International Journal of Electronics Communication and Computer Engineering
Volume 10, Issue 3, ISSN (Online): 2249–071X

Enhancing Integration of Renewable Energy Resources in Power Grid Through Back to Back Converter

Ihsan Mizher Baht
University College of Engineering Craiova, Romania.
Corresponding author email id: imb121378@yahoo.com

Date of publication (dd/mm/yyyy): 18/05/2019

***Abstract* – Choosing effective method for penetrating renewable sources to power system grid is an important issue for economical operation of the system and controlling the system. Different electronic interface has been used to connect renewable sources to power system that have their corresponding advantages and drawbacks. Diode electronic interface for connecting renewable sources to power system is very economical but its main drawback is that it can't be controlled. Thyristor electronic interface can overcome uncontrollability problem of diode, but it observes reactive power which destroys voltage profile of the system. This thesis mainly discusses effective method of connecting double fed induction generator wind turbine into power grid through Insulated Gate Bipolar transistor (IGBT). The work consists of 4 different procedures for connecting double fed induction generator wind turbine into grid has been evaluated based on grid voltage profile and power losses. Voltage profile and losses of every method is calculated through forward backward sweep load flow method. Wind turbine is connected into transmission system and distribution system both with back to back converter and without back to back converter. From aforementioned four methods of connecting wind turbine into gird optimum method is selected for further analysis. Based on monitoring of the system economic adjustment of dispatching generation units has been made according to loading condition of the system. A 14 bus power system is used for case study. For calculating losses of the system a MATLAB code based on forward backward load flow technique is written and it is applied on the system both in case on direct connection and with IGBT electronic interface. This code is also tested on an IEEE 15 buses and IEEE 33 buses power system.**

***Keywords* – Iraq, Smart Link, Renewable Energy, Control Power Flow, Matlab.**

I. INTRODUCTION

The issue of power and energy management has become a major problem that confronts the world in the 21st Century. As the world population increases, it has become complex for the energy needs of the people to be met as effectively as possible. It is also vitally important to highlight the fact that the issue of global warming and climate change has become a major challenge that confronts the world. This is a phenomenon characterized by drastic changes in climatic patterns as well as increased surface temperatures. Despite the fact that there are many issues and factors that have contributed towards the occurrence of the phenomenon of climate change, the absence of effective strategies of energy and power management is a factor that has inevitably been influential. Some of the strategies used within the context of harnessing and management of renewable energy have not had the intended implications especially when it comes to the issue of energy use efficiency. In view of such issues, it then follows that there is the need for a holistic approach that is strongly aligned towards modern platforms of electric engineering.

II. INTEGRATING RENEWABLE ENERGY RESOURCES

Actually the integration of renewable energy resources to conventional grid is very important to enhance the systems, The Renewable energy is a green energy, and it can protect the environmental with very low cost. The

International Journal of Electronics Communication and Computer Engineering
Volume 10, Issue 3, ISSN (Online): 2249–071X

renewable energy resources (sun, wind, water, biogas etc.) needs to select the best performance it depends on the city climate or location (place installed). In this project we use the wind turbine connect through the system in two cases: The First is to connect directly (without BTB) to transmutation line and distribution system with comparing results immediately. The Second is to connect the wind turbine to the system through VSC (BTB converter) in transmutation line and distribution system. But the first of all we must select the type of wind turbine depending on the speed and we select (DFIGWT), in the Fig (1) below the internal design of the wind turbine with (output power, voltage, torque,) regarding to input speed (constant or variable).

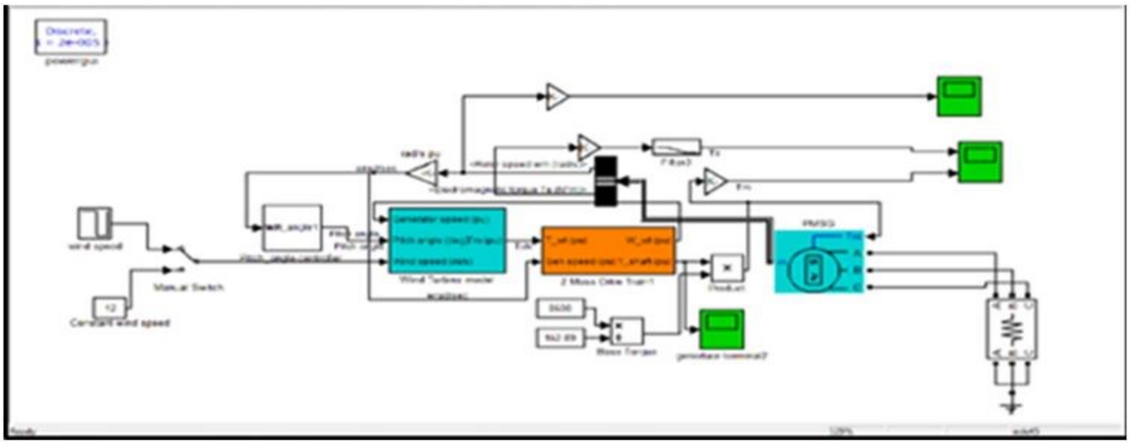


Fig. 1. Internal design of wind turbine.

