Stability and Power Flow Control For Practical System With Wind Farm Using STATCOM

***Abstract*—In this study, a Static Synchronous Compensator (STATCOM) is used to regulate power flow in the TNEB-62 bus system (practical system).**

The test system for the wind farm is linked to the 34th bus (Nagercoil). The wind farm model was made using information acquired from the Nagercoil wind farms. The TNEB-62 bus system and wind farm modelling are done in the MATLAB environment. After the wind farm is connected to the specified bus, the voltage profile changes. The STATCOM that is connected to the particular bus in the test system gives the system the required reactive power under various operating conditions. This enhances the voltage profile of the system. Two distinct scenarios—one with and one without the usage of STATCOM in the wind farm—are simulated. The simulation results show that STATCOM-using wind farms perform better and have better control over the flow of power.

Keywords- Static Synchronous Compensator(STATCOM); Tamil Nadu Electricity Board (TNEB); Flexible AC Transmission System(FACTS).

I. INTRODUCTION

Due to the South West Monsoon's tunneling effect, Tamil Nadu has a great potential for wind. 7134 MW, or a stunning 40% of the nation's total installed wind capacity, is the state's installed wind capacity. In terms of the installed base, this elevates wind power to the position of greatest power generation technology in Tamil Nadu. Compared to approximately 1,000 MW in 2011–2012, only a little over 200 MW of wind generating capacity was built this year. The previous summer, wind energy was responsible for almost a third of the grid's power supply. According to the Ministry of New and Renewable Energy (MNRE), wind energy alone made up 12.6% of all the electricity that was fed into the grid in 2011–12. In the years 2012 to 2013, an extra 1000 MW of wind capacity is projected. The 6000 MW installed capacity of wind energy plants is to be increased according to the 12th five-year plan.The usage of a Static Synchronous Compensator (STATCOM) in conjunction with wind farms is investigated in [1] with the goal of stabilizing grid voltage following grid-side disturbances such as a three-phase short circuit failure, a transient trip of a wind turbine, and abrupt load changes. Static synchronous compensator STATCOM, a FACTS controller, was implemented to boost the efficiency of grid-connected wind farms. One essential function of the STATCOM is its capacity to either take in or add reactive power to the electrical grid. The power grid voltage management is thus achieved using STATCOM (a FACTS device). As soon as the wind farm is introduced into the system, there will be issues with the electricity quality.

A STATCOM can generate more reactive power than other FACTS devices like Static VAR Compensator (SVC) [5]. In [6], the performance of a PMG-based wind energy system employing a dynamic voltage regulator (DVR) was compared to one of the systems employing a STATCOM. It is recommended to use STATCOM in systems with large loads where reactive power consumption from the grid could cause serious effects on connected loads.

In [2], a comparison of stabilizing a wind farm with (Double Fed Induction Generators) DFIGs against (Static Synchronous Compensator) STATCOM under changing wind conditions and grid faults is presented. According to simulation data, both systems could stabilize the wind farm effectively, however the DFIGs system would be less expensive because it can supply reactive power through its frequency converters without the requirement for an external reactive power compensation unit, unlike the STATCOM system. It is now vital to address issues related to maintaining a reliable electric power system because wind power is the renewable energy source with the fastest-rising electrical output. In order to account for unforeseen circumstances like production-related fluctuations, the distribution network uses Flexible AC Transmission Systems (FACTS).

II. TEST SYSTEM CONFIGURATION

A. Bus test system TNEB 62

The TNEB 62 bus system consists of 89 transmission lines, 33 loads, and 19 generators. The starting point is 100 MVA. Table 1 provides information about the system's generator power and voltage rating.

