DISTRIBUSTED GENERATION WITH MICROGRID BY USING S.V.C

DISSERTATION

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By

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CANDIDATE'S DECLARATION

I Satish Kumar, student of M.Tech (Electrical Engineering) under school of Electronics and Electrical Engineering of Lovely Professional University, Punjab, hereby declare that all the information furnished in this dissertation report is an authentic record of my own work carried out under the supervision of Mr. Niraj Kishore, Assistant Professor, School of Electronics and Electrical Engineering. The matter presented in this dissertation has not been submitted to Lovely Professional University or to any other university or institute for award of any degree.

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This is to certify that the above statement made by the candidate is correct to the best of my knoweldge.

Signature of the Supervisor

The M.tech Viva-Voce Examination of (Dissertation-II) has been held on _____ and found satisfactory/Not satisfactory.

Signature of the Internal Examiner Signature of the External

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I would like to thank **LOVELY PROFESSIONAL UNIVERSITY** for giving me opportunity to use their resources and work in such a challenging environment. I am grateful to all individual whom contributed there valuable time towards my thesis.

I wish to express my sincere and heart full thanks to my guide "**Mr. Niraj Kishore** " Assistant professor, who guides me to take up this thesis in sync with global trends in scientific approach. I would also extend my gratitude to my family who always encourage me in this thesis work.

And I would like to thanks all the staff member of department of Electronics and Electrical Engineering who have been very co-operative with us.

Satish Kumar

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CERTIFICATE

This is to certify that **Satish Kumar** bearing registration number **11503045** has completed objective formulation of Thesis title **"DISTRIBUTED GENERATION WITH MICRO GRID BY USING SVC (STATIC VAR COMPENSATOR)"** under my guidance and supervision to the best of my knowledge, the present work is the result his original investigation and study. No part of thesis has ever been submitted for any other degree at any university.

The thesis is fit for submission and the partial fulfillment of the conditions for the award of **MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING).**

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CANDIDATE DECLARATION

I, **Satish Kumar** student of **MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING) in POWER SYSTEM** under department of **ELECTRICAL ENGINEERING of LOVELY PROFESSIONAL UNIVERSITY**, Punjab hereby declare that all the information of this dissertation II report based on my own intensive knowledge and research. The matter present in this seminar has not been submitted to Lovely Professional University or to any other university.

This dissertation II does, to the best of my knowledge, contain part of my work which has been submitted to the award of my degree either of this university.

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ABSTRACT

Modern electric power system around the world is enhancing day by day, so the problems are occurring in large amount. The main problems like voltage instability, poor electric power factor, poor power quality due to disturbances, even black or brown out problems from main grid. When such problems occur, consumer face difficulties in their life because without electricity or poor electrical output it is difficult to survive. In this thesis work, introduce a distributed generation system with grid i.e micro-grid.by using SVC technique. Distributed generation system are more economical and renewable. SVC can absorb and deliver real reactive power to line that can stabilize voltage profile in system, with the help of this we can install grid near to end user and can supply power to local area. Which can fulfill demand of consumer without any interruption, in this research use of wind generation as a DG, which is efficient to generate electricity 24 hour's that is day and night. Its most impressive benefit is that it is eco-friendly with environment and cheap. In thesis work, the interconnection of automatic controlling device that is SVC (Static var compensator) is done. On MATLAB/SIMULINK software the analysis of different wave form at normal condition and during fault, without SVC and with SVC is done.

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LIST OF ABBREVIATIONS

DG	-	Distributed generation
MG	-	Micro-grid
P.F	-	Power Factor
HEWT	-	Horizontal Axis Wind Turbine
VEWT	-	Vertical Axis Wind Turbine
TCR	-	Thyristor Controller Reactor
TSC	-	Thyristor Switched Capacitor
SVC	-	Static VAR Compensator

CHAPTER 1
INTRODUCTION

1.1 Basic overview

In the current scenario of hike in energy prices, here deal with fossil fuel evisceration, increased awareness of DG, according to the Government's Energy Review Report that draw special attention to the challenges world is facing in climate change and invigorate security of energy fulfillment and supplies. main part of this how answering to this challenge which is to investigate to what extent DG could supplement for longer potentially resolution an alternative to centralized system.

The main aim of this study, will thus be to understand that why not we should construct an electrical energy generation system that was so cheaply extinguished, in a past and to recognize drivers of similar a trendz reversal i.e. the major advantages of DG that are at commencement of a exemplification change. Very first objective of the dissertation study is to characterize the present state of electrical power market, where we see centralized power generation is dominant and DG computed for those comparative small share of the total power generation on average.

Drawbacks against elaboration of present global electrical power system utility, hence we already know as time increases demand of electricity increases. From the recent years power system engineers and expert scientists has been researched that how this power system instability, power system poor power factor and interruption due to faults that may be internal and external faults can be remove automatically with the help of controlled device, Which can compensate the fault by firing capacitance and inductance at various faults.so that static var compansator is one of best device which can compensate the faults and detect it leading and lagging condition of p.f, because fault causes fluctuation in p.f.

Another drawback is when sudden increase and decrease in load it causes shorting of active and reactive power of electrical system network. That also cause the effect of leading and lagging p.f. so that kind of problem can be removed from the svc(static var campansator), but connection with the DG and its small grid can make the system more reliable. Thus absorb and prove in this report that how svc is more efficient and reliable with power system network. And also how this integration can provide the sufficient supply without interruption, such type of system is more cheaper than centralized grids, so this kind of integration that is DG with micro grid by using svc can install in universities/colleges/schools, laboratories, factories(where continuous production is going on), other shopping malls ,apartments building and also can install as charging station for electrical vehicles.

Smalls Grids are connected near to the consumer end. And provide electrical energy to the consumers, this can be use transmit electrical power to domestic ,industrial purpose ,and also use when failure of main grid due to heavy fault or black out, it can acts as emergency power. but day by day consumption of electrical power shows that there is necessary to have DG with micro grid near to load end . it spreading very good impact on business point of view[1].

As we explain earlier, with this increasing ample use of electrical energy, many technical problems are occurred in the power system. Unpredictability , poor quality, poor electrical p.f, comes when number of non linear loads are in use , most of the load in nowadays are

non-linear loads .so that effect electrical power as well as power factor. To over come such a problem, a flexible A.C transmission devices are comes in contact, such devices STATCOM, DSTATCOM, SVC, UPFC etc[2]. with the help of those devices we can improve all the problems upto desired level. In this dissertation work I introduce a use of Static VAR Compensator (svc).with this facts device I can improve the system stability and poor power quality as well as prevent poor electrical power factor.
Here in this dissertation work, I study the use of wind distribution generation and use of FACTs device with the power system network. Its use with power system is very economical.its automatic function seems to quit impressive with Wind as DG. SVC can not only provide full control over different situations of grid and can bind continuous supply to consumer.

1.2 Objective of thesis

The study of this thesis is discussed the modeling and design of DG with micro grid By using SVC(static var compensator), with this modeling the uninterruptedness of flow of supply to load end. In which the modeling is done with the help of MATLAB software and there factors related to power quality are discussed and analyzed by changing various parameters of components of SVC like changing components of SVC like TCR, TSC and its grid transformer reactance and impedance values by analyzing various parameters of FACTS device with line THD values at 60Hz and 50Hz fundamental frequency. All the analysis has been done though FFT analysis at discrete function. And find the profitable parameter for SVC which is DG connected, also find at what frequency has less harmonics THD value. In this process we can find economical side of transmission and distribution. Economical for both side, reliable and stable [3]. Function, of SVC facts device is to inject reactive power and real power to power distribution system. when need of these power. So capacitor bank and reactor bank is connected in shunt with line. Device having good control to eliminate and detection of fault.its use with DG connected is more economical and less use convention sources to minimize the consumption and create less pollution in the environment.

The world is demanding more energy, as population increases, the control of transfer and distribute power to the load is more difficult. Which cause the instability and unreliability in power system source. So use of SVC with its controller it can help to manage the power loss which generally comes from internal and external faults. And can control the power transferring and absorbing techniques.

1.3 Organization of thesis

In chapter 1, shows the culmination of basics overview of dissertation work and its objective work.

In chapter 2, highlights the literature survey of different research papers of authors with their used techniques.

In chapter 3, shows the theoretical and constructional work of thesis which explain the working , characteristics of SVC. In this work I have also describe the different types of DG with micro grid operation.

In chapter 4, explain the methodology of research which having experimental set-up ,contol and improve power quality.

In chapter 5, highlights the simulation output results of SVC with a.c source.

In chapter 6, explain the conclusion of thesis work and its future scope.

CHAPTER 2

LITERATURE SURVEY

1.Ali abdul wahhab abdulrzzaq, mircea eremia, (2014)

In this paper author perform static and dynamic simulations, with the help of EUROSTAG software, and analyzing of voltage control and reactive power control under various conditions of electrical power system. as we familiar that various abnormal conditions occurs in power system transmission so that can lose control of every system and goes under losses, so svc help indirectly and provide control to system.[4]

2. k.sujitarchary,sabyaschi behra and p.raja, (2016)

In this paper, shows analytical and simulation results by examining the impact on the mho relay in transmission line with svc. The simulation has done in PSCAD software to recognize response of mho relay at various conditions and abnormal situations. here in this paper author trying to pleased and address of svc nature with transmission system.[5]

3.Omer mohammed benaissa, samir hadjeri, sid ahmed zidi, (2016),

Here author, integrate the PSS (power system stabilizer) with SVC(static var compensator) to reduce transient stability.PSS is used to damp electromechanical oscillation which is occur in power system. with the increase number of oscillation in system cause disturbance and hence instability occurs in system, and svc also reduce lagging power p.f by injecting reactive power. So, in this paper integration of pss with svc modeling and design has done in matlab simulation.[6]

4.Goli Chandra Sekhar, Dr. V.S Kale, G. Vamsi Krishna,(2014)

Author's have been done research on svc and its application of svc to improve voltage profile of Indian railway traction system, because excessive load on traction system line, it is important duty for the government to provide facility to passengers journey with out any interruption. So, authors introduce use of svc a static var compensator with the line which can overcome the unstable voltage profile with the help of simulation, they have done various effect of different load on traction and its line.[7]

5.Dominik Szabo,Michal Regula,Roman Bodnar And Juraj Altus, (2014)

Control of svc for power system correction has been discussed in this paper for this author has done matlab simulink is used. This paper deals with modeling with svc (static var compenstaor) is designed and implement 23kv power network model. In this simulink various analysis and test has been performed to check up the controlled algorithm with svc system.[8]

6.J.A Pecas Lopes, (2010)

In this paper author has been researched for defining control strategies for mico grid in islanded operations. Normally operation of micro grid on islanded mode occurs when the external fault occurs and utility has failed to operate at main grid operation, then control strategies for the micro grid comes. So, after attaining fault micro grid fails to operate at its nominal voltage in this research author trying to evaluate and shedding strategies for control.[9]

7.Shuiming Chen, Hongqiao Yu, (2010)

Here in this paper, basic idea to design micro grid and summarize its overvoltage cases, which occurred in line at abnormal conditions, micro grid installation with DG's are now trend like solar photo-voltaic cell, wind generation and other micro- turbines for generation connected or integrated with micro grid, so at abnormal condition overvoltage occurs and chances of having disturbance in the network. In this paper author has done analysis to obtains and reduce following terms like resonant over voltage , stokes etc.[10]

8.Kalpesh C.Sonio, Firdaus F. Selim, (2015)

In this paper author has given a review over micro grid during grid connected mode and islanded mode. DG sources are connected with micro grid to operate when islanded mode condition occur by line. Islanded mode occur only when external faults happen in line with this it automatically or manually operate with DGs and to give supply to consumers. But when after removing or correcting the fault it get connected to main grid xlled grid connected mode. At this mode when connected it resynchronize itself to main grid, it cause transients when resynchronize with main grid. So, author has done power control and management of connecting both modes in micro grid with the help of matlab/simulink softaware.[11]

9.Jinwei Li Jianhui Su , Xiangzhen Yang, Tao Zhao, (2011)

Here in this paper discussed , the most important problem for small grid is controlling. Author identify the current scenario situation and implement technologies for control to micro grid. micro grid help in emergency conditions when brown and black out comes on main grid. With the help of this technology micro grid can control on various situation that may grid connected time or may be local DG connected time that is islanded operation with DG. In which renewable energy sources are connected like wind,solar,diesel generator, bio-mass, micro turbines system with svc.[12]

10.Liang Che,Ahmed Alabdul Wahab And Yusuf Al-Turki, (2012)

Author of this paper , introduce the concept of alternating current micro grid and direct current micro grid. It having both individual micro grid having non matching frequency so that self governing controlling existences, author also states it hierarchical co-ordination with primary, secondary and tertiary operation at islanded mode of micro-grid.[13]

11.Shuiming Chen, Hongqiao Yu, (2013)

In this paper author trying to create attraction towards DG's. distributed generation with micro grid application and a review on over voltages on micro grid. In which DG having gas turbine, micro-turbines, solar energy ,wind fuel cell etc. which are more eco-friendly and paying attention to the people because having production of pollution. When suddenly change from grid connected to islanded and islanded to grid connected modes this conversion cause over-voltage and oscillation in frequency occurs.[14]

12.Zinquan Liu, Wei Yao,(2013)

Here in this paper, author introduce the concept of effect of static var compensato-DC as damp controller,according theoretical analysis shows that svc-dc gain increases and became reason of unstable control mode of working. To solve this kind of problem,author introduce feeback controller to SVC-DC which stabilize the grid . and also took results of this controller by modeling and designing it on matlab/simulink software. So that operator can examine the problem and can control over its drawbacks.[15]

13.J.J Jamian,H.Musa,M.W.Mustafa,H.Mokhils And S.S.Adamu, (2013)

The author of this paper has been researched, analysis of distribution generation operation modes using new effective voltage stability in index in radial system. results of this renewable source energy with load is analyzed with help of simulation so that author obtained VSI stability of voltage index or voltage stability index. it also serve as indicator of stability. in this paper charging station considered as a load. In which VSI value gives indication of voltage collaboration with the system.the has been performed on the radial network with multiple DG units and gives better injection of reactive power voltage stability index.[16]

14.N.Rugthaicharoencheep ,S.Auchariyamet, (2012)

Author of this paper has been researched on technical and impacts of distributed generation on distributed system. it has a very good impact on distribution generation system, depending upon the good or bad impact over distribution system. if there is bad impact over the system than there will be technical impacts and if bad impact over distribution system that there will be economical impacts so, in this paper author can submit the results over different condition of system.[17]

15.Houari Bhoudjella,Fatima Zohra Gherbi And Fatiha Lakdja, (2014)

