INVESTIGATION OF THE CONTROL VOLTAGE AND REACTIVE POWER IN WIND FARM LOAD BUS BY STATCOM AND SVC

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Abstract

In this study, the voltage stability of the bus load in various static and dynamic load systems that are fed by a wind farm has been examined. In the control of load voltage and reactive power, 10 MVAr Static Synchronous Compensator (STATCOM) and Static Var Compensator (SVC) is used. In the wind farm examined, Double Feed Induction Generator (DFIG) is used. In voltage and reactive power control, the results of time response and damping oscillation have been found using MATLAB / Simulink . The results achieved have proved that SVC and STATCOM yield good results when used in terms of voltage stability of the system.

1. Introduction

In Power systems, voltage and reactive power control problems are important for continuous case stability [1].These problems have been solved through power electronics drivers included in Flexible AC Transmission systems (FACTS). Parallel FACTS drivers such as SVC and STATCOM have been used widely in transient voltage control due to their high-performance [2].

When the load connected to a bus load in STATCOM controlled wind farm is installed into the circuit, the effects of terminal voltage, reactive power and speed regulation have been examined in terms of rotor stability performance and STATCOM control has been observed to yield good results [3]. The moment-slip characteristics of Induction Generator operating under low voltage in the system to which wind farm is connected have been examined. It was found that with the use of SVC and STATCOM, the results can be improved in case of an unexpected condition in the system [4]. By using SVC and STATCOM, failure analysis has been done in DFIG at different times, and it was observed that SVC and STATCOM yield time responses quickly in the control of voltage, reactive power and speed characteristics [5]. Oscillation dampings at the bifurcation point at the time of overload in the power system have been examined in terms of voltage stability; and it was observed that oscillation dampings can extinguish in a shorter span of time when STATCOM and SVC are used [6,7]. STATCOM and the installation of various load values at different times have been performed with the use of Proportion Integrate and Fuzzy Logic in bus load voltage and reactive power control [8]. Generic STATCOM has been designed in order to improve wind farm stability that is formed in Fixed speed induction generator. PV curves in bus loads with and without STATCOM have been examined. It was shown that the stability points of this generic STATCOM in dynamic systems can spread into a wider area [9].In power system, the voltage and current change in bus loads have been examined at different times. In this study, SVC and Thyristor Controlled Series Compensator (TCSC) have approached the reference value of time responses in dynamic loads [10].The effects of various dynamic loads on the voltage profile of load system have been examined through SVC; and good results have been obtained in the active and reactive power control of bus load in terms of voltage regulation[11].

In this study, a 9 MW wind farm operates as connected to network. SVC and STATCOM have been used in order to stabilize the voltage and reactive power flow in the bus load of this power system when static and dynamic powers have entered the current. In voltage and reactive power control of bus load , the curves of various static and dynamic load time responses and oscillation damping have been drawn. In time responses and oscillation dampings, SVC and STATCOM have been compared to one another.

2.Statcom

STATCOM work produces active and reactive power dependent on the transform leakage reactance between voltage source inventor generator and AC voltage source control [12]. The ultimate goal of STATCOM is to produce a reactive impedance that can be adjusted in continuous or gradual manner in order to meet the compensation need of transmission line [13]. STATCOM voltage source convertor and transform are connected to AC system in a parallel manner. In STATCOM control system, d-q reference can usually be defined in frame network voltage synchronism. It is possible to control d-q current independent of DC voltage and reactive power of STATCOM. SVC and this closed loop are similar in AC voltage control [7]. STATCOM circuit model has been shown Fig. 1.

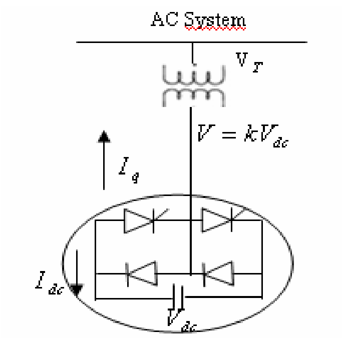

Fig 1.Systematic study of STATCOM

The voltage produced by STATCOM is beneficial in providing for the network. The leakage reactance used in transform, however, enables the system to function in a stable manner by enabling the unexpected current that comes out when the voltage value is higher than the voltage generated by STATCOM to flow on itself. Moreover, STATCOM improves the damping oscillation that come out in dynamic voltage control with the rise in demand in the load system.

3. Svc

The line voltage, in closed loop AC voltage control, gives out reference value and error signal in the measurement of the point in which SVC is connected to the network [3]. SVC has been designed for reactive power control against dissipation and fast voltage control. In most of its application fields, SVC has been designed for reactive power generation and control. Moreover, it is used for voltage control. It can be used for reducing power oscillations, as well [14]. The fundamental function of SVC is to control bus voltage for reactive power control in the area into which it is installed [15]. SVC circuit model has been shown on Fig.2.

