A

PROJECT REPORT

ON

ACTIVE POWER AND FREQUENCY ANALYSIS OF SMART GRID USING SIMULINK

Submitted in partial fulfillment of the requirements of the degree of

BACHELOR OF ELECTRICAL ENGINEERING

By

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CERTIFICATE

This is to certify that the project entitled **"Active Power and Frequency Analysis of Smart Grid Using Simulink"** is a bonafide work of **Mr. MOHAMMED AHMED SAYYED (12EE04), Mr. AMOL ANANT KADAM (12EE17), Mr. SUMEETKUMAR MISHRA (12EE30), Mr. OMKAR DIPAK UTEKAR (12EE63)** submitted to the University of Mumbai in partial fulfillment of The requirement for the award of the degree of **Bachelor of Engineering** in **Electrical Engineering.**

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DECLARATION

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Last but not the least a bunch of thanks to all who helped us directly or indirectly to make this a great success.

ABSTRACT

In this project, a Smart Grid has been designed by MATLAB/SIMULINK approach for synchronization of Thermal and Wind power plant and for analysis of Active-Reactive power and grid frequency. Analysis of Active power and frequency gives the exact idea to know the range of maximum permissible loads that can be connected to their relevant bus bars. Reactive power flow between a wind turbine system and the grid is an important issue especially when the wind turbine is connected to a grid because

Wind turbine power production depends on wind speed. The output power is not constant at all as wind speed changes all times. Output Voltage and frequency of these power plants must be same to avoid circulating current in existing power system network in the synchronization process. The maximum and minimum frequency deviation calculated for this smart power system network explains about the permissible range of active and inductive load applied at different load bus, from which stable working condition of the system has been deduced in order to satisfy the frequency deviation of + 3%.

The Smart Grid, regarded as the next generation power grid, uses two-way flow of electricity and information to create a widely distributed automated energy delivery network.

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LIST OF ABBREVIATIONS

DFIG: Doubly Fed Induction Motor

ALFC: Automatic Frequency Control Loop

PMU: Phasor measurement unit

AMI: Advanced Metering Infrastructure

DC: Direct Current

AC: Alternating Current

CHAPTER 1

INTRODUCTION

A future Smart Grid power system network is a dynamic network for bi-directional energy flows, linking widely distributed small capacity renewable energy systems at consumer level (distribution network) and centralized higher-capacity power generators, facilitating active participation of customer choice for energy production/source and demand management, and providing real-time information on the performance and optimal operation of the power system network. Smart grid is technically classified in three categories namely Smart Infrastructure System, Smart Management System and Smart Protection System. The simulation works of this project is done under the Smart Power generation technique which is a part of Smart Infrastructure System.

Frequency and Active power are the main parameters to show the stability of any power system network like conventional power grid, micro grid or any virtual power plant. Micro grid is designed to operate in grid connected and isolated mode. Active and Reactive Power Control of the Electronically Interfaced DG Sources for the Realization of a Virtual Power Plants also been done. This research paper only depicts the power flow analysis in virtual power plant having small capacity.

In present scenario of power system network, conventional and distributed generation are combined used to control the active power flow. This is necessary in order to get a highly stable electrical network. This project is about to synchronize these two power plant one is conventional and second is non-conventional. These are namely thermal and wind power plant because both sharing maximum percentage of electricity generation in their respective field.

Analysis of Active power and frequency gives the exact idea to know the range of maximum permissible loads that can be connected to their relevant bus bars. The Smart Grid, regarded as the next generation power grid, uses two-way flow of electricity and information to create a widely distributed automated energy delivery network

We are analysis both the power and frequency of both plant. In case of thermal power plant if there is any change in steady state frequency, then it can be brought back to steady state by proportional plus integral control method. The power generation can be analysis by turbine speed governing system. In case of wind power plant, doubly fed induction generator used for power generation. Generally, the wind speed is not constant, therefore frequency of stator and system will vary. For inducing the e.m.f in stator winding the frequency of stator and system should be same. The frequency can be adjusted by feeding required frequency to rotor winding through power converter.

CHAPTER 2

LITERATURE REVIEW

- The United States Department of Energy (DOE) is a Cabinet-level department of the United States Government concerned with the United States' policies regarding energy.
  - We have heard of the Smart Grid on the news or from your energy provider. But not everyone knows what the grid is, let alone the Smart Grid electric grid.
  - "The grid," refers to the, a network of transmission lines, substations, transformers and more that deliver electricity from the power plant to your home or business.
  - The smart grid the digital technology that allows for two-way communication between the utility and its customers, and the sensing along the transmission lines is what makes the grid smart.
  - Like the Internet, the Smart Grid will consist of controls, computers, automation, and new technologies and equipment working together, but in this case, these technologies will work with the electrical grid to respond digitally to our quickly changing electric demand.

- Smart Grid: Fundamentals of Design and Analysis, James Momoh , ISBN: 978-0-470-88939-8 , March 2012, Wiley-IEEE Press.
  - It specifies the fundamentals of smart grid. It provides the working definition the functions, the design criteria and the tools and techniques and technology needed for building smart grid.
  - A smarter grid will add resiliency to our electric power System and make it better prepared to address emergencies such as severe storms, earthquakes, large solar flares, and terrorist attacks. Because of its two-way interactive capacity, the Smart Grid will allow for automatic rerouting when equipment fails or outages occur.
  - It incorporates all the essential factors of Smart Grid appropriate for enabling the performance and capability of the power system.

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  - Smart grid is technically classified in three categories namely Smart Infrastructure System, Smart Management System and Smart Protection System.
  - The stability of power system is determine by analyzing frequency an Frequency and Active power of any power system network like conventional power grid, micro grid or any virtual power plant d active power.
  - In power system active and reactive power demand are never steady and changes continuously.
  - In thermal power plant, frequency can be controlled by automatic frequency control loop (ALFC) which comprises generator, load, prime mover and governor.

CHAPTER 3

SMART GRID SYSTEM

3.1 The smart grid

Maybe you have heard of the Smart Grid on the news or from your energy provider. But not everyone knows what the grid is, let alone the Smart Grid. "The grid," refers to the electric grid, a network of transmission lines, substations, transformers and more that deliver electricity from the power plant to your home or business. It's what you plug into when you flip on your light switch or power up your computer. To move forward, we need a new kind of electric grid, one that is built from the bottom up to handle the groundswell of digital and computerized equipment and technology dependent on it and one that can automate and manage the increasing complexity and needs of electricity in the 21st Century.

3.2 What Makes a Grid "Smart?"

Smart grid is the digital technology that allows for two-way communication between the utility and its customers, and the sensing along the transmission lines is what makes the grid smart. Like the Internet, the Smart Grid will consist of controls, computers, automation, and new technologies and equipment working together, but in this case, these technologies will work with the electrical grid to respond digitally to our quickly changing electric demand.

3.3 What does a Smart Grid do?

The Smart Grid represents an unprecedented opportunity to move the energy industry into a new era of reliability, availability, and efficiency that will contribute to our economic and environmental health. During the transition period, it will be critical to carry out testing, technology improvements, consumer education, development of standards and regulations, and information sharing between projects to ensure that the benefits we envision from the Smart Grid become a reality. The benefits associated with the Smart Grid include:

•More efficient transmission of electricity

•Quicker restoration of electricity after power disturbances

•Reduced operations and management costs for utilities, and ultimately lower power costs for consumers

•Reduced peak demand, which will also help lower electricity rates

•Increased integration of large-scale renewable energy systems

•Better integration of customer-owner power generation systems, including renewable energy systems

•Improved security.

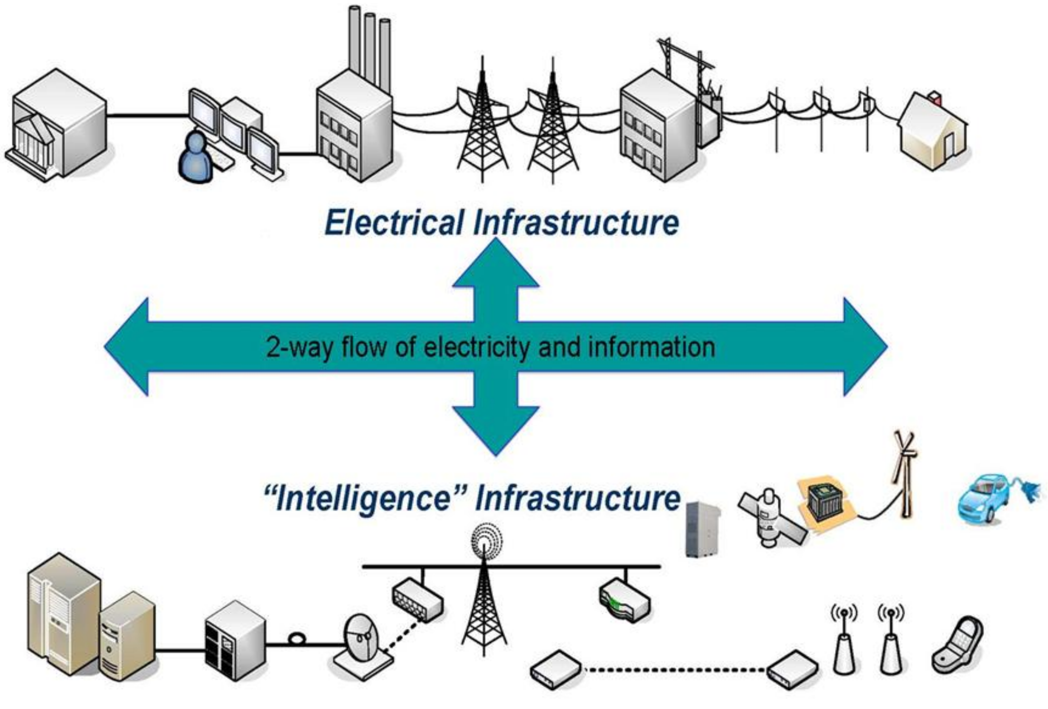

Fig 3.1. Electrical structure & "Intelligence" structure

3.4 Difference between Conventional Grid and Smart Grid

POINTS	CONVENTIONAL GRID	SMART GRID
COMMUNICATION	One way; not real time	Two-way; real-time
CUSTOMER INTERACTION	Limited	Extensive
METERING	Electromechanical	Digital
OPERATION AND MAINTAINANCE	Manual equipment checks, time based	Remote monitoring, predictive condition-based
GENERATION	Centralized	Centralized and distributed
POWER FLOW CONTROL	Limited	Comprehensive
RESTORATION	Manual	Self -healing

Today, an electricity disruption such as a blackout can have a domino effect a series of failures that can affect banking, communications, traffic, and security. This is a particular threat in the winter, when homeowners can be left without heat. A smarter grid will add resiliency to our electric power System and make it better prepared to address emergencies such as severe storms, earthquakes, large solar flares, and terrorist attacks. Because of its two-way interactive capacity, the Smart Grid will allow for automatic rerouting when equipment fails or outages occur. This will minimize outages and minimize the effects when they do happen. When a power outage occurs, Smart Grid technologies will detect and isolate the outages, containing them before they become large-scale blackouts. The new technologies will also help ensure that electricity recovery resumes quickly and strategically after an emergency routing electricity to emergency services first, for example. In addition, the Smart Grid will take greater advantage of customer-owned power generators to produce power when it is not available from utilities. By combining these "distributed generation" resources, a community could keep its health centre, police department, traffic lights, phone System, and grocery store operating during emergencies. In addition, the Smart Grid is a way to address an aging energy infrastructure that needs to be upgraded or replaced.

