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Scherbius wind farm based fuzzy SSSC

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ABSTRACT

The wind is a clean, free, and readily available renewable energy source, it is cost-effective in several regions, it is a domestic source of energy and it is a sustainable source of energy. The SSSC system is a FACTS voltage compensator, it is inserted in series with the electrical transmission line through a coupling transformer, its role is to inject a voltage which allows to influence the active power transmitted. The goal of this paper is to examine the effect of using a wind farm SSSC to improve flexibility of a multi-machine perturbed network.

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1. INTRODUCTION

The world energy market wind turbine is growing faster than any other renewable energy source. Total worldwide, which did not exceed 4800 MW in 1995, reached 318 000 MW in 2013, after 158 505 MW in 2009, 74,052 MW in 2006 and 93,835 MW in 2007 and 120,297 MW in 2008, according to forecasts 2011 GWEC, global capacity is expected to reach 493,330 MW by the end of 2016. By 2020, their approximately 832,000 MW of installed capacity [1, 2].

The synchronous series static compensator SSSC is a modern FACTS which provides voltage compensation, it is placed directly on the line [3]. Its presence translates into several advantages in terms of loss and planning and energy circulation [4, 5].

The phenomena that impair the quality of electrical energy are of different natures: short circuit, voltage dips, breakdowns, harmonic pollution. Whatever the origin of these disturbances, it is essential to maintain or improve the quality of the electricity that passes through the transmission and distribution networks [6, 7].

In this work we will study the advantage of the uses of wind-SSSC to increase transit power stability in the case of multi bus, multi machines perturbed network.

2. SCHERBIUS DFIG WIND SYSTEM

The Scherbius wind turbine system using a DFIM and an indirect matrix converter back-to-back converter, has many assets [8-10]. One of the advantages of this configuration is that the power elements used are dimensioned to pass part of the total power of the system, which makes it possible to reduce the power losses, illustrated in Figure 1 [11, 12].

The dual feed induction machine is a powered rotor asynchronous machine with stator windings connected to the network through a power converter [13, 14]. The simplified model is presented in Figure 2 [15].

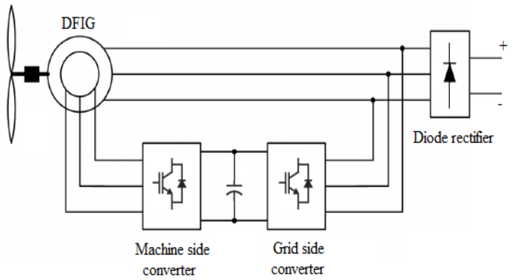

Figure 1.Wind system compenents

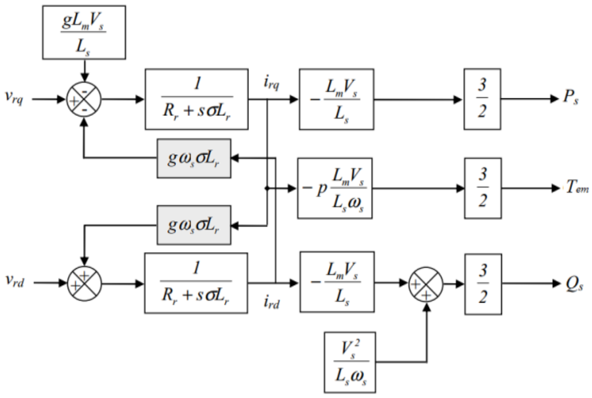

Figure 2.Simplified model of DFIG

The wind farm is an association of several wind turbines in series, each one is constitued of a double feed asynchronous machine, 850kW / 690V wound rotor sized for an air density of 1.225 kg / m^3 with a rotation speed between 14.6 and 30.8 rpm [16-18].

3. STATICS SYNCHRONOUS SERIES COMPENSATOR BASED WIND FARM

The composition of the synchronous static compensator in series of (SSSC) is based on three parts: the first is a continuous source or else the continuous storage element which is behaved from batteries, it will be determined according to the need for network, the second part is presented by the DC-AC converter and with the help of the command it can be used as an adjustable voltage source,the third part presents the output filter es the series coupling transformer, as described in Figure 3 [19, 20].

