Comparison of the Impacts of SVC and STATCOM on the Stability of an Electrical Network Containing Renewable Energy Sources

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Abstract. Currently and in the coming decades the subject of integrating FACTS into a power network will have more importance within the scientific community. This is mainly due to the liberalization of the electricity sector and advances in power electronics [1].

This work deals with the impact of the integration of renewable energy into the electricity network, and comparisons between two types of FACTS (SVC, STATCOM), with particular reference to transient stability. This work shows that the introduction of SVC (Static Var Compensator), and STATCOM (Static Synchronous Compensator) allowed the improvement of the stability of the network in the presence of voltage fault.

Keywords: Renewable energy · Transient stability · SVC · STATCOM · Electricity network

1 Introduction

Modern power system is a complex network comprising of numerous generators, transmission lines, variety of loads and transformers. As a consequence of increasing power demand, some transmission lines are more loaded than was planned when they were built. With the increased loading of long transmission lines, the problem of transient stability after a major fault can become a transmission limiting factor [2].

This paper deals with the problem of static voltage stability in electrical networks. Basic notions of integrating FACTS to solve instability and voltage collapse have been presented.

The purpose of this work is to analyze the temporary stability of an electrical network containing photovoltaic generator and wind turbine in case of voltage fault in the presence of a FACTS device (SVC or STATCOM).

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2 Studied System

The studied network is modeled thanks to the software PSAT, it is represented in Fig. 1. It consists of three conventional generators, slack bus, PV generator, a wind turbine, solar source, 14 transmission lines, 11 static loads and three transformers. The base power is 100 MVA and the base voltage is 13.8 kV.

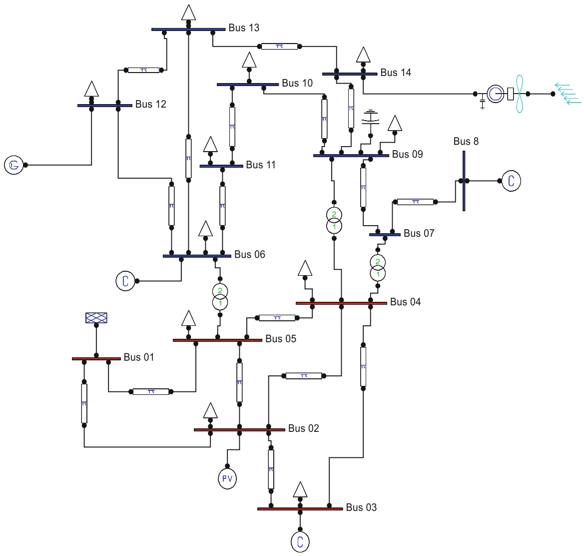

Fig. 1. Studied network

3 Static Var Compensator (SVC)

Static VAR systems are applied by utilities in transmission applications for several purposes. The primary purpose is usually for rapid control of voltage at weak points in a network. Installations may be at the midpoint of transmission interconnections or at the line ends. Static VAR Compensators are shunting connected static generators/absorbers whose outputs are varied so as to control voltage of the electric power systems. In its simple form, SVC is connected as Fixed Capacitor Thyristor Controlled Reactor (FC-TCR) configuration as shown in Fig. 2 [3].

The SVC is connected to a coupling transformer that is connected directly to the AC bus whose voltage is to be regulated. The effective reactance of the FC-TCR is varied by firing angle control of the anti-parallel thyristors. The firing angle can be controlled through a PI (Proportional + Integral) controller in such a way that the voltage of the bus, where the SVC is connected, is maintained at the reference value.

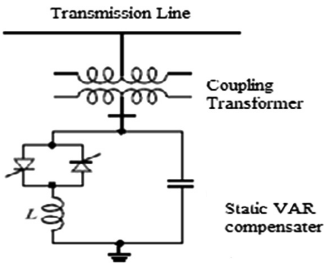

Fig. 2. Static VAR compensator of SVC [3].

4 Static Synchronous Compensator (STATCOM)

The STATCOM is based on a solid state synchronous voltage source which generates a balanced set of three sinusoidal voltages at the fundamental frequency with rapidly controllable amplitude and phase angle. The configuration of a STATCOM is shown in Fig. 3.

Basically it consists of a voltage source converter (VSC), a coupling transformer and a DC capacitor. Control of the reactive current and hence the susceptance presented to power system is possible by variation of the magnitude of output voltage (V_{VSC}) with respect to bus voltage (V_B) and thus operating the STATCOM in inductive region or capacitive region [3].

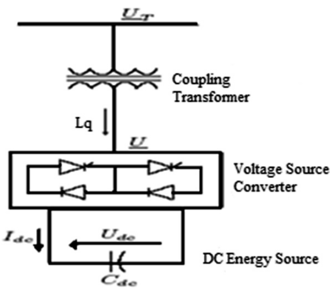

Fig. 3. Static synchronous compensator (STATCOM) [3].