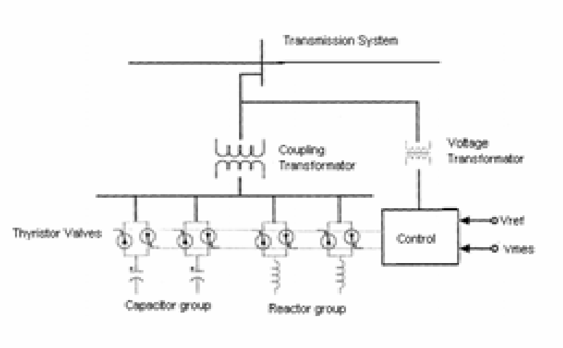

Fig 2.Systematic study of SVC

In general, SVC consists of thyristor controlled reactor and thyristor switching compensators [15,16]. Depending on operating conditions of the circuit, the trigger angles of thyristors have been identified and they have been introduced into the circuit. In Forward and backward operation of the circuit, the triggering angles are set during the operation and reactors and capacitors are introduced into the circuit. In convertor circuit, just as capacitor provides voltage for the circuit as a generator, so it can minimize the loss that will come out as a result of switching losses of Insulated Gate Bipolar Transistor and Gate Turn off Thyristor, used as power electronics elements.

4.Statcom and Svc Controller

STATCOM and SVC of Voltage and Reactive power Control circuit shown on Fig. 3.

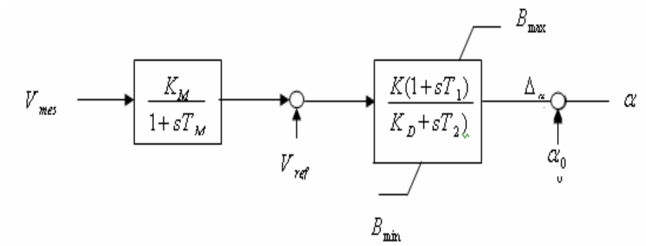

Fig 3.Controller unit

Here, the measured value of voltage V to the bus, Vref (reference voltage) and the T1 and T2 are constant time.

In this study, the wind farm connected to the network running of load bus will be voltage control and reactive power control. 10 MVAr STATCOM and SVC will be used for Reactive power and voltage control. It is expected that the voltage per bus load and reactive power will fall somewhere in the reference value through control. Proper PI coefficients are aimed to be provided so that the response time of reactive power and voltage that correspond to reference value will be short and damping oscillations will not pose unfavorable effects for the sake of voltage stability of bus load.

5.Wind Turbine

In this study the focus is set to the DFIG. The stator of DFIG is directly connect to the grid whereas the rotor winding is connect with voltage source convertor. By supplying a voltage with variable frequency and variable amplitude to the rotor circuit,the voltage at the stator terminal can be kept constant. Rotor side converter usually provides active and reactive power of the machine while the line side converter keeps the voltage of the DC circuit constant [17].Wind Turbine circuit model has been shown on Fig.4.

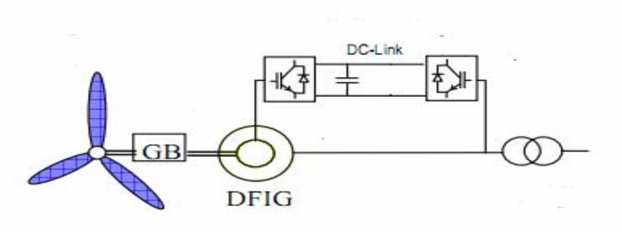

Fig. 4. Wind Turbine circuit model

6. Study of System

In this study, 575V, 60 hz and 9MW wind farm is used .The wind farm generates power with the induction generator in it. The wind farm produces voltage regulation dependent on the voltage value of capacitor included in the back to back convertor .with the control of the system frequency depending on the f convertor, network voltage is assured to be equal. Moreover, thanks to a booster transformer, voltage was raised from 575 volt to 25 Kv. Network voltage and frequency values are regarded to be 120 Kv 60 hz. In the network, the voltage was reduced from 120 Kv to 25 Kv with the use of transformer as in the wind farm. In the system, number 1 bus is connected to the network, number 2 bus is connected to wind farm, and number 3 bus has been examined as the bus that is involved in the area where the network and wind farm has been converted to 25 Kv. Various active and reactive powers have been connected in load bus. Both dynamic and static load measurements of these loads have been conducted at the same values. In this simulation study, SVC and STATCOM of 10 Mv has been used as parallel to bus load. It is aimed that voltage and reactive power controls are conducted with PI Control and the reactive power will be brought to reference values in the number 3 load bus of the system. Kp=1, Ki=500 have been adopted for voltage control, however for reactive power control, Kp=0.1, Ki= 50 have been adopted. In this study, for voltage reference value, 1.0 p.u have been identified, yet for reactive power reference value, 0.0 has been identified. System circuit model have been shown on Fig.5.