CHAPTER 4

ELECTRIC POWER & DIFFERENT TYPES OF LOAD

4.1 Introduction

In the 20th century local grids grew over time, and were eventually interconnected for economic and reliability reasons. By the 1960s, the electric grids of developed countries had become very large, mature and highly interconnected, with thousands of 'central' generation power stations delivering power to major load centre's via high capacity power lines which were then branched and divided to provide power to smaller industrial and domestic users over the entire supply area. Through the 1970s to the 1990s, growing demand led to increasing numbers of power stations. In some areas, supply of electricity, especially at peak times, could not keep up with this demand, resulting in poor power quality including blackouts, power cuts, and brownouts. Increasingly, electricity was depended on for industry, heating, communication, lighting, and entertainment, and consumers demanded ever higher levels of reliability.

AC power sources are essential pieces of equipment for providing flexible and reliable power generation. However, the concepts of power generation and power loss can be daunting for end users and sales personnel alike. This is especially true when it comes to talking about the different types of power quantities. Energy and Power In order to fully understand power, it is critical to grasp the concept of energy and how it relates to power. Energy is a force multiplied by a distance. The term "Joule" is the quantity used to define energy.

Power is defined as the amount of energy expended per unit time. Power is a force multiplied by a rate. Using this concept, it can be applied to electrical quantities. This dynamic is the same when dealing with power in electronics.

Voltage or "potential" is the force necessary to move electrons. Current is actually a rate of flow of charges per second through a material with that voltage applied.

By taking that force (voltage) multiplied by a rate (current), the end result is energy expended over time. This quantity is power. Thus electrical power is voltage multiplied by current. $P = V * I$ where power (P) is in watts, voltage (V) is in volts and current (I) is in amps. The voltage and current of an AC circuit are sinusoidal in nature. This means that the amplitude of the current and voltage of an AC circuit will constantly change over time.

Since power is voltage times current (P= V*I), power is maximized when the voltage and current are "lined up" with one another. The peaks and zero points on the waveform for voltage and current occur at the same time. When this happens, the two signals are said to be "in phase" with one another. Two waveforms are said to be "out of phase" or "phase shifted" when the two signals do not match up from point to point.

Due to the behaviour of voltage and current in AC circuits, power is a quantity that comes in several different flavors.

The three main circuit components are the resistor, the capacitor and the inductor. Each component has a different effect on the phase shift between voltage and current. A resistor causes no shift between current and voltage (a zero degree shift).

Power that is the result of a purely resistive load is known as "true" power. It is the power that performs work in the circuit and it is measured in Watts (W). This is the power that will drive a circuit board or a motor. It is the desired outcome of an electrical system.

A capacitor and inductor will cause a 90 degree phase shift between voltage and current. The resulting power will have a value of zero every time the voltage or current has a zero value since the two quantities are multiplied to get power. This is not a desirable model because although the source is generating power, no work is being done at the load. This type of power is known as "reactive" power because it counteracts the effects of true power. Reactive power is the lazy brother of true power. True power is doing all the work while reactive power is actually taking away from the power in the system making the true power work harder to get the job done. It is measured in what is known as reactive volt-amps (VAr).

A capacitive load will introduce negative reactive power and the voltage "lags" the current waveform by 90°. An inductive load will introduce positive reactive power and the voltage "leads" the current waveform by 90°. This is because capacitors "generate" reactive power and inductors "consume" reactive power.

In case of Negative Reactive Power Voltage Lags Current & in case of Positive Reactive Power Voltage Leads Current Why are these values important? The reason is because all practical electrical applications will contain a combination of resistive, capacitive and inductive elements. Therefore, any practical AC circuit or system will have a combination of both true and reactive power which will vary the phase angle between voltage and current. The desired outcome is to maximize true power while limiting reactive power. Taking both into account, the end result of the tug of war battle between true and reactive power is called complex power. It is measured in volt-amps (VA).

The apparent power is a combination of both reactive power and true power. True power is a result of resistive components and reactive power is a result of capacitive and inductive components. Almost all circuitry on the market will contain a combination of these components. Since reactive power takes away from true power, it must be considered in a system to ensure that the apparent power output from a system is sufficient to supply the load. This is a critical aspect of understanding AC power sources because the source must be capable of supplying the necessary volt-amp power for a given application. As with any product, understanding the needs and specifications of the end user will ensure a successful application.

"Active" power is power that does actual work - e.g.: creating heat, lifting loads, etc.

"Reactive power" is power where the current is out of phase with the voltage, and the "Volts x amps" doesn't do any real work. Current that charges a capacitor, for example or current that creates the magnetic field around a coil for another.

"Apparent power" is the mathematical combination of these two. The generating utility cares about the apparent power because whether the current being drawn is producing useful work or not, the utility has to be able to provide that many amps. The better the power factor, the lower the total amp draw.

4.2 Real Power (P):

Alternative words used for Real Power (Actual Power, True Power, Watt-full Power, Useful Power, Real Power, and Active Power)

In a DC Circuit, power supply to the DC load is simply the product of Voltage across the load and Current flowing through it i.e., P = V I. because in DC Circuits, there is no concept of phase angle between current and voltage. In other words, there is no Power factor in DC Circuits.

But the situation is Sinusoidal or AC Circuits is more complex because of phase difference between Current and Voltage. Therefore average value of power (Real Power) is,

$$P = VI \cos\theta$$

is in fact supplied to the load. The unit of Active or Real power is Watt where

$$1W = 1V \times 1 A.$$

In AC circuits, When circuit is pure resistive, then the same formula used for power as used in DC as

$$P = V\ I.$$

Power Formulas in DC, AC Single Phase and AC Three Phase Circuits.

Real Power formulas:

$P = V\ I$ (In DC circuits)

$P = VI\ Cos\theta$ (in Single phase AC Circuits)

$P = \sqrt{3}\ V_L\ I_L\ Cos\theta$ or (in Three Phase AC Circuits)

$P = 3\ V_{Ph}\ I_{Ph}\ Cos\theta$

$P = \sqrt{(S^2 - Q^2)}$ or

$P = \sqrt{(VA^2 - VAR^2)}$ or

Real or True power = $\sqrt{(\text{Apparent Power}^2 - \text{Reactive Power}^2)}$ or

$kW = \sqrt{(kVA^2 - kVAR^2)}$

4.3 Reactive Power (Q):

Also known as (Use-less Power, Watt less Power)

The powers that continuously bounce back and forth between source and load is known as reactive Power (Q)

Power merely absorbed and returned in load due to its reactive properties is referred to as reactive power

Reactive power represent that the energy is first stored and then released in the form of magnetic field or electrostatic field in case of inductor and capacitor respectively.

Reactive power is given by

$$Q = V\ I\ Sin\theta$$

Which can be positive (+ve) for inductive, negative (-Ve) for capacitive load.

The unit of reactive power is Volt-Ampere reactive. I.e. VAR where

$$1\ VAR = 1V \times 1A.$$

In more simple words, in Inductor or Capacitor, how much magnetic or electric field made by 1A x 1V is called the unit of reactive power.

Reactive power formulas:

$$Q = V\ I\ Sin\theta$$

$$\text{Reactive Power} = \sqrt{(\text{Apparent Power}^2 - \text{True power}^2)}$$

$VAR = \sqrt{(VA^2 - P^2)}$

$kVAR = \sqrt{(kVA^2 - kW^2)}$

4.4 Apparent Power (S):

The product of voltage and current if and only if the phase angle differences between current and voltage are ignored.

Total power in an AC circuit, both dissipated and absorbed/returned is referred to as apparent power

The combination of reactive power and true power is called apparent power

In an AC circuit, the product of the r.m.s voltage and the r.m.s current is called apparent power.

It is the product of Voltage and Current without phase angle

The unit of Apparent power (S) VA i.e.

$$1VA = 1V \times 1A.$$

When the circuit is pure resistive, then apparent power is equal to real or true power, but in inductive or capacitive circuit, (when Reactances exist) then apparent power is greater than real or true power.

Apparent power formulas:

$$S = V\ I$$

Apparent Power = $\sqrt{}$ (True power^2 + Reactive Power^2)

$$kVA = \sqrt{}kW^2 + kVAR^2$$

Important:

Resistor absorbs the real power and dissipates in the form of heat and light. Inductor absorbs the reactive power and dissipates in the form of magnetic field Capacitor absorbs the reactive power and dissipates in the form of electric or electrostatic filed

CHAPTER 5

ELECTRICAL LOAD CLASSIFICATION & TYPES

5.1 Electrical Load Definition:

The Electrical Load is the part or component in a circuit that converts electricity into light, heat, or mechanical motion. Examples of loads are a light bulb, resistor, or motor.