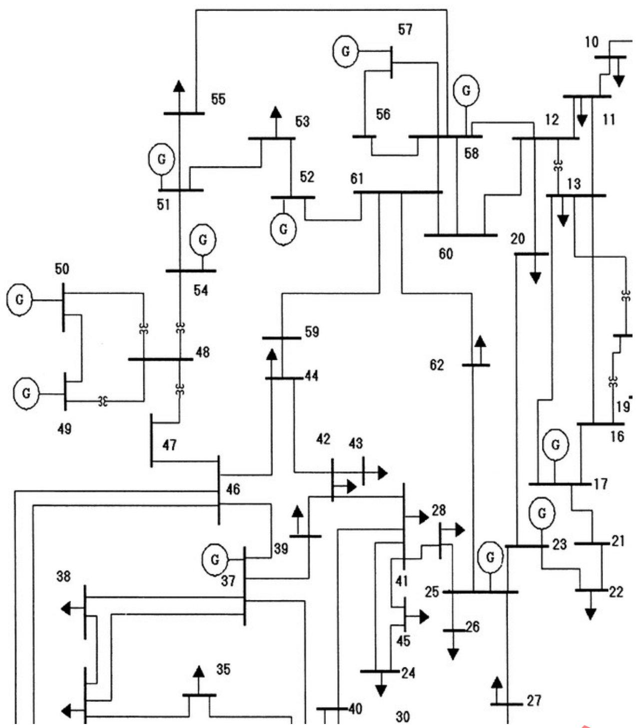


Fig.1 TNEB 62 bus test system

B. Model of a Wind Farm

Wind power refers to the energy that is contained in the wind. It is based on the third power cube of the wind speed. According to this relationship, even the smallest fluctuations in wind speed have a big impact on power. The mechanical power (in W) of a VSWT is given by,

$$P_m = 1/2 \rho . A_r . V_w^3 . C_p(\lambda, \beta) \quad (1)$$

where,

ρ is the air density (kg/m3)

Ar is the blade impact area (m3)

Vm is the wind speed (m/s)

Cp is the dimensionless power coefficient.

Table 1. Generator and Transformer Data for TNEB 62 Bus system

Sl. No	Bus no.	Generator Name	Generator Rating (MW)	Generator Voltage (KV)	GT Rating (MVA)	GT Voltage Rating (KV)
1	49	KADAMPARAI	400	11	540	11/220KV
2	2	ETPS	450	11	500	11/220KV
3	5	BBGAS	450	15.75	672.68	15.75/220KV
4	14	SPUDUR	300	11	424.26	11/220KV
5	17	MAPS	440	15.75	500	15.75/220KV
6	23	NLC1	2070	15.75	2514	15.75/220KV
7	25	N2MIN4	840	15.72	1008	15.75/220KV
8	32	TTPS	1050	15.75	1260	15.75/220KV
9	34	NAGERCOIL	500	33	600	33/220KV
10	33	KAYATHAR	100	11	180.27	7 11/220KV
11	51	KUNDAH	500	11	743.30	11/220KV
12	54	THUDAR	100	18	180.27	18/220KV
13	52	GOPI	150	18	250	18/220KV
14	57	MTRT	300	15.75	500	15.75/220KV
15	58	MTPS(swing)	840	15.75	1008	15.75/220KV
16	9	G POONDI	180.277	18	100	18/220KV
17	50	UDUMLPT	150	18	250	18/220KV
18	37	MADURAI	50	18	90.138	18/220KV
19	1	NMTPS	630	15.75	756	15.75/220KV

Table 2. Wind farm data

Wind Generator Rating		Transformer voltage Rating (KV)	Number of Units	Generating Capacity
Power (KW)	Voltage (V)			
250	415	415/33KV,33/220KV	452	113MW
500	690	690/33KV,33/220KV	363	181.5MW
1500	690	690/33KV,33/220KV	148	217.5MW

Data about wind farms is provided in Table 2. Three different power rating generators' data are shown in this table. The wind farm has a 512MW overall capacity, and its voltage ratings are 415V and 690V. By employing a step-up transformer attached to the wind-generating unit, the voltage is raised to 33KV (415V/33KV, 690V/33KV). Using a 33KV/220KV step-up transformer, the voltage is once more increased to 220KV.

C. STATCOM Model

By regulating the amount of reactive power injected into or absorbed from the power supply, the STATCOM controls the voltage at its terminal. The STATCOM produces reactive power (STATCOM capacitive) when the system voltage is low. At high system voltages, reactive power (STATCOM inductive) is absorbed. The reactive power is changed using a voltage-sourced converter (VSC) connected to the secondary side of a coupling transformer. The VSC converts a DC voltage source into a voltage V2 using forced-commutated power electronic components (GTOs, IGBTs, or IGCTs). The operating principle of the STATCOM is illustrated in the image below, which shows the transmission of active and reactive power between sources V1 and V2. In this diagram, V1 denotes the voltage of the system that needs to be controlled, and V2 denotes the voltage that the VSC generates.