According to this paper author has done work of modeling and simulation of static var compensator in power system studies by MATLAB. Analysis has been done in four steps, in first step main focus is designing the system. in the second step, controlling range and its behavior. Third step, load flow analysis and open and close loop configuration for lag ,lead , phase and gain margin. now in fourth one, analyze proper control of reactive power and its injection to power system line by using static var compensator device.[18]

16.Ali Abdulwahhab Abdulrazzaq, Mircea Eremia, (2014)

The paper published by author work on the controlling and performance of voltage of static var compensator under various abnormal conditions which occur in transmission line. with the help of EUROSTAG software, and analyzing of voltage control and reactive power control under various conditions of electrical power system. as we familiar that various abnormal conditions occurs in power system transmission so that can lose control of every system and goes under losses, so svc help indirectly and provide control to system.[19]

17.J.Balcells, P.Bogonez-Franco, (2015)

In this paper , author has given a review of installing svc that is static var compensator with micro grid instead of capacitor bank. As we know that micro grid operate at LV (low voltage), and medium voltage (MV) at islanded mode when connected to DG source. Sometime it operated at high voltage(HV) when connected to grid. So, changing of micro grid modes need resynchronization with its components and controlling equipments or system. This is only the problem which can create problem of instability, transients and power quality factors in power network. These type of problems can control on the bases of reactive power flow in the grid. static var compensator is based on combination of TSC(thyristor switched capacitors) and thyristor controlled reactors(TCR).[20]

18.Shagufta Khan, Raju Meena, Suman Bhowmick, (2015)

In this paper, use of FACTS device to improve stability of bus introduce by author. Small signal stability improvement of single machine infinite bus system using SVC as the name of paper given by author, to full fill this research author took some tests over SMIB system with svc connected at the mid-point of transmission line. To perform this he added a damping controller with SVC which can sense the voltage instability and achieve small stability margins in the line. The damp controller is used with extra auxiliary signals. These signals help to improve the oscillation damping. Basically power, frequency, and line current etc. also supplementary use. Here according to this paper author done multiple case studies with SMIB test and carried out various results.[21]

19.Sheil Mahapatra, Neharika Kapil, (2014)

Here author of this paper, has been researched that how power factor can remove by adding thyristor controlled reactor with line. A 8051 microcontroller is integrated with TCR for better utility under abnormal loading conditions. This microcontroller is programmed in keil software. Here in this paper author also add two another software in there research one is PSpice and another is loadproteus software. One is used to check p.f abnormality that is lagging load and leading load but another software is used to check load variation.

Shunt connected capacitor bank with power system network inject reactive power to system where the need of reactive power that is VAR. shunt connected reactor is also connected with line whose function is inject real power when capacitive load in the system. so, thyristor controlled reactor compensate the problem and improve power factor level.[22]

20.M.B.Kammoun, 2014

In this research paper the employment of static VAR compensator with line to reduce and eliminate power system transient stability. Better use of FACTS device with power system network for proper compensation of disturbance. So, that maximum reliability and security provide to consumer and meet there requirements.[23]

CHAPTER 3

DIFFERENT DG SOURCES AND SVC

3.1 Different Types Of DG Sets

1. Fossil fuel DG set
2. Micro Hydro DG set
3. Solar DG set
4. Wind DG set.
5. Biomass DG set.
6. Geothermal DG set.
7. Ocean wave DG set.[24]

3.1.1 Fossil Fuel DG

Fossil fuels are coal, gas and oil because they are fomed from prehistoric plants and animals in earths crust. They provide 65 percent of global electrical power and 96 percent of world electrical energy demand.

Commonly fossil fuels comes from coal which is further crushed to fine dust and brunt in a machine. Oil and gas can burnt directly. It the process of producing electrical energy , when fossil fuel is burnt heat energy is form with this water is heated up and make produce steam after that steam goes to steam turbine ,turbine teds to rotate generator rotor, and with the help of generator electrical energy is produced.

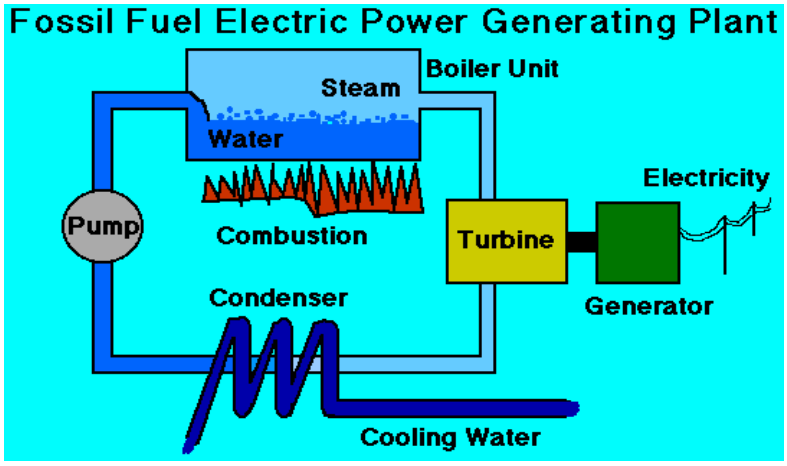


Figure.1 Schematic diagram of fossil fuel generation system

Total data of fossil fuel provided to worlds energy are

- Energy provided by coal is around 30%.
- Energy provided by oil is around 40% .
- Energy provided by natural gas is about 22%.

Advantages of fossil fuels

Transporting of fossil fuels from one place to another is easy.

Gas and oil power stations are very efficient.

In large amount of electrical energy produced from coal, oil and natural gas in entire world.

Disadvantages of fossil fuels

- Its main problem and limitation is pollution because fuels and oil and gas are burnt and cause pollution in environment.
- Harm full gases produced in atmosphere such as carbon dioxide and other harm full green house gases.
- Due to burning of coal sulphur dioxide is produce in atmosphere and became reason of acid rain.

3.1.2 Micro-Hydro DG

It is generation of electricity from water, in which mechanical energy is getting from water which further mounted with turbine and generator shaft, so that through this way we can get a source of energy

Micro hydro electric projects generally up to 100 KW capacity and below 5 KW it said to be pico- hydro generation. With the help of run-off river we can collect the source of water and feed to the turbine section.

Micro hydro are constructed at the rural areas, where connections of centralized grid can reach , so that to provide them electricity it must be good source but it is possible only where the source of is continue from the mountains.

Different components are connected in micro hydro like, conveyance such as water pipelines, penstocks etc. second thing is turbine and water pumps, third thing is generator and transformer, t=fourth thing is regulator whose work to control generator, last one is transmission lines section.

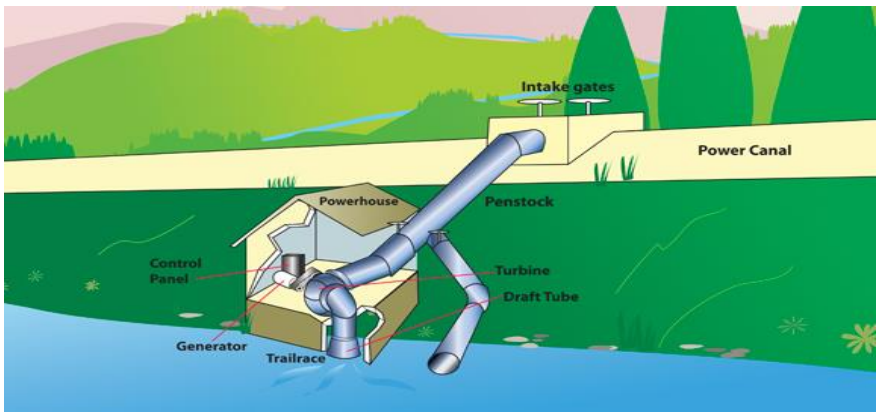


Figure.2 Schematic diagram of micro-hydro generation

Advantages

- It can produce electricity with the help of less natural and continuous flow of water.
- Its installation cost is not much high.
- In micro hydro energy, no use of conventional fuel, so that pollution free system.

Disadvantages

- The problem with this scheme , it is not available at every part of country.
- The major problem comes when extremely less or small flow of water.
- Plant can not in work while water in run off get reduced.[24]

3.1.3 Wind Distributed Generation

Wind energy is the conversion of mechanical energy to electrical to energy, mechanical power comes via air flow (i.e act as s prime mover) through a turbine i.e wind turbine. Wind is natural resource of energy, uses as a prime mover rotate the rotor of generator and hence conversion of electrical energy take place[2]. It is the conversion of wind flow energy into electrical energy. As we know sun light falls on earths surface that light heat up some patches and those warm patches became rise of air other blows into replace them so anyhow we fell wind is blowing, and that blowing wind is used as resource of energy, that can extract by mounting and building tall towers with mechanical device called propeller in propeller angle of blades mounted with shaft which rotate as the wind is blowing.

Use of expending day by day because of its effective and better benefits.
Some of benefits are

- It is alternative generation to burning fossil fuels, its better impact on environmental, eco-friendly.
- Less production of green house gases.
- Consume no water resource.
- Nothing requirements harmful liquid as well as gases.

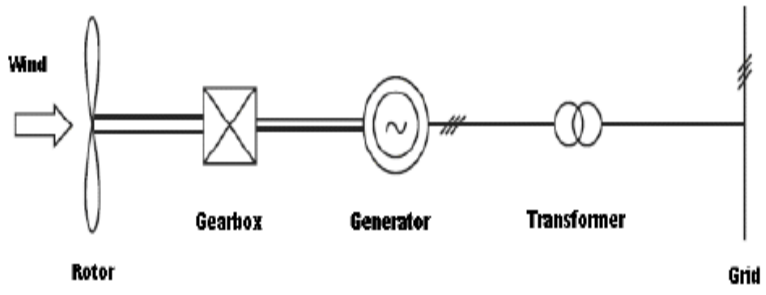


Figure.3 wind distributed generation

One or more individual turbines are placed together and consist of a wind farm, which are connected to the electric power transmission network. Air is also most cheap or inexpensive source of nature, takes zero cost. Offshore and onshore grids are there, off shore grid require

more maintenance cost and construction cost. But onshore grid can use to feed electricity to isolated off grid locations.
Varying Wind provide variable power to system so that various techniques and generator are inverted already to minimize the problem and generator can generate constant power.
The wind power developed by the turbine is given by the equation

$$P = ½ C_p.A.\rho.V^3$$

Where, C_p = Power Co-efficient,
ρ = air density in kg/m3 ,
A = area of the turbine blades in m2 and
V = wind velocity in m/sec[3].

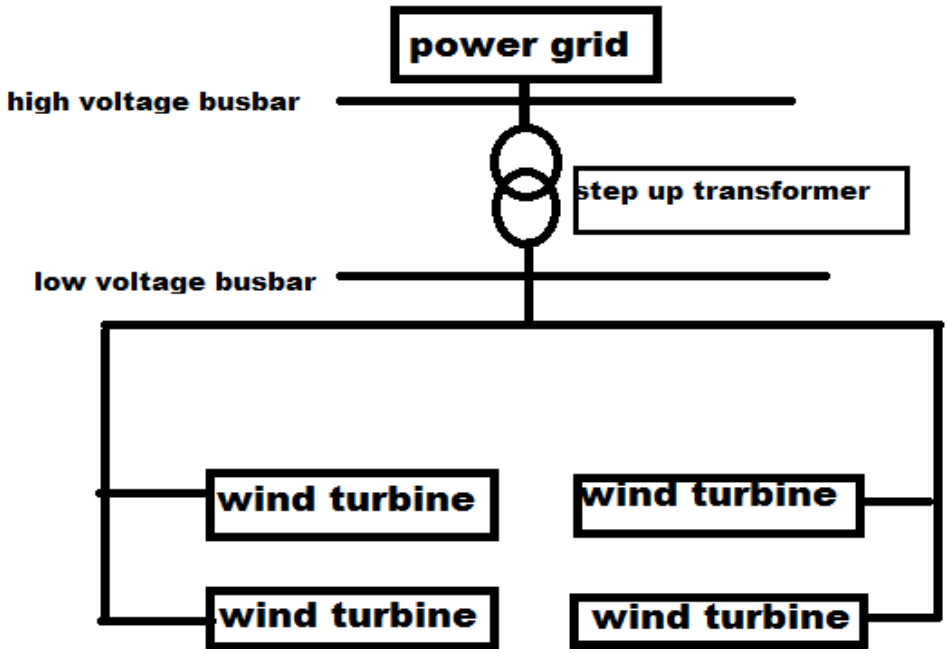


Figure.4 Single line diagram for wind generation

Advantages

- Wind power generation is alternative to burning fossil fuels, its better impact on environmental.
- Less production of green house gases.
- Consume no water resource.
- Nothing requirements harmful liquid as well as gases.

Disadvantages

- Generally wind farms constructed near the coastal areas because the blow of wind is more on these sites.
- Wind farm towers are also reason to kill the birds.
- Wind generator s are noisy that create low, swooshing noise in whole day and night.

3.1.4 Solar distribution generation

Generation of solar from sun light to electrical, sun is one of continuous source of energy on our universal system. Which can constantly emit its light radiation to planets, with the help of solar panel we can get the sun light energy that transfer from electrical energy. In solar panels ,solar cells are mounted which are also called photovoltaic or photoelectric cells, whose function is to excite the electron from n junction and can help to flow of electron from n-junction to p-junction to p-junction, from one square meter of solar panel, we can get enough power to run 100W electric light bulb.

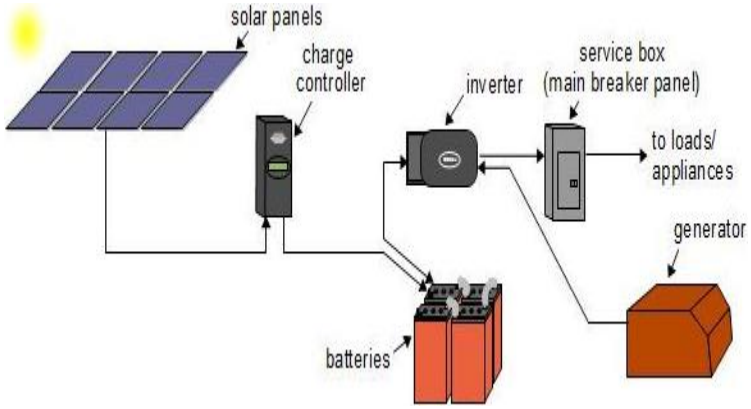


Figure.5 Schematic diagram of solar generation

Advantages

- Solar energy is free can not going to end
- No pollution create from this, because it can not need any fuel.
- Also use in low power devices such as charger garden lights and batteries etc. so it can be handy.

Disadvantages

- Biggest drawback of this energy is it can not work at night. So at that time solar plants won't work.
- At very high temperature or full sunny climate panels can be unreliable.
- Its efficiency is more than 20 percent, so maintenance cost is high as well as installation cost also high.