Another definition:

If an electric circuit has a well-defined output terminal, the circuit connected to this terminal (or its input impedance) is the load. (fig.1)

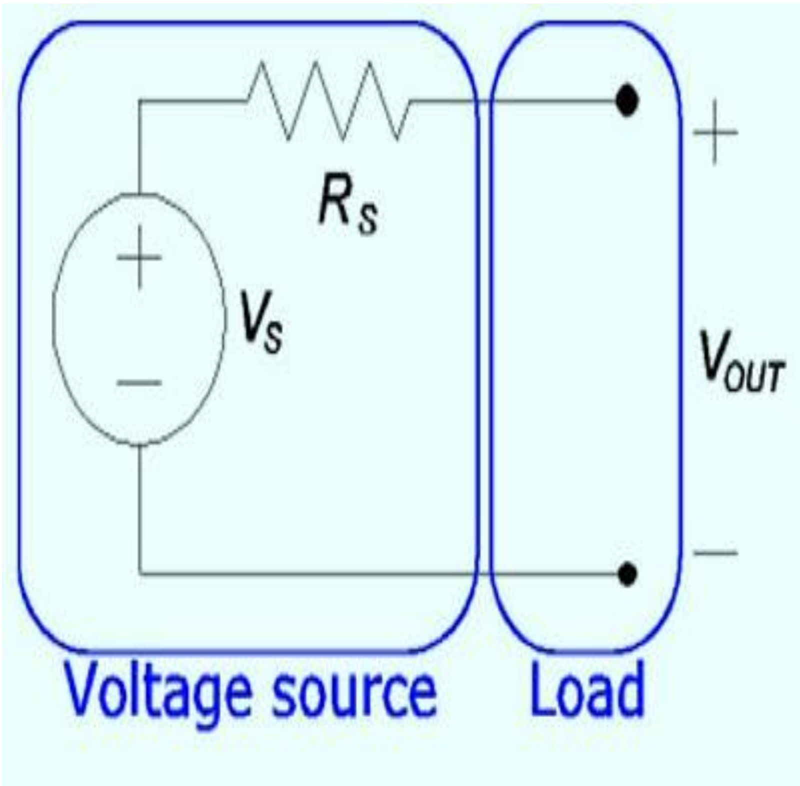

Fig. 5.1 Electrical Load

5.2 Electrical Load Classification and Types:

The electrical loads can be classified into various categories according to various factors as follows:

(1) According To Load Nature

- Resistive Electrical Loads.
- Capacitive Electrical Loads.
- Inductive Electrical Loads.
- Combination Electrical Loads.

Electrical Load Classification According To Load Nature

Resistive Electrical Loads:

The Resistive Electrical Loads naturally resist the flow of electricity through it by converting some of this electrical energy into heat (thermal energy), the result will be a drop in the amount of electrical energy transferred through it.

Examples for Resistive Electrical Loads:

Incandescent light bulbs:

An incandescent light bulb produces light by passing an electric current through a filament in a vacuum. The resistance of the filament causes it to heat up and the electrical energy is converted to light energy.

Electric heaters:

Electric heaters work in the same way, its resistance convert the electrical energy to thermal energy (heat) and they may produce little, if any, light.

Characteristics of Resistive Electrical Loads :(see fig.1)

- Resistance (R) is measured in ohms.
- The electrical current and the voltage in a resistive load are said to be "in phase" with each other. As voltage rises or falls, the current also rises and falls with it.
- As the voltage and current are in phase, the power factor is in unity.
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- Resistive loads not having any significant inrush current. When a resistive load is energized, the current rises instantly to its steady-state value, without first rising to a higher value.

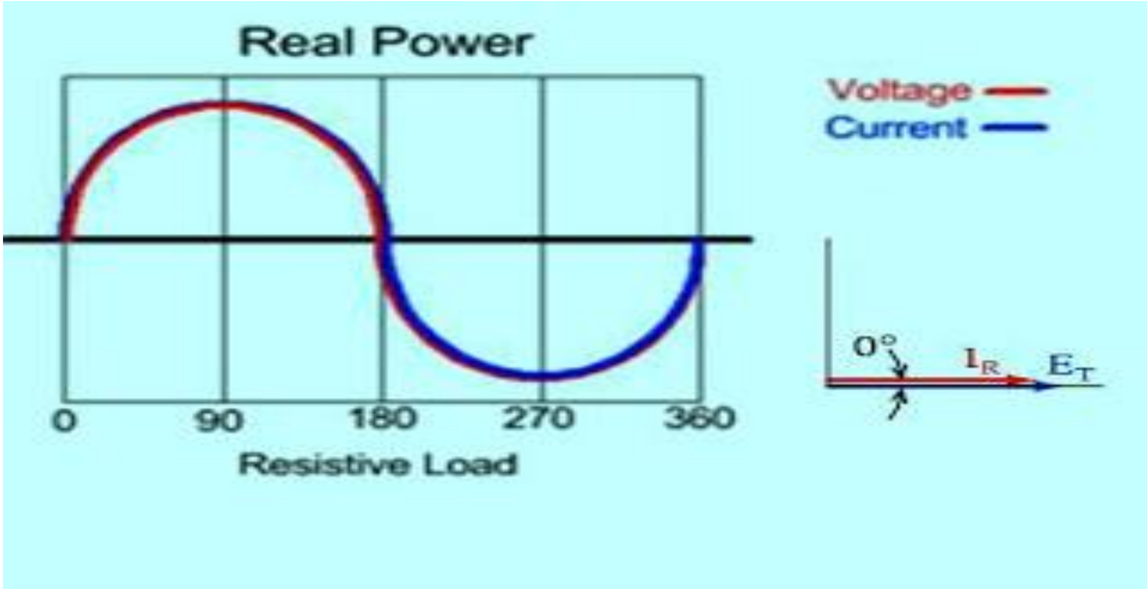


Fig 5.2 : Characteristics of Resistive Electrical Loads

<u>Capacitive Electrical Loads</u>:

A capacitor stores electrical energy. Two conductive surfaces are separated by a non-conductive insulator.

An electrical current is applied to a capacitor, electrons from the current gather on the plate attached to the terminal to which the electric current is applied. When the current is removed, the electrons will to flow back through the circuit to reach the other terminal of the capacitor.

Examples for Capacitive Electrical Loads:

Capacitors are used in electric motors, radio circuits, power supplies and many other circuits.

Characteristics of Capacitive Electrical Loads: (see fig.2)

- The capability of a capacitor to store electrical energy is called capacitance (C). The main unit of measure is the farad, but most capacitors are measured in microfarads.
- The current leads the voltage of a capacitor. The voltage across the terminals starts out at zero volts while the current is at its maximum. As the charge builds on the capacitors plate, the voltage rises and the current falls. As a capacitor discharges, the current rises as the voltage falls.
- The current waveform is leading the voltage waveform; therefore, the voltage peaks and current peaks are not in phase. The amount of phase delay is given by the cosine of the angel (Cos) between the vectors representing voltage and current.

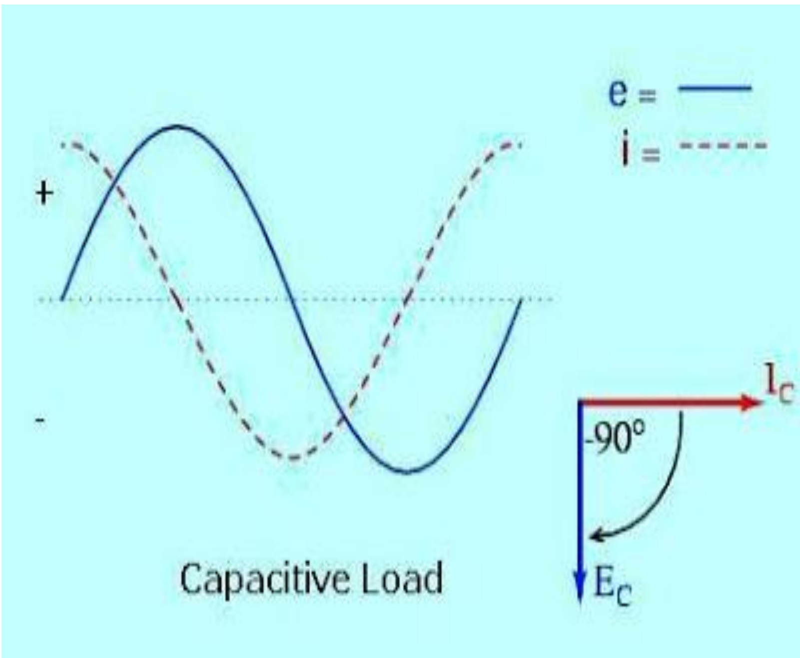


Fig 5.3 : Characteristics of Capacitive Electrical Loads

Inductive Electrical Loads

An inductor may be any conductive material. When a changing current passes through an inductor, it induces a magnetic field around itself. Turning the inductor into a coil increases the magnetic field. A similar principal occurs when a conductor is placed within a changing magnetic field. The magnetic field induces an electrical current within the conductor.

Examples for Inductive Electrical Loads:

Examples of inductive loads include transformers, electric motors and coils. Two sets of magnetic fields in an electric motor oppose each other, forcing the motor's shaft to spin. Transformer has two inductors, a primary and a secondary. The magnetic field in the primary winding induces an electric current in the secondary winding. A coil stores energy in the magnetic field it induces when a changing current passes through it and releases the energy when the current is removed.

Characteristics of Inductive Electrical Loads: (see fig.3)

- Inductance (L) is measured in henries.
- The changing voltage and current in an inductor are out of phase. As current rises to a maximum, the voltage falls.
- The current waveform is lagging behind the voltage waveform, therefore, the voltage peaks and current peaks are not in phase. The amount of phase delay is given by the cosine of the angel (Cos) between the vectors representing voltage and current.
- Inductive load pulls a large amount of current (an inrush current) when first energized. After a few cycles or seconds the current "settles down" to the full-load running current.

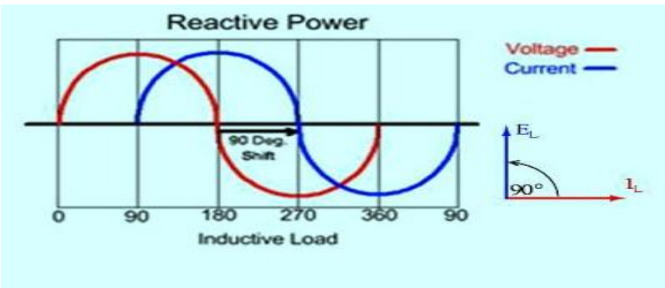


Fig 5.4. Characteristics of Inductive Electrical Loads

5.3 Combination Electrical Loads:

Examples for Combination Electrical Loads:

a- Cable and Conductors

All conductors have some resistance under normal conditions and also exhibit inductive and capacitive influences, but these small influences are generally dismissed for practical purposes.

b- Radio Tuning Circuit

The tuning circuit of a radio uses variable inductors or capacitors in combination with a resistor to filter out a range of frequencies while allowing just one narrow band to pass through to the rest of the circuit.

c- Cathode Ray Tube

A cathode ray tube in a monitor or television makes use of inductors, resistors and the inherent capacitance of the tube to control and display a picture on the phosphor coatings of the tube.

d- Motors

Single phase motors often use capacitors to aid the motor during starting and running. The start capacitor provides an additional phase of voltage to the motor since it shifts the current and voltage out of phase with each other.