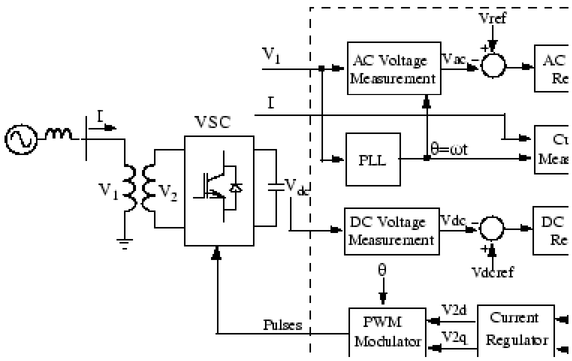


Fig.2 Single-line diagram of a Static VAR Compensator (STATCOM)

III. SIMULINK MODEL OF TEST SYSTEM CONFIGURATION

A. TNEB 62 bus System

The TNEB 62 bus system will be simulated using the MATLAB Simulink Model. 33 loads, 19 generators, and 89 gearbox lines make up this Simulink model. This image displays the TNEB 62 bus system's Simulink model. Fig.3.

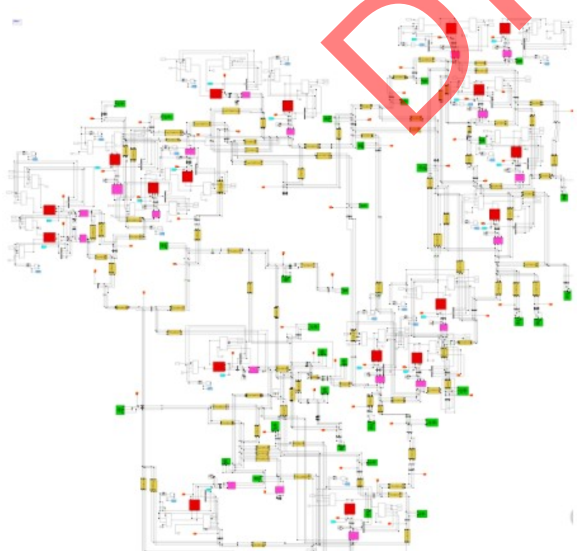


Fig.3 Simulink model of TNEB 62 bus system

B. Model of a Wind Farm

The wind farm's voltage rating is 690V. The Simulink model of the wind farm is shown in Figure 4. By connecting a 690V/33KV step-up transformer to the wind generator unit, the voltage is raised by 33KV. With the aid of a step-up transformer, the voltage is once more increased to 220KV. The wind farm has a 512 MW capacity.

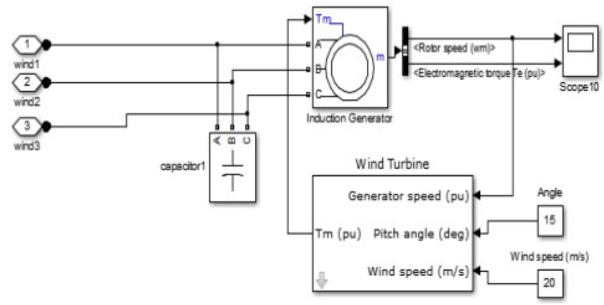
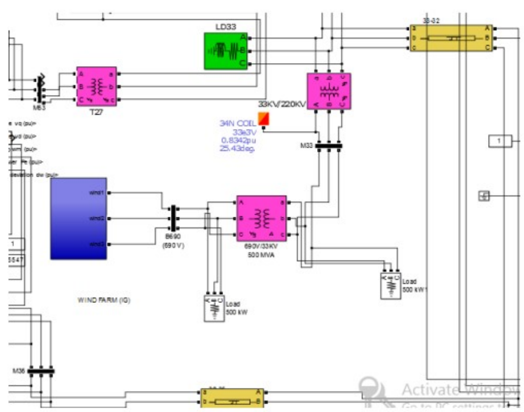


Fig.4 Simulink model of Wind farm model

The 34th bus (Nagercoil) of the system is where the 512MW wind farm is connected. The wind farm's voltage rating is 690V. Using a 690V/33KV step up transformer linked to the wind generator unit, the voltage is raised by 33KV. With the aid of a step up transformer, the voltage is once more increased to 220KV. Fig. 5 depicts a wind farm with a 690V/33K, 33KV/220KV transformer arrangement.