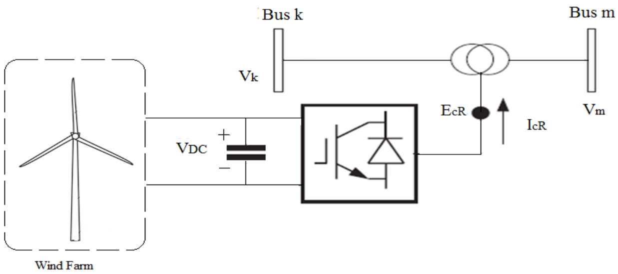

Figure 3. Configuration of wind WSSSC

3.1. Modelling and control of WSSSC

Figure 4 shows the equivalent circuit of the network equipped with the synchronous series static compensator [21].

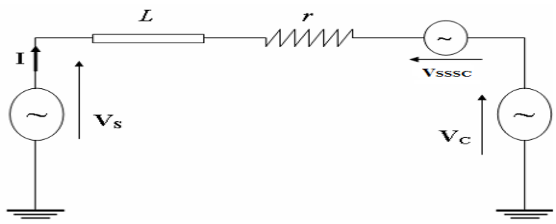

Figure 4.WSSSC model in the case of insertion between two generator bus

The r and L are parameters of including series transformer. The dynamic behavior of currents in Park coordinate system is given by:

$$\frac{d}{dt}\begin{bmatrix} i_d \\ i_q \end{bmatrix} = \begin{bmatrix} -\frac{r}{L} & \omega \\ -\omega & -\frac{r}{L} \end{bmatrix} \cdot \begin{bmatrix} i_d \\ i_q \end{bmatrix} + \frac{1}{L}\left(\begin{bmatrix} V_d \\ V_q \end{bmatrix} - \begin{bmatrix} V_{cd} \\ V_{cq} \end{bmatrix} - \begin{bmatrix} V'_d \\ V'_q \end{bmatrix}\right) \tag{1}$$

The active P and reactive powers Q to be controlled are given by equations (2) and (3) below:

$$P = \frac{3}{2}(V_d . i_d + V_q . i_q) \tag{2}$$

$$Q = \frac{3}{2}(V_q . i_d - V_d . i_q) \tag{3}$$

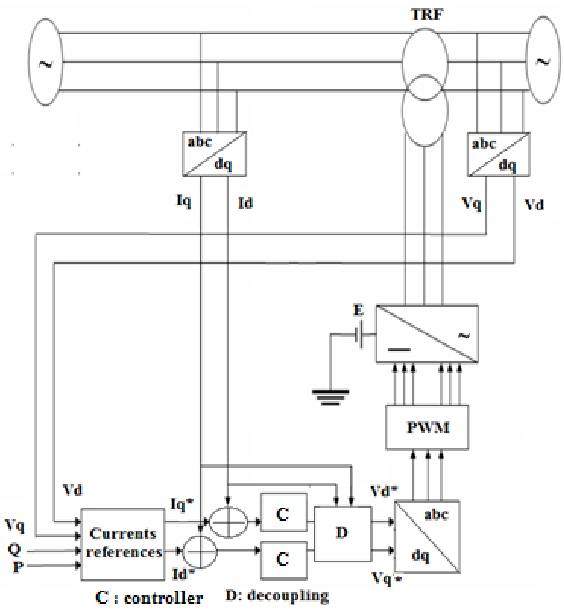

Figure 4. Control circuit of SSSC

3.2. Fuzzy control

Some processes are inherently difficult to model because they vary over time or cannot be correctly represented by a linear model. In this case, the regulator setting parameters will not be optimal and the system may not be properly controlled. This is why we introduce the notion of fuzzy logic [22]. Figure 5 shows the decomposition into three main stages of a fuzzy controller [23].

a. Fuzzification of the inputs is the evaluation of the membership functions of the input variables.

b. The inference engine: the evaluation of the output functions by the rules table

c. Dfuzzification: evaluation of the fuzzy controller output by calculating the center of gravity) [24].

