Improving Dynamic Performance of Wind Power Generation System by Using Static Var Compensator

Prechanon Kumkratug

Abstract— This paper applies the static var compensator (SVC) to improve dynamic performance of wind power generation system. The mathematical model of double fed induction generator (DFIG) and grid power system are systematically derived and incorporated into the dynamic equation of the wind energy system. The suitable control of the SVC can improve the dynamic of the system under disturbances. The proposed method is tested on the new version of MATLAB/Simulink 2022.

Keywords—Win energy, DFIG, dynamic, SVC, MATLAB.

I. Introduction

Wind energy system generating electrical power has significantly increased in the last decade. Generation of mechanical energy by a wind turbine takes place via conversion of the kinetic energy that fed to the blades of the turbine. The rotating energy is converted into electrical energy by the generator. Synchronous generator and induction generator are mainly used in wind turbines. Induction generator is the most common type of electrical machine used in wind turbine systems because it is simple, reliable lightweight, cheaper, and ruggedness. A large number of modern wind turbines are equipped with double fed induction generator (DFIG) that has the stator connected directly to the electrical network, meaning that it operates synchronously at the network frequency, and the three-phase wound rotor connected via a back-to-back voltage source converter and transformer, as shown in Fig. 1 [1]-[4].

Disturbances such as fluctuation of wind power, fault in electrical network, mechanical outages, load shedding, etc. can occur at any moment in wind energy power generation system. This results in negative effects of dynamic performance of the system [5]-[8]. This challenge facing engineers of the present and future is to improve the dynamic performance of wind power generation.

Static var compensator (SVC) based on thyristors controller system have been used in power system to control the amount of reactive power compensation as shown in Fig. 2. For the steady state, SVC is usually controlled by a system voltage. However, with the generator speed or active power flow, SVC can improve the dynamic performance of power system [9]-[12].

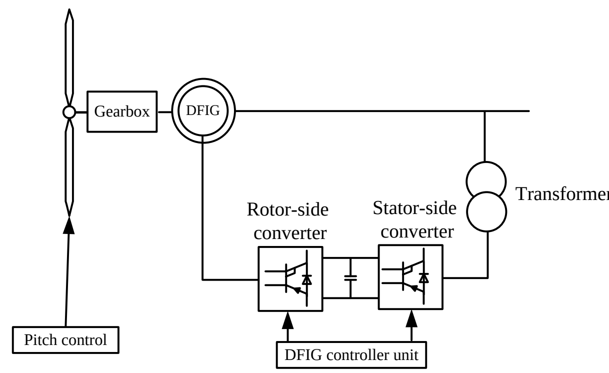

Fig. 1 Wind energy power generation system based DFIG

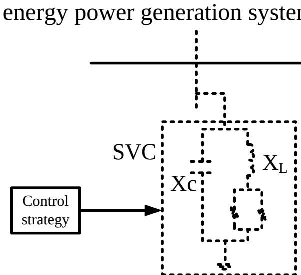

Fig. 2 SVC system

This paper applied the static var compensator (SVC) to improve dynamic performance of double fed generator (DFIG) system. The presented method is validated on the sample system subjected to a severed disturbance through the new version of MATLAB/Simulink 2022.

II. Mathematical Model

A. Energy Conversion in Wind Turbine

Wind turbines system as shown in Fig. 3 convert the kinetic energy in the wind into mechanical torque .The mechanical torque that the wind turbine extracts from the wind is calculated by [13]

Prechanon Kumkratug, Department of Electrical Engineering/Kasetsart University at Sriracha Campus, Thailand, Email: prechanon@eng.src.ku.ac.th

$$T_m = \frac{\rho A c_p v^2}{2\omega_t} \tag{1}$$

Here

ρ = tip speed ratio

A = the area swept by the rotor blades

c_p = the coefficient of the wind turbine

v = wind speed

ω_t = turbine speed equal to generator speed

B. Dynamic of Wind Power Generation Based DFIG

The dynamic equation of the DFIG is given by [14]