5 Network Test Settings

See Tables 1, 2, 3 and 4.

Table 1. Parameters of the wind turbine and Photovoltaic generator

Wind turbine

parameters	Meaning
Apparent power S (MVA)	4
Nominal voltage U (KV)	2.3
Nominal frequency F (Hz)	50
Radius of the Wind turbine m	R=35
Speed multiplier gain	G=90
Density of air (kg/m^3)	ρ=1.225
Stator resistance (*pu*)	R_s =1.6
Rotor resistance (*pu*)	R_r =0.4
Magnetization inductance (pu)	X_m =0.055
Stator inductance (pu)	X_s =0.15
Rotor inductance (pu)	X_r= 0.023
Inertia of the tree (*pu*)	J=0.01
Number of pole pairs	P=3

Photovoltaic generator

Activer power P (MW)	40
Nominal voltage U (KV)	13.8
Nominal frequency F (Hz)	50
Reference voltage	1.045
max current (p.u)	1.2
min current (p.u)	0.8

Table 2. Generator parameters

Generator parameters	Generator 1	Generator 2	Generator 3	Generator PV	Slack bus
U (KV)	139.88	147.66	150.42	144.21	146.28
F (Hz)	50	50	50	50	50
δ [deg]	−12.7250	−14.2209	−13.3596	−4.9826	0.0000
P [pu]	0.0000	0.0000	0.0000	0.4000	2.3239
Q [pu]	0.2508	0.1273	0.17.62	0.4356	−0.1655

Table 3. Parameters (a) SVC and (b) STATCOM

(a)SVC

Apparent power S (MVA)	100
Nominal voltage U (KV)	13.8
Nominal frequency F (Hz)	50
Reference voltage	1.00
Bmin (p.u)	-1.00
Bmax (p.u)	1.00

(b) STATCOM

Apparent power S (MVA)	100
Nominal voltage U (KV)	13.8
Nominal frequency F (Hz)	50
Reference voltage	1.00
max current (p.u)	1.2
min current (p.u)	0.8

Table 4. Transformer parameters

Transformer	S (MVA)	First voltage	Secondary voltage	R (p.u)	X (pu)
T1	100	69	13.8	0	0.17615
T2	100	69	13.8	0	0.17615
T3	100	69	13.8	0	0.17615

6 Simulation Résultats

The simulation is run for four cases as follows:

6.1 Results Without Fault

In this case, we integrate a renewable source with four conventional generators. A very slight disturbance of the voltage at the bus levels (V_{BUS08}–V_{BUS14}) is shown in the figure below (Fig. 4).

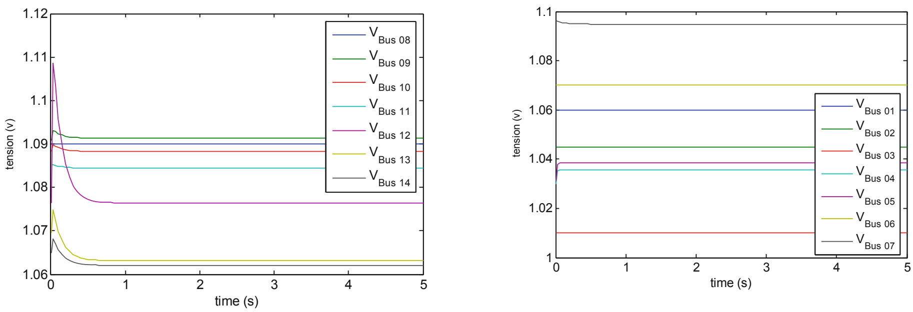

Fig. 4. Tensions to the bus (Without default and FACTS)

6.2 Results with Voltage Fault

A three-phase fault has been applied on the bus 11 at time t = 3 s and deleted at time t = 3.25 s. This causes breakdowns in the lines. The simulation results are shown in Fig. 5. There is a voltage drop (short circuit) in the buses (4, 5, and 7 to 14) as shown in the figure below.

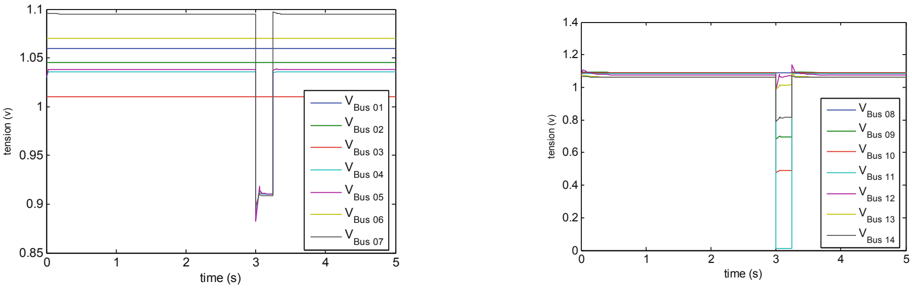

Fig. 5. Voltage to the bus a fault and without FACTS.