Characteristics of Combination Electrical Loads: (see fig.4)

The phase angle, φ, may be positive or negative depending on whether the overall voltage (the sum of the voltage phasors) leads or lags the current in the circuit (which is the same everywhere).

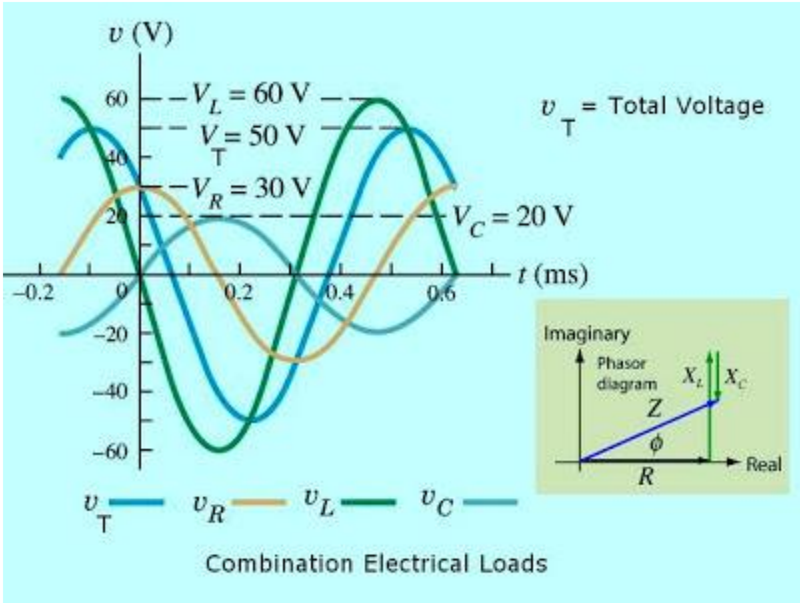


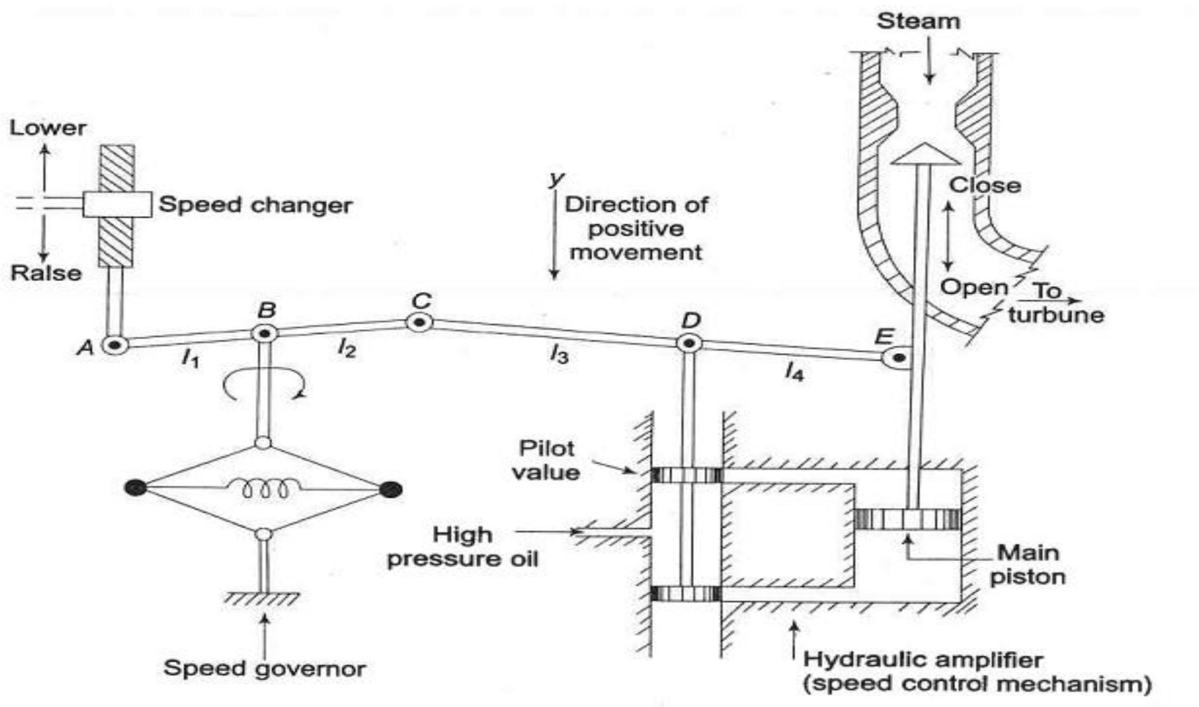
Fig 5.5 : Characteristics of Combination Electrical Loads

Chapter 6

THERMAL POWER PLANT

6.1 Real power control mechanism of a generator

TURBINE SPEED GOVERNING SYSTEM



The main parts are:

- Fly ball speed governor
- Hydraulic amplifier
- Linkage mechanism
- Speed changer

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- **Fly ball speed governor**: This is the heart of the system which senses the change in speed (frequency). As the speed increases the fly balls move outwards and the point B on linkage mechanism moves downwards. The reverse happens when the speed decreases.

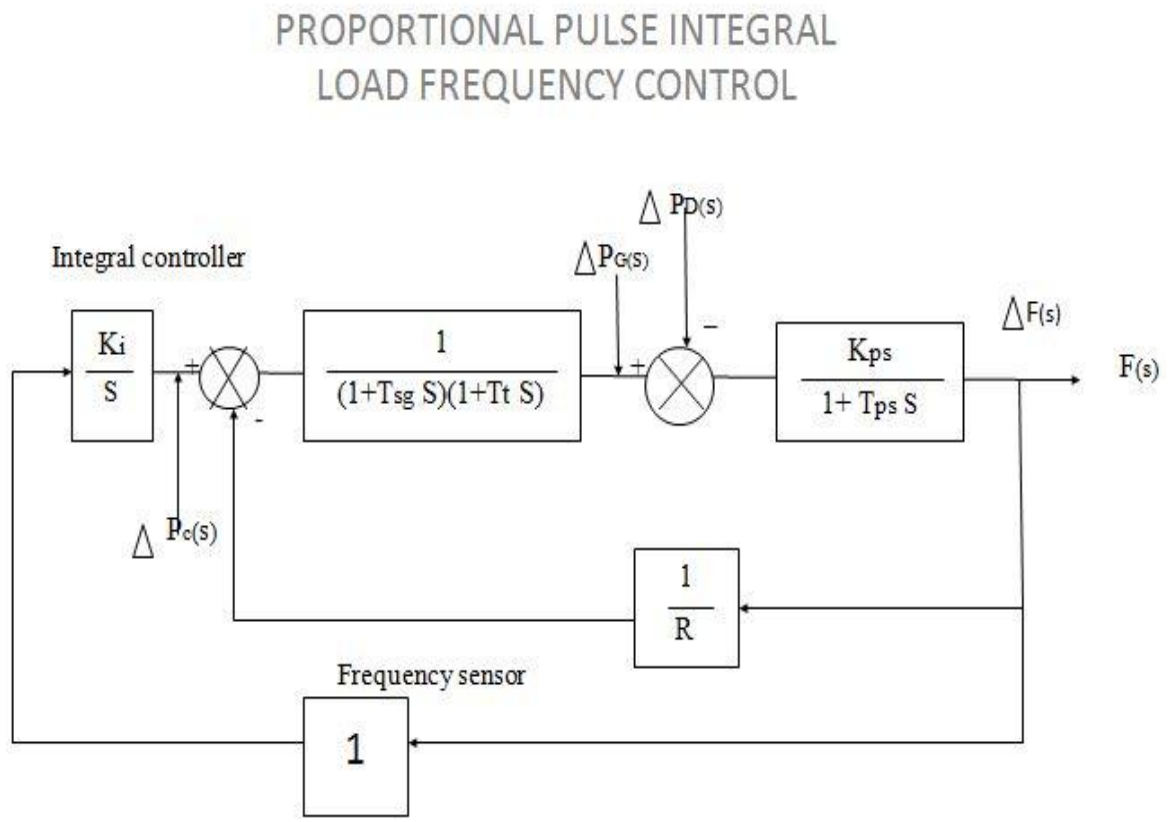
- **Hydraulic amplifier:** It comprises a pilot valve and main piston arrangement. Low power level pilot valve movement is converted into high power level piston valve movement. This is necessary in order to open or close the steam valve against high pressure steam.
- **Linkage mechanism:** ABC is a rigid link pivoted at B and CDE is another rigid link pivoted at D. This link mechanism provides a movement to the control valve in proportion to change in speed. It also provides a feedback from the steam valve movement.

- **Speed changer**: It provides steady state power output setting for the turbine. Its downward movement opens the upper pilot valve so that more steam is admitted to the turbine under steady conditions the reverse happens for upward movement of speed changer.

When the load is increases the speed changer will move down i.e. point B linkage mechanism move downwards and also the fly ball speed governor will move outward, therefore upper valve of pilot valve opens and high pressure oil goes into the hydraulic amplifier. Due to this high pressure oil, the main piston valve moves downwards and steam valve opens and more steam is fed into turbine so that required load can be met.

Similarly, when the load is decreases the speed changer will move upward i.e. point B linkage mechanism move upwards and also the fly ball speed governor will move inward, therefore upper valve of pilot valve open depending upon the load requirement and high pressure oil goes into the hydraulic amplifier. Due to this high pressure oil, the main piston valve moves depending upon the load and steam valve opens and steam is fed into turbine so that required load can be met.

6.2 Automatic load frequency control loop of synchronous generator



It is expected that the steady change in frequency will be zero. While steady state frequency can be brought back to the scheduled value by adjusting speed changer setting, the system could undergo intolerable dynamic frequency changes with changes in load. It leads to the natural suggestion that the speed changer setting be adjusted automatically by monitoring the frequency changes. For this purpose, a signal from Δf is fed through an integrator to the speed changer. The system now modifies to a proportional plus integral controller, which, as is well known from control theory, gives zero steady state error, i.e. $\Delta f = 0$

The signal $\Delta Pc(s)$ generated by the integral control must be of opposite sign to $\Delta F(s)$ which accounts for negative sign in the block for integral controller. Now

We find that the steady state change in frequency has been reduced to zero by the addition of the integral controller. This can be argued out physically as well. Δf reaches steady state only when $\Delta = \Delta$ = constant. Because of the integrating action of the controller, this is only possible if $\Delta f = 0$.