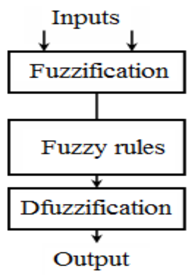

Figure 5. Fuzzy controller Steps

4. STUDIED SYSTEM

Our objective is to examine the effect of the synchronic static serial compensator on the stability of an IEEE-14 node network, and demonstrate its feasibility. In a first section, the IEEE-14 bus network will be presented, and after that in a second section, a fault near a generator node will be applied under the simulation study; and finally, the WSSSC will be introduced to solve the problem of voltage drop propagation [25, 26]. The WSSSC is installed in the most perturbed in the node 8 as shown in Figure 6.

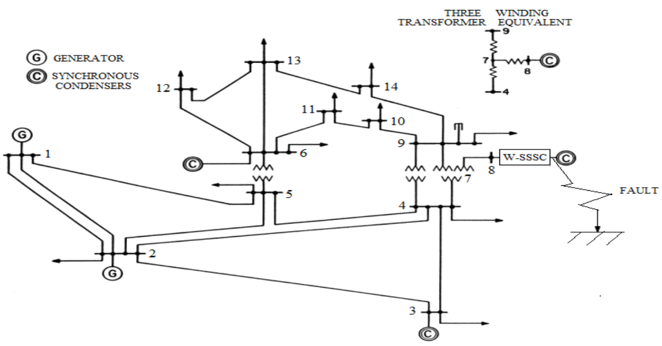

Figure 6. Perturbed IEEE 14 bus network

4.1. Without compensation

The Figures from 7 to 20 show the voltage curve in eache node of network, in this case the WSSSC is not installed and we can examine the fault propagation consequences in all of nodes between times 0,5s and 0,7s.

