SAPKAL KNOWLEDGE HUB

Kalyani Charitable Trust's
Late G. N. Sapkal College of Engineering
Kalyani Hills, Anjaneri, Trimbakeshwar Road,
Nashik – 422 213

Department of Electrical Engineering

List of Project Based Learning (Projects)

Academic Year	Group No.	Name of Student	Name of Guide/Mentor	Project Title
2018-19	NIL	NIL	NIL	NIL
2019-20	NIL	NIL	NIL	NIL
2020-21	NIL	NIL	NIL	NIL
2021-22	G1	AHIRE DIPTI BALASAHEB	Prof. R.N.Baji	Three Phase Condition Monitoring And Controlling System
		ALHAT ROHIT BALASAHEB		
		BARHE KIRAN JAYRAM		
		BHAGAT SATISH LAXMAN		
	G2	BHAWAR PREM ROHIDAS	Prof. P.R.Gajare	Home Automation Using PLC & SCADA
		BHOYE PRANALI BALWANT		
		CHAUDHARI ADITYA SANJAY		
		CHAVAN YOGESH AVINASH		
	G3	DHANWATE ADITYA BHAURAO	Prof.S.S.Tidke	Energy Generation By Using Waste Water
		DUKALE MAHESH SANJAY		
		GAWALI KHUSHABU SHAHIRAM		
		GITE TEJAS BHAUSAHEB		
	G4	KAKAD NIKHIL SURESH	Prof.S.N.Hurpade	Wireless control sharp shooter vehicle using Microcontroller
		KARABAND SHUBHAM SADANAND		
		KETAN SAHEBRAO SURYAWANSHI		
		KULKARNI SAURABH SHEKHAR		
		MAHAJAN VIPUL PRASHANT		
	G5	MAHESH SHIVAJI AHER	Prof. P.R.Gajare	Energy Storage Technologies
		MALI VAIBHAV KISHOR		
		MALI YASH KAILAS		
		RAJPUT KARANSING SURENDRASING		
		RAUTMALE CHANDRAKALA ASHOK		
	G6	SATHE TEJAS SHASHIKANT	Prof.P.V.Mohod	Wireless Speed Control Of AC Drive System
		SHEJWAL NILESH RAJESH		
		SHIVADE GANESH ROHIDAS		
		SHIVANI DNYANESHWAR HALDE		
	G7	SINDHIKAR SIDDHESH GHANASHYAM	Prof.S.N.Hurpade	Smart Grid Power System Control In Distribute Generation Environment.
		SONAWANE ROHIT JITENDRA		
		SONAWANE SAMRUDDHI KESHAV		
		SURYAWANSHI TEJAS DNYANESHWAR		
	G8	TARWARE AMIT JANARDHAN	Prof. R.N.Baji	Energy Conservation In Industry
		WADWALE OMKAR SHIVAJI		
		WAYKOLE KAUSTUBH VIKAS		

		ZOLE MAHENDRA RAMDAS		
2022-23	G1	BHAMARE VIRAJ ASHOK	Prof. R.N.Baji	Electricity Theft Identification System.
		BORSE ASHWINI BAPU		
		CHAVANKE VEDANT SANTOSH		
		DEORE SANDIP PRUTHVIRAJ		
		DESHMUKH ALKESH CHANDRAKANT		
	G2	GADAKH NAKUL SURESH	Prof. P.R.Gajare	Automatic Meter Reading
		GANGURDE HRITIK KHANDU		
		GIRI SHREYASH SHRIKANT		
		GODSE PRANJALRAMNATH		
		HIRE VISHAL DILIP		
	G3	JADHAV DARSHANA DINESH	Prof.S.N.Hurpade	Smart Meter for Power Grid
		KHAIRNAR ANAND SUNIL		
		MADANE PARTH DATTATRAY		
		MONDHE PRANAV KAILAS		
		MUSALE HITESH RAVINDRA		
	G4	NAGARE SWAPNIL MANOJ	Prof. P.R.Gajare	Alternative Energy Source(Wind Power)
		NAGRALE RAJRATNA ASHOK		
		NIKAM KISHOR BHAUSAHEB		
		PAGARE VRUSHALI RATAN		
		PALVI SAURABH DEORAM		
	G5	PATIL ANUJ JITENDRA	Prof.R.U.Pawar	AC Drives
		PATIL BHAGYASHRI ANIL		
		PATIL NIRUJA ONKAR		
		PATIL RUSHIKESH ARUN		
		PATIL RUTUJA PRAKASH		
	G6	POTDAR PRANAV VIJAY	Prof. R.N.Baji	Eddy Current Brakes
		SANDESH RAMCHANDRA JADHAV		
		SANGAMNERE SHUBHAM MADHUKAR		
		SHEWALE ADITYA SAHEBRAO		
		THAKARE BHAGYASHREE ULHAS		
	G7	TRIBHUVAN GAURAV JAYVANT	Prof.R.U.Pawar	Magnetic Levitation Trains
		UGALE ASHISH KHANDU		
		VAGHMARE VINOD LOKAPPA		
		WAKALKAR BHUSHAN SURESH		