3.1.5 Biomass distribution generation

The energy is used for electrical energy. In this heat energy is produce by burning the waste of animal and plants and that heat energy get converted to steam, further inject to steam turbine to turbine turn generator. It is renewable source of energy. Bagasse" is also can burn in some power stations and sugar factories for generation of electricity. Animal dung are used as animal waste, woodchips , seaweed, corn stalks and other useless dry grass as a plant waste.

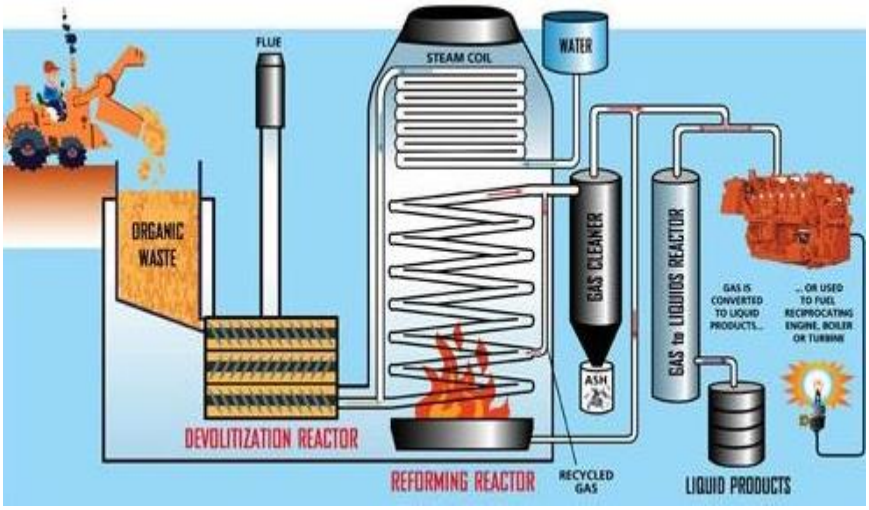


Figure.6 Schematic diagram of biomass energy source

In this animal manure and or animal dung are used as animal waste, woodchips , seaweed, corn stalks and other useless dry grass as a plant waste. "Bagasse" is also can burn in some power stations and and sugar factories for generation of electricity. When sugar cane is harvest and taken to factory there it is crushed and extract juice for making of jaggery or sugar, so remaining part is bagasse.

Advantages

- It make sense to proper use waste materials
- It eliminates fuel cost and cheap.
- Due to biomass energy, conventional resource are going to reduce and tends to less demand.

Disadvantages

- Some waste material are not available everywhere.
- Burning of waste material leads to pollution so it is not having eco-friendly environment.
- To provide sufficient waste for power plant is also difficult challenge.

3.1.6 Geothermal distribution generation

It is a heat energy which generated or produced from beneath of earth's surface. Resource of geothermal energy are hot rocks and hot water from beneath of earth's surface. These temperature gradient like geothermal gradient , which is temp. difference between core of planet and its surfaces, and drives constant conduction of thermal energy .Geothermal energy resources maintained its temperature under the ground about 4500˚C (8132 ˚F).

Due to this earth's crust contain 50000 times more energy than other resources like natural oil and gas in the global.

In U.S, 17,500 MW is generated from the geothermal resource and become worldwide leader of installed geothermal capacity.[26]

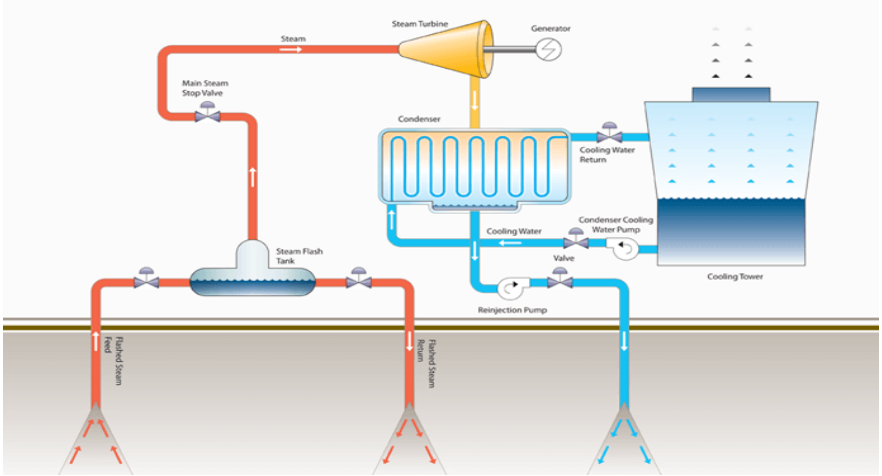


Figure.7 Schematic diagram of geothermal generation

3.6.1.1 Geothermal technologies

1. Geothermal direct use(GDU)
2. Geothermal electricity production or generation(GEP)
3. Geothermal heat pumps(GHP)
4. Geothermal direct use(GDU)

In this we use direct energy of geothermal, under the earth's crust or surface there are reservoirs of hot water, so that can use to provide direct thermal energy or heat.

In this well is perforator into reservoir to provide stream of hot water and water is bring up through well with mechanical system like piping, heat exchanger and controllers. So that it deliver the heat energy directly for its purporting use.

Geothermal direct use(GDU)

In this we use direct energy of geothermal, on couple of miles or more under the earths surface there are reservoirs of hot water, so that can use to provide direct thermal energy or heat.

Steam is collect from hot water reservoir through well with the help of some mechanical device system such as pipelining, exchangers and controllers etc. So that it deliver the heat energy directly for its purporting use.

Geothermal electricity production

Firstly, plant generate steam than electricity. Three type of geothermal electricity production are

- Dry steam system

- Flash steam system
- Binary cycle system

through these process of systems electricity can be produced.

In dry steam, there underground wells to power plant ,these wells are piped directly and fed straightly to turbine or generator.

In flash steam, very hot water flows through tubes under its rated pressure . as it flow upword its pressure tends to decrease and some of hot water convert into steam. Generated steam into electricity.

In binary cycle, its temperature is low , in this heat from hot water use to boil the fluid .the fluid which is organic thing and having low boiling point. this working fluid is vaporized and use to rotate turbine than electric generator .

Geothermal heat pumps(GHP)

It is basically consist of three types

- Heat exchanger (H.E)
- Unit of heat pump (H.U)
- Air distribution system.

H.E commonly consist of pipes so also known as loop. In the loops number pipes are constructed and on those pipes a fluid is circulate to absorb and reject heat.

Heat pump unit remove heat from H.E in winter time. And reverse process will happen in summers.

Heat pump unit consume less amount of energy since they scoop heat from earth's crust.

3.1.7 Ocean Energy Resources

Western coast of Scotland, northern Canada, southern Africa ,Australia ,the north western coast of U.S have ample amount of energy resources in the different areas of world.

Waves and tidal resources potential given in terawatt hour per year i.e TWh/year. Where one TWh/yr can supply around 93,860 average US homes with power annually.

Technology

- terminator devices
- attenuator
- a point absorber
- over topping devices

GENERATION TYPE	TOTAL INSTALLED CAPACITY (MW)	2022 TARGET (MW)
Solar Power	8514.24	100,000.00
Small Hydro Power	4353.36	5,000.00
Wind Power	28092.65	60,000.00
Waste-to-Power	115.08	10,000.00
Biomass Power	4882.43	
TOTAL GENERATION	**45958.76**	**175,000.00**

Table.1 Installed Grid Interactive Renewable Power Capacity in India , 2016

3.2 MICRO GRID

Micro grids are small grids, these are different from main or centralized grid. These grid operate separate and are self governing. The comes when centralized or main grid tends to fail the supply due to heavy fault across the system and line that causes grid failure, in that case black out and brown cases comes, to prevent these case use of micro grid with DG are come in use so that can supply electrical power to consumers or locomotive traction system which is more important. But now days these days small grids are used with DG sets for personal use in factories school/colleges/universities, laboratories etc. with this consumer's don't face any kind of interruption in supply at homes or institutions and factories. [27]
Its use with various DG set like solar, wind, geothermal, ocean thermal, fossil fuel energy generation etc. can be possible which tends to reduce losses in transmission lines and distribution system, serve continuous load without any interruption.
Various areas where micro grids can install-

(a) Remote (off-grid) grid

Need of grid for communities of remote areas and under developed countries basically look for miscellaneous and distributed source of power. Today's regions of different countries focusing to development in remote area electricity projects and infrastructure with these govt. take actions to connect small grids with main grid and also use of distributed generation source for better output move toward eco-friendly projects.

Military base gird Plenty of military areas are situated far away from city or rural area so that requirement of electricity necessary to distribute those camps or areas so that micro grid helpful for military use.

(b) Campus or institutional

It consist of number of certain grids connected in limited area. most of government or private college buildings research institutes etc. need of electricity on those places are more so full fill that requirement is by installing micro grid .

(c) Commercial grids

These are similar to above mentioned grid. the main thing is to provide normal power at peak and base load to commercial areas so that planners and investors decide to meet reqirment for all consumers.

(d) Industrial grids

Ample amount of is now a day not delivering to industrial so that it lead to difficulties to establish more industries, by observing all type of problem commercial-industrial parks are projected or plans to install i.e green field project with normal and premium supply.

3.2.1 M.G (Micro grid) features

- Autonomy
- Stability
- Compatibility
- Flexibility
- Scalability
- Economics
- Peer to peer models.

3.3 Modes Of Micro-Grid

- Grid Connected Mode
- Islanded Mode

(i) Grid Connected Mode

In this grid connected mode main grid exert and transmit to utility distribution grid which is totally which is depend upon demand of load and supply of generation. At this grid connected mode the micro grid which is also know main grid, different kind of load at receiving side directly got supply from grid, at this w grid connected mode the utility of supply is much higher/greater than original micro grid.

(ii)Islanded Mode

In islanded case when main grid getting failed to supply due to any kind of fault, and due to some external faults of transmission in which transmission wires broke due to by falling tree over the electric line and or electric poles, when this happen than micro grid failed to get supply from main grid source and operate with some DG sets. But during grid connect mode, exert and transmit to utility distribution grid, which is depend upon demand of load and supply of generation.

3.4 Components In Micro Grid

- Circuit breaker
- Transformer
- Current transformer
- Potential transformer
- isolators
- Relays

- Control panels

(a) Circuit Breaker

it is automatic conducted switch and used to preserve high power electric circuit. It operates only when over-voltage and over-current occurs in system due to any fault. Lightning, sudden switching and disturbance cause fault.[28]

(i)Types of circuit breaker

- Oil circuit breaker
- Air C.B
- Sf6 C.B
- Vacuum C.B

(b) Transformer

It is static device use to transfer of electrical energy from one place to another place without change in frequency. Its working depend upon principle of mutual induction.

i)Types of transformer

1)Step up transformer

Generally this type of transformer is used for transfer of high electrical energy, and power to distribution network.

2)Step down transformer

This type of transformer generally used for transfer of low voltage electric energy to the consumer end.

(c)Current transformer

This type of transformer is used for protection purpose. Which step down electric current and measure the how much electric current flow through the line.

(d) Potential transformer

This typr of transformer also used as protection device and can measure the electric voltage flow through the line.

(f) Isolator

Isolator is not an automatic device it can operate by manually, it operate at no-load condition. It can operate after the circuit breaker contacts open, generally operation of isolators comes when need of maintenance on overhead lines, its main function is to isolate one section of line not whole section means in which we want to maintenance, with the help of this leakage of current also earthed or eliminate properly. It is so called a protective device. Generally operation of isolators comes when need of maintenance on overhead lines, its main function is to isolate one section of line not whole section means in which we want to maintenance.

a) Types

- Double break
- Single break
- Pantograph

(e) Relays

It is an automatic and controlled device whose function is to protect electrical power system circuit and network. When the fault comes due to sudden switching, lightning and other external faults due to weather condition of atmosphere then relay gives command to circuit breaker to trip nand protect the whole power system circuit.

(i) Different Types Of Relays Are

- Definite time relay
- Inverse definite minimum time
- Instantaneous relay
- Voltage restraint over current relay.
- Stepped char.

(ii)On The Basis Of Sequence Relays Are

- Current
- Voltage
- Frequency
- power

3.5 Benefits Of Installing Micro-Grid

- Factors like stability insecurity and power quality can be provided by micro grid
- It explore the hybrid and integration of distribution generation.
- It became inexpensive and more efficient.
- Helps to improve power quality by installing micro grid with distribution system.
- It is also helps in making environment more eco-friendly.
- It increases consumers collaboration and efficient service.

3.6 Future With Micro Grid

- Broad installation of micro grids is likely to slow down electric energy cost and balance availability of electric power.
- Pushes for renewable energy sources and make blunt impact of fuel prices.
- Use of renewable sources leads to make eco-friendly world.

3.7 FACTS device -SVC

3.7.1 Definition of FACTS devices

FACTS means flexible alternating current transmission system whose function is remove fault and at static and dynamic conditions it overcome the transmission system. it is combination of traditional and power electronic components with better controlling techniques that can help to maintain system within stability and reliability conditions. It is also helps to improve power quality and real and reactive components of load. FACTS device have ability to maintain efficiency of power system circuit and network. Its features are

- Voltage regulation is very fast

- It increases transmission capability aver long transmission lines.
- It can produce damping of oscillations.
- Create control in load flow.

Compensation of real and reactive power in device is occur when load side is consuming more, because as we know that the load are non liner in nature so use capacitive and inductive load is common . so case one, the load is inductive and system consuming more inductance at that time system p.f became lagging with phase and need more reactive power compensate the problem. Otherwise system goes to fail. So we need capacitor bank to overcome this problem.

Case second, occur when load is capacitive in nature and consume more capacitance from the system, so that in this way the load goes go to leading p.f and need more active power to compensate, hence need of shunt inductance to compensate system problem.

Different classifications-

- Series type
- Shunt type
- Combined series-series type
- Combined series-shunt type

(a) Series Type

It is connected in series with line whose function is to inject voltage through line . it is kind of control which con control and compensate the voltage magnitude in line which came through fault. It is power electronics device that could varying real and reactive power for control purpose.

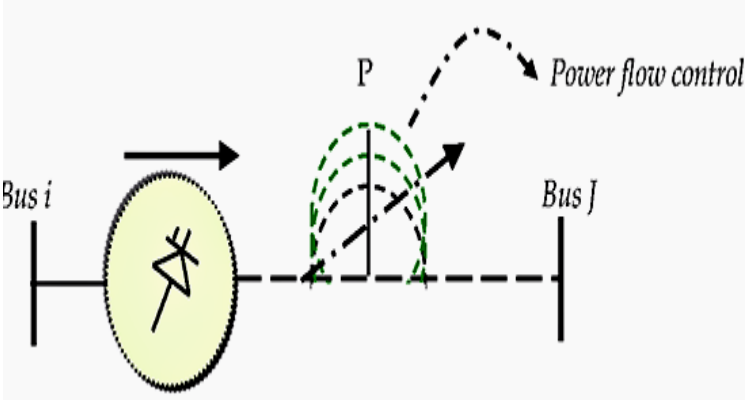


Figure.8 schematic diagram series controller

i)These controllers are comes under series controller

- SSSC-Static Synchronous Series Compensator
- TCSC-Thyristor Controlled Series Capacitor
- TCSR-Thyristor Switched Series Reactor
- TSSC-Thyristor Switched Series Capacitor.
- TSSR-Thyristor Switched Series Reactor.