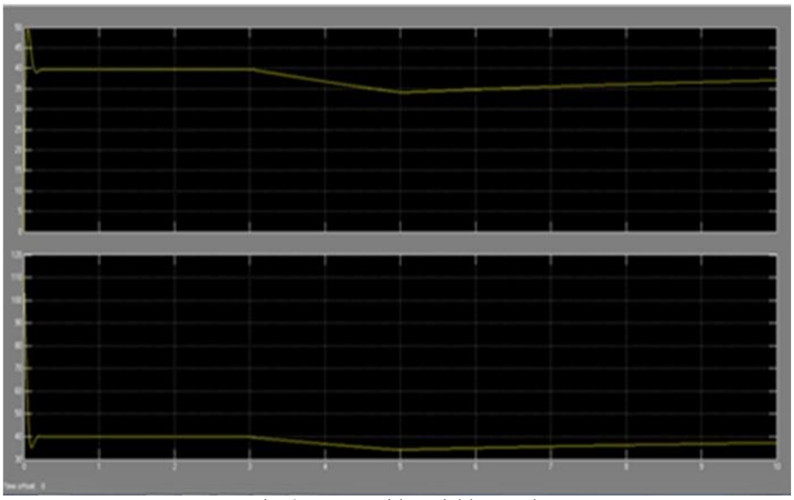


Fig. 2. Power with variable speed.

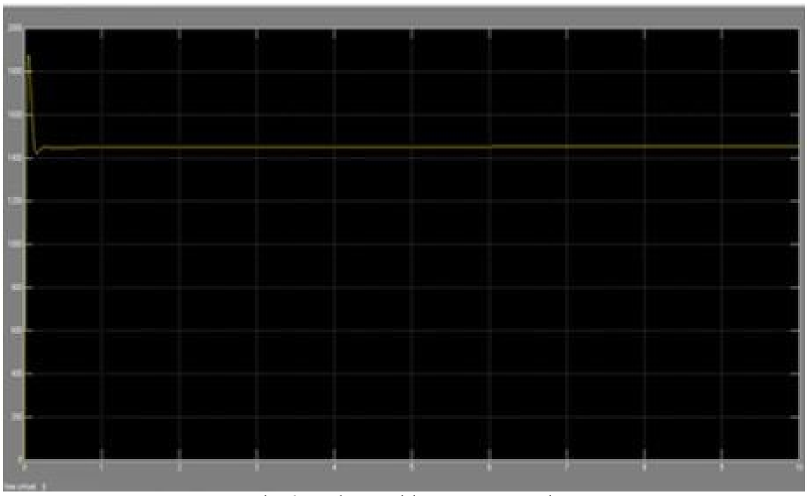


Fig. 3. Voltage with constant speed.

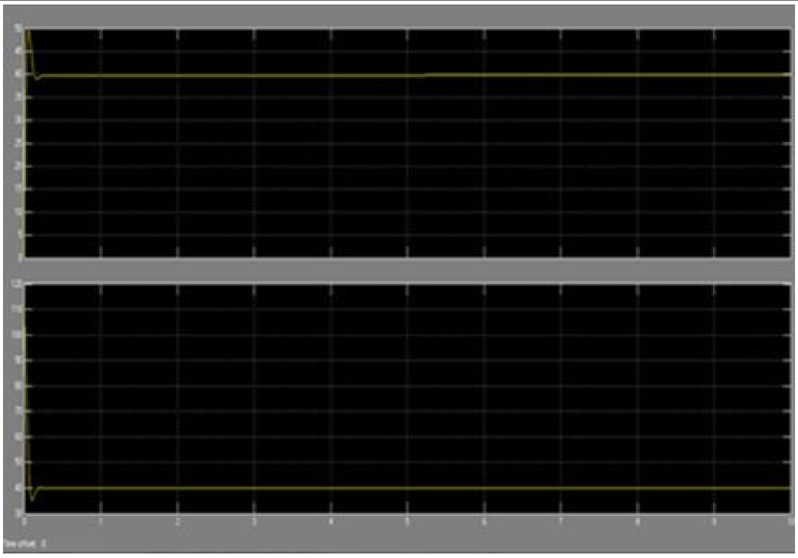


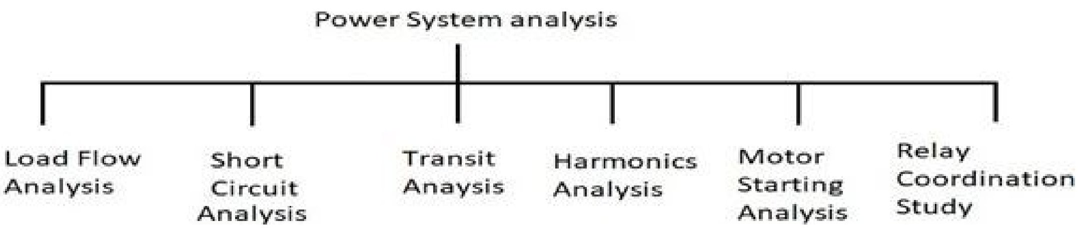
Fig. 4. Power with constant speed.

III. Power System Analysis

Electrical power system consists of a group of components that are connected to each other, including generation, transformers (step up or step down), transmission lines, distribution lines, etc.

The process of analyzing and studying the physical properties for all stages of electrical power system, and controlling the operation of the system within the required stability conditions, for example, it is always needed that generated voltage