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SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE

A

PROJECT REPORT

ON

"Interconnected Power System"

Submitted as partial fulfillment of **Project Based Learning**

SE (Electrical)

(Electrical Engineering)

By

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Academic Year 2022-2023

CERTIFICATE

This is to certify that GADAKH NAKUL SURESH, GANGURDE HRITIK KHANDU, GIRI SHREYASH SHRIKANT, GODSE PRANJALRAMNATH, HIRE VISHAL DILIP **of S.E. (Electrical Engineering)** successfully completed project on **"Inetrconnected Power System"** during the SEMESTER-2 of Academic Year 2022-2023 towards the partial fulfillment of Project Based Learning of Savitribai Phule Pune University under the Department of Electrical Engineering, Late G. N. Sapkal College of Engineering, Nashik.

Prof. P.R.Gajare
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PRINCIPAL

ACKNOWLEDGEMENT

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HIRE VISHAL DILIP

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CHAPTER NO. 1

INTRODUCTION

An electrical grid is an interconnected network for delivering electricity from suppliers to consumers. It consists of generating stations that produce electrical power, high-voltage transmission lines that carry power from distant sources to demand centers, and distribution lines that connect individual customers.

Power station may be located near a fuel source, at a dam site, or to take advantage of renewable energy sources, and are often located away from heavily populated areas. They are usually quite large to take advantage of the economic of plant. The electric power which is generated is stepped up to a higher voltage at which it connects to the electrical network.

The bulk power transmission network will move the power long distances, sometimes across international boundaries, until it reaches its wholesale customer (usually the company that owns the local electrical power network.

On arrival at a substation, the power will be stepped down from a transmission level voltage to a distribution level voltage. As it exits the substation, it enters the distribution wiring. Finally, upon arrival at the service location, the power is stepped down again from the distribution voltage to the required service voltage.

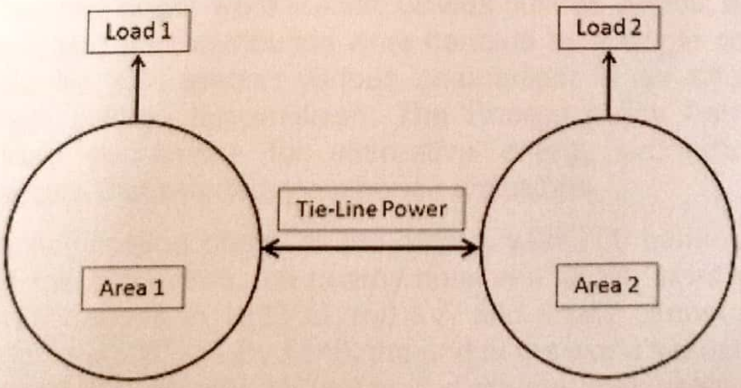


Fig 1.1 Interconnected power system.

CHAPTER NO. 2

HISTORY

Early electric energy was produced near the device or service requiring that energy. In the 1880s, electricity competed with steam, hydraulics, and especial coal gas. Coal gas was first produced on customer's premises but later evolved into gasification plants that enjoyed economic. In the industrialized world cities had networks of piped gas, used for lighting. But gas lamps produced poor light, wasted heat, made rooms hot and smoky, and gave off hydrogen and carbon dioxide. In the 1880s electric lighting soon became advantageous compared to gas lighting.

Electrical utility companies took advantage of economies of scale and moved to centralized power generation, distribution, and system management.[2] With long distance power transmission it became possible to interconnect stations to balance loads and improve load factors.