$$J\frac{d\omega_t}{dt} = T_m - T_e \tag{2}$$

Here
J = inertia
T_e = electrical torque

C. SVC

Fig. 3(a) shows the single line diagram of the power system equipped with a SVC at the midpoint of transmission line. The equivalent circuit for investigation is shown in Fig. 3(b) where the transmission line 1 and line 2 are represented by x_1 and x_2, respectively. The optimal location of SVC for enhancing dynamic performance is approximately installed at mid-point of transmission line [14]. The SVC is represented by controllable reactance (x_{svc}). The SVC supplies reactive power to the system, $x_{svc\ c}$ is in capacitive mode, $x_{svc}<0$. Alternatively, the SVC absorbs reactive power to the system, x_{svc} is in reactive mode, $x_{svc}>0$. To easier incorporate the SVC model into the electrical power, the transformation of Delta-Wye reactance network between bus i and bus k as shown in Fig. 3(c) and given by

$$x_{ik} = x_1 + x_2 + \frac{x_1 x_2}{x_{svc}} \tag{3}$$

Then, the electrical power (P_e) transferred from bus i to k is given by

$$P_e = \frac{V_i V_k}{x_{ij}}\sin(\theta_{ij}) \tag{4}$$

To understand the SVC effect on the wind power generation system based DFIG, let us consider the sample system in Fig 4. The P_e in (4) can be computed the T_e in (3) by dividing generator speed (ω_t). Then, it can be seen that the SVC can improve the dynamic performance of the system.

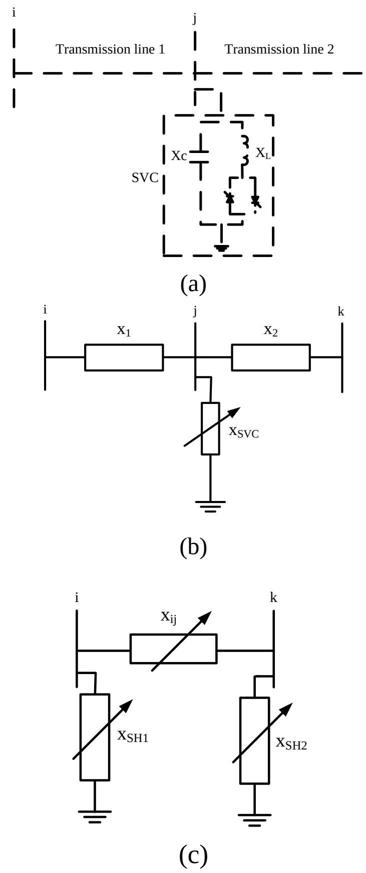

Fig. 3 SVC model representation

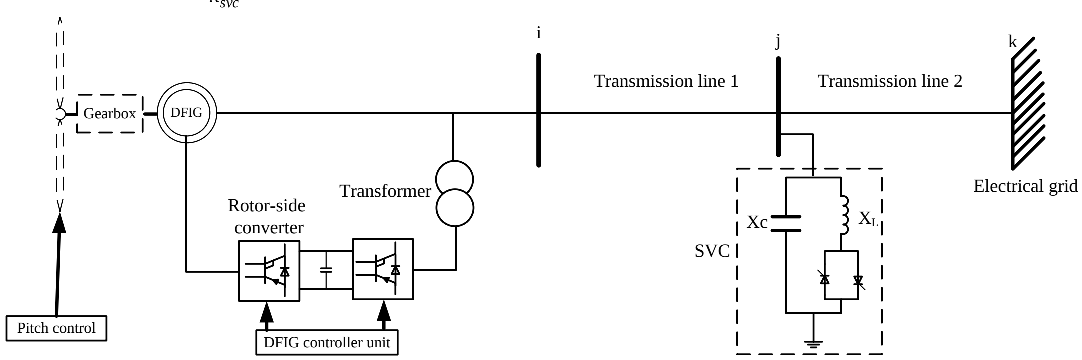

Fig. 4 Sample system of improving dynamic performance of wind power generation system by using SVC

