SIMULATION OF GRID CONNECTED WIND ENERGY SOURCE WITH STAT-COM TO IMPROVE VOLTAGE PROFILE

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Abstract— A renewable energy source consisting wind energy system connected with the grid, is proposed in this paper. This system is suitable for supplying electricity to isolated locations or remote villages far from the grid supply. The wind energy system is modeled with a wind-turbine prime mover with varying wind speed and fixed pitch angle to drive a squirrel cage induction generator. The wind system is integrated through an AC bus and the proposed system is supplied to R-L load. A static compensator is proposed to improve the load voltage profiles; it also mitigates the harmonic contents of the voltage and current. The static synchronous compensator is realized by means of a three-phase IGBT-based current controlled voltage source inverter with a self-supporting DC bus. The complete system is modeled and simulated using Matlab/Simulink. The simulation results obtained illustrate the feasibility of the proposed system and are found to be satisfactory.

Key words — stat-com, induction generator,

I. INTRODUCTION

Unlike the conventional energy sources, the non-conventional energy sources are clean, reliable, and abundant in nature. The environmental degradation such as pollution, global warming, and greenhouse gas emissions which are caused by conventional sources of energy and accelerated by ever-growing industrial activities throughout the world is a concern for all. The current researches, therefore, lay emphasis on harnessing renewable energy sources (RES) for generating electricity to supply power especially, to rural consumers where grid connection is not available. For such locations, decentralized power generation using available dispersed RES is a better and workable solution. A technological innovation, however, is needed to utilize these energy sources to an optimum level and to obtain greater efficiency. The combined system is likely to improve the generating capacity as well the reliability of the power supply. The reliability and cost-effectiveness of integrated renewable energy system at remote and distant places is evaluated using optimization technique with fairly good results. However, it is found that not many works have been done on the power quality analysis of integrated renewable energy system using solar and wind energy sources.

This system could be very successful especially in the sub-tropical region where there is sufficient rainfall. A. With the development of large wind turbine generators and advancement in solid-state devices, wind energy system (WES) has become one of the most viable options of generating energy. The proposed system is a combination of a variable-speed wind-turbine coupled to induction generator. The performances of the system under load namely R-L load are presented. The reactive power compensation using static synchronous compensator (STATCOM) is presented. The STATCOM is observed to be working well thereby regulating the terminal voltage and reducing the harmonic contents of the system voltage and current.

II TYPES OF WIND TURBINE GENERATORS

- Doubly Fed Induction Generators (DFIG)
- Squirrel cage Induction Generators (SCIG)

DOUBLY FED INDUCTION GENERATOR (DFIG)

Currently DFIG wind turbines are increasingly used in large wind farms. A typical DFIG system is shown in the below figure 1. The AC/DC/AC converter consists of two components: the rotor side converter $C_{rotor}$and Grid side converterC_{grid}. These converters are voltage source converters that use forced commutation power electronic devices (IGBTS) to synthesize AC voltage from DC voltage source. A capacitor connected on DC side acts as a DC voltage source. The generator slip rings are connected to the rotor side converter, which shares a DC link with the grid side converter in a so called back -to-back configuration. The wind power captured by the turbine is converted into electric power by the IG and is transferred to grid by stator and rotor windings. The control system gives the pitch angle command and the voltage commands for $C_{rotor}$and C_{grid} to control the power of the wind turbine, DC bus voltage and reactive power or voltage at grid terminals.

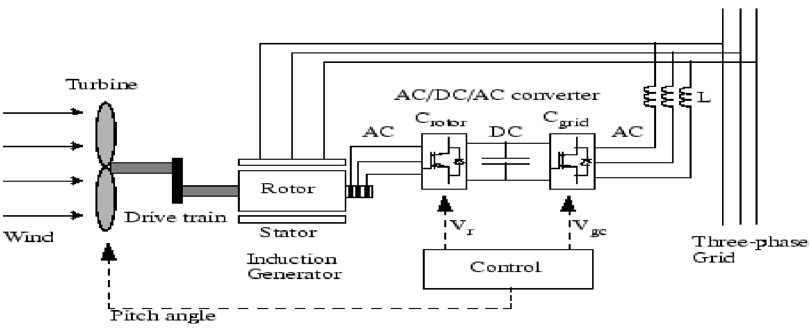

Fig1: A DFIG and wind turbine system

SQUIRREL-CAGE INDUCTION GENERATOR (SCIG)