6.3 Two area load frequency control

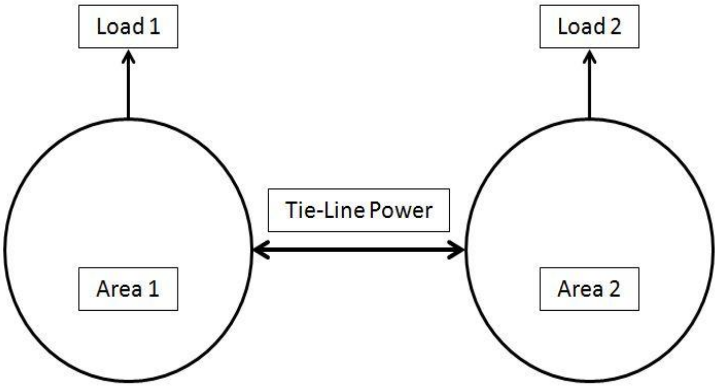


Fig above shows two areas connected by a single tie line. The control objective is to regulate the frequency of each area and simultaneously regulate the tie line power. As in case of frequency, proportional plus integral controller will be used to achieve zero steady state error in tie line power flow as compared to contracted power. The symbol used with suffix 1 represent control area 1 & suffix 2 represent control area 2.

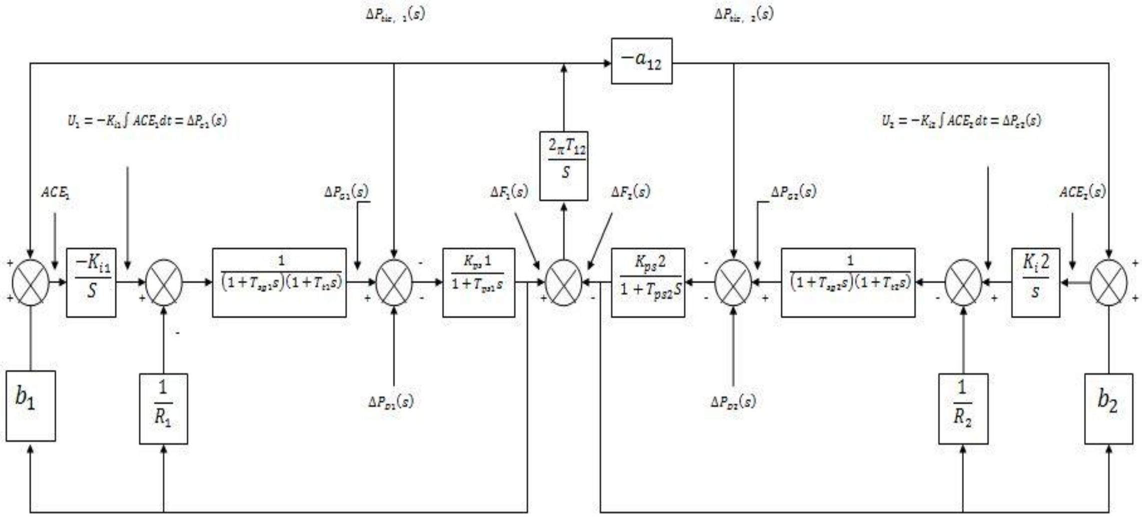


Fig.- Composite block diagram of two-area load frequency control.

REACTIVE POWER CONTROL OF SYCHRONOUS GENERATOR

Automatic voltage regulator

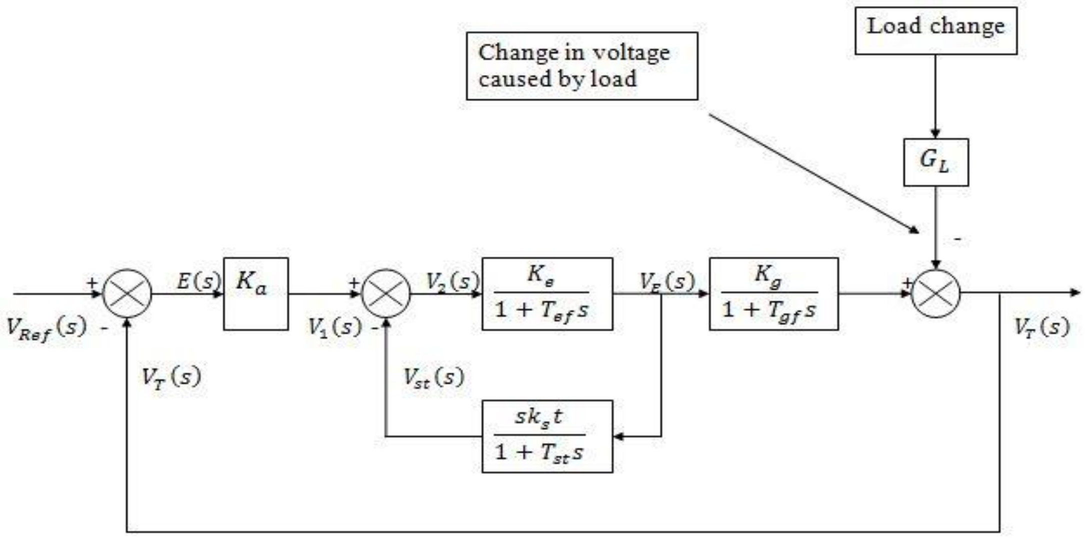


Fig- Block diagram of alternator voltage regulator scheme

The main parts:

- Potential transformer
- Differencing device
- Error amplifier
- SCR power amplifier and exciter field
- Alternator
- Stabilizing transformer

It mainly consist of main exciter which excite alternator field to control the output voltage. The exciter field is automatically controlled through error suitably amplified through voltage and power amplifier

Potential transformer – it gives a sample of terminal voltage

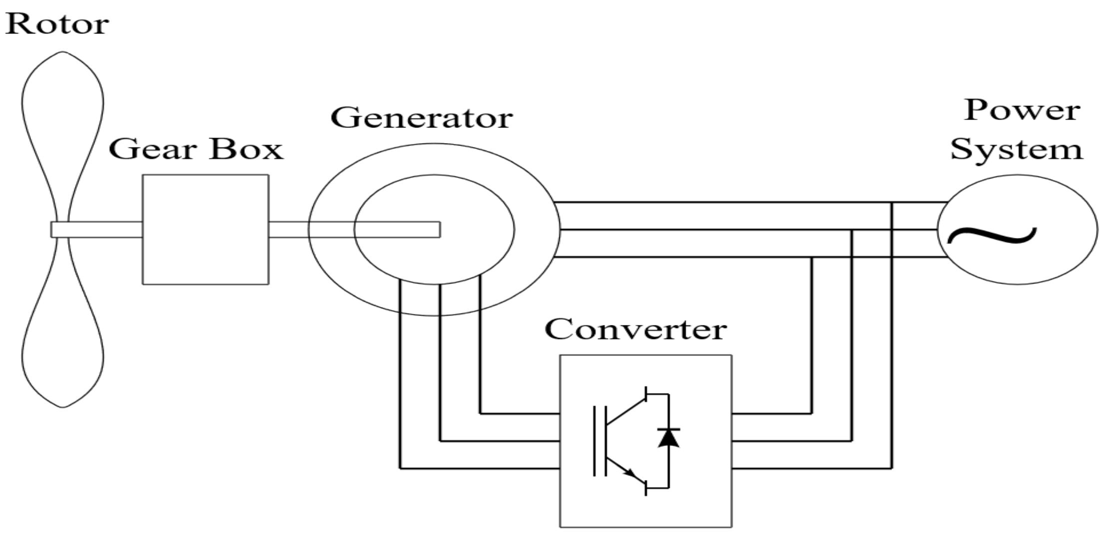
Differencing device – it gives actuating error.

CHAPTER 7

WIND POWER PLANT

7.1 Doubly fed induction generator

DOUBLEY FED INDUCTION GENERATOR OPERATION



A three phase wound rotor induction machine can be set up as doubly fed induction motor. A three phase wound rotor induction machine can be set up as doubly fed induction motor. In a conventional three-phase synchronous generator the rotor is driven by prime mover and dc current fed into rotor winding. As a result continually changing magnetic flux passes through the stator windings as rotor magnetic field rotates, inducing voltage across stator winding.

Same principle operating principle apply in doubly fed induction generator as in conventional induction generator. The only difference is that the field produced by rotor is not static as it is fed by three phase supply. Therefore in this both stator and rotor are fed by three phase ac supply.

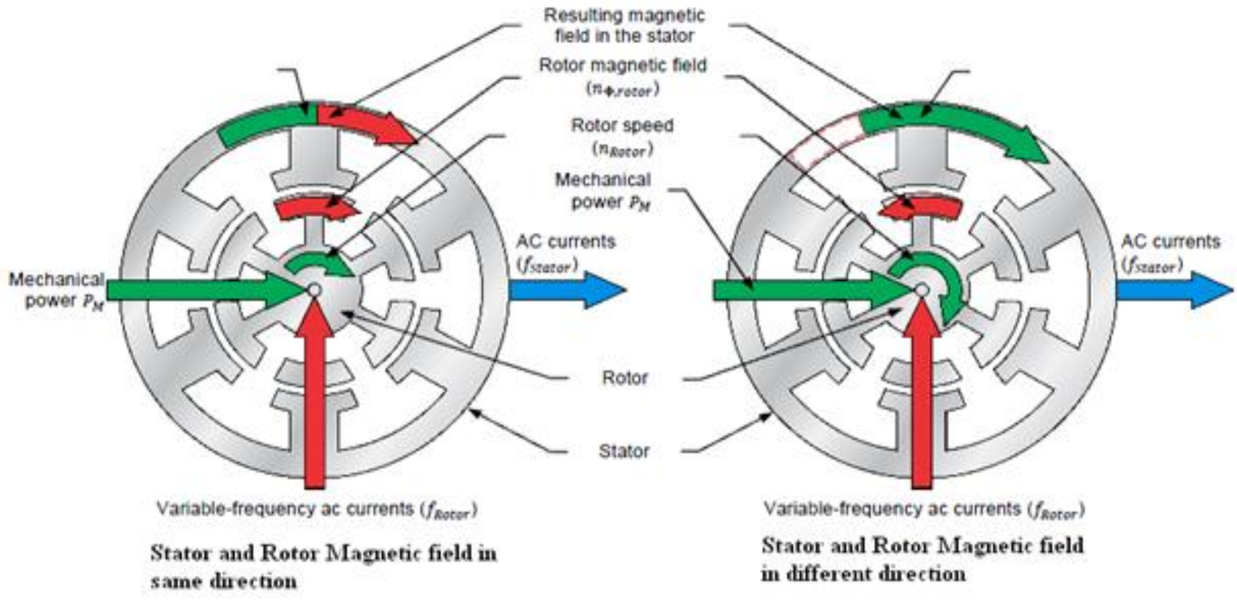


FIG. DOUBLY CONCEPTUAL DIAGRAM FED INDUCTION GENERATOR

Taking into account the principle of operation of doubly-fed induction generator, it can thus determine that, when magnetic field of at rotor rotates in same direction as the generator rotor, the rotor speed and the speed of the rotating magnetic field adds up. The frequency of voltage induced across stator windings of the generator can be calculated as