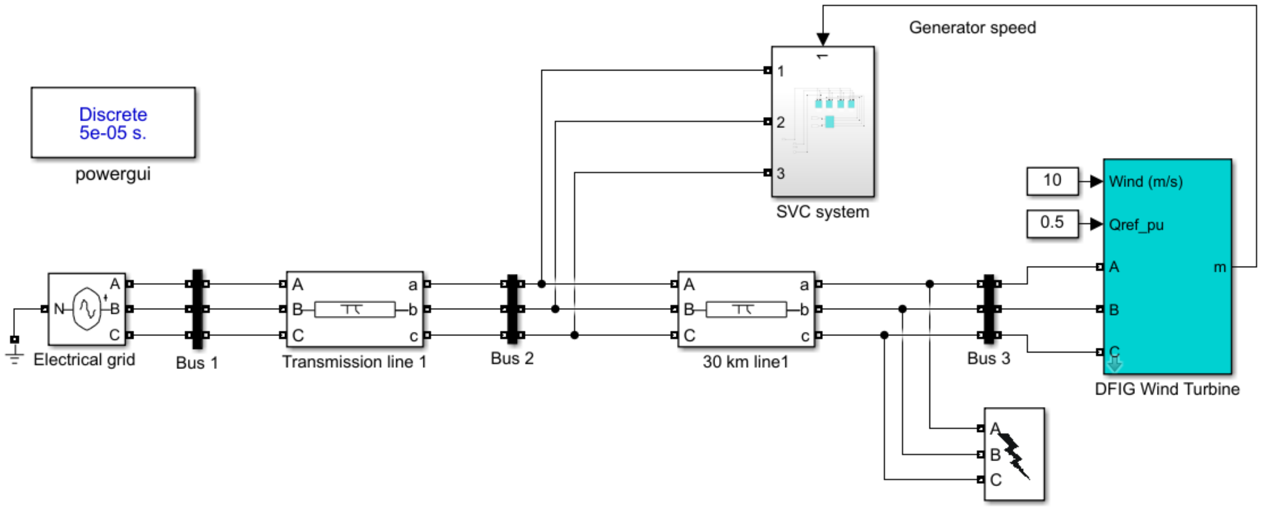

Fig. 5 Simulation block diagram

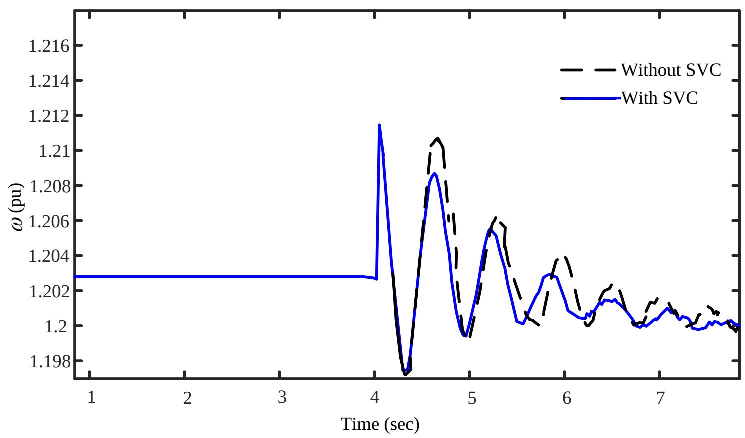

Fig. 6 Generator speed of DFIG in the system without and with SVC

III. Simulation Results

The presented method was tested through a simulation tool MATLAB/SIMULINK 2022. Fig. 5 shows the Simulink block diagram of sample system as shown in Fig. 4. It was assumed that a temporary three-phase fault occurs at the bus 3 for 30 *msec*. The DFIG speed is used to represent the dynamic performance of the system without and with SVC. It can be observed from Fig. 6 that the SVC can improve the dynamic performance of wind power generation system.

IV. Conclusion

This paper invested the effect of the SVC for improving dynamic performance of wind power generation system based DFIG. The mathematical of the wind power generation system including DFIG, transmission line, and SVC are derived and showed how SVC can effect on dynamic performance. It was found from the simulation results that the SVC can improve the dynamic performance of the wind power generation.

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Prechanon Kumkratug received his B.E. a M.E., and D.E. degrees from King Mongkut's Institute of Technology Ladkrabang, in 1996, Asian Institute of Technology, in 1999, and Kasetsart University, Bang Khean Campus, in 2008, respectively.

Currently, he is an Associate Professor in the Department of Electrical Engineering, Kasetsart University, Sriracha Campus. His research interests are the power system stability, renewable energy, and application of power electronics in power system.