In the United Kingdo charles, of the consulting partnership, built the Neptune pwer plan Newcastlen upon power plant in 1901,and by 1912 had developed into the largest integrated power system in Europe.—Merz was appointed head of a Parliamentary Committee and his findings led to the Williamson Report of 1918, which in turn created the Electricity Supply Bill of 1919. The bill was the first step towards an integrated electricity system. The Electricity (Supply) Act of 1926 led to the setting up of the National Grid. The central electricity standardized the nation's electricity supply and established the first synchronized AC grid, running at 132 kilo volts and 50 hertz. This started operating as a national system, the national grid, in 1938.

In the United States in the 1920s, utilities formed joint-operations to share peak load coverage and backup power. In 1934, with the passage of the electric utilities were recognized As public goods importance and were given outlined restrictions and regulatory oversight of their operation Energy Policy Act of 1992 required transmission line owners to allow electric generation companies open access to their network and led to a restructuring of how the electric industry operated in an effort to create competition in power generation. No longer were electric utilities built as vertical monopolies, where generation, transmission and distribution were handled by a single company. Now, the three stages could be split among various companies, in an effort to provide fair accessibility to high voltage transmission. The Energy policy Act of 2005 allowed incentives and loan guarantees for alternative energy production and advance innovative technologies that avoided greenhouse emissions.

In France electrification began in the 1900s, with 700 communs. In 1919, and 36,528 in 1938. At the same time, the nearby networks began to interconnect: Paris in 1907 at 12kV, the Pyrenees in 1923 at 150 kV, and finally almost all of the country interconnected in 1938 at 220 kV. By 1946, the grid is the world's most dense. That year that state nationalized the industry, by uniting the private companies as electrical. The frequency was standardized at 50 Hz, and the 225kV network replaces 110 and 120. From 1956, household current is standardized at 220 / 380V, replacing the previous

127/220V. During the 1970s, the 400kV network, the new European standard, is implemented.

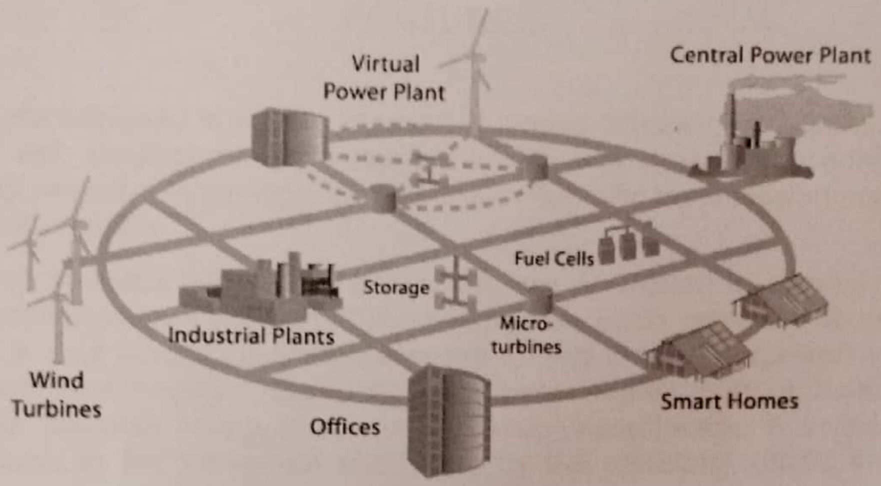


Fig. 2.1 layout of interconnected grid

CHAPTER NO. 3

FEATURES

Grids are designed to supply voltages at largely constant amplitudes. This has to be achieved with varying demand, variable reactive loads, and even nonlinear loads, with electricity provided by generators and distribution and transmission equipment that are not perfectly reliable.

In a synchronous grid all the generators are connected in parallel and run not only at the same frequency but also at the same phase. Each generator is maintained in this state by a local governor that regulates the driving torque by controlling the steam supply to the turbine driving it. Generation and consumption must be balanced across the entire grid, because energy is consumed almost instantaneously as it is produced. Energy is stored in the immediate short term by the rotational kinetic energy of the generators.

Although an entire grid runs at the same frequency, normally only in very small grids is the frequency fixed. More typically, the frequency of the grid is designed to vary slightly (by 1 percent or so) depending on the load on the grid. When the grid is very heavily loaded, the frequency slows, and governors adjust their generators so that more power is on. When the grid is lightly loaded the grid frequency runs above the nominal frequency, and this is taken as an indication by automatic generation station systems across the network that generators should reduce their output.