Conversely when magnetic field of at rotor rotates in opposite direction as the generator rotor, the rotor speedand the speed of the rotating magnetic field subtract from each other. The frequency of voltage induced across stator windings of the generator can be calculated as

$$F_{stator} = \frac{n_{rotor} * \ n_{poles}}{120} + f_{stator}$$

Conversely when magnetic field of at rotor rotates in opposite direction as the generator rotor, the rotor speed$N_{rotor}$and the speed $n\emptyset_{rotor}$ of the rotating magnetic field subtract from each other. The frequency of voltage induced across stator windings of the generator can be calculated as

$$F_{stator} = \frac{n_{rotor} * \ n_{poles}}{120} - f_{stator}$$

Smart Grid Component

Some typical components of a smart grid include:

- Intelligent appliances capable of deciding when to consume power based on pre-set customer preferences. This can go a long way toward reducing peak loads which has a major impact on electricity generation costs - alleviating the need for new power plants and cutting down on damaging greenhouse emissions. Early tests with smart grids have shown that consumers can save up to 25% on their energy usage by simply providing them with information on that usage and the tools to manage it.
- Smart power meters featuring two-way communications between consumers and power providers to automate billing data collection, detect outages and dispatch repair crews to the correct location faster.
- Smart substations that include monitoring and control of critical and non-critical operational data such as power factor performance, breaker, transformer and battery status, security, etc.
- Smart distribution that is self-healing, self-balancing and self-optimizing including superconducting cables for long distance transmission, and automated monitoring and analysis tools capable of detecting or even predicting cable and failures based on real-time data about weather, outage history, etc.
- Smart generation capable of "learning" the unique behaviour of power generation resources to optimize energy production, and to automatically maintain voltage, frequency and power factor standards based on feedback from multiple points in the grid. Universal access to affordable, low-carbon electrical power generation (e.g., wind turbines, concentrating solar power systems, photovoltaic panels) and storage (e.g., in batteries, flywheels or super-capacitors or in plug-in hybrid electric vehicles).

CHAPTER 8

MEASUREMENT TECHNOLOGIES

8.1 Phasor measurement unit

A **Phasor Measurement Unit (PMU)** is a device which measures the electrical waves on an electricity grid using a common time source for synchronization. Time synchronization allows synchronized real-time measurements of multiple remote measurement points on the grid. The resulting measurement is known as a synchro phasor. PMUs are considered to be one of the most important measuring devices in the future of power systems. A PMU can be a dedicated device, or the PMU function can be incorporated into a protective relay or other device.

8.2 Advanced metering infrastructure

Advanced Metering Infrastructure (AMI) is an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers. These meters wirelessly transmit electronic meter readings to your utility, virtually eliminating the need for on-site meter reading. The meters will also provide a host of other benefits.

Two-way communication between consumers and utilities comes with many advantages. The utility can monitor systems to ensure proper operation, functionality, and efficiency.

Consumer benefits include:

Customer Web Portal View daily and hourly electricity consumption of your household with an online web portal. Improved Bill Accuracy Near elimination of estimated bills and incorrect meter reads. Outage Detection Notification to the utility of an outage and assistance with pinpointing the exact location of the problem, allowing for quicker restoration of electric service.

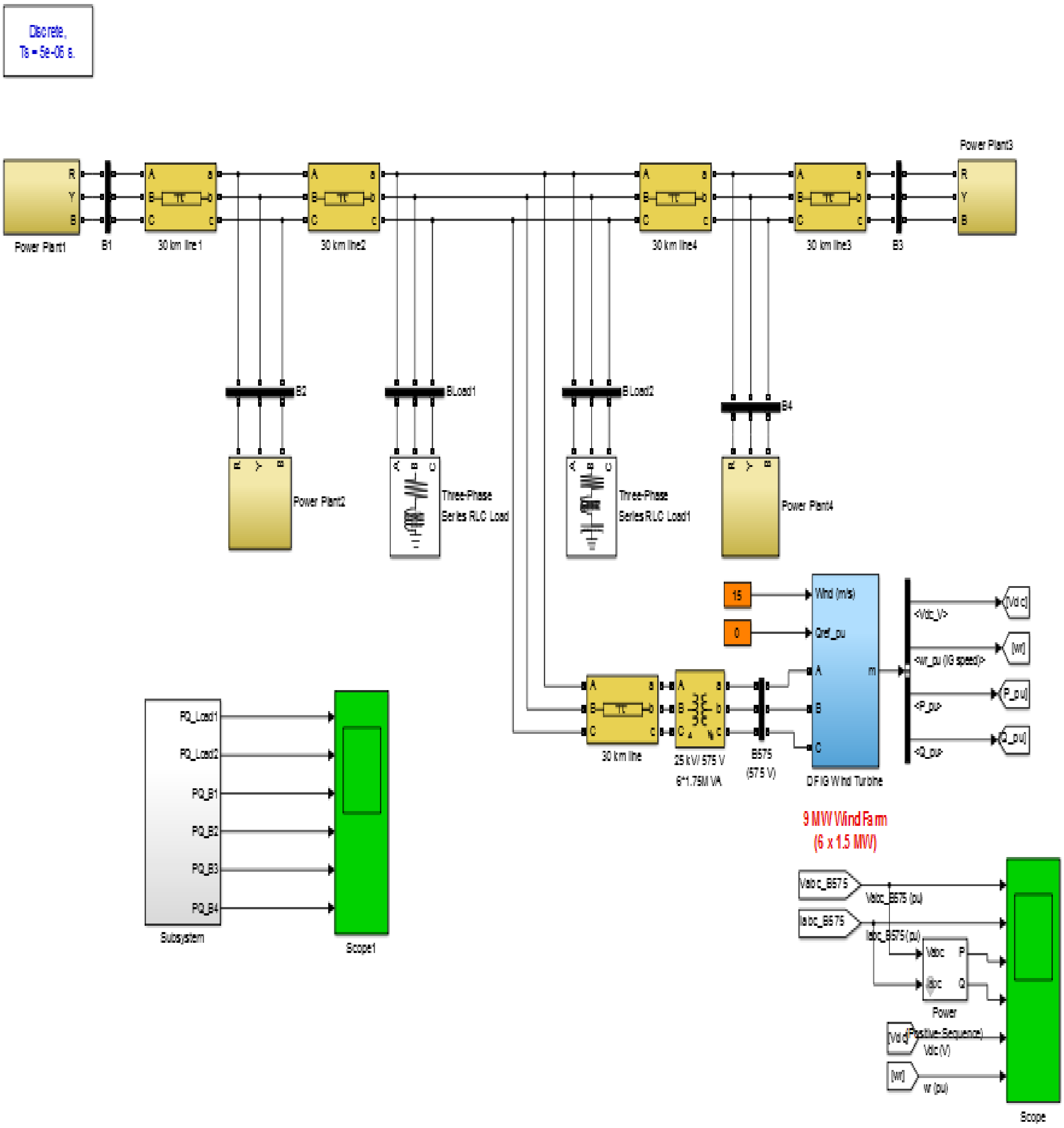
Grid Reliability Increased ability to monitor grid conditions making it possible to anticipate and mitigate potential power integrity issues, resulting in fewer outages and power quality events.

8.3 Wide area measuring system

Wide Area Monitoring System use a GPS satellite signal to time-synchronize from phasor measurement units (PMUs) at important nodes in the power system, send real-time phasor (angle and magnitude) data to a Control Centre .The acquired phasor data provides dynamic information on power systems, which helps operators to initiate corrective actions to enhance the power system reliability.