(b) Shunt Type

This is another type of controller, which is connected to the line in parallel with line, whose function is to inject current into system through line. And it has also capability to handle power system problem at various power requirements.

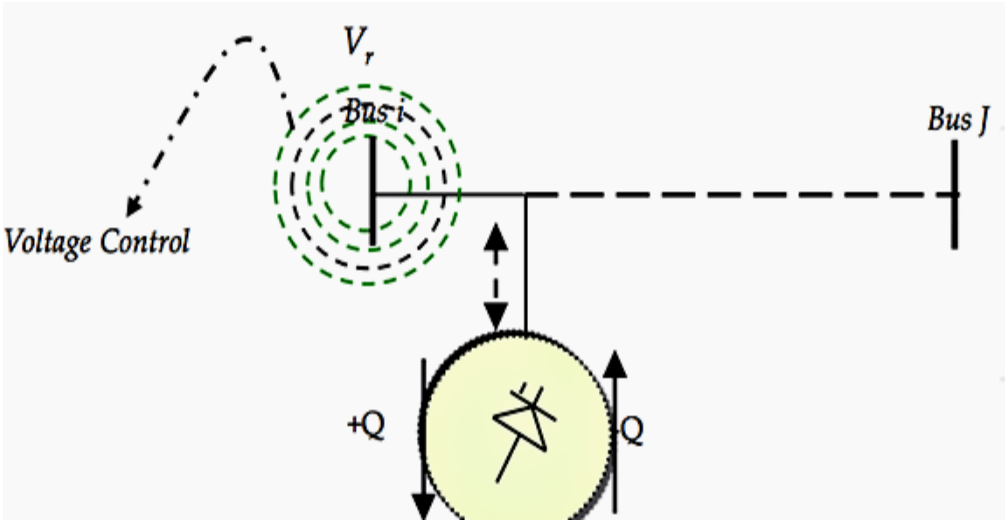


Figure.9 schematic diagram of shunt controller

i)These controller comes under shunt controller

STATCOM-static synchronous compensator
SVC-static var compensators.

c)Combined series-series controller

Two or more series controller connected to line in series with line whose function to inject controlling current and perform reactive power compensation. In this two or more controller connected to DC link.

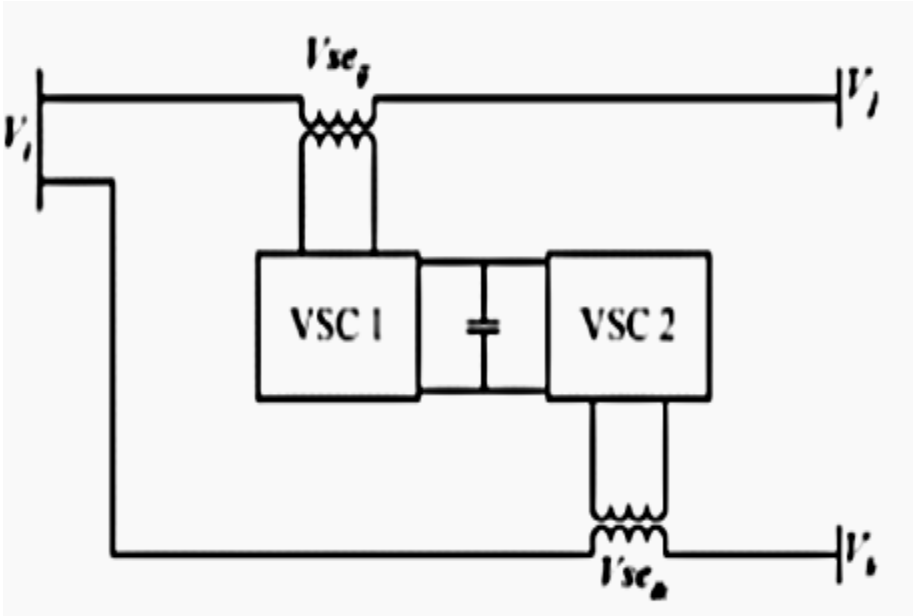


Figure.10 schematic diagram of combined series-series controller

i)Controller comes under series-series contoller

IPFC-Interline power flow controller.

d)Combined series-shunt controller

This is another type of controller whose work function is to inject voltage and current into the system through line. This is combination of two or more sets of controller connected with the line one set connected in series, other set is connected in parallel with line.[22].

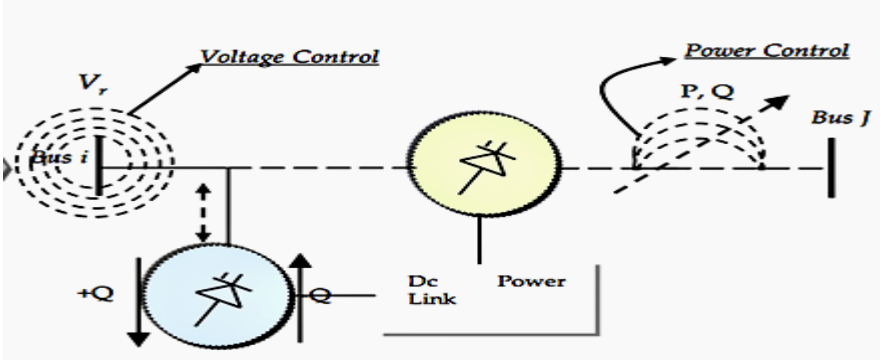


Figure.11 schematic diagram of combined series-shunt controller

i)Controller comes under series-shunt controller

UPFC-unified power flow controller

Advantages of FACTS devices or controller

- Power transfer capability can be improved.
- Use to improve stability like static and dynamic.
- It is help to reduce damping of oscillation.
- It make voltage regulation more better.
- Flexible operation of power system and equipments.
- Due to fault the cascading of connection is there so it help to prevent it.

3.8 SVC (static var compensator)

Static var compensator is connected with line. It is a shunt connected device whose function is to inject active and reactive power to the system. It can improve p.f issues with power system. It has mainly constructed with transformer, reactor, capacitors and bi-directional thyresitor valves.

There are mainly fixed capacitor TCR and TSC –TCR. Means thyristor controlled reactor and thyristor switched capacitors and rector.

This device has very important applications with transmission and distribution line system, which helps to improve in its transfer capability and also helps to improve steady and dynamic stability. Only this device can helps to compensate leading and lagging p.f capabilities. This device can match impedance automatically, and helps the system to bring at unity p.f factor.

- It is Connected with power system to regulate the transmission voltage.
- Also can connected near large industrial area where load demand is high, and helps to improve power quality.

When the load is capacitive than system consumes reactive so this time p.f goes to under leading power factor svc gives ommand to TCR to switch on, but under inductive load condtion the p.f goes to lagging, and than svc gives command to TSC to switched on. It can improve p.f issues with power system.
In this device filters circuit is connected to eliminate harmonics from the system, because use of capacitor bank that and as mentioned that power electronics device whose function , that is only the source having diods, thyristor and capacitors which release the harmonic and that harmonics causes poor power of power system.
So that can cause to increase device maintenance of circuit and time to time testing of its firing angle control.

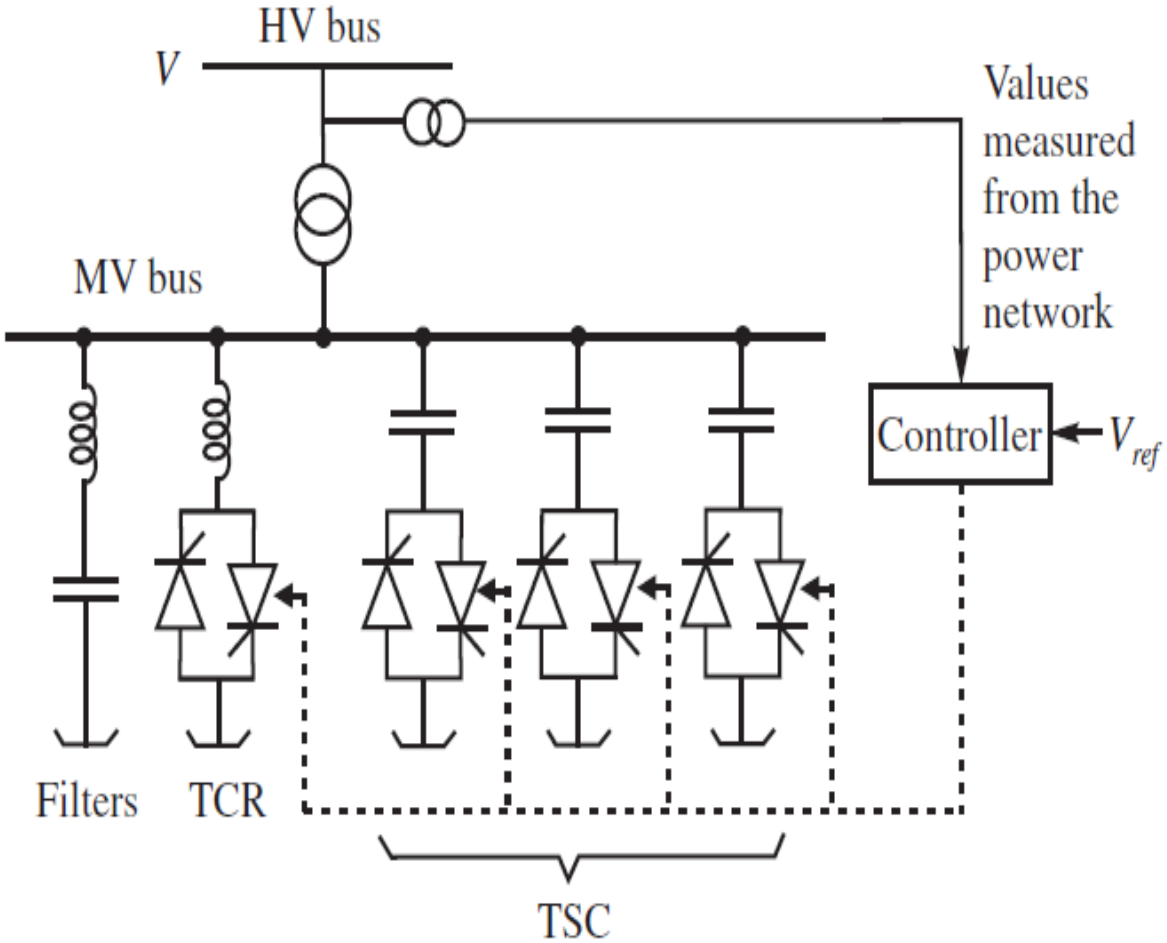


Figure.12 schematic diagram of static var campansator

Device filters circuit is connected to eliminate harmonics from the system, because use of capacitor bank that and as mentioned that power electronics device whose function , that is only the source having diods, thyristor and capacitors which release the harmonic.

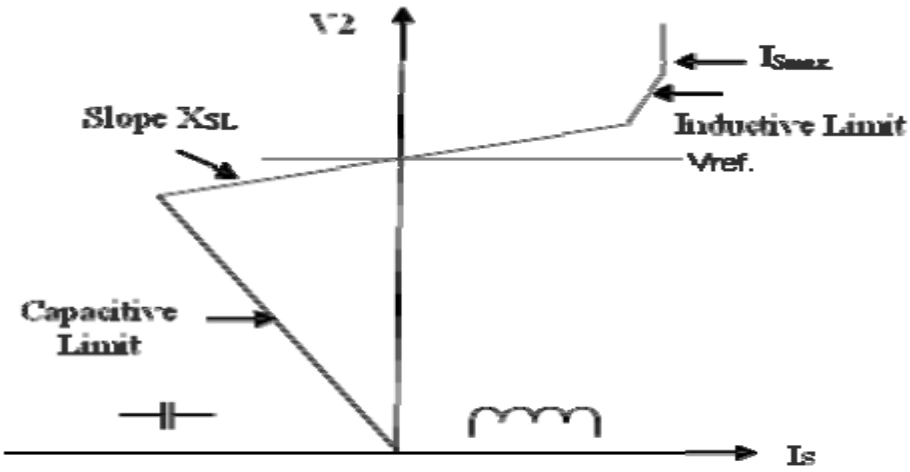


Figure.13 Steady state V-I characteristics of SVC

(i) Thyristor Controlled Reactor

Thyistor controlled reactor consist having fixed inductance L and bi-directional thyristor valve. From the fig. given below Thyristor can block voltage up to 10kV and conduct current up to 7kV. Therefore, in practically many thy. Joined in series to fulfill require blocking voltage level at particular rating.

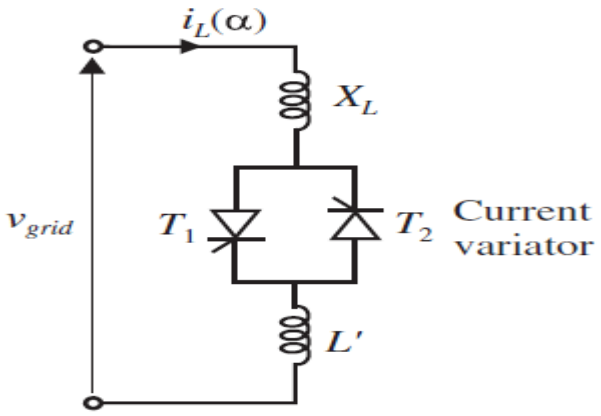


Figure.14 schematic diagram of TCR

ii)TSC(thyristor control capacitor)

TCR consist of bidirectional thyristor valve and small 'L' connected to limit the surge current in thyristor valve during communication and also avoid resonance at specific frequencies. The circuit is completed by an RC series connected in parallel with each thyristor bank; their function is to limit dangerous surge currents that may appear at thyristor blockings and to balance the voltage levels on the thyristor banks. The two thyristor modules are connected anti-parallel and are controlled by a control and command device. Depending on the bus voltage, the control and command device connects a lower or higher number of elements.

When the load is capacitive than system consumes reactive so this time p.f goes to under leading power factor svc gives command to TCR to switch on, but under inductive load condition the p.f goes to lagging, and then svc gives command to TSC to switched on. It can improve p.f issues with power system.