Fig.5 Simulink model of the TNEB 62 bus system with Wind Farm



C. STATCOM Model

The STATCOM's simulink model is depicted in Figure 6. The system performance will be enhanced because the STATCOM is connected to the TNEB62 bus system's 34th bus. Figure 7 depicts the TNEB 62 bus system using STATCOM. 300 Mvar is the STATCOM rating.

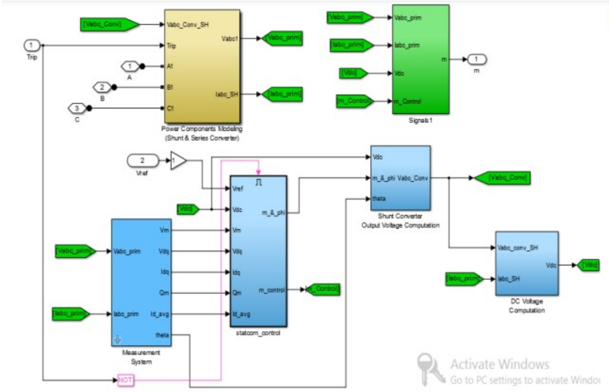


Fig.6 Simulink model of STATCOM

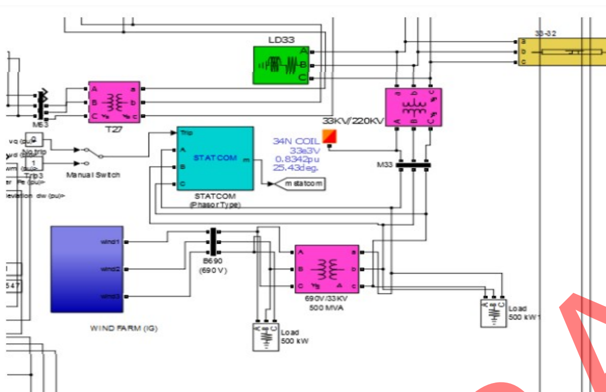


Fig.7 Simulink model of the TNEB 62 bus System with wind farm and STATCOM

IV RESULTS AND DISCUSSIONS

A. Bus Voltage

Fig. 5.1 displays the system's 34th bus voltage both with and without STATCOM. The bus voltage was below the permitted value (0.83pu) prior to connecting the STATCOM; as a result of the STATCOM, the bus voltage has increased. The STATCOM connection raises the bus voltage by 1.00pu.

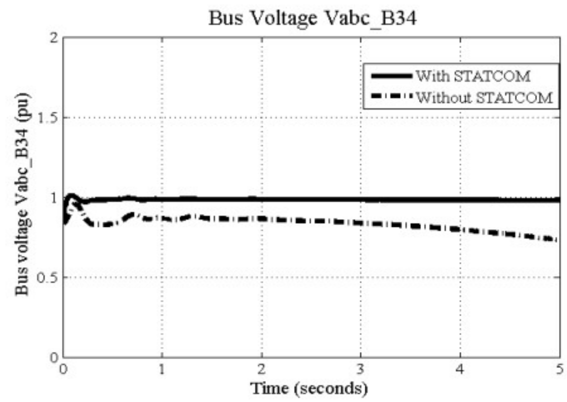


Fig.8 Waveform for bus voltage

B. Reactive Power in bus

Figure 9 compares the system's 34th bus reactive power with and without STATCOM. Prior to connecting the STATCOM, the reactive power value is high; the reactive power is offset by STATCOM.