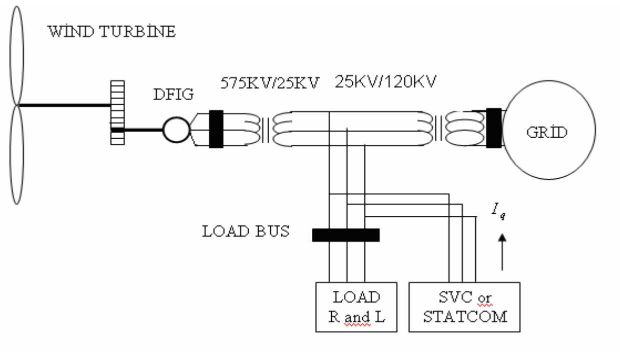

Fig. 5.System circuit model

7.Results

On the operation of the system, the static and dynamic load values dependent on load bus have been shown on the table give. Static and Dynamic load values remain the same.

Table 1. Different Loads

Different Loads	
P(Active Load)	Q(Reactive Load)
4MW	2MVAr
5MW	1.5 MVAr
3MW	2.1 MVAr

Voltage and reactive power control of STATCOM which is connected to the load bus when active load is 4MW and reactive load is 2MWAr static have been shown Fig.5 and Fig.6.

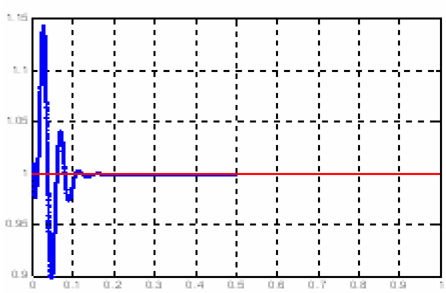

Fig. 6.STATCOM Voltage Controller

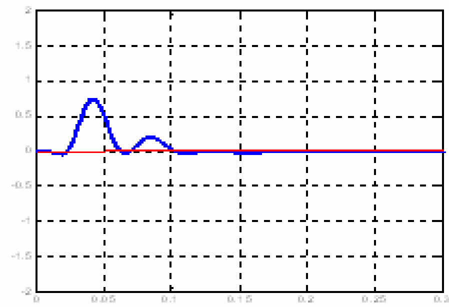

Fig. 7.STATCOM Reactive Power Controller

Voltage and reactive power control of SVC which is connected to the load bus when active load is 4MW and reactive load is 2MWAr static have been shown Fig.7 and Fig.8.

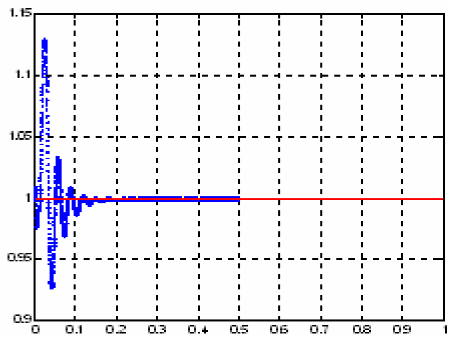

Fig 8. SVC Voltage Controller

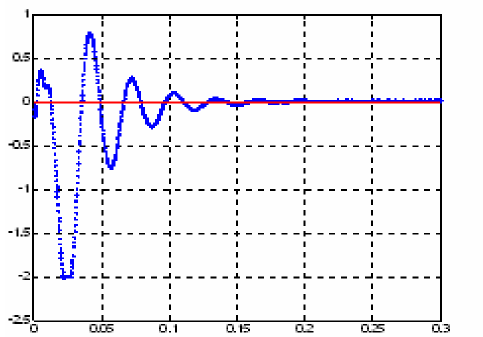

Fig.9.SVC Reactive Power Controller

Voltage and reactive power control of STATCOM which is connected to the load bus when active load is 4MW and reactive load is 2MWAr dynamic have been shown Fig.9 and Fig.10.