In addition, there's often central control, which can change the parameters of the AGC systems over timescales of a minute or longer to further adjust the regional network flows and the operating frequency of the grid.

Transmission networks are complex with redundant pathways. For example, see the map of the United States' high-voltage transmission network structure or "tpology" of a grid can vary depending on the constraints of budget, requirements for system reliability, and the load and generation characteristics. The physical layout is often forced by what land is available and its geology. Distribution networks are divided into two types, radial or network.

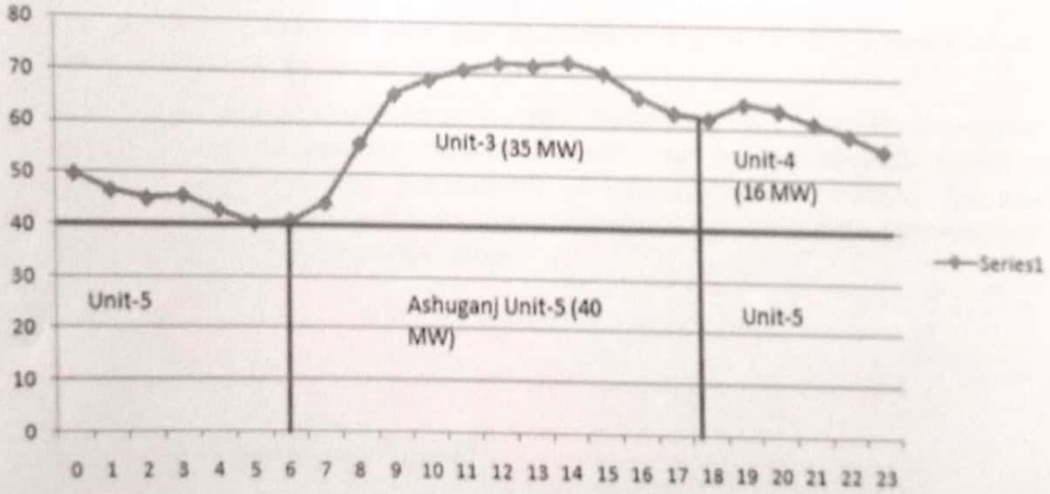
The simplest topology for a distribution or transmission grid is a *radial* structure. This is a tree shape where power from a large supply radiates out into progressively lower voltage lines until the destination homes and businesses are reached. However, single failures can take out entire branches of the tree.

Most transmission grids offer the reliability that more complex mesh networks provide. The expense of mesh topologies restricts their application to transmission and medium voltage distribution grids. Redundancy allows line failures to occur and power is simply rerouted while workmen repair the damaged and deactivated line.

Other topologies used are looped systems found in Europe and tied ring networks.

In cities and towns of North America, the grid tends to follow the classic radially fed design. A substation receives its power from the transmission network, the power is stepped down with a transformer and sent to a bus from which feeders fan out in all directions across the countryside. These feeders carry three phase power and tend to follow the major streets near the substation. As the distance from the substation grows, the fan out continues as smaller laterals spread out to cover areas missed by the feeders. This tree-like structure grows outward from the substation, but for reliability reasons, usually contains at least one unused backup connection to a nearby substation. This connection can be enabled in case of an emergency, so that a portion of a substation's service territory can be alternatively fed by another substation.

LOAD DISTRIBUTION GRAPH



Wide area synchronous grid

A wide area synchnous or "interconnection" is a group of distribution areas all operating with alternating current (AC) frequencies synchronized (so that peaks occur at the same time). This allows transmission of AC power throughout the area, connecting a large number of electricity generators and consumers and potentially enabling more efficient electricity markets and redundant generation. Interconnection maps are shown of North America (right) and Europe (below left).

A large failure in one part of the grid - unless quickly compensated for - can cause current to re-route itself to flow from the remaining generators to consumers over transmission lines of insufficient capacity, causing further failures. One downside to a widely connected grid is thus the possibility of cascading failure and widespread power outage. A central authority is usually designated to facilitate communication and develop protocols to maintain a stable grid. For example, the NORTH AMERICAN ELECTRICAL RELIABILITY CORPORATION gained binding powers in the United States in 2006, and has advisory powers in the applicable parts of Canada and Mexico. The U.S. government has also designated National interest electrical transmission corridors, where it believes transmission bottlenecks have developed.

Some areas, for example rural communities in Alaska, do not operate on a large grid, relying instead on local diesel generators.