The second concept consists of a rotor coupled to a SCIG through a gearbox as illustrated in Figure 2 the SCIG is directly grid coupled. The SCIG speed changes by only a few percent because of the generator slip caused by changes in wind speed. Therefore, this generator is used for constant-speed wind turbines. The generator and the wind turbine rotor are coupled through a gearbox. Wind turbines based on a SCIG are typically equipped with a soft-starter mechanism and an installation for reactive power compensation, as SCIGs consume reactive power. SCIGs have a steep torque speed characteristic and therefore fluctuations in wind power are transmitted directly to the grid. These transients are especially critical during the grid connection of the wind turbine, where the in-rush current can be up to 7–8 times the rated current. Therefore, the connection of the SCIG to the grid should be made gradually in order to limit the in-rush current. The major problem is because of the magnetizing current the full load power factor is relatively low. Too low a power factor is compensated by connecting capacitors in parallel to the generator. In the case of a fault, SCIGs without any reactive power compensation system can lead to voltage instability on the grid. The wind turbine rotor may speed up, for instance, when a fault occurs, owing to the imbalance between the electrical and mechanical torque. Thus, when the fault is cleared, SCIGs draw a large amount of reactive power from the grid, which leads to a further decrease in voltage.

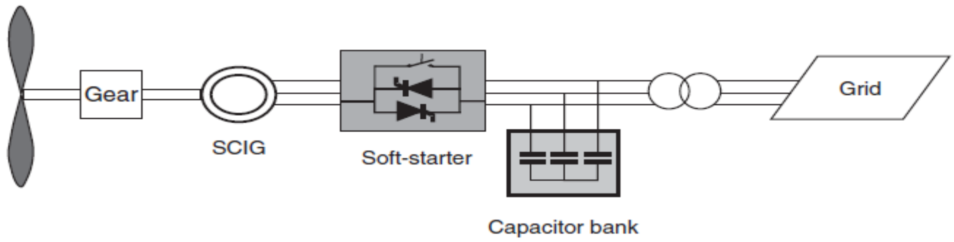

Fig 2 SCIG and wind turbine system

III STATCOM

BASICS OF STATCOM

Reactive power compensation is an important issue in the control of electric power systems. Reactive power increases the transmission system losses and reduces the power transmission capability of the transmission lines. Moreover, reactive power flow through the transmission lines can cause large amplitude variations in the receiving-end voltage. This chapter illustrates the effect of STATCOM in power system on reactive power control by proper modeling of simple power system and voltage source converter based. STATCOM using simulink and simpower system toolboxes in MATLAB. Today's power transmission and distribution systems face increasing demands for more power with better quality and higher reliability at lower cost. Developing countries can apply versatile voltage regulation and system stabilization measures in order to effectively utilize the existing transmission networks. The use of power electronics in the form of SSSC, STATCOM and UPFC is well-established independent of the specific Application.

A STATCOM is a controlled reactive-power source. It provides the desired reactive-power generation and absorption entirely by means of electronic processing of the voltage and current waveforms in a VSC. A STATCOM principle diagram is shown in the fig 3

