the implementation of AI techniques in TNEB grid for active and reactive flow which paves the way for smart grid.

1.6. Organization of the thesis.

Chapter 1 gives an introduction to voltage & power coordination in power system through newer technologies like IoT, AI techniques and objectives of the study.

Chapter 2 gives a detailed literature review of different scholars pertaining to the research done in the area of FACTS and Self-Healing system dealing with IoT.

Chapter 3 presents the modelling and analysis of smart grid using D-FACTS devices using various compensation techniques using various Artificial Intelligence techniques that enables the view of optimal power flow analysis.

Chapter 4 provides the comparison analysis of all the method proposed in this study with respect to previous studies. This details the structure of Self-Healing power flow implementation.

Chapter 5 discuss about the results and discussions of the study.

Chapter 6 gives Conclusions and scope of further study.