International Journal of Applied Power Engineering (IJAPE)
Vol. 2, No. 1, April 2013, pp. 39~44
ISSN: 2252-8792

Improving Electrical Power Grid of Jordan and Control the Voltage of Wind Turbines Using Smart Grid Techniques

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Article Info

Article history:

Received Nov 12, 2012
Revised Jan 24, 2013
Accepted Feb 5, 2013

Keyword:

EATAB
Sensitivity theory
Smart grid
Voltage control
Wind turbines

ABSTRACT

In this paper, we improved the national grid of Jordan country by adding a renewable resources specifically a wind turbines generation unites distributed on different places in Jordan to compensate the losses of the power in Jordan and to dispense with using the generation of fuel and gas by representing the national grid of Jordan in ETAB simulator and we solved the voltage problems of wind turbines using a new mythology using smart grid techniques.

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1. INTRODUCTION

The Jordanian electrical system now has a problems because the load rising and the generation units in future will not cover all the loads so it needs another extension sources like renewable energy resources (wind turbines, solar cells) to cover the loads and does not depends on the generation by fuel and gas because Jordan it has not in sources for fuel and gas. We were studied the Jordanian power grid to solve the generation problems and to improve the controlling of the system using a new techniques like Smart Grid technique and to connect all system together to be system controlled by one central control station and the system depends to each other.

ETAB simulator is the best software to represents real electrical power grid system and to study all case studies of electrical power applications (balanced load flow, unbalanced load flow, arc flash, transient stability and harmonics study) [1] , when we was represents the Jordanian power grid in ETAB simulator it was given results closed to the real results.

Due to the development of Distributed Generation (DG), which is installed in Medium-Voltage Distribution Networks (MVDNs) such as generators based on renewable energy (e.g., wind energy or solar energy), voltage control is currently a very important issue[2].The voltage of MVDNs is now regulated acting only on the On-Load Tap Changer (OLTC) of the HV/MV transformer [3]. The OLTC control is typically based on the compound technique, and this method does not guarantee the correct voltage value in the network nodes when the generators deliver their power [4],[5].When a generator injects power in the network, the voltage tends to rise.

In HV networks this phenomenon happens mainly when reactive power is injected, because the resistance is negligible if compared with the inductive Reactance [6]. Instead in MVDNs the resistance is not negligible and the result is that an injection of active Power also increases the voltage.Instead in MVDNs the resistance is not negligible and the result is that an injection of active power also increases the voltage.

When a generator injects power, the voltage rises in all network nodes, but some nodes are mainly influenced than others by the power injection. This influence can be obtained using a Sensitivity method using Smart Grid techniques.

In this paper representation of Electrical Power Grid of Jordan by ETAB simulator and improving the power grid by adding a distribution generation units (wind turbines) and solve the problems of rising the voltage in wind turbines due to variable power output using Sensitivity method in Smart Grid techniques.

2. REPRESENTATION OF ELECTRICAL POWER GRID OF JORDAN USING ETAB SIMULATOR

To represent any electrical power grid it will be represented in single line diagram and it needs to details and all parameters to design electrical power grid those parameters are:

2.1. Generation information

2.2. Transformers information

2.3. Transmission Lines information

2.4. Load information

2.5. Busbars information

See Fig.1 it is a schematic diagram for electrical power grid of Jordan it represents the generation station, transformation stations and distribution stations.

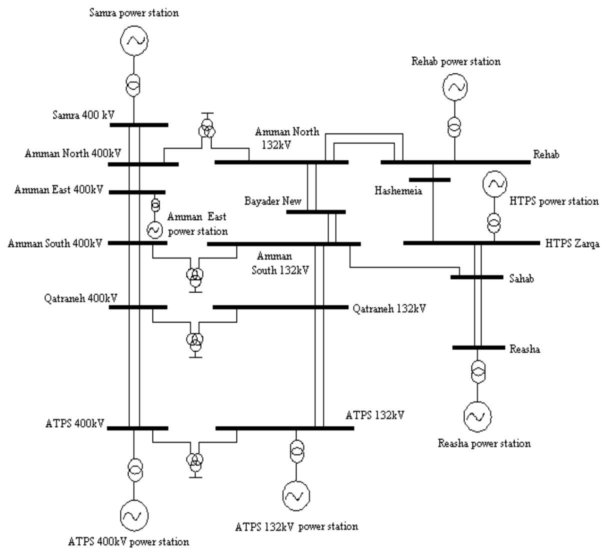


Figure. 1.Single Line diagram of Jordanian network

a. Generation Information Of Gordanian System

The generation information included by rated power, voltage in generator side, power factor of the generator andtransient Reactance xd '. see Table 1.