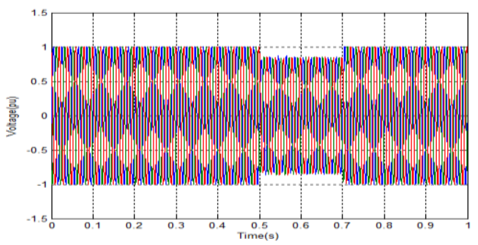

Figure 7. Bus 1 Voltage

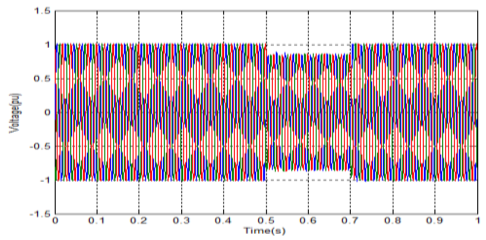

Figure 8. Voltage at node 2

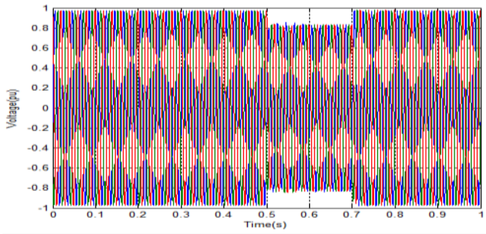

Figure 9.Tension at bus 3

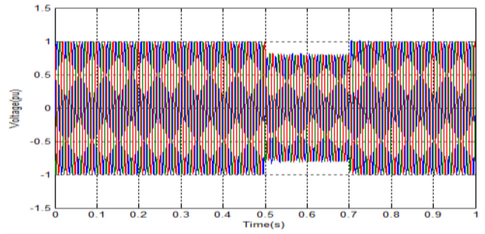

Figure 10.bus 4 voltage

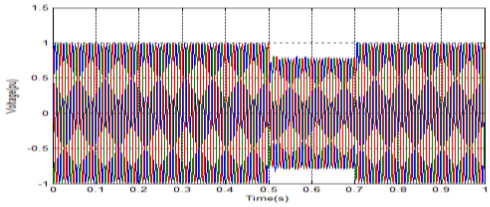

Figure 11.Node 5 voltage

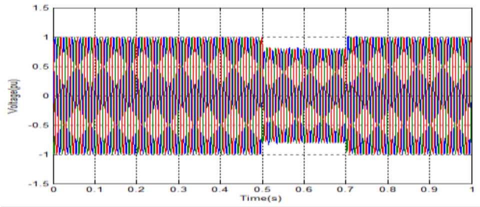

Figure 12.Node 6 tension

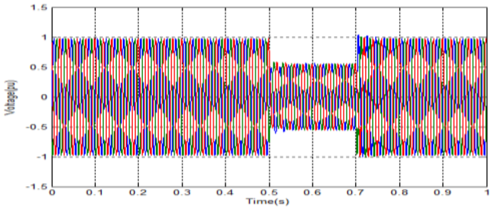

Figure 13. Voltage at bus 7

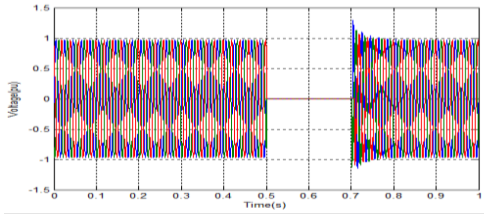

Figure 14.Node 8 voltage

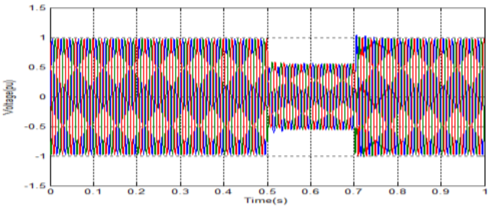

Figure 15.Tension at bus 9

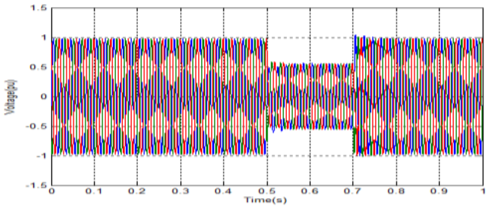

Figure 16.Tension at node 10

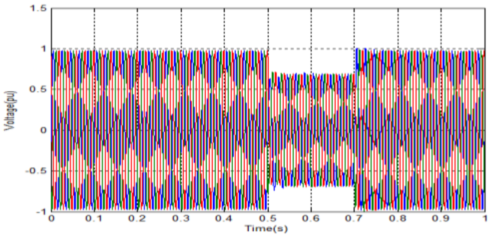

Figure 17.Bus 11 voltage

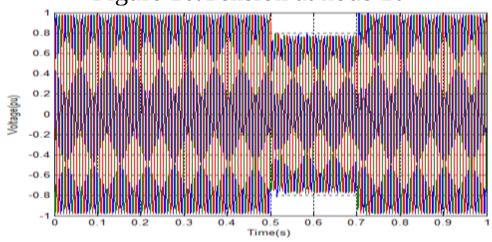

Figure 18.Bus 12 voltage

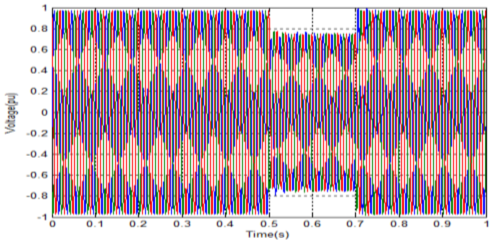

Figure 19.Bus 13 tension

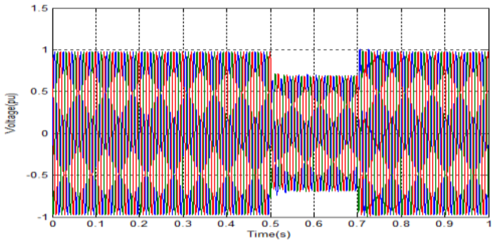

Figure 20.Bus 14 tension

4.2. Uses of WSSSC

In this case the WSSSC is connected to the bus 8, As in the previous section, we present the voltage curve in eache node of network in Figures 21 to 34, the voltage of WSSSC is mentioned in Figure.35, the impact of this voltage restore the network to its stability and cancela te the propagation of the disturbance caused by the fault.