CHAPTER 9

SIMULATION MODEL

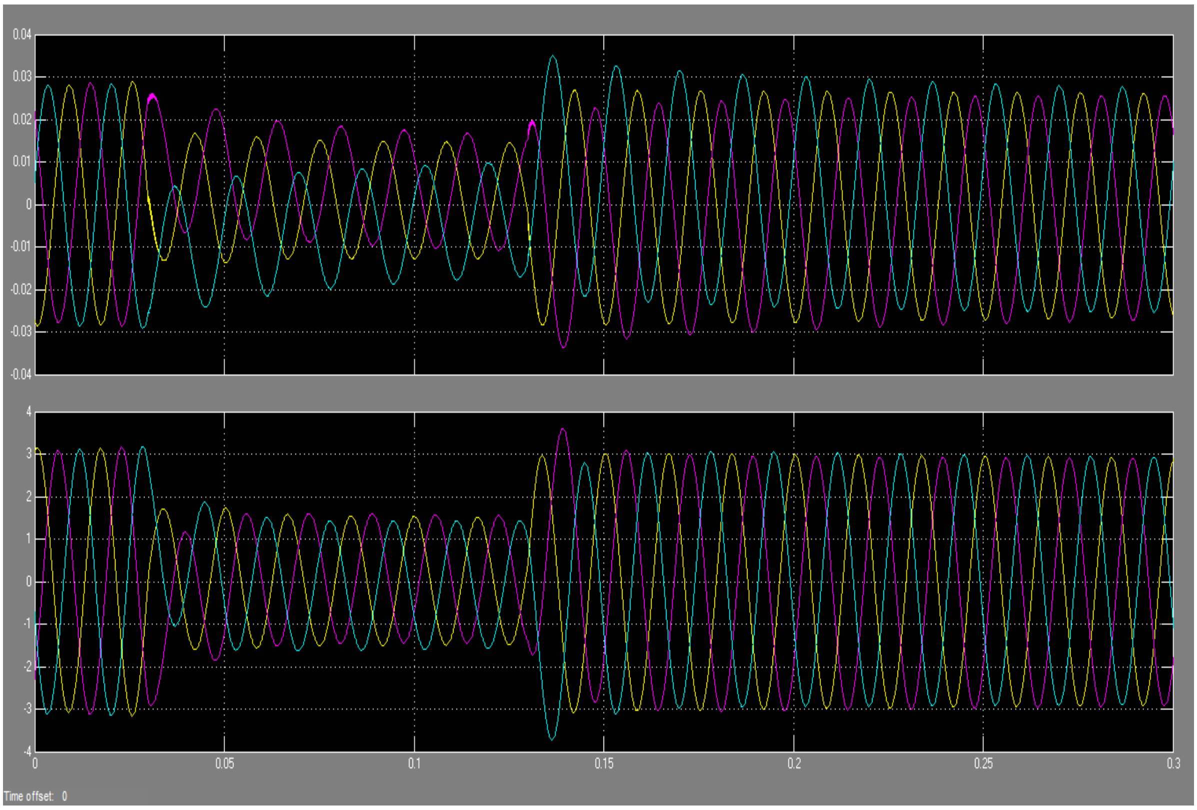


RESULT/GRAPH

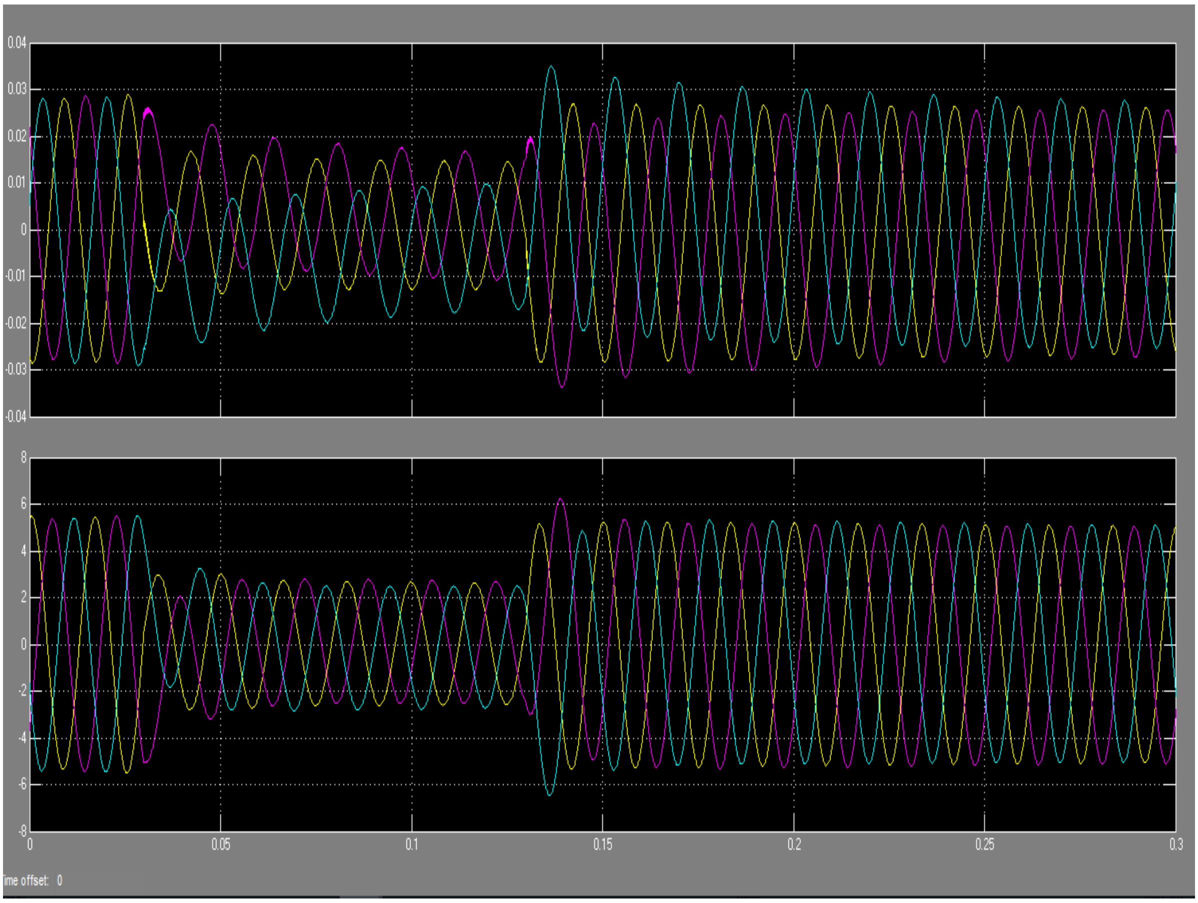
CASE 1

Load at bus 3			
Active	Inductive	Active	Capacitive
1900 MW	100MVAR	1900MW	120MVA
Load at bus 5			
Active	Inductive	Active	Capacitive
1900MW	110MVAR	1900MW	150MVAR