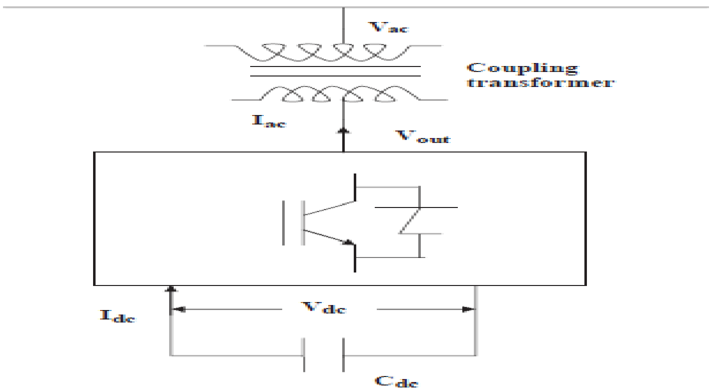

Figure 3 A functional model of STATCOM

The VSC is connected to a utility bus through shunt transformer. Vac is the bus voltage. Iac is STATCOM injected current. Vout is the VSC output voltage. Vdc and Idc are the DC capacitor side voltage and current. An IGBT with back to back diode denotes the 3 arm IGBT bridge. Top three IGBTs are called as positive group and bottom three IGBTs are called as negative group IGBTs. The inverter operation takes place, when IGBTs conduct and converter operation takes place, when diodes conduct. Figure 4 shows the concept of STATCOM power exchange.

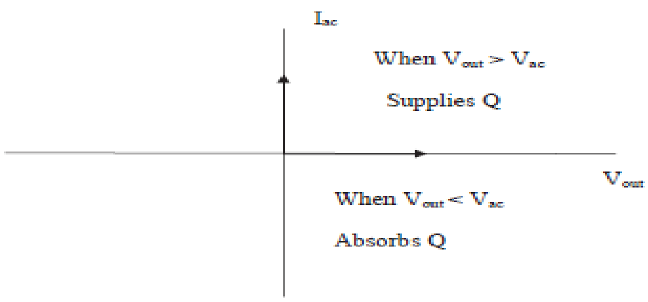

Figure 4 STATCOM power exchange

STATCOM is seen as an adjustable voltage source behind a reactance. It means that the capacitor banks and shunt reactors are not needed for reactive-power generation and absorption, thereby it gives the STATCOM, a compact design. Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads—the template will do that for you.
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EQUIVALENT CIRCUIT MODEL OF STATCOM

The STATCOM consists of 3 phase bus, shunt transformer, VSC and DC capacitor. Figure 5 .a shows the equivalent circuit of the STATCOM.

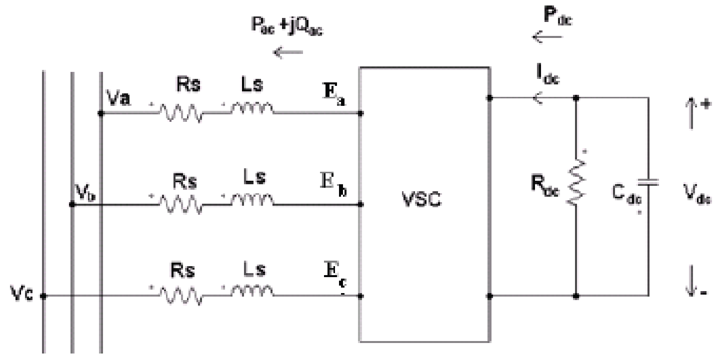
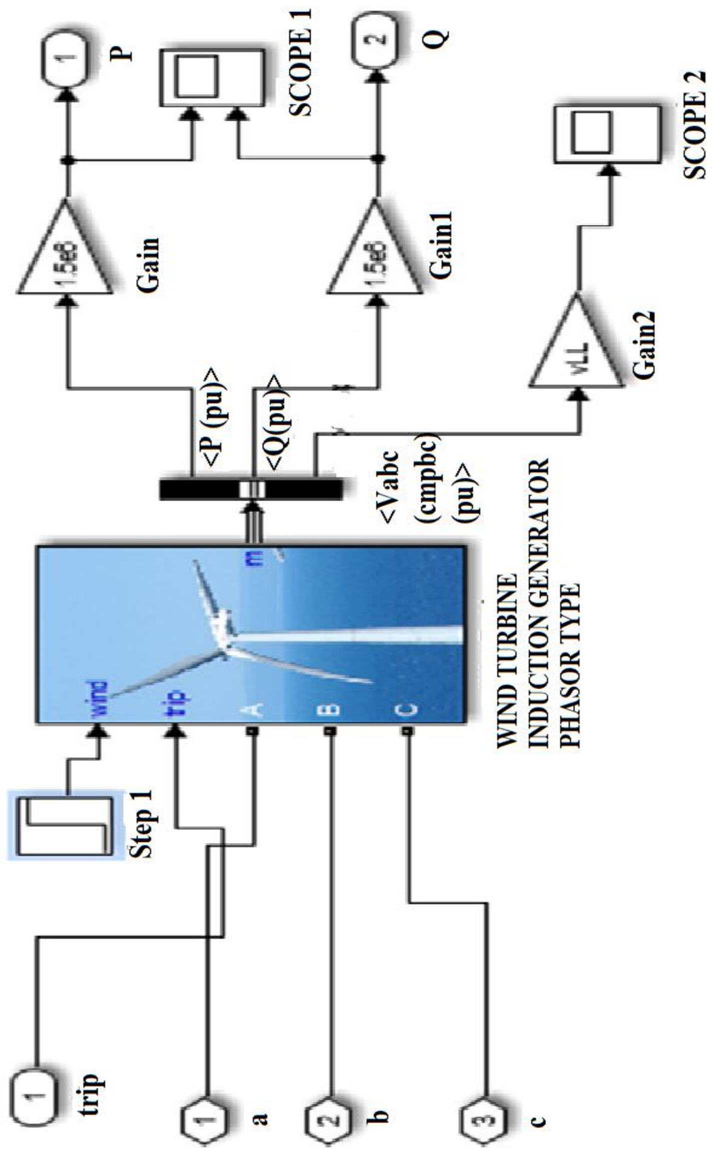