6.3 Simulation Results with Integration of the SVC

The same fault as in the previous paragraph is applied to the bus 11 in the presence of the SVC reactive energy compensator at the same bus. The simulation results are shown in Fig. 6. There is a marked improvement in the stability of voltage of the buses 7 to 14 (Fig. 7).

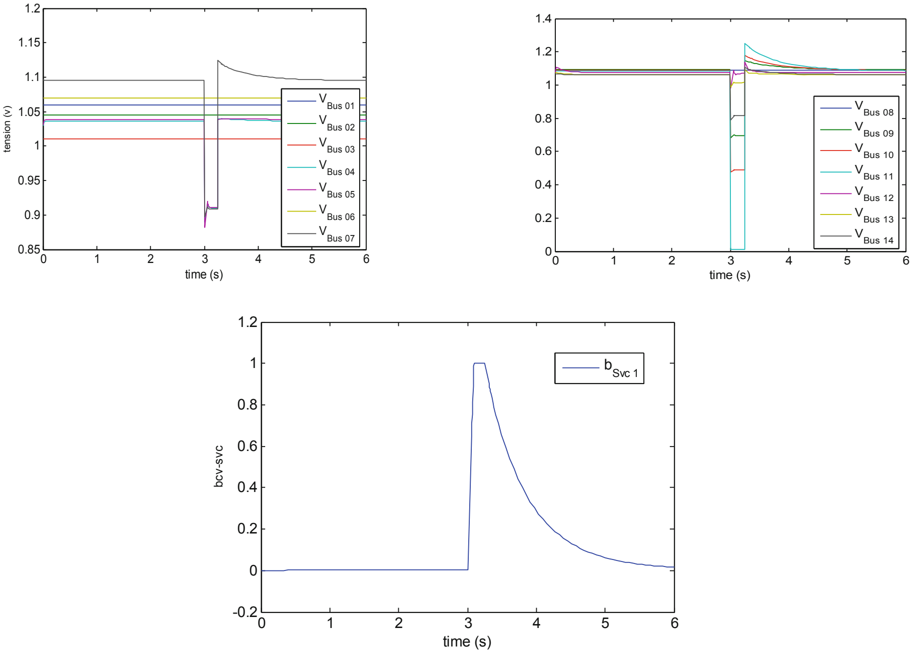

Fig. 6. Voltage to the bus a fault and SVC

6.4 Simulation Results with Integration of the STATCOM

The same fault as in the previous paragraph on Bus 11 is applied in the presence of the STATCOM. The simulation results are shown in Fig. 6. There is a marked improvement and rapid return to stability of voltage of the buses 7 to 14.

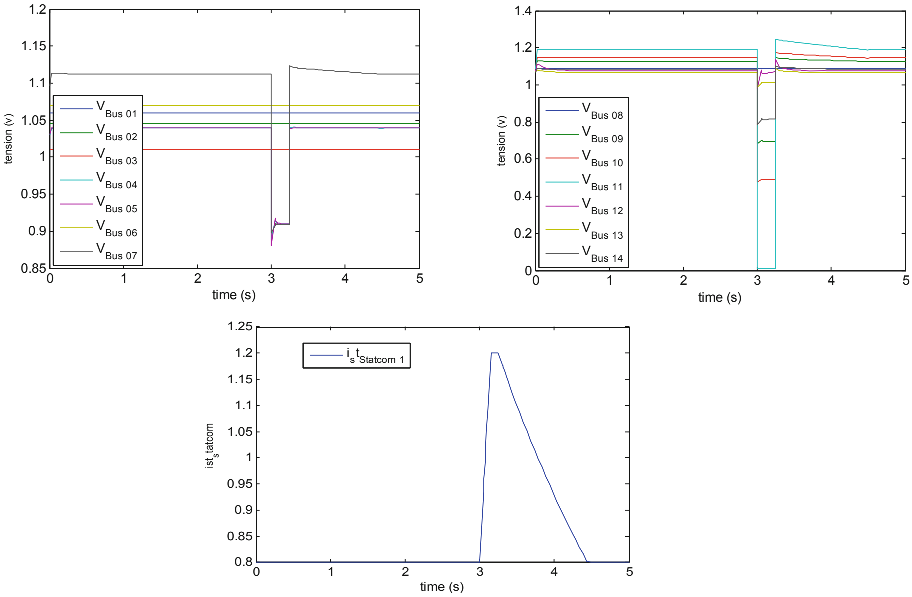

Fig. 7. Voltage to the bus a fault and STATCOM

7 Conclusion

In this work, we studied the stability of a network system containing a renewable energy sources in the presence of a fault. We used PSAT simulation tool running under MATLAB environment. After applying a three-phase fault on one bus, we found that the network became completely unstable. For this reason, we used compensation mechanism connected to the network. We proposed to install a flexible system (SVC and STATCOM). The results obtained show that this FACTS system gives good results for the improvement of the transient stability of the studied network with a slight superiority to STATCOM over SVC.

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