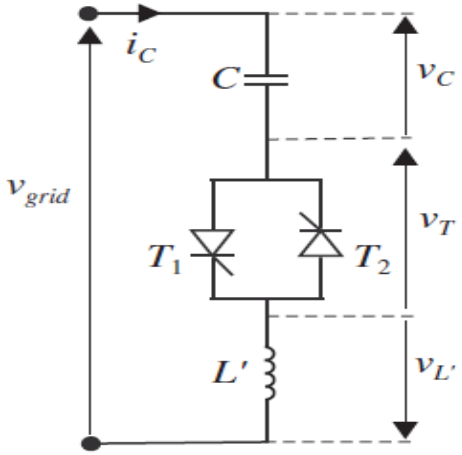


Figure.15 schematic thyristor controlled capacitor

3.9 V-I Characteristics of TSC –TCR

TSC and a TCR controlled by the firing delay angle alpha. The controlled characteristic of a TCR and the characteristic of a TSC are shown in Figure , Similar to the case of an FC–TCR, the two elements are connected in parallel and therefore the total current is the algebraic sum of the current absorbed by the TCR and the current generated by the TSC, when it is ON.

If the TSC is OFF, the total current will be equal to the inductive current in the reactor only. Thus, by switching off the capacitor, the resulting characteristic of the SVC is the same as the characteristic of the TCR, and the current can handle from its maximum inductive upto zero varying the A_d alpha[28].

1. Characteristics when TCR and TCS operating separately.
2. Characteristics when TCR and TCS operating when connected parallel.

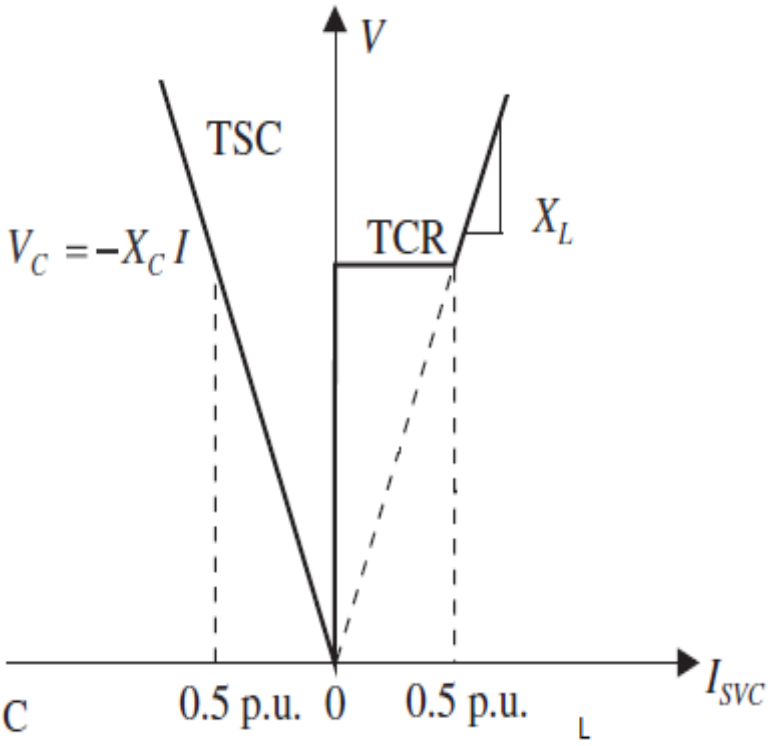


Figure.16 TCR and TSC operating separately

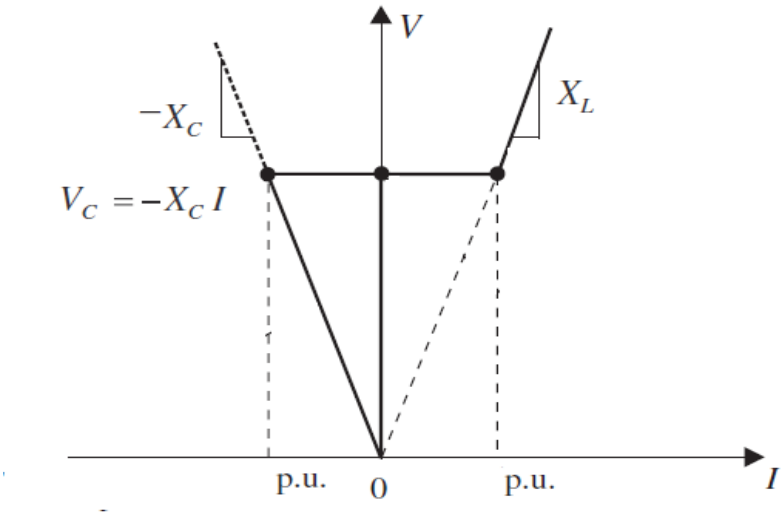


Figure.17 TCR and TSC connected in parallel

3.10 Conventional Power Flow

Static var compensator as a generator used by analyzing modeling of conventional power flow behind the 'X'(reactance).it also shows voltage regulation characteristics.

Assume when static var compensator having slop zero, by assumption as SVC work withing its designed limits, than it lead to gross error point. The point is shown given fig. and also shows upper characteristics only when device operate at low load situation.if the slope of svc taken as zero than generator will have its minimum limits at point $A_{x=0}$. Voltage and current slope comes in front at point A.

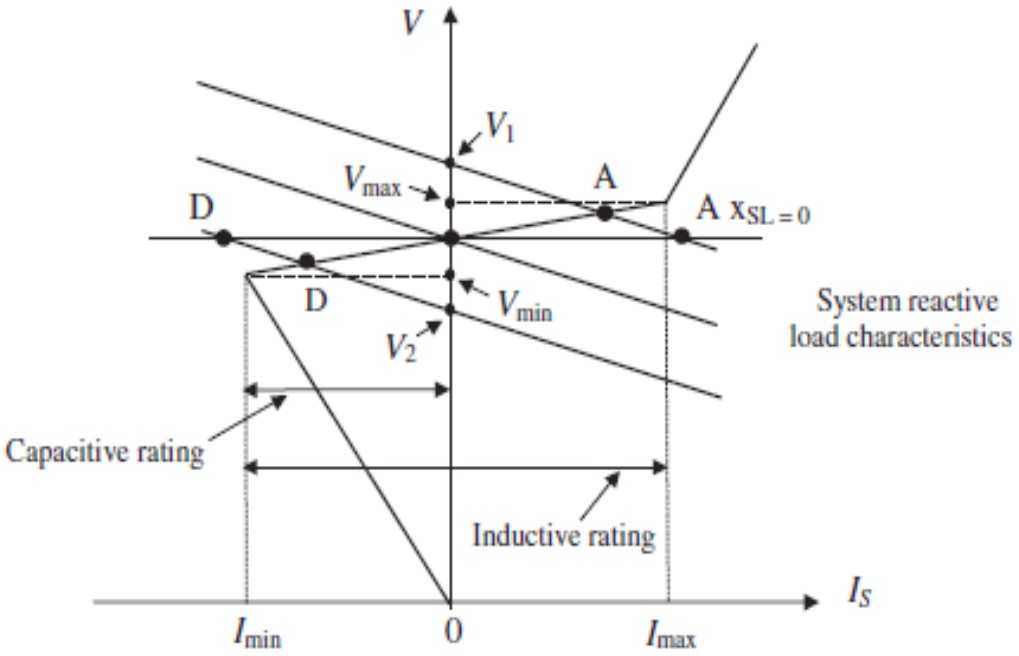


Figure.18 SVC with voltage-current characteristics

The slope represents voltage-current characteristics, slope of this device connecting with auxiliary bus to high voltage bus by an X_L which consist of $T_{Rec.}$ .this auxiliary bus can represent PV_{bus} and high-voltage bus is shown as PQ_{bus}.

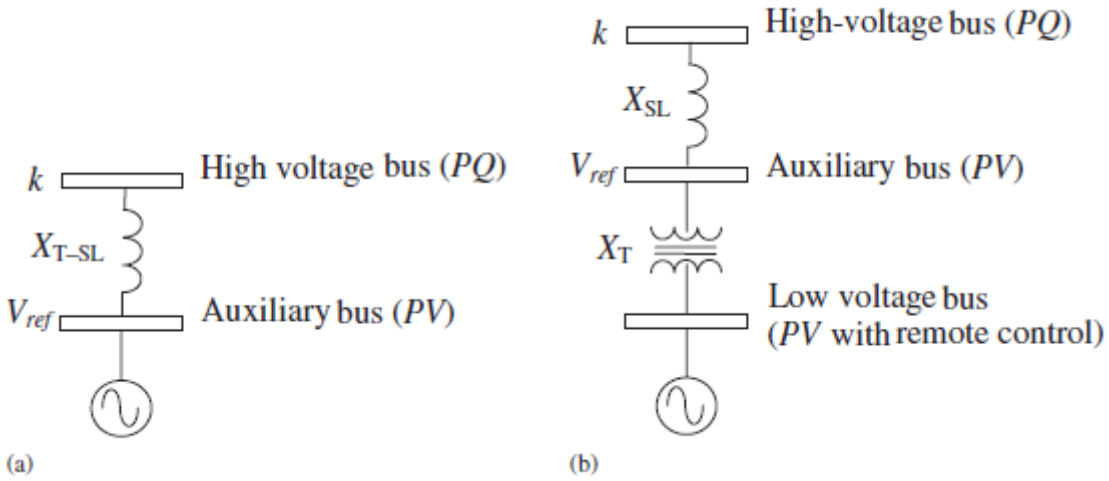


Figure.17 (a) Representation of slope (b) slope with transformer representation.

Representation of fixed $X_{susptance}$, is given below equation,

$$B_{\text{SVC}} = -\frac{Q_{\text{lim}}}{V_{\text{SVC}}^2},$$

Where, V_{svc}-voltage, due to limited reactive power Q_{Lim}. Varies. But if we neglect this point or assumption than may be there will inaccurate results. The behined is product of t fixed voltage (B_{fix}) and nodal voltage magnitude (V_k) is drawn by svc device.so that reative power of fixed susceptance model is different from generator model.

$$Q_{\text{lim}} \neq -B_{\text{fix}} V_k^2.$$

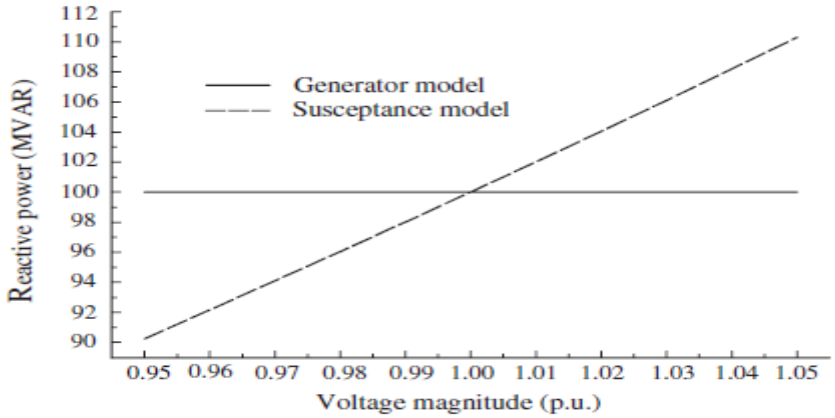


Figure.18 Compare of drawn reactive power with voltage magnitude

3.11 Shunt Susceptance Model

The equivalent circuit as shown below the fig. in which static var copensator derive the non-linear power equation and linearised equations with the help of newon raphson method.

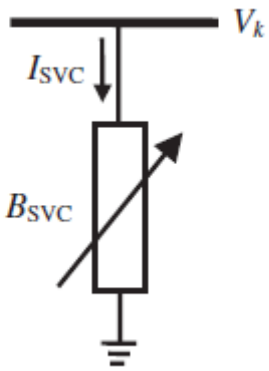


Figure.19 Shunt suscetance equivalent circuit

Current drawn by svc, given below,

$$I_{SVC} = jB_{SVC}\,V_k,$$

Reactive power drawn by svc and injected by bus ,

$$Q_{SVC} = Q_k = -V_k^2 B_{SVC}.$$

Now, Variable susptance is taken by state variable,

$$\begin{bmatrix} \Delta P_k \\ \Delta Q_k \end{bmatrix}^{(i)} = \begin{bmatrix} 0 & 0 \\ 0 & Q_k \end{bmatrix}^{(i)} \begin{bmatrix} \Delta\theta_k \\ \Delta B_{SVC}/B_{SVC} \end{bmatrix}^{(i)}.$$

At last of iteration the variable shunt susceptance is updated accordingly,

$$B_{SVC}^{(i)} = B_{SVC}^{(i-1)} + \left(\frac{\Delta B_{SVC}}{B_{SVC}}\right)^{(i)} B_{SVC}^{(i-1)}.$$

This is necessaary to maitain the voltage magnitude at rated value. And additional calculation require becouse svc susptance and firing angle of thyristor are non-linearly related.[29]

Advantages With Transmission Line System

- In weak systems it can stabilize the voltage.
- It Can reduce losses in transmission.
- It helps to increase transmission capacity .

- SVC can improve in transient stabilities limits an also static and dynamic stability limits.
- Helps to reduce oscillation damping.

Disadvantage With Distribution Line System

- Stable voltage is receive from the distribution end side.
- Productivity of voltage is increase that means utilizing capacity is also raised.
- It Help to balance reactive and real power and trying to improve tariffs.
- It has Chances of symmetrical and asymmetrical faults to reduce.
- It eliminates problems like voltage fluctuation and flicker
- It also help to remove harmonic distortion at load end side.

CHAPTER 4

RESEARCH METHODOLOGY

From the literature survey of this thesis it is recognize that how the main grid source and DG source are connected with each other and various problems occurs when interconnection of these source with load. the major problem of connecting the source with load through transmission and distribution system is power quality. Here in this thesis work source is well connected with load. Wind DG source and main three phase source or grid is connected with load by using FACTS device that is SVC(static vae compensator).with the help of MATLAB/SIMULIK software the modeling of DG system with small grid by using SVC has been done. Here SVC is used to control and improve the system when fault occur in system.TCR and TSC a thyristor capacitor bank and reactor bank with control is introduced. It is connected to improve of power system instability and unreliability which occur a time of fault. In this thesis simulation has been done in three phases or cases. in first case, modeling of wind DG and main source having connected load of 50KW and 2KW from distribution side. We had not apply any fault here in this case. In second case, modeling of wind DG with proper load and also interconnection of main source when three-phase fault is apply fault having resistance of 0.001Ω. in third case, we have done modeling of wind DG source and main source with SVC at fault condition. Static var compensator is one of the controlled device which can inject reactive and inductive power to system when need during fault and can protect all home appliances as well as heavy and costly as well as controlling equipments of power system. so, here when extra will come during fault at load side which will eliminate before connecting the SVC controlling device.