High voltage direct current lines or variable frequency can be used to connect two alternating current interconnection networks which are not necessarily synchronized with each other. This provides the benefit of interconnection without the need to synchronize an even wider area. For example, compare the wide area synchronous grid map of Europe with the map of HVDC lines.

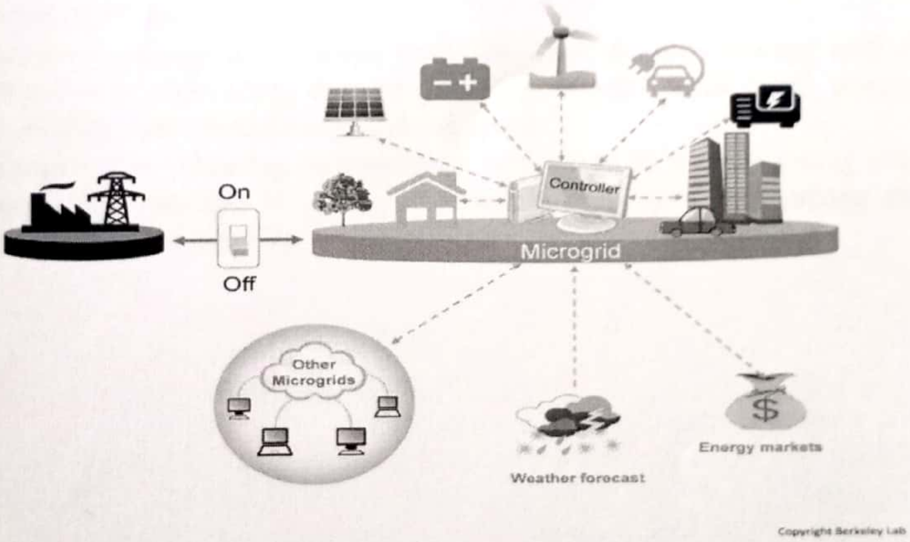
Redundancy and defining "grid"

A town is only said to have achieved grid connection when it is connected to several redunt sources, generally involving long-distance transmission.

This redundancy is limited. Existing national or regional grids simply provide the interconnection of facilities to utilize whatever redundancy is available. The exact stage of development at which the supply structure becomes a *grid* is arbitrary. Similarly, the term *national grid* is something of an anachronmsin many parts of the world, as transmission cables now frequently cross national boundaries. The terms distribution grid for local connections and transmission grid for long-distance transmissions are therefore preferred, but *national grid* is often still used for the overall structure.

Interconnected Grid

Electric utilities across regions are many times interconnected for improved economy and reliability. Interconnections allow for economics plant, allowing energy to be purchased from large, efficient sources. Utilities can draw power from generator reserves from a different region in order to ensure continuing, reliable power and diversify their loads. Interconnection also allows regions to have access to cheap bulk energy by receiving power from different sources. For example, one region may be producing cheap hydro power during high water seasons, but in low water seasons, another area may be producing cheaper power through wind, allowing both regions to access cheaper energy sources from one another during different times of the year. Neighboring utilities also help others to maintain the overall system frequency and also help manage tie transfers between utility regions.



Interconnected Grid.

CHAPTER NO. 4

AGING INFRASTRUCTURE

Despite the novel institutional arrangements and network designs of the electrical grid, its power delivery infrastructures suffer aging across the developed world. Contributing factors to the current state of the electric grid and its consequences include:

- Aging equipment – older equipment has higher failure rate, leading to interruption rates affecting the economy and society; also, older assets and facilities lead to higher inspection maintenance costs and further repair and recost costs.
- Obsolete system layout – older areas require serious additional substation and right way sites to that cannot be obtained in current area and are forced to use existing, insufficient facilities.
- Outdated engineering – traditional tools for power delivery planning and engineering are ineffective in addressing current problems of aged equipment, obsolete system layouts, and modern deregulated loading levels.
- Old cultural value planning engineering, operating of system using concepts and procedures that worked in vertically integrated industry exacerbate the problem under a deregulated industry.

CHAPTER NO. 5

MODERN TRENDS

As the 21st century progresses, the electric utility industry seeks to take advantage of novel approaches to meet growing energy demand. Utilities arnsee under pressure to evolve their classic topologies to accommodate distributed. As generation becomes more common from rooftop solar and wind generators, the differences between distribution and transmission grids will continue to blur. Also, demand response is a grid management technique where retail or wholesale customers are requested either electronically or manually to reduce their load. Currently, transmission grid operators use demand response to request load reduction from major energy users such as industrial plants.