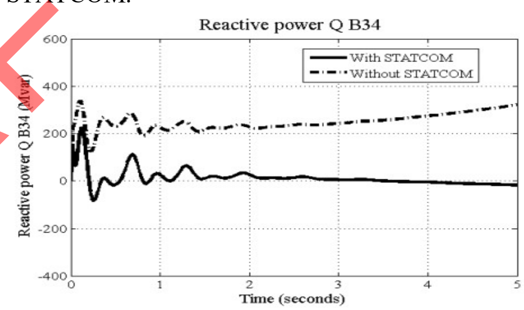


Fig.9 Waveform for reactive power

C. Bus voltage in a transient fault condition

Fig. 10 depicts the system's 34th bus voltage in a transient fault condition for both the system with and without STATCOM. The bus voltage was below the permitted level (0.83pu) prior to connecting the STATCOM; the STATCOM raised the bus voltage. The bus voltage is raised by 1.00pu when the STATCOM is connected. Under transient fault situations (three-phase to ground fault), STATCOM yields the best results.

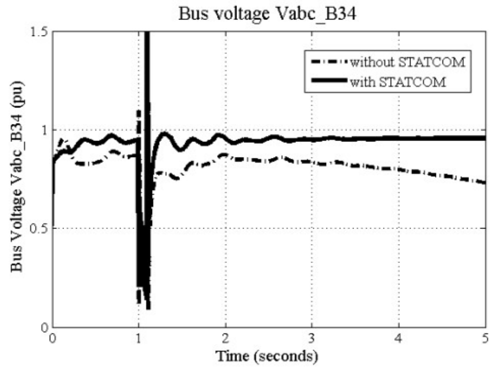


Fig.10 Waveform for bus voltage in a transient fault condition

D. Real power in a transient fault condition

Figure 11 depicts the system's 34th bus real power under transient fault conditions with and without STATCOM. Prior to connecting the STATCOM, the reactive power value is high; the reactive power is offset by STATCOM. A better outcome is also provided by the transient fault state (three phases to ground fault).

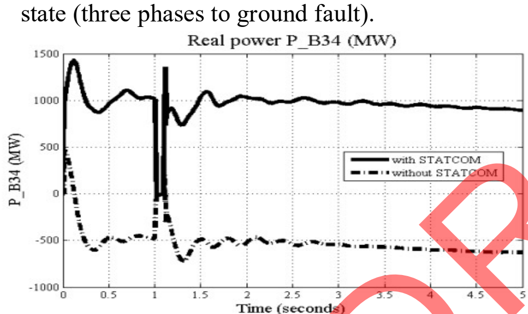


Fig.11 Waveform for real power in a transient fault condition

E. Reactive power in a transient fault condition

The system's 34th bus reactive power in a transient fault scenario is shown in Fig. 12 for both the system with and without STATCOM. Prior to attaching the STATCOM, the reactive power value is high; the reactive power is corrected (by about 300Mvar) using STATCOM. The better outcome is also provided by the transient fault state (three phases to ground fault).

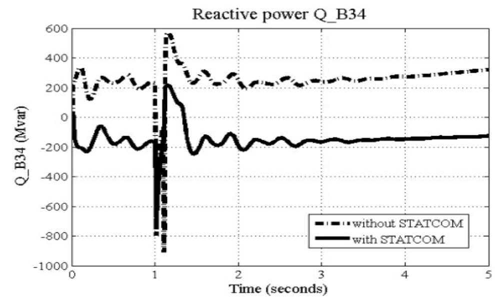


Fig.12 Waveform for reactive power in a transient fault condition

V CONCLUSION

The MATLAB The wind farm and TNEB 62 bus system were both designed using the Simulink model. The 34th bus of the TNEB 62 bus system connects to the proposed wind farm. The performance of the system declines after entering the wind farm. When the bus voltage drops below the permitted level, it also has an effect on the real and reactive power values on that particular bus. The system performs better when STATCOM is used within it. Reactive power on the bus is balanced by it. The bus voltage, real power, and reactive power are all improved after the STATCOM is connected. The findings demonstrate that the TNEB 62 bus system of the wind farm uses STATCOM to regulate the flow of power. In transient fault scenarios (three-phase to ground faults), STATCOM provides a superior result.