4.1Description Of The System

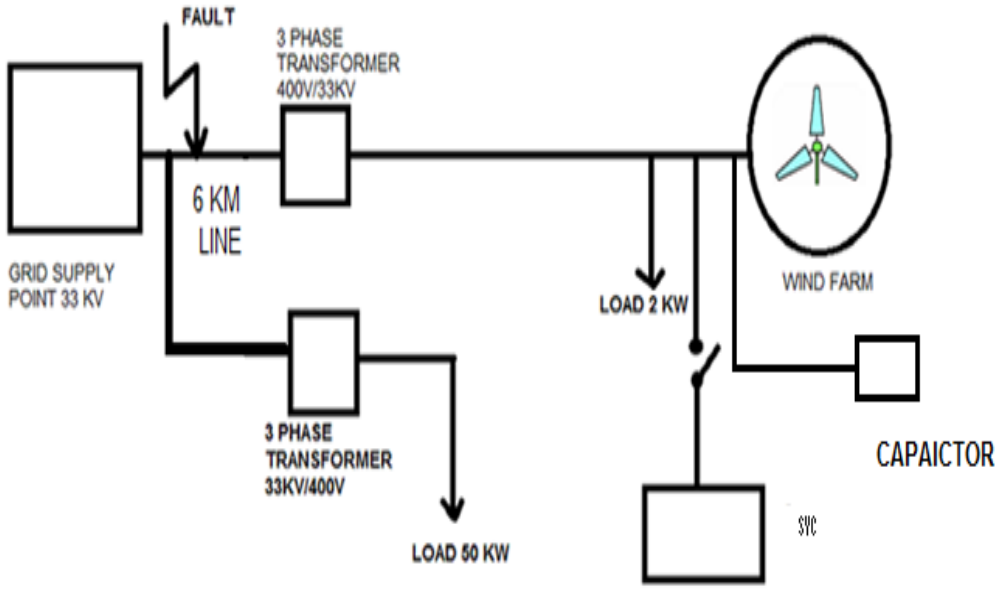


Figure.20 Single line diagram for simulation

4.2 Modeling For Main Supply

This is also called main supply source from grid, whose function is to give full supply to load end and so here is load connected through transformer. After stepping down the voltage it directly goes to the load side. When grid supply is connect to small grid than immediately trying to synchronize the system with whole equipments and load with desirable output tendency or demand. But when fault is coming and or in black outs cases we need to shut down the system and run with the DG source. Here in simulation I have shown wind generation as a DG but we can take any other one or more DG like solar, fossil fuel, geothermal, ocean wave, bio-mass energy generation system. those DG systems are having less pollution. So here parameter of Grid source is given below.

Phase to phase voltage (rms)	33KV
Frequency (Hz)	60Hz
Base voltage (KVA)	25
x/r ratio	7
Three phase short circuit voltage (VA)	100e6

Table.2 Grid source parameter values

4.3 Modeling of Transformer

Three phase transformer is connecting with the line which having function either to step down the voltage or step up the voltage. Basically, two transformer are connected with the line. One, is connecting before the non linear load. And another one is connected after the feeder for stepping down the voltage. Different parameter has discussed in given table.

Nominal power	250 MVA (T_1)	250MVA (T_2)
W_1 ,ph-ph voltage	33KV (T_1)	40KVA (T_2)
W_2 ,ph-ps voltage	400 V (T_1)	33KV (T_2)
Magnetization resistance and reactance	500 Rm &Lm (T_1)	500 Rm &Lm (T_2)

Table.3 Parameter values for transformer

4.4 Modeling of Three Phase Fault for system

Three phase fault may be any kind of fault that may be single line, double line to ground fault, triple line to ground etc. basically two types of faults in system tends to have. One is

internal fault and another is external. In internal fault, tendency of occurring internal fault is sudden switching and short circuit in components and other protecting equipments. When this kind of fault occur it deviate the waveforms and produce transients in them. Which further cause harmonics in system and became the reason of system failure, also increases the system maintenance. In external fault, there case of damaging the transmission line due bad environment conditions. Some time trees are bend down over the transmission pole and line. This kind fault responsible to hug loss in sub-station or grid. So, here in this thesis work modeling of three phase fault has been done for getting appropriate results from the system.

Fault resistance (ohm)	0.001
Ground resistance(ohm)	0.01
Snubber resistance(ohm)	1e6
Snubber capacistance(ohm)	Inf

Table.4 Parameter Values For Three Phase Fault In System Modeling

4.5 Modeling of Wind Turbine

Wind turbine, which are responsible to generate electricity from wind flow in air. Air is natural resource of nature which has no cost. In practical wind turbine are mostly available on sea coastal site. Two types of wind turbine are manufactured in industries names as Horizontal Axis Wind Turbine (HEWT) and Vertical Axis Wind Turbine (VEWT).

1. HEWT, are of 2 or 3 blades, but some have few or more blades. there are two kinds HAWT are Upwind turbine and Downwind turbine. HEWT, make difference in the pressure of top and bottom surface results in an aerodynamic life Horizontal axis wind turbine make difference in the pressure of top and bottom surface results in an aerodynamic life.
2. Rotor of VEWT turbines are constructed vertically and component like generator and other primary and secondary components are mounted nearer to ground so maintenance is easy. When the turbine is mounted on roof of building this can be increase the speed of wind can double speed of turbine. if the height of roof top fifty percent of building height, than this is near to optimum maximum energy and minimum win turbulence.

Here, in this thesis work at specific parameter the modeling of wind turbine has been done.

Nominal output power	1.5MW
Base power at electrical generator	1.5/0.9 MVA
Wind speed	14 m/s

Maximum power at base wind speed	0.73 p.u
Base rotational speed	1.3 p.u
Pitch angle	0

Table.5 Parameter Values For Wind Turbine

Characteristics of wind turbine when pitch angle of the rotor is Zero degree, the characteristics is shown given below fig. is between turbine speed (p.u) of nominal generator speed at x-axis of plane and turbine output power (p.u) of nominal mechanical power at y-axis.

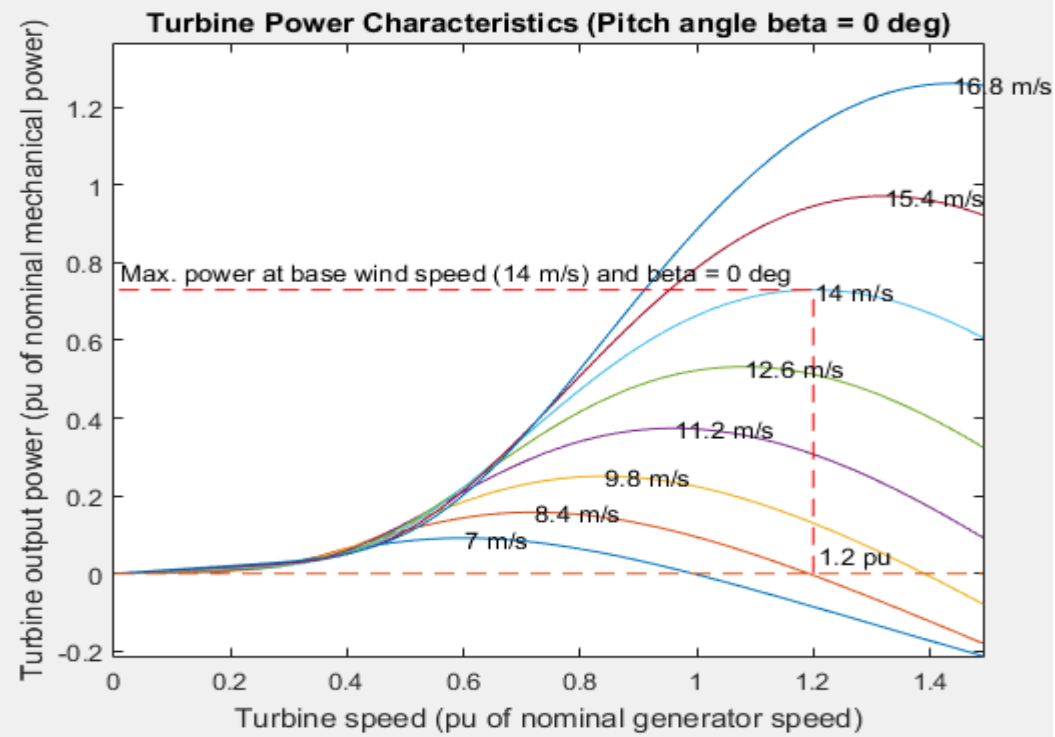


Figure.21 Wind Characteristics At Zero Degree Pitch Angle

4.6 Modeling of Induction generation

Generator is feeding power from the wind turbine, here in this system model of squirrel-cage induction generator has been designed. which is generally set at specific parameter to describe the output results but we can change the generator type and its parameter function. So, given below the table different parameter values has set to achieve appropriate result.

Voltage	400 V
Stator resistance (R_s)	0.01481
Stator inductance (L_{Is})	0.04881

Rotor resistance ($R_{r'}$)	0.008464
Rotor inductance ($L_{lr'}$)	0.04881
Mutual inductance (L_m)	2.241
Inertia constant	0.258
Friction factor	0.05479
Pole pair	2
Frequency (Hz)	60

Table.6 Parameter values for asynchronous machine or induction generator

4.7 Modeling of Static var compensator (SVC)

Phasor type model has taken to simulate with the system and controller having regulated voltage reference and Droops Xs is 0.03 p.u/phase and also having voltage regulator gain, Kp=0, Ki=300.and compensate reactive and real power to system when system under fault and various load are connected. It prevent the system from leading and lagging p.f. it is help to improve power quality issues by analyzing the fault automatically and compensate without manual operation. So , in this thesis work ,modeling of SVC in MATLAB simulation has done at standard parameter values which is given below the fig.

Nominal voltage	500KV
Three phase base power (Pbase)	110KVA
Reactive power limits(Qc)	200MVAR, -200MVAR
Average time delay(Td)	4e-3

Table.7 Parameter values for static var compensator a FACTS device

4.7.1 SVC Basic simulation Model

In simulation of basic static var compensator model, purpose to design the model for injection of reactive power (Q) and real power (P). TCR and TSC means Thyristor controlled reactor and Thyristor switched capacitor, are two branches of SVC and their rating selection depend upon operation condition. For example, inductor having 10H and capacitor having 4μF. then SVC tends to inject 0.3 to 0.8MVAR into 33KV system.[30]

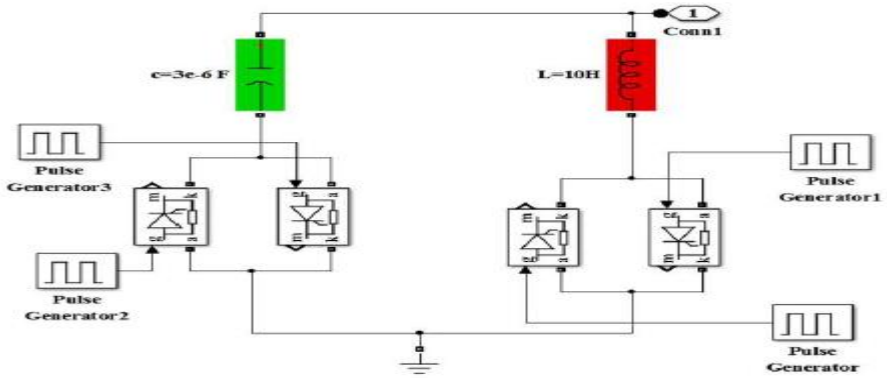


Figure.22 Basic model for SVC

Thyristor controlled reactor and Thyristor switched capacitor, are two branches of SVC and their rating selection depend upon operation condition.

CHAPTER 5

RESULT AND DISCUSSION

Result has taken into three cases from the MATLAB/SIMULINK software , in this software simulation of different models of power system with wind DG system as well as main source interconnecting with line to load and SVC a static VAR compensator model which shunt connected with transmission and distribution system. due to this, control and flow of real and reactive power is inject to system which prevent from hug loss at generation, transmission and distribution side.

In case 1, simulation model of distributed generation and grid without SVC and fault.

5.1 Model Without SVC And Fault

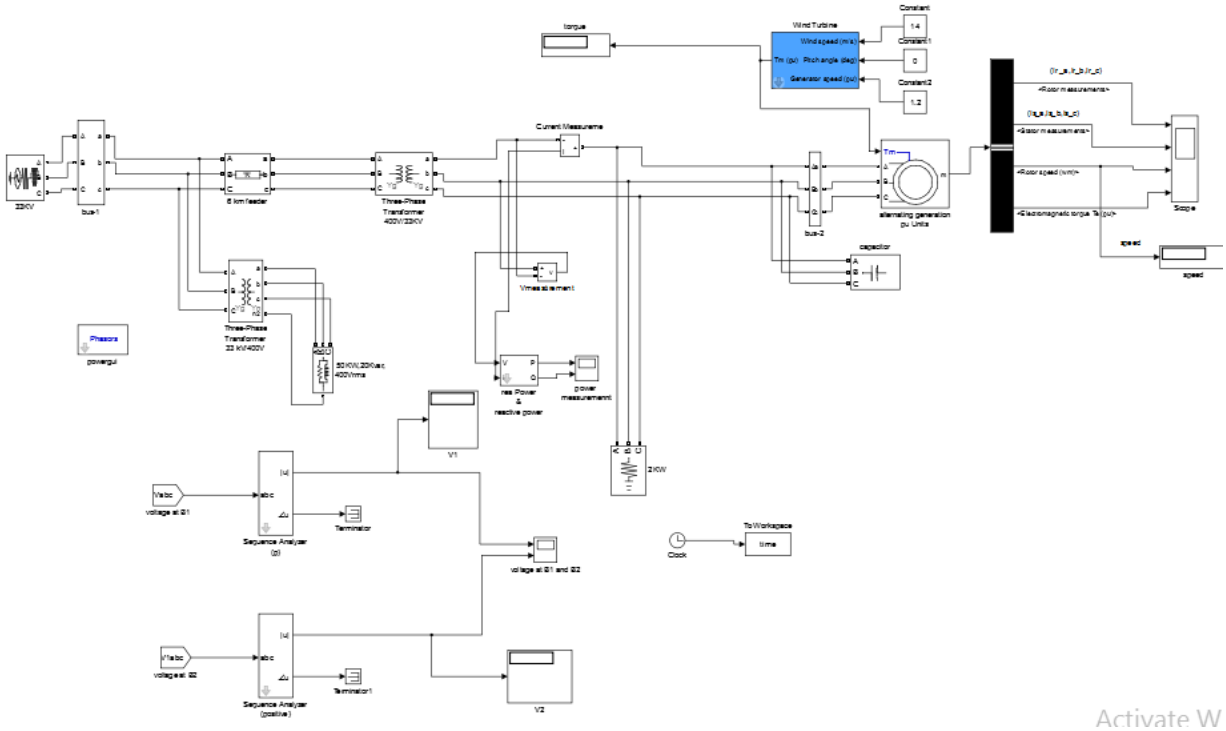


Figure.23 MATLAB simulation model without fault and SVC

The above the figure is DG with main grid supply without Static VAR compensator and fault. This model has supplying load to end user. Normally loads are non linear in nature, so inductance and capacitance have consume by load, 50KW and 2KW load is connected to the transmission and distribution side. This time positive sequence of voltage at BUS-1 and BUS-2 can evaluated are positive sequence at Voltage at B-1 is 0.9940 and positive sequence of voltage at B-2 side is 0.9925

Without fault torque at wind turbine which form due to rotation of rotor and leads to torque so this should not be more exceeding so it is about -0.9656 and rotor speed of squirrel cage induction generator that is W_m should be 1.0876

5.1.1 Output Results For This Modeling Simulation

Output for current of modeling, in three forms, one is Rotor measurement in which rotor current, rotor voltage and rotor flux is taken out.