Table 1 . Examples for generations Units Capacity in Jordan

Unit Name	S	V	P.F	Xd'
	(MVA)	(kV)		(PU)
HTPS Gen1	38.82	13.8	.85	.17
HTPS Gen2	38.82	13.8	.85	.17
HTPS Gen3	38.82	13.8	.85	.17
HTPS Gen4	77.65	13.8	.85	.186
HTPS Gen5	77.65	13.8	.85	.186
HTPS Gen6	77.65	13.8	.85	.186
HTPS Gen7	77.65	13.8	.85	.186
ATPS Gen1	160	15	.85	.165
ATPS Gen2	160	15	.85	.165
ATPS Gen3	160	15	.85	.165
ATPS Gen4	160	15	.85	.165
ATPS Gen5	160	15	.85	.165

b. Transformer Information In Jordanian System

It is included by MVA Capacity, the voltages in primary and secondary sides of the transformers and impedance % of the transformers see Table 2.

Table 2.Examples for transformers in Jordan

S/S Name	Trans No	Voltage Transformation kV		Capacity	Imp. %
		From	To	MVA	
Zerqa	STR1	132	33	15/30	9.7
	STR2	132	33	20/30	9.9
	STR3	132	33	18/30	10.25
	STR4	132	33	26/40	10.17
Marqa	STR1	132	33	27/45	12.1
	STR2	132	33	42/63	12.8
	STR3	132	33	54/80	12.6
Abdali	STR1	132	33	40	10.74
	STR2	132	33	40	10.78
	STR3	132	33	40	12.9
Bayader Old	STR1	132	33	22.5/45	12.4
	STR2	132	33	22.5/45	12.1
	STR3	132	33	22.5/45	12.84

c. Transmission lines Information of Jordanian system:
It consists of the length of line, resistance and reactance for each line.

d. Load Information of Jordanian system:
It consists of the MVA for each feeder and the voltage a cross the feeder.

e. Busbars Information of Jordanian system:
Included by the voltage a cross each bus and the rated current can flows the bus.

3. DESIGN WIND TURBINES GENERATION UNITS IN ETAB

ETAB simulator designs the wind turbines and allows inputting the real data of wind generation (i.e., average speed).

In the improvements of Jordanian power network to give enough electrical power to cover the demands and to compensate the losses by adding wind generation units each unit included groups of winds turbine and each wind turbine rated by 2 MVA connected to 0.4 kV bus with power factor equal to 80% and each two winds turbine connected to one transformer rated by 5 MVA See Figure.2.

4. PERFORMANCE OF WIND TURBINES IN JORDAN

The wind turbine is measured by the power curve and C_P curves. The power curve is the relation between the power out and the average speed of the wind turbine see Figure.3, it is a wind turbine has 10 m/s average speed and produces 0.676 MW.

The coefficient of power is the most important variable in wind turbine aerodynamics.**Buckingham π theorem** can be applied to show that non-dimensional variable for power is given by the equation below. This equation is similar to efficiency, so values between 0 and less than one are typical. However this is not the exactly the same as efficiency so in practice some turbines can exhibit greater than unity power coefficients. In these circumstances one cannot conclude the first law of thermodynamics is violated because this is not an efficiency term by the strict definition of efficiency [7].

$$C_P = \frac{P}{\frac{1}{2}\rho A V^3} \quad (1)$$

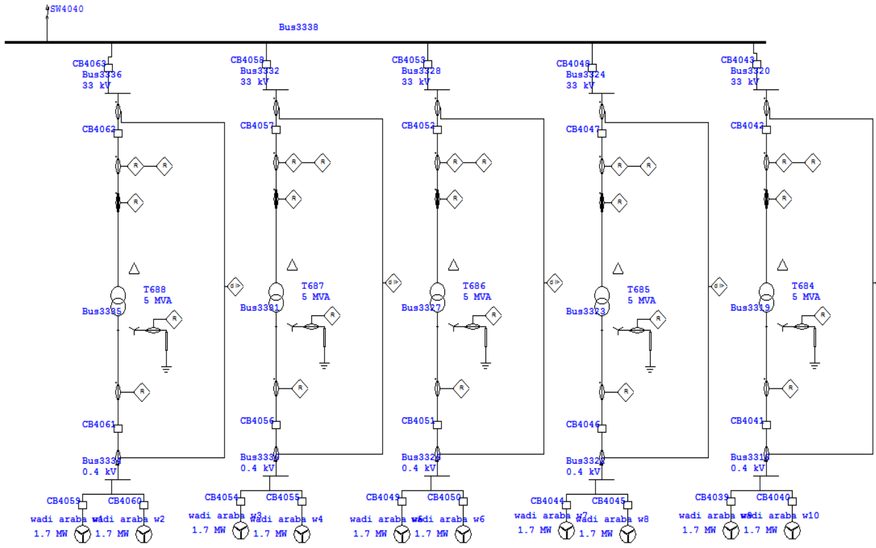
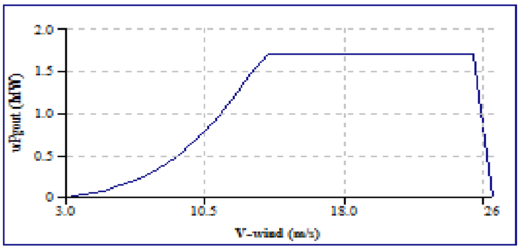