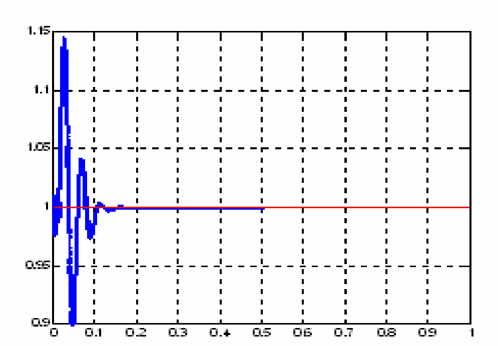

Fig. 10.STATCOM Voltage Controller

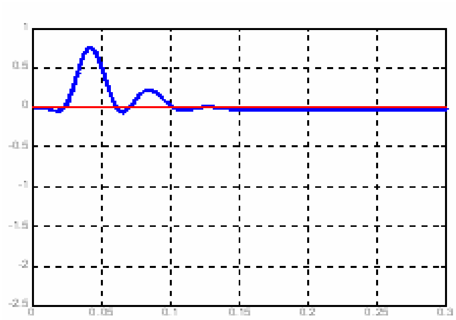

Fig. 11.STATCOM Reactive Power Controller

Voltage and reactive power control of SVC which is connected to the load bus when active load is 4MW and reactive load is 2MVAr dynamic have been shown Fig.11 and Fig.12.

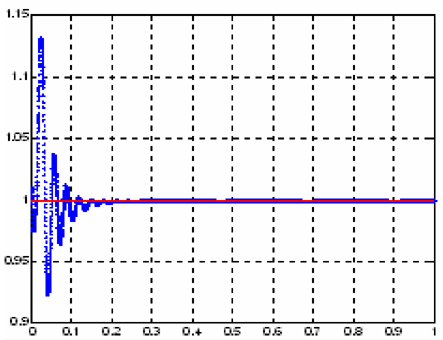

Fig. 12. SVC Voltage Controller

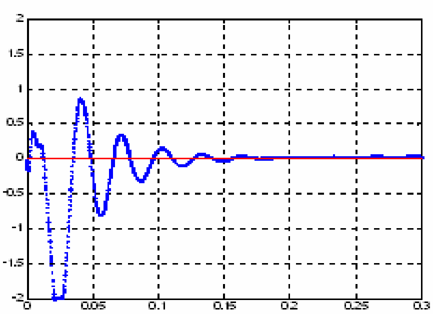

Fig. 13.SVC Reactive Power Controller

The results of voltage and reactive power controls in load bus with 4MW and 2 MVAr load values have been voltage and reactive control.

Table 2. Measurement Values

Compensator type and load	Vmes (p.u)	Qmes (p.u)	Time response (sn)	Damping Oscillation between
STATCOM Statik load	0.9970	-0.0030	0.17 sn	[1.145-0.896]p.u
SVC Statik	0.9965	-0.0035	0.23sn	[1.129-0.930]p.u
STATCOM Dinamik	0.9950	-0.0050	0.15sn	[1.150-0.890]p.u
SVC Dinamik	0.9945	-0.0055	0.21sn	[1.132-0.925]p.u

The results of voltage and reactive power controls in load bus with 5MW and 1.5 MVAr load values have been voltage and reactive control.

Table 3. Measurement Values

Compensator type and load	Vmes (p.u)	Qmes (p.u)	Time Response (sn)	Damping Oscillation between
STATCOM Statik	1.0003	0.003	0.17 sn	[1.145-0.896]p.u
SVC Statik	1.0002	0.002	0.23sn	[1.129-0.930]p.u
STATCOM Dinamik	1.0001	0.001	0.15sn	[1.150-0.890]p.u
SVC Dinamik	1.0000	0.000	0.21sn	[1.132-0.925]p.u

The results of voltage and reactive power controls in load bus with 3MW and 2.1 MVAr load values have been voltage and reactive control.

Table 4. Measurement Values

Compensator type and load	Vmes (p.u)	Qmes (p.u)	Time response (sn)	Damping Oscillation between
STATCOM Statik	1.0003	0.003	0.17 sn	[1.145-0.896]p.u
SVC Statik	1.0002	0.002	0.23sn	[1.129-0.930]p.u
STATCOM Dinamik	1.0002	0.002	0.15sn	[1.150-0.890]p.u
SVC Dinamik	1.0002	0.002	0.21sn	[1.132-0.925]p.u

In the wind farm which operates as connected to the network, the control of the decrease in voltage as a result of the connection of load to load bus has been examined through STATCOM and SVC. The Proportion Integrate time stables used to control voltage and reactive power have been taken to be the same for different static and dynamic loads. The results that have been achieved through voltage and reactive power in connecting STATCOM and SVC to load bus have proved to be close to reference value. It has been found that STATCOM yields better results in terms of time response than SVC in voltage control. It has been found that, if system is examined in terms of static and dynamic load, the oscillation dampings of static loads can extinguish in a shorter time than the oscillation dampings of dynamic loads.

8.References

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