Second one, stator measurement in which stator current, stator voltage and stator flux are present.

Third one, mechanical measurement in which speed of rotor and electromagnetic torque are present.

1. Given below figure is output of plots between rotor current and stator current.

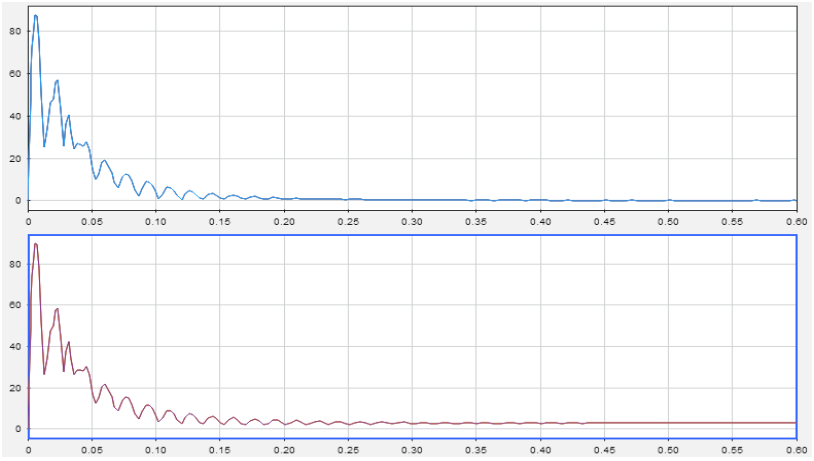


Figure.24 Plot of Rotor current, Ir_abc (p.u) and stator current, Is_abc(p.u)

2. Output plot between rotor and stator flux without fault and SVC

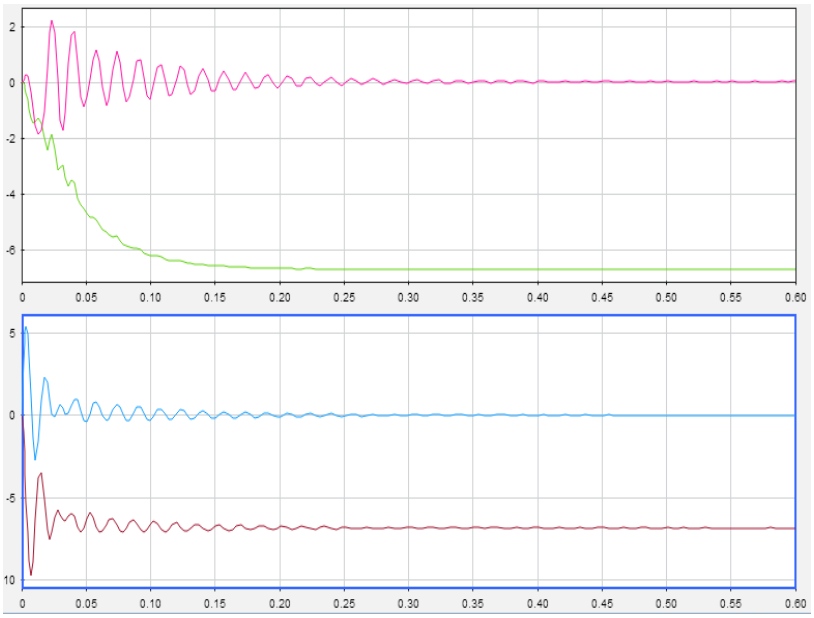


Figure.25 Rotor flux and stator flux,phis_d(p.u) &phis_q(p.u)

3. Output plot between stator and rotor voltage , V_s &V_r

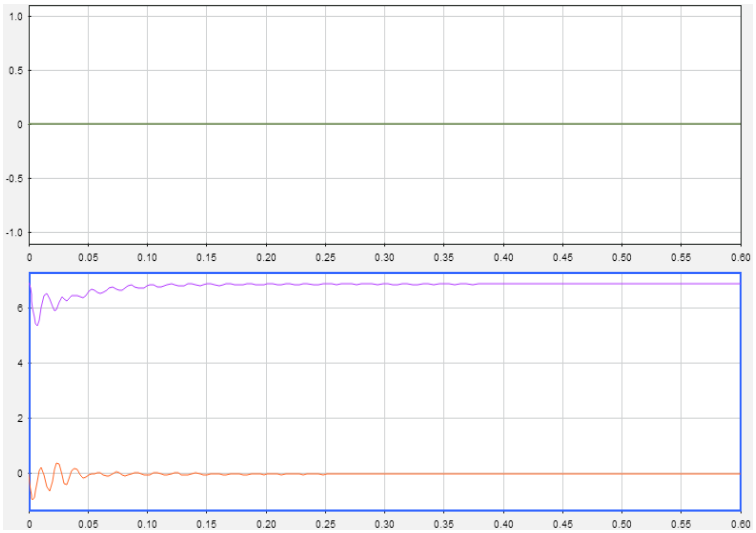


Figure.26 Plot between rotor voltage and stator voltage

4. Output for rotor speed, W_m

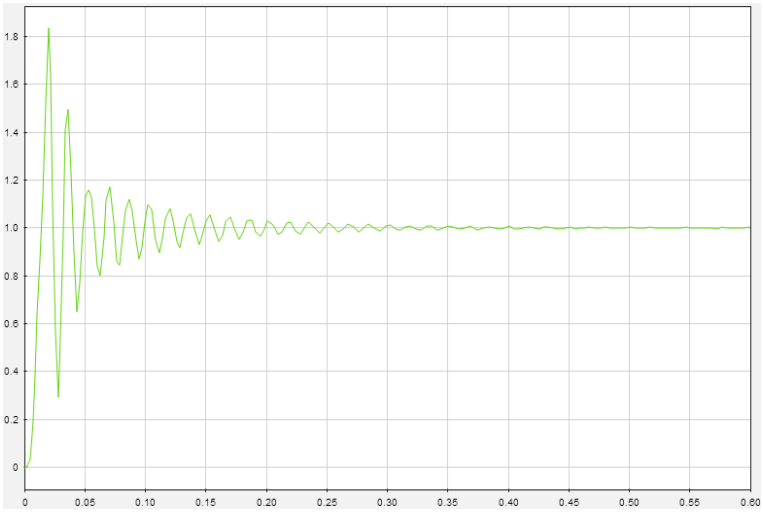


Figure.27 Rotor speed W_m

5. Output graph for electromagnetic torque, T_m

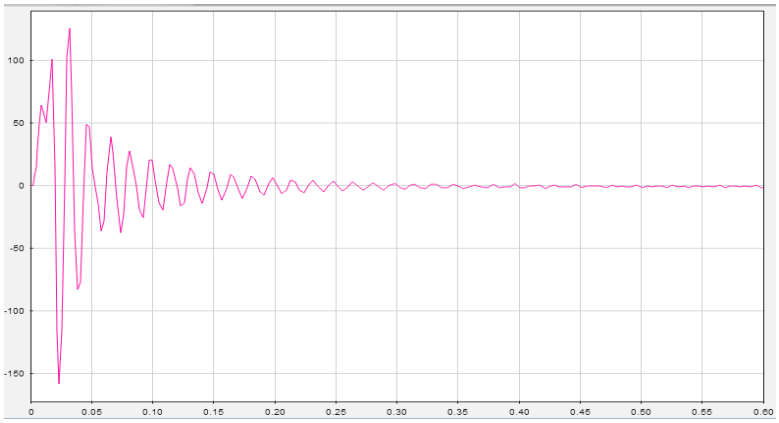


Figure.28 Electromagnetic torque T_m

6. Output for over signals like Rotor, Stator and Mechanical measurement

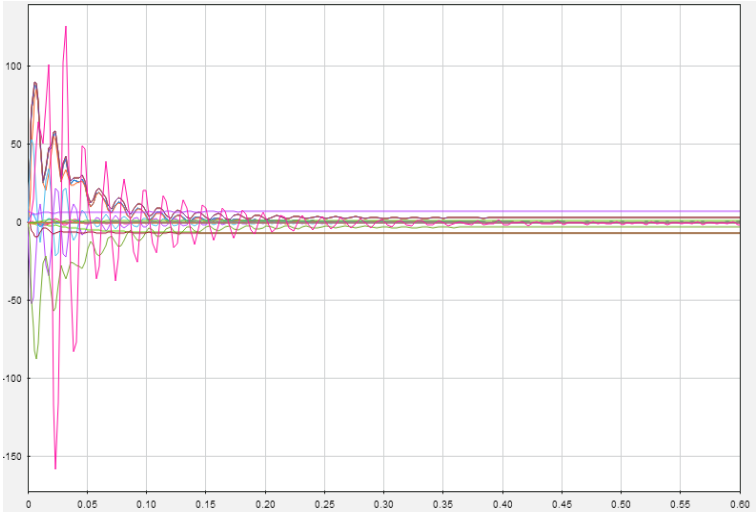


Figure.29 Overall scope output of induction generator

7. Output for Voltage at Bus-1 and Bus-2

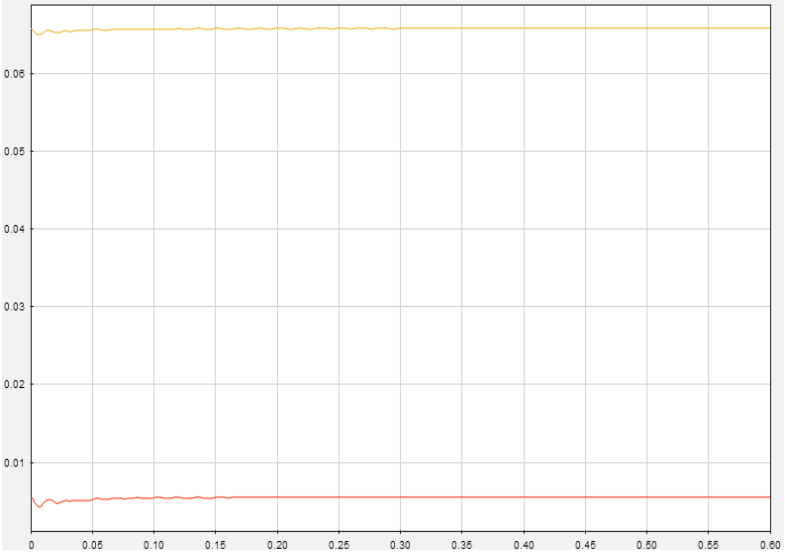


Figure.30 Voltage at Bus-1 and Bus-2 ,V_{b-1} &V_{b-3}

In case 2, simulation model of DG and grid with Fault but without SVC

5.2 Model With Fault And Without SVC

The above the figure is DG with main grid supply without Static VAR compensator but with fault. This model has supplying load to end user. Normally loads are non linear in nature, so inductance and capacitance have consume by load, 50KW and 2KW load is connected to the transmission and distribution side. This time positive sequence of voltage at BUS-1 and BUS-2 can evaluated are positive sequence at Voltage at B-1 is 0.9950 and positive sequence of voltage at B-2 side is0.9945

With fault, torque at wind turbine which form due to rotation of rotor and leads to torque so this should not be more exceeding so it is about -0.9652 and rotor speed of squirrel cage induction generator that is W_m should be 1.008

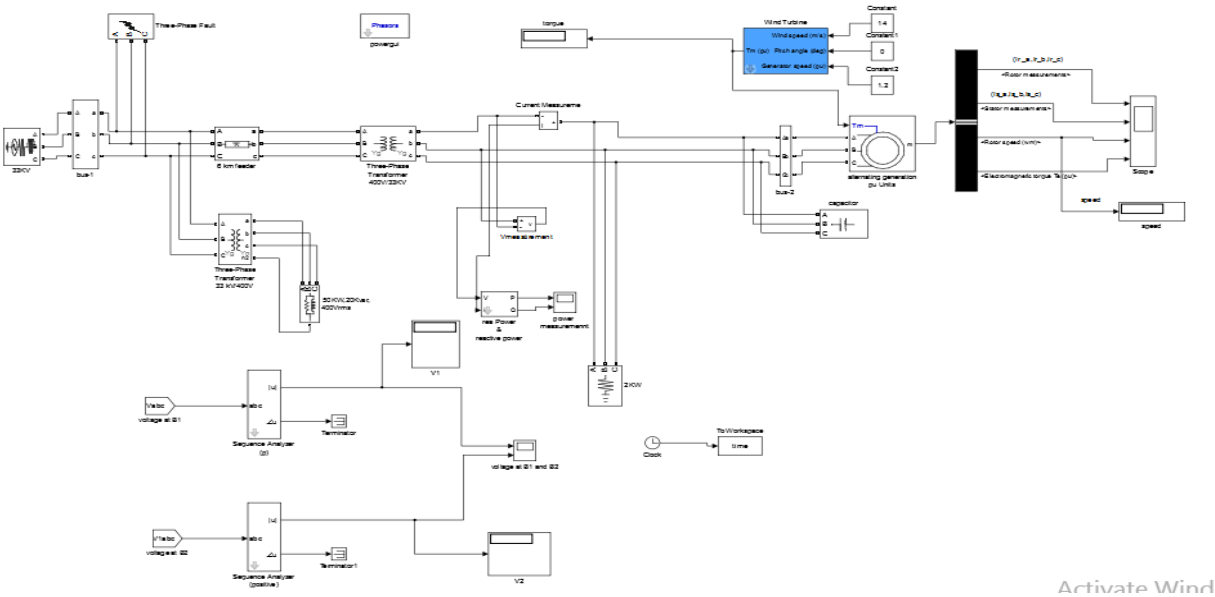


Figure.31 MATLAB simulation under fault without SVC

5.2.1 Output results for this modeling simulation

Output for modeling is given in three forms which are given below.

One is Rotor measurement in which rotor current, rotor voltage and rotor flux is taken out.

Second one, stator measurement in which stator current, stator voltage and stator flux are present.

Third one, mechanical measurement in which speed of rotor and electromagnetic torque are present.

1) Output for overall system in which Stator,Rotor and Mechanical measurements has shown after applying three phase fault.