With everything interconnected, and open competition occurring in a free market economy, it starts to make sense to allow and even encourage distribution generation (DG). Smaller generators, usually not owned by the utility, can be brought on-line to help supply the need for power. The smaller generation facility might be a home-owner with excess power from their solar panel or wind turbine. It might be a small office with a diesel generator. These resources can be brought on-line either at the utility's behest or by owner of the generation in an effort to sell electricity. Many small generators are allowed to sell electricity back to the grid for the same price they would pay to buy it. Furthermore, numerous efforts are underway to develop a "smartgrid". In the U.S., the Enery Policy Act 2005 and Title XIII of the Energy Independence and Security Act 2007 are providing funding to encourage smart grid development. The hope is to enable utilities to better predict their needs, and in some cases involve consumers in some form of time-of-use based tariff. Funds have also been allocated to develop more robust energy control technologies.

Various planned and proposed systems to dramatically increase transmission capacity are known as super and mega grids. The promised benefits include enabling the renewable energy industry to sell electricity to distant markets, the ability to increase usage of intermittent energy sources by balancing them across vast geological regions, and the removal of congestion that prevents electricity markets from flourishing. Local opposition to siting new lines and the significant cost of these projects are major obstacles to super grids. One study for a European super grid estimates that as much as 750 GW of extra transmission capacity would be required- capacity that would be accommodated in increments of 5 GW HVDC lines. A recent proposal by Transcanada priced a 1,600-km, 3-GW HVDC line at $3 billion USD and would require a corridor wide. In India, a recent 6 GW, 1,850-km proposal was priced at $790 million and would require a wide right of way. With 750 GW of new HVDC transmission capacity required for a European super grid, the land and money needed for new transmission lines would be considerable.

CHAPTER NO. 6

FUTURE TRENDS

SMART GRIDS

The electrical grid is expected to evolve to a new grid paradigm: the smart grid, an enhancement of the 20th century electrical grid. The traditional electrical grids are generally used to carry power from a few central generators to a large number of users or customers. In contrast, the new emerging smart grid uses two-way flows of electricity and information to create an automated and distributed advanced energy delivery network.

Many research projects have been conducted to explore the concept of smart grid. According to a newest survey on smart grid,[15] the research is mainly focused on three systems in smart grid- the infrastructure system, the management system, and the protection system.

The infrastructure system is the energy, information, and communication infrastructure underlying of the smart grid that supports

1. advanced electricity generation, delivery, and consumption;
2. advanced information metering, monitoring, and management; and
3. Advanced communication technologies.

In the transition from the conventional power grid to smart grid, we will replace a physical infrastructure with a digital one. The needs and changes present the power industry with one of the biggest challenges it has ever faced.

A smart grid would allow the power industry to observe and control parts of the system at higher resolution in time and space It would allow for customers to obtain cheaper, greener, less intrusive, more reliable and higher quality power from the grid. The legacy grid did not allow for real time information to be relayed from the grid, so one of the main purposes of the smart grid would be to allow real time information to be received and sent from and to various parts of the grid to make operation as efficient and seamless as possible. It would allow us to manage logistics of the grid and view consequences that arise from its operation on a time scale with high resolution; from high-frequency switching devices on a microsecond scale, to wind and solar output variations on a minute scale, to the future effects of the carbon emissions generated by power production on a decade scale.

The management system is the subsystem in smart grid that provides advanced management and control services. Most of the existing works aim to improve energy efficiency, demand profile, utility, cost, and emission, based on the infrastructure by using optimization, machine learning and Within the advanced infrastructure framework of smart grid, more and more new management services and applications are expected to emerge and eventually revolutionize consumers' daily lives.

The protection system is the subsystem in smart grid that provides advanced grid reliability analysis, failure protection, and security and privacy protection services. The advanced infrastructure used in smart grid on one hand empowers us to realize more powerful mechanisms to defend against attacks and handle failures, but opens up new vulnerabilities. For example National Institute Standards and Technology pointed out that the major benefit provided by smart grid, the ability to get richer data to and from customer smart and other electric devices, also give major privacy concerns, since the energy use information stored at the meter acts as an information-rich side channel. This information could be mined and retrieved by interested parties to reveal personal information such as individual's habits, behaviors, activities, and even beliefs.