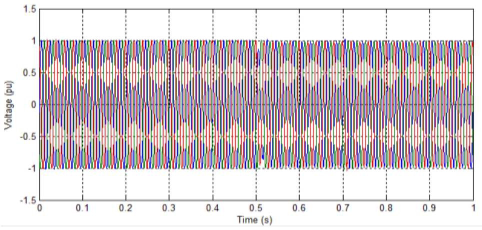

Figure 21. Voltage at node 1

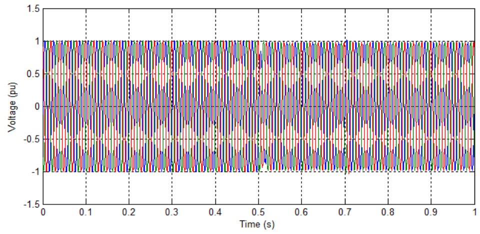

Figure 22. Voltage at node 2

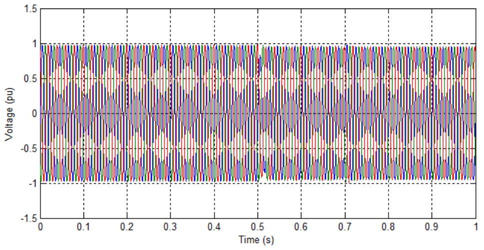

Figure 23.Node 3 voltage

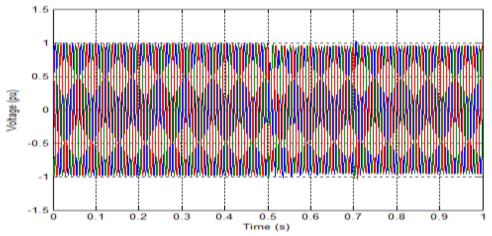

Figure 24.Node 4 voltage

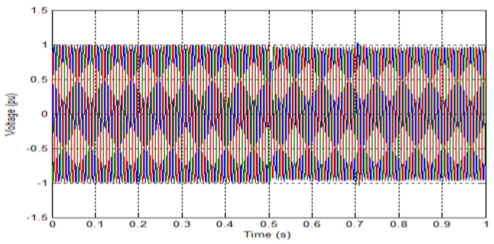

Figure 25.Tension of node 5

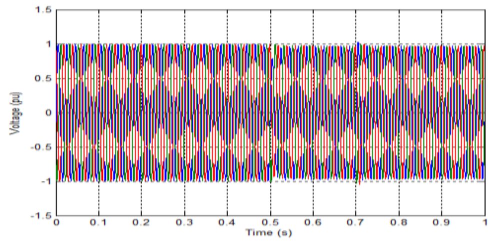

Figure 26.Tension of node 6

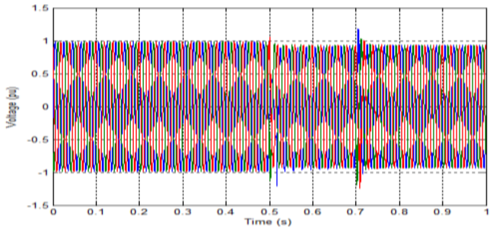

Figure 27.Tension of bus 7

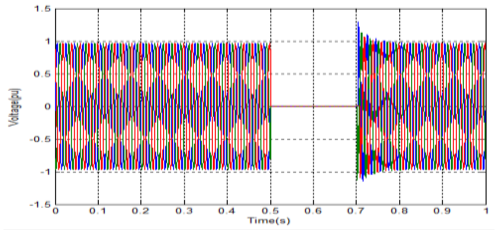

Figure 28.Tension of bus 8

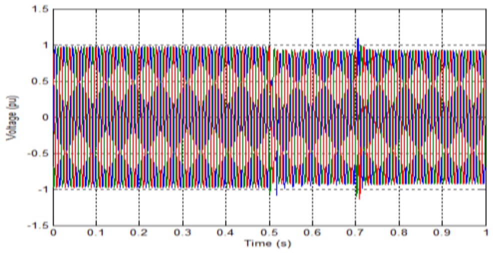

Figure 29.Bus 9 voltage

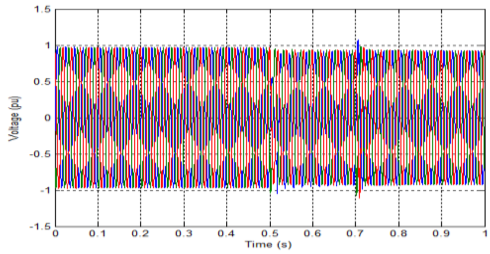

Figure 30.Bus 10 voltage

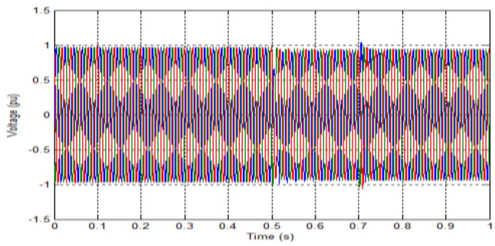

Figure 31.Node 11 tension

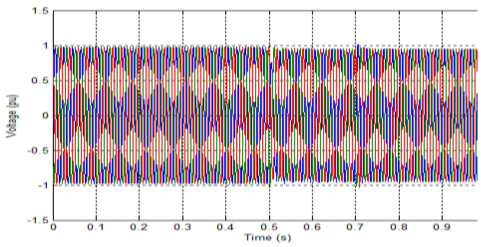

Figure 32.Node 12 tension

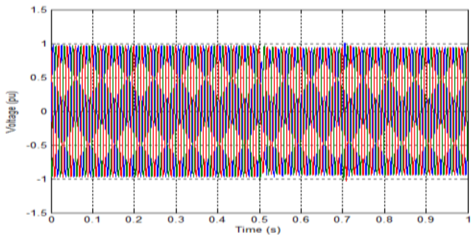

Figure 33.Node 13 voltage

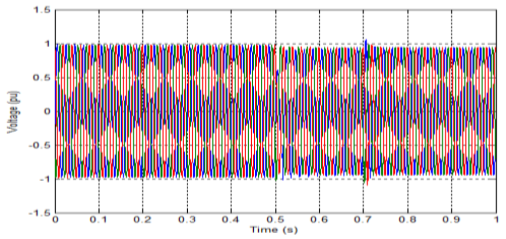

Figure 34.Node 14 voltage

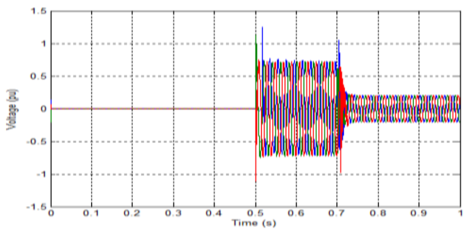

Figure 35. Voltage gouverned of WSSSC

4.3. Discussion of results

Table 1 shows the voltage drop in the nodes. There is a deletion almost total voltage drop for all nodes except bus 8 (the default location).

The WSSSC prevents the consequences of the fault (voltage drop, harmonics,...) from reaching the other regions of the electrical network.

The SSSC can’t manage to eliminate the consequences of the defect totally, and this amounts to the maximum compensation capacity delivered by the WSSSC.

Table 1. The tainsient voltage drop

Bus	Withoutcompensation	With WSSSC
1,2	18%	1.3%
3	21%	2.8%
4,5,6	26%	4.5%
7,9,10	47%	8%
11,14	34%	8%
12	22%	7%
13	25%	6%

5. CONCLUSION

In this work, we examine the impact of a cascading wind farm as an SSSC which is a FACTS capable of compensating for voltage, faced with the propagation of voltage drops in the case of the IEEE 14 bus. The results obtained show that WSSSC provide a strong action in the voltage compensation and reduction of losses in power lines. Its uses make it possible to cancel the propagation of voltage drops in the network. However, in the case of a multi-machine network and loop lines, several compensators must be used to obtain perfect compensation.

ACKNOWLEDGEMENTS

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