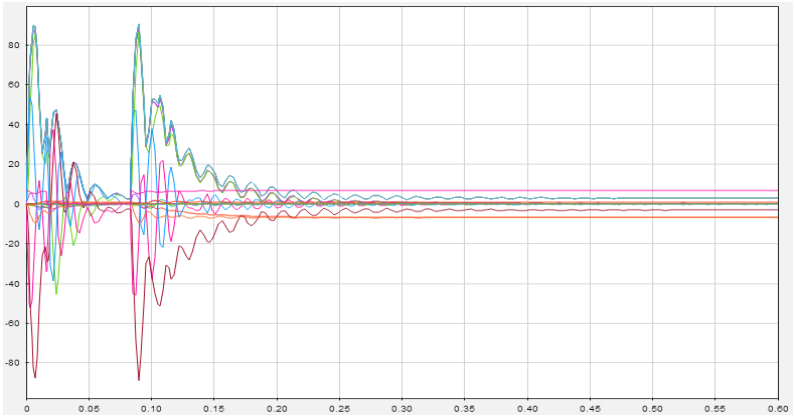


Figure.32 Overall plot of scope having three-phase fault without SVC

2) Output of Bus-1 and Bus-2 after three phase fault, V_{b-1},V_{b-2}

Figure.33 BUS-1 and BUS-2 having fault without SVC

3) Overall output for waveform of this modeling

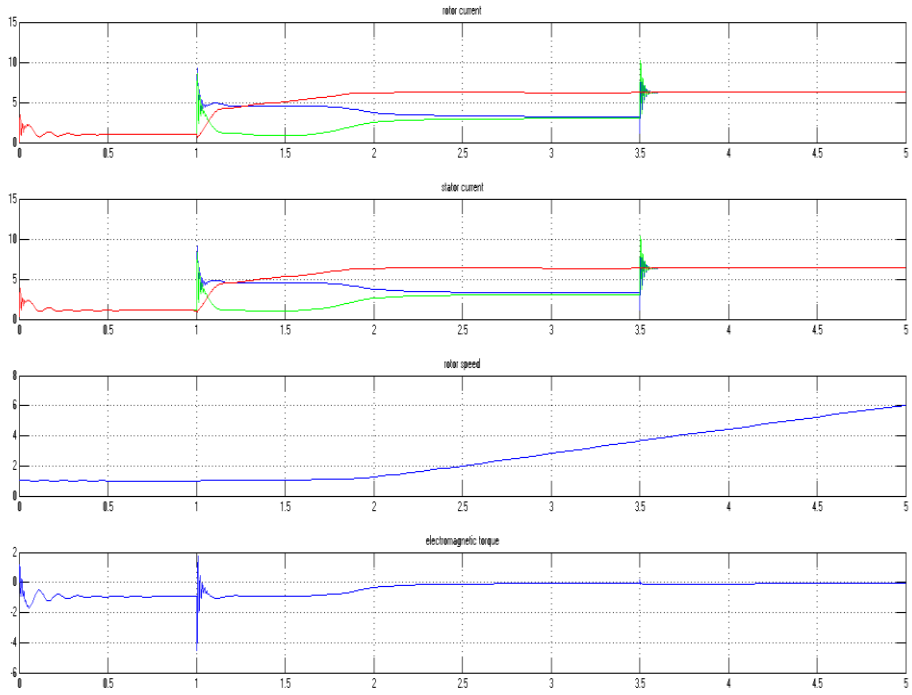


Figure34. output waveform under fault situation with normal capacitor bank

In case 3, simulation model of DG and grid with Fault and SVC

5.3 Model with fault and SVC

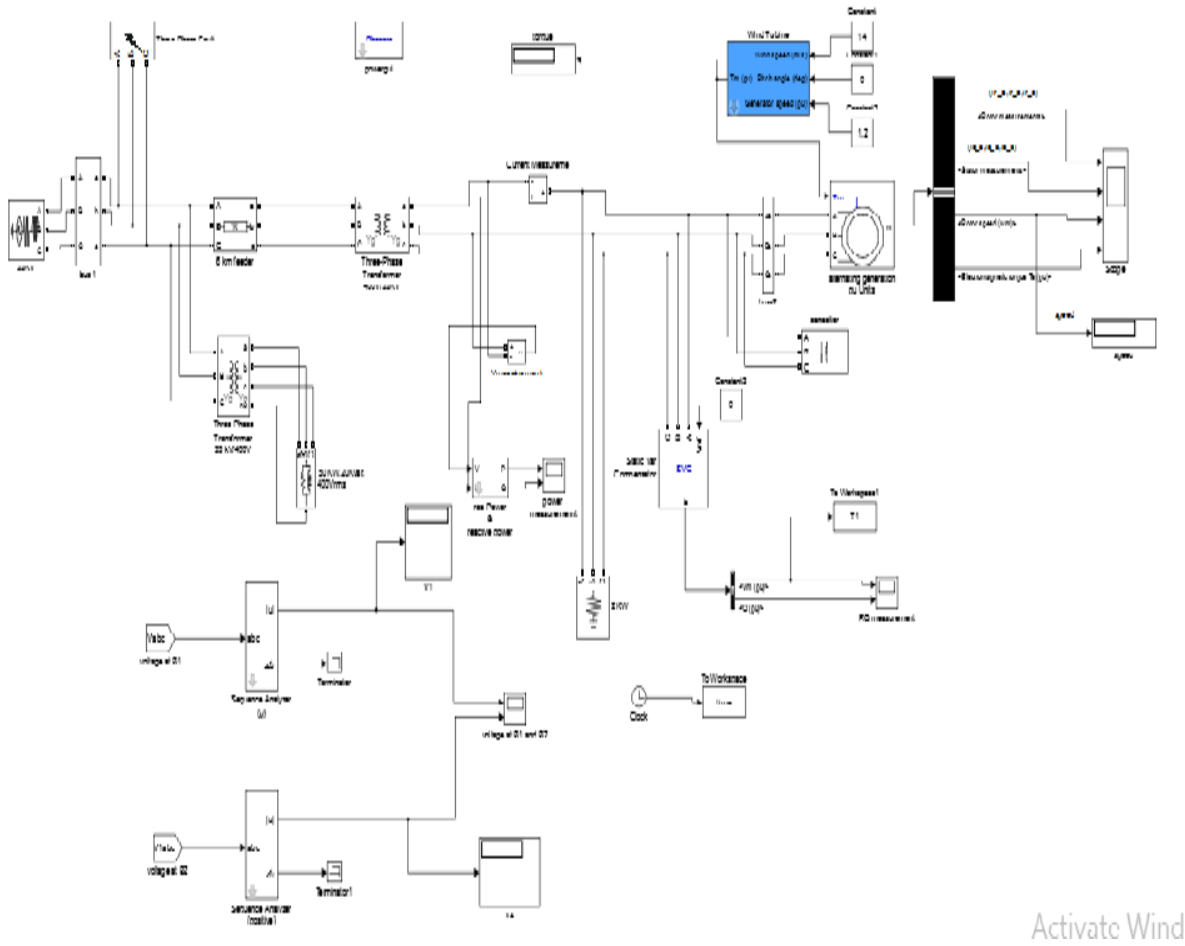


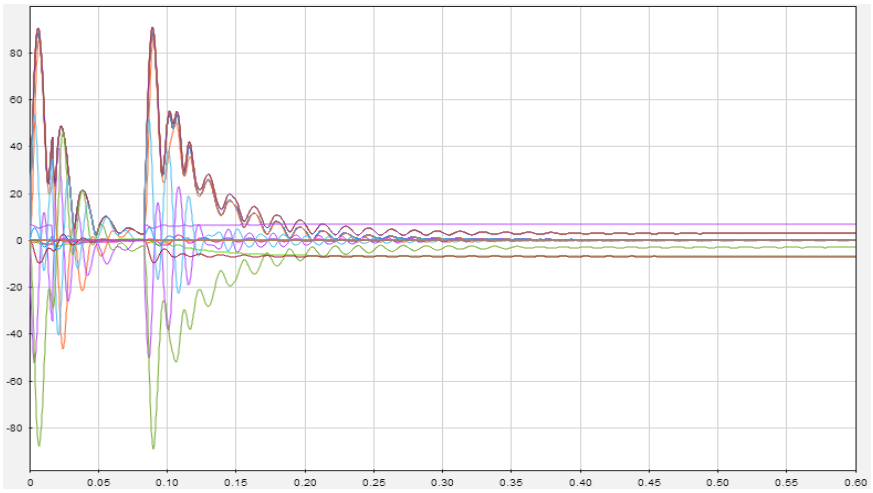
Figure.35 MATLAB simulation during fault with SVC

The above the figure is DG with main grid supply with Static VAR compensator and fault. This model has supplying load to end user. Normally loads are non linear in nature, so inductance and capacitance have consume by load, 50KW and 2KW load is connected to the transmission and distribution side. This time positive sequence of voltage at BUS-1 and BUS-2 can evaluated are positive sequence at Voltage at B-1 is 0.9956 and positive sequence of voltage at B-2 side is 0.9967

With fault torque at wind turbine which form due to rotation of rotor and leads to torque so this should not be more exceeding so it is about -0.9652 and rotor speed of squirrel cage induction generator that is W_m should be 1.010.

5.3.1 Output For This Simulation Model

1) Output for overall system in which Stator,Rotor and Mechanical measurements has shown after applying three phase fault with SVC.



Fgure.36 Overall graph of rotor measurement and stator measurement

2) Output graph for reactive and real power compensation after fault

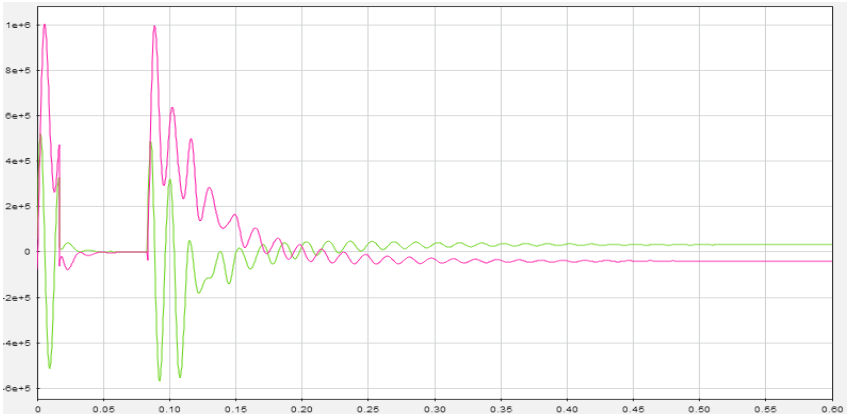


Figure.37 Compensation of Real and Reactive power after fault

3) Overall ouput waveform for SVC when fault connected

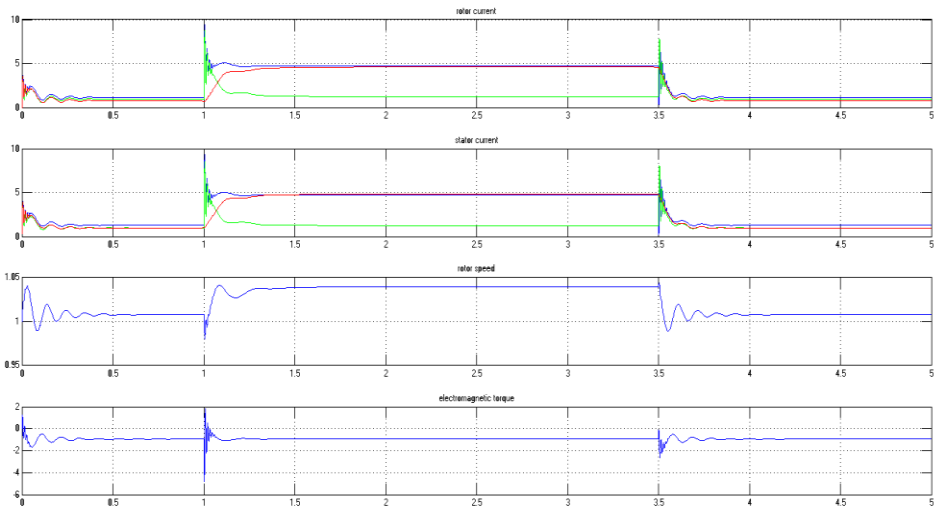


Figure.38 Overall graph under fault condition with static var compensator

CHAPTER 6

CONCLUSION AND FUTURE SCOPES

6.1 CONCLUSION

In this thesis work it is discussed that the modeling and reactive and real power flow of wind DG with main source by using static var compensator (SVC) with the help of SIMULINK/MATLAB. The flexible alternating current transmission device that is static var compensator is used with DG power system to maximize the efficiency of output and can detect, analyze and prevent the fault, here fault may symmetrical or asymmetrical in nature. During fault in system, it will get effect on system p.f. which may minimize or maximize the lagging and leading p.f. For example, the system have configuration like 11KV generation and generated supply is transfer through power transformer without any change in frequency. The step up voltage 132 KV is further used for distribution purpose. But, when fault comes it may decrease or increase the value of voltage magnitude that causes fluctuation or deviating the p.f. of power system network. So, instead of capacitor bank we use a static var compensator to compensate the power flow in system due to any abnormal condition. More than 50MW load is demanding every day in rural and urban areas so, function static var compensator provide appropriate output and maintain unity power factor. In this way the power quality of power system network can be improved by connecting and automatic controlling device with transmission line. According to this paper the simulation of system model has done in three ways to understand the problem and correction of problem.

1. Simulation of DG without fault and SVC
2. Simulation of DG with fault and without SVC
3. Simulation of DG with fault and SVC.

In first simulation, it is shown that the DG has connected without SVC and fault. With this it is shown that load is consume normally as the generation take place. Here in this no need to control device to maximize the efficiency.

In second simulation, it is shown that the DG has connected with fault and without SVC. With this it is showing that consumers are not getting proper load. Even their appliances are also affected with this fault and also system components are in danger zone. So here need of automatic controller or device which can compensate the problem.

In third case, it is showing that simulation of DG with fault and SVC to maximize the efficiency of generation, transmission and distribution system by compensating the power problem automatically.

6.2 FUTURE SCOPE

Distribution generation sources are basically made up of renewable resources like wind ,solar, geothermal, ocean wave , biomass and micro hydro generation sources. These sources are more reliable and eco-friendly with environment. If two or more sources are combined

that make hybrid source than it will more reliable and economical in installation and operation. The interconnection one or more distributed generation sources have good impact in rural and urban electrification. Basically there are lots of rural areas in the world where no source of main grid connected. So, this thesis has shown best and economical use for those areas.

The installation of static var compensator a FACTS device in power system future will be of it. Because automatic controlling action with help of it TCR and TSC branches which are fully connected through thyristor bank. for automatic controlling and firing angle at various fault situations. In Present its use with EHV line is famous in US countries. Its future with micro grids having supply from DG to load may increase the power quality of system.

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