GRID DEFECTION

As there is some resistance in the electric utility sector to the concepts of distributed generation with various renewable energy sources and microscale cogen units, several authors have warned that mass-scale grid detection is possible because consumers can produce eletctricity using off grid systems primarily made up of solar photovoltaic technology.

The Rocky Mountain Institute has proposed that there may wide scale grid defection. This is backed up by studies in the Midwest.

CHAPTER NO. 7

ADVANTAGES

1) **Exchange of peak loads** : An important advantage of interconnected system is that the peak load of the power station can be exchanged. If the load curve of a power station shows a peak demand that is greater than the rated capacity of the plant, then the excess load can be shared by other stations interconnected with it.

2) **Use of older plants** : The interconnected system makes it possible to use the older and less efficient plants to carry peak loads of short durations. Although such plants may be inadequate when used alone, yet they have sufficient capacity to carry short peaks of loads when interconnected with other modern plants. Therefore, interconnected system gives a direct key to the use of obsolete plants.

3) **Ensures economical operation** : The interconnected system makes the operation of concerned power stations quite economical. It is because sharing of load among the stations is arranged in such a way that more efficient stations work continuously throughouts the year at a high load factor and the less efficient plants work for peak load hours only.

4) **Increases diversity factor** : The load curves of different interconnected stations are generally different. The result is that the maximum demand on the system is much reduced as compared to the sum of individual maximum demands on different stations. In other words, the diversity factor of the system is improved, thereby increasing the effective capacity of the system.

5) **Reduces plant reserve capacity** : Every power station is required to have a standby unit for emergencies. However, when several power stations are connected in parallel, the reserve capacity of the system is much reduced. This increases the efficiency of the system.

6) **Increases reliability of supply** : The interconnected system increases the reliability of supply. If a major breakdown occurs in one station, continuity of supply can be maintained by other healthy statio.

DISADVANTAGES

1) Fault current and fault level increases. This results higher rating of protective devices.

2) Long length transmission lines and tie lines are required which results increased cost of transmission.

3) Capacity increases with requirement of frequent synchronization of generators. Stability of system is more concerned for interconnected system.

CHAPTER NO. 8

FUTURE SCOPE

The work done in the thesis may be extended in the following directions:

1. The PFC and adaptive PFC developed in this thesis may be used for deregulated power system models.

2. The PFC can also be made adaptive using ANN or other approaches and compared with adaptive PFC developed in this work.

3. The proposed adaptive PFC may be used as power system stabilizer for controlling excitation system. 4. The particle swarm optimization may also be integrated with fuzzy system approach to improve the results.

CHAPTER NO. 9

CONCLUSION

The thesis is an attempt to contribute towards building an intelligent controller for load frequency control of modern interconnected power systems. The intelligent controller consists of fuzzy logic approach and its variants in isolation and also in combination with Genetic Algorithms to control interconnected power system with and without nonlinearities. This is a well known fact that when the complexity of the system increases as in case of power systems from a simple radial system to rather complex interconnected grid system of today. The large interconnected highly complex power system cannot be well defined and modeled with all nonlinearities of real time system. Therefore, it is not an easy task to control such complex power system with simple conventional PI controller effectively and efficiently. A number of control schemes have been developed in this thesis to control the power system of this complex nature.

The main emphasis of the work is on Fuzzy Logic controllers. The Fuzzy Logic, Polar Fuzzy Logic and real coded Genetic Algorithm based Polar Fuzzy Logic controllers have been developed and used for controlling load frequency problem. The performances of these controllers have been compared for 1% load disturbance in different areas. The power systems considered in this work have thermal, nuclear and hydro systems with and without non-linearities. The non-linearities have been taken into consideration are backlash, boiler dynamic and generation rate constraints (GRC) etc. These systems are controlled using Fuzzy logic controller. The performance of fuzzy logic controller depends upon the accurate and sufficient fuzzy rule base.

As the number of rules increases the controller response is better and smoother. On the other 308hand, as the size of fuzzy rule base increases, the computation effort and time both increase. To overcome this problem, a polar fuzzy logic based controller (PFC) is proposed in this work. The performance of PFC is compared with conventional PI controller and fuzzy logic controllers. The PFC is further improved by making it adaptive using real coded genetic algorithm-fuzzy system approach and the results are compared with fixed parametric PFC. The research work is divided in seven chapters and the following inferences are drawn from the results obtained with different controllers under different operating conditions

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