Figure 5.Equivalent circuit model of STATCOM

IV WIND SYSTEM SIMULATION MODEL



SIMULATION PARAMETERS FOR WIND ENERGY SYSTEM

SL.No	Parameter	Value
1	Frequency	50HZ
2	Positive sequence amplitude	25KV
3	Nominal power	4MW
4	Winding resistance	0.01ohm
5	Positive sequence no load excitation current	2A
6	Positive sequence no load losses	1000W
7	Zero-sequence resistance(R0)and reactance(X0)	0.025 ohm,0.75ohm
8	Magnetization-branch resistance	500 ohm
GENERATOR PARAMETERS		
9	Nominal power	1.5Mw
10	Stator resistance	0.004843
11	Stator inductance	0.1248ohm
12	Rotor resistance	0.004377ohm
13	Rotor inductance	0.1791ohm
14	Magnetizing reluctance	6.77
15	Inertia constant (k)	5.04
16	Friction factor (f)	0.01
17	Pair of poles(p)	3
TURBINE PARAMETERS		
18	Pitch angle	0
19	Nominal wind turbine mechanical o/p power	1.5MW
20	Base wind speed	12m/sec
21	Maximum pitch angle(deg)	45
22	Maximum rate of change of pitch angle(deg/sec)	2

V SIMULINK MODEL OF WIND SYSTEM CONNECTED TO GRID WITH STATCOM

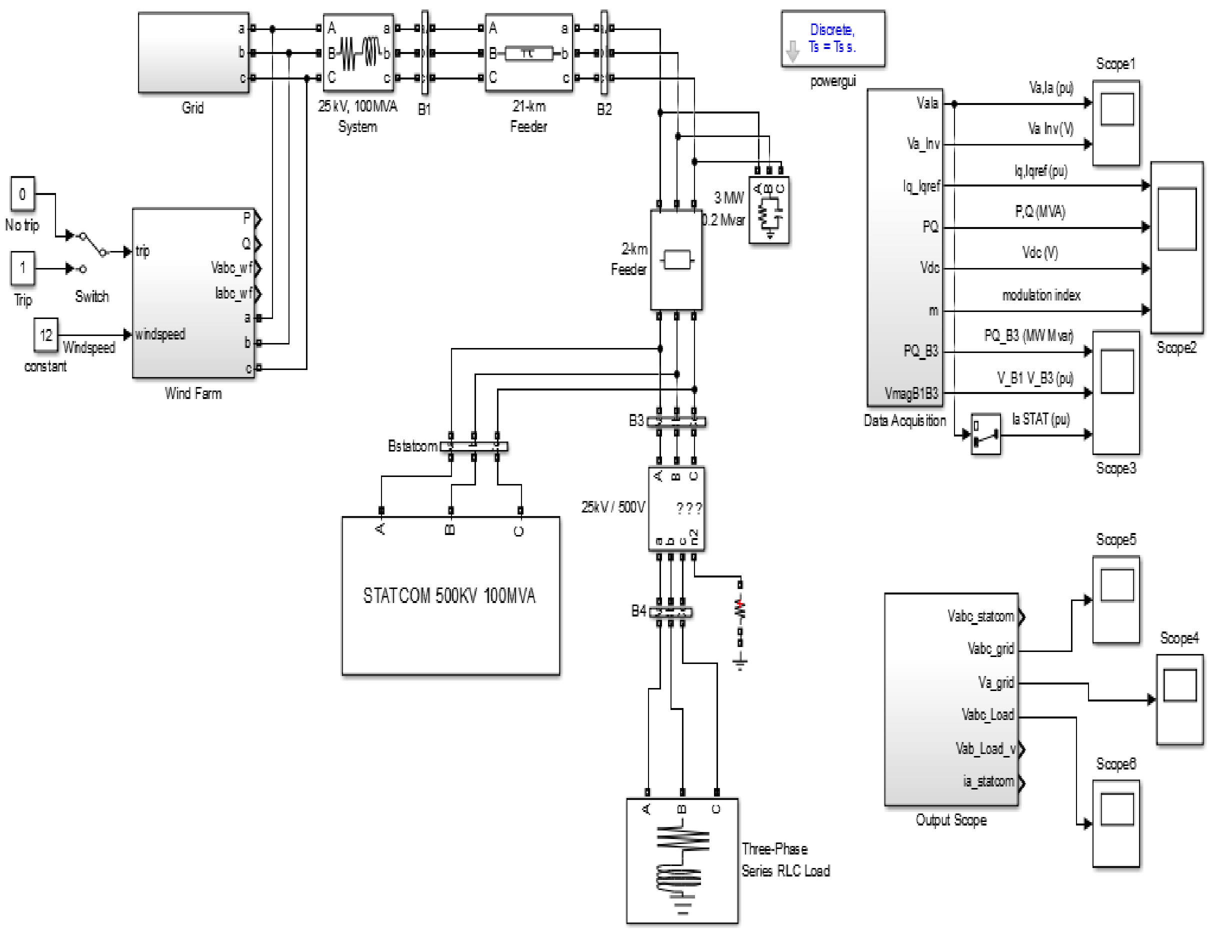
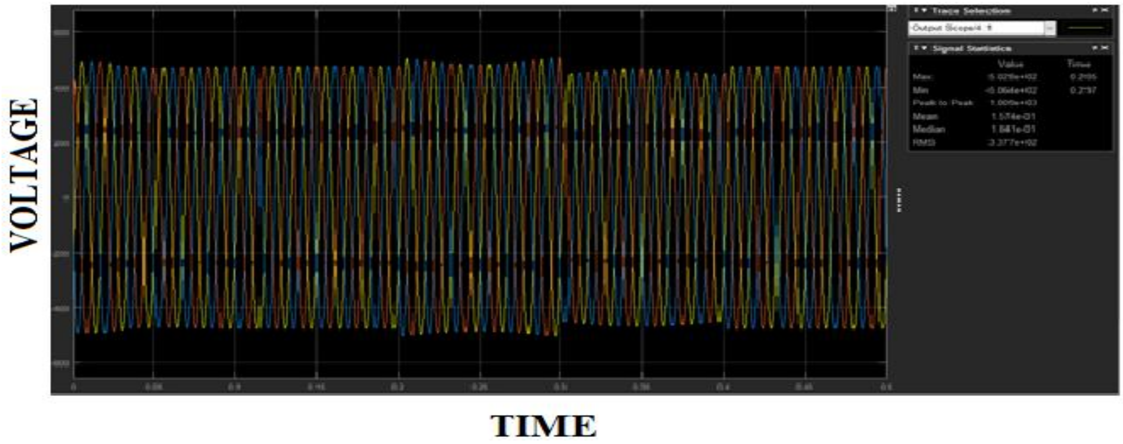