GRAPH AT LOAD BUS 3



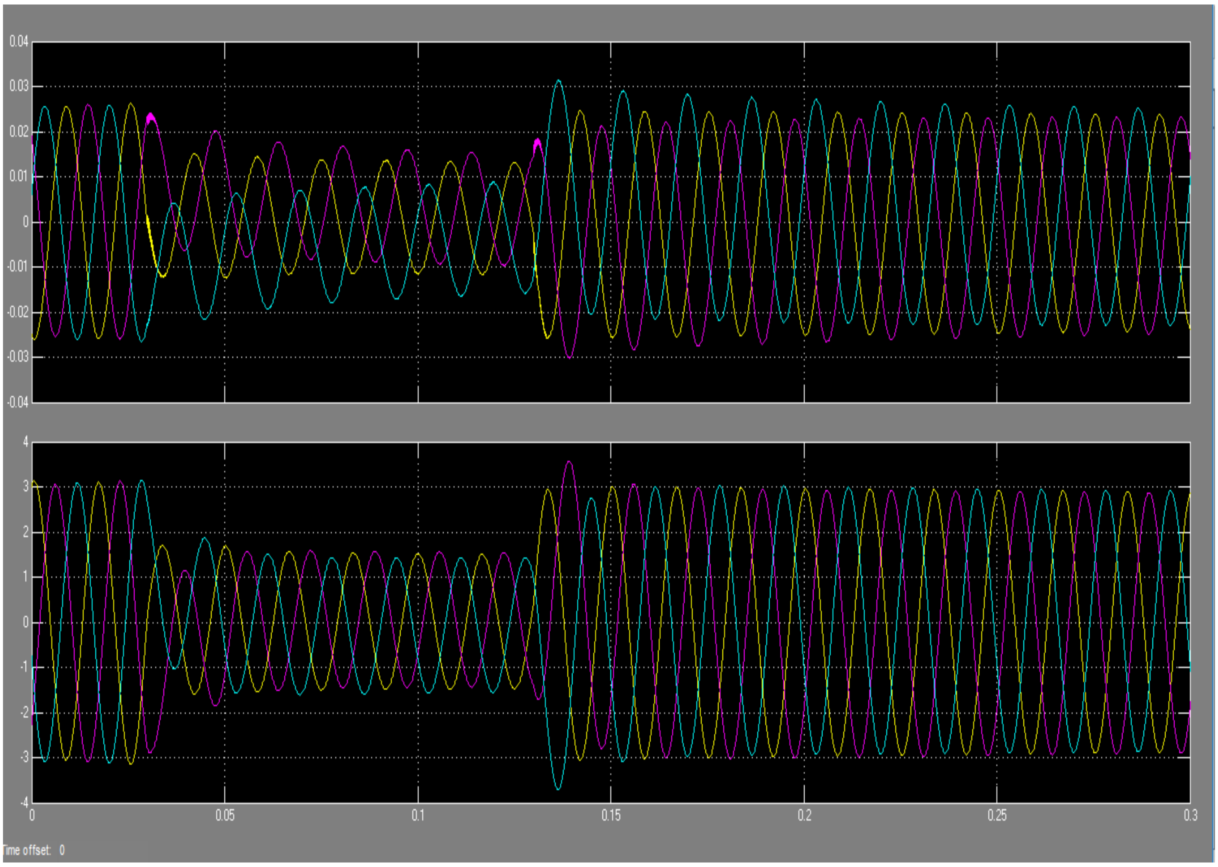
GRAPH AT LOAD BUS 5



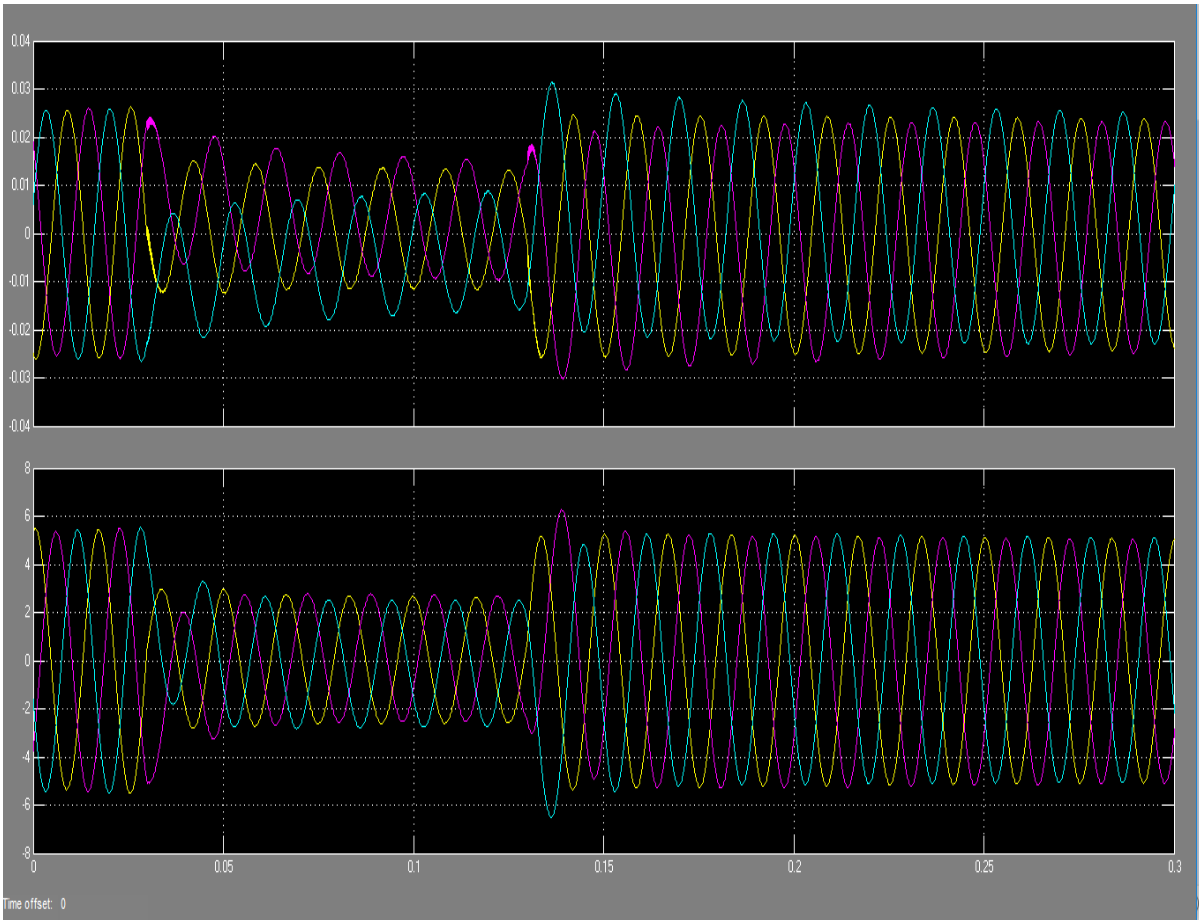
CASE 2

Load at bus 3			
Active	Inductive	Active	Capacitive
1800MW	100MVAR	1900MW	120MVAR
Load at bus 5			
Active	Inductive	Active	Capacitive
1900MW	110MVAR	1900MW	150MVAR

GRAPH AT LOAD BUS 3



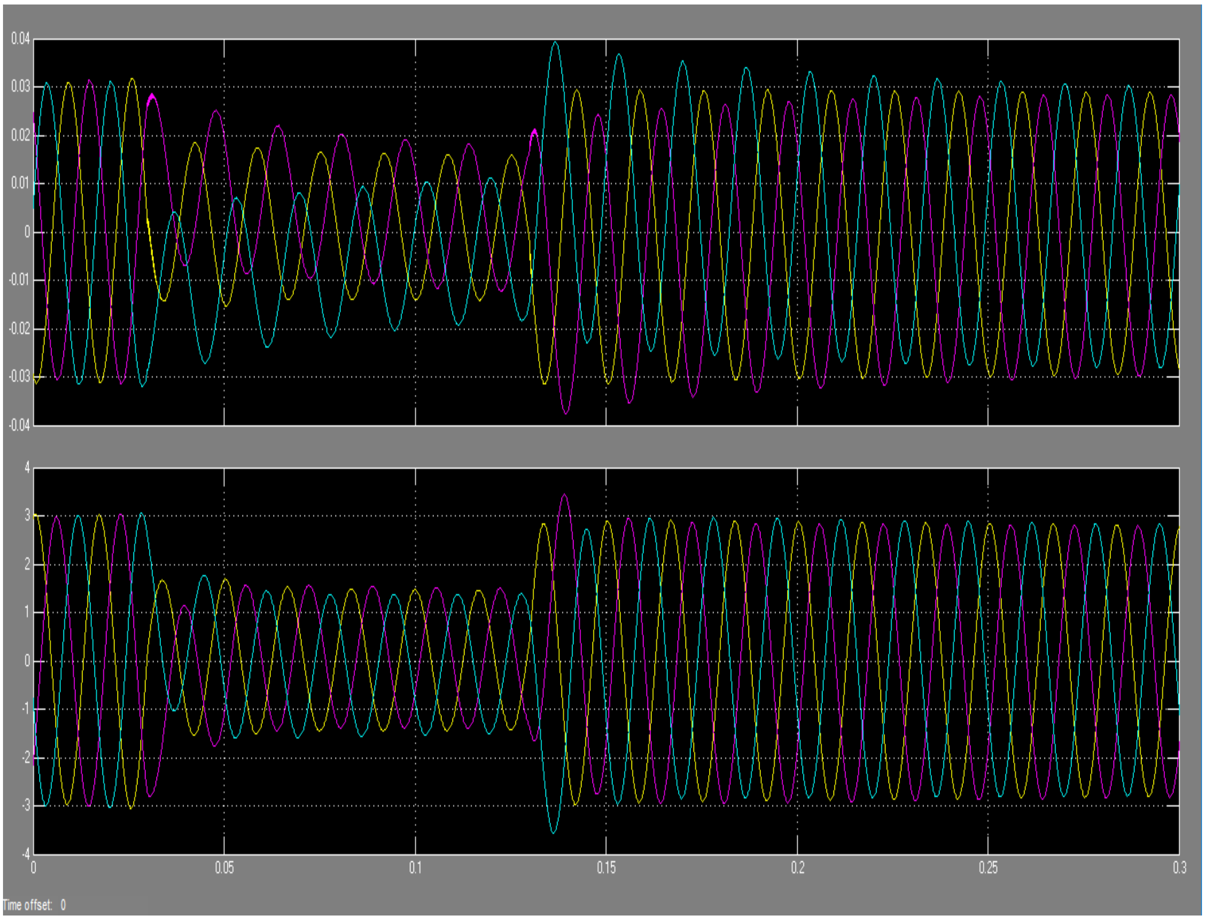
GRAPH AT LOAD BUS 5



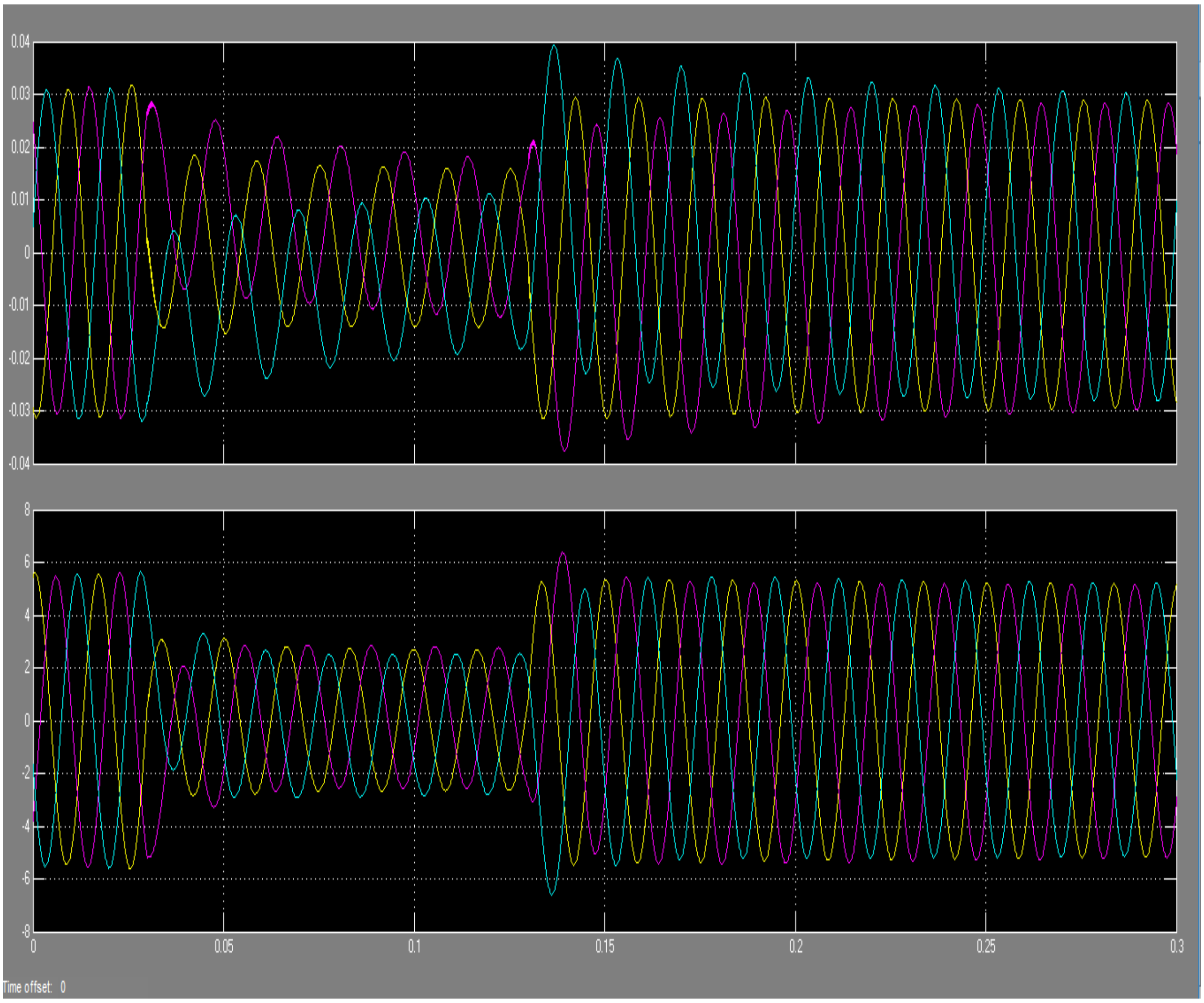
CASE 3

Load at bus 3			
Active	Inductive	Active	Capacitive
1200MW	100MVAR	1600MW	120MVAR
Load at bus 5			
Active	Inductive	Active	Capacitive
1500MW	110MVAR	1400MW	150MVAR

GRAPH AT LOAD BUS 3



GRAPH AT LOAD BUS 5



ADVANTAGES

- It gives the exact idea to know the range of maximum permissible loads that can be connected to their relevant bus bars.
- Better the balance between generation and consumption.
- Problems such as harmonics, unbalancing, excessive neutral current can be solved.
- To control of converters connected to electric network for improve voltage regulation, and increasing transient stability margin
- To show the stability of any power system network.
- This paper is about to synchronize these two power plant namely thermal and wind power plant because both sharing maximum percentage of electricity generation in their respective field.'

CONCLUSION

In this paper, load analysis has been done on this smart grid to check the stability in terms of active power flow. Active power values at all buses has been changed with respect to changes in active and inductive load values at bus bar B3 and B6 keeping capacitive load constant. Frequency has been also measured and keeping values of both active power and frequency, magnitude of inductive and active load has been deduced while maintaining synchronism of the proposed smart grid model.

FUTURE SCOPE

We shall try to implement this smart grid model in future.

Present grid have much losses by implementing this smart grid we can reduce the losses also the loss of power can be adjusted from it.

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