Figure.2.wind turbine generation units

Where: C_P is the coefficient of power ρ is the air density, ***A*** is the area of the wind turbine, and finally V is the wind speed see Figure.4.chosen each year by the Society's Awards Committee.



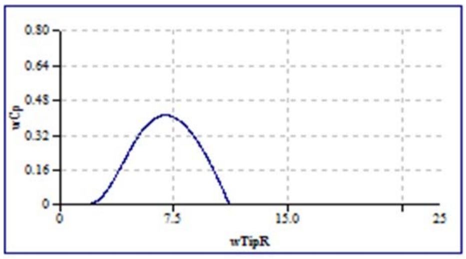


Figure.3.Power curve of wind TurbineFigure.4.C_P curve of Wind Turbine

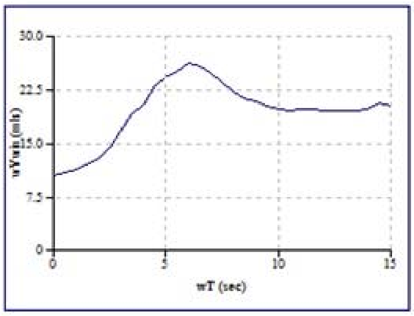


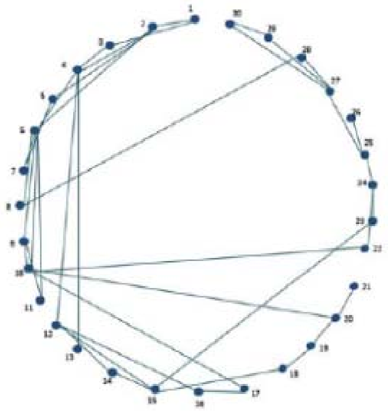
Figure.5.Wind Profile resulted from simulation in ETAB

5. MAPPING OF SINGLE LINE DIAGRAM

To analyze the power system within the context of complex network theory, the first step is to model the system as a graph [8]. From the perspective of network theory, a graph is an abstract representation of a set of objects, called nodes or vertices, where some pairs of the objects are connected via links or edges. The power system of today is a complex interconnected network which can be subdivided into four major parts of generation, transmission, distribution and loads [9]. To portray the assemblage of various components of power system, engineers use single-line or one-line diagram which provides significant information about the system in a Concise form [10].The principle of mapping is described as follows:

a) All impedances between any bus and neutral are neglected,
b) All transmission and/or distribution lines are modeled except for the local lines in the plants and substations,
c) All transmission lines and transformers are modeled as weighted lines, the weight is equal to the admittance between the buses, and

d) Parallel lines between buses are modeled as an equivalent single line**.** convert single line diagram Figure.7 to nodes diagram Figure.6.



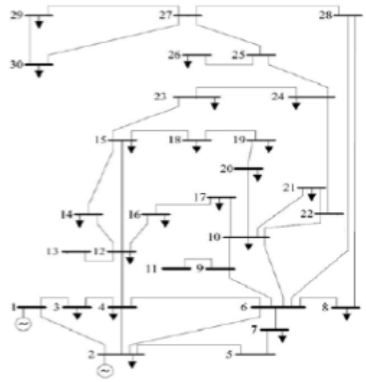


Figure.6.Physical topology graph of IEEE-30 bus systemFigure.7.the IEEE-30 bus system.

6. VOLTAGE CONTROL OF WIND TURBINES USING SMART GRID COMPONENTS OBTAINED WITH SENSITIVITY THEORY

If the generators are able to control the injected or absorbed reactive power, the network voltage profiles can be modified by acting on the reactive powers. It is clear that each controllable generator needs a smart grid components like (GRTU) Generator Remote Terminal Unit that is connected to a central control system to set the generator reactive power and (GCC) Generator control Center [3,4].

When the voltage in the ith node exceeds max V , the GRTU installed in the same node sends the signal "Voltage Threshold Overall" (VTO) to the GCC using a communication channel. The GCC then selects the generator in the j_{th} node that has the maximum influence on the voltage of the i_{th} node, the "Best Generator" (BG), and switches it to RPA (the reactive power absorption mode). Therefore, the voltage in the ith node tends to decrease. The problem is thus to determine the best generator and ensure that the GCC chooses it. In this work, a sensitivity- based method is proposed to select the BG see Figure.8.

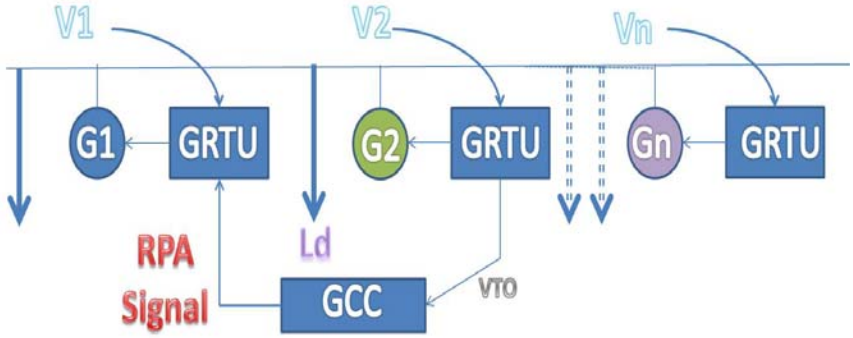


Figure.8.voltage controlled by GCC and GRTU

Let us suppose that load Ld suddenly decreases its power (for example, due to a trip) and V2 exceed V_{max} . The GRTUs of G2 send the signal VTO to the GCC that must choose the BG using the sensitivity method. Assuming that the BG is G1, it will be switched by the GCC in the RPA mode; therefore, the reactive power absorbed by G1 becomes Q1=P1tan φ1. As explained in the following, the GCC must know the reactive power that each controllable generator can absorb in order to choose the BG. We suppose that this information is acquired the GCC using a polling technique on each GRTU. See **Fig.9**.

It will choose the best generation by choose the best absolute value of sensitivity factor so by ETAB the result for the best generation to reduce the voltage of node 5 is

$t_{s5,4}$ = -164.53 V

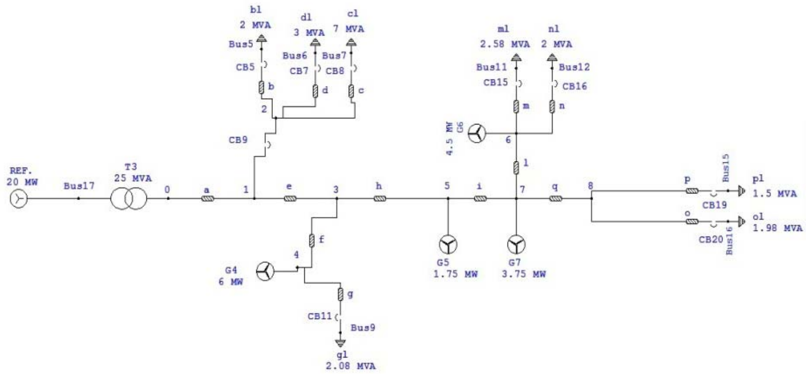


Fig.9.Medium voltage distribution network

7. CONCLUSION

The proposed sensitivity method allows the voltage within network acting on single generators to be regulated by choosing the most effective generator on the controllednode (i.e., the Best Generator). This is a very important feature in grids that have distributed generation (e.g., in a Smart Grid context). The proposed method uses a topological approach. Moreover, the sensitivity table can be constructed automatically. In addition to the BG choice, the proposed method also evaluates the voltage in all network nodes after a reactive power variation.

After choosing the BG, but before its commutation during RPA, it is possible to verify that the voltage variation in the other nodes is tolerable for the connected loads.Moreover, it is necessary to verify that the threshold settings of the voltage relay installed in the same nodes.

ACKNOWLEDGEMENTS

The authors would like to thank Dr.Moahmmad AL-Zoubi for his support and they would thank the NEPCO company for given data for them.their financial support and offering the software to completethis work.

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