FIG 6 SIMULINK MODEL OF WIND SYSTEM CONNECTED TO GRID AND STATCOM

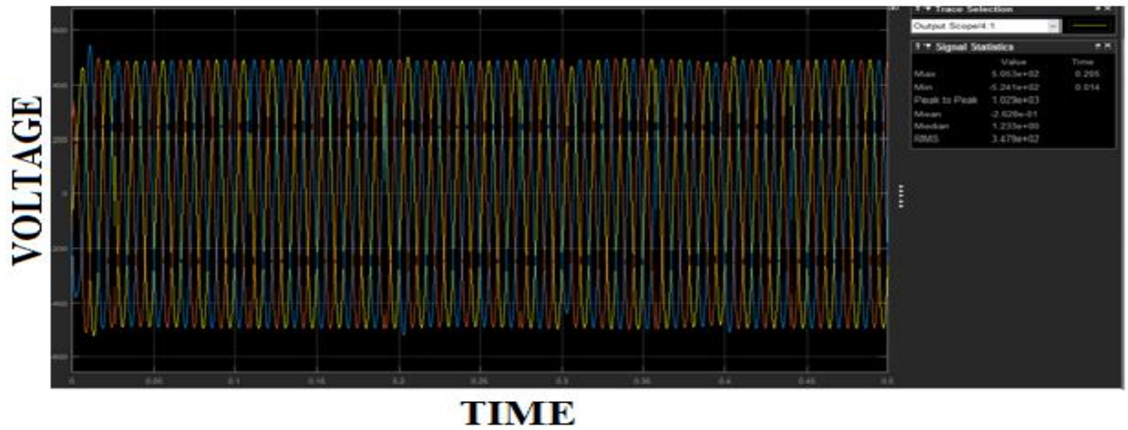
VI RESULTS

WAVEFORMS

LOAD VOLTAGE WITHOUT STATCOM



LOAD VOLTAGE WITH STATCOM



VARIATIONS IN OUTPUT WITHOUT STATCOM FOR RL LOAD OF 1MW AND 10MVAR

WIND SPEED IN (m/sec)	WIND FARM VOLATGE (VOLTS)	ACTIVE POWER (KW)	GRID VOLTAGE (VOLTS)
2	445.5	-82.6	436.5
3	445.2	-114	436.2
4	445	-114	436
5	445.1	-127	436.1
6	445.1	-127	436.1
8	448.1	15.1	437
10	444.7	349.4	435.7
12	429.6	303.6	421.6

VARIATIONS IN OUTPUT WITH STATCOM FOR RL LOAD OF 1MW AND 10MVAR

WIND SPEED IN (m/sec)	WIND FARM VOLATGE (VOLTS)	ACTIVE POWER (KW)	GRID VOLTAGE (VOLTS)
2	478.7	-61.38	469
3	479.1	-90.25	469.4
4	478.7	-112	469
5	478.5	-119.7	468.9
6	478.9	-986	469.3
8	479.3	322	469.6
10	479.2	311	469.5
12	484	466	469.4

VII CONCLUSIONS

In this work, an attempt has been made to investigate in detail the possibility of RES as one of the most effective ways of decentralized power generation. Besides increasing the generating capacity of the energy sources, the scheme is envisaged to greatly liberate the rural populace of the perennial energy demands. With the energy sources connected together, the reliability of the power system increases. The volatge aspects are studied and with the use of STATCOM the voltage regulations improves. The system voltage is well maintained at 500 V (rms) under different load conditions. The integrated system along with the addition of STATCOM can be seen as a viable option for supplying electricity to far flung areas.

We have observed that variations in output with and without statcom at different loads.With variable wind speed we are getting variable wind voltage,

1. For RL load of P=1MW & Q=5MVAR,with statcom
   a.For wind speed 2 m/s,the grid voltage is 490.3 volts.
   b. For wind speed 8 m/s,the grid voltage is 490.4 volts.
2. For RL load of P=1MW & Q=5MVAR,without statcom
   a.For wind speed 2 m/s,the grid voltage is 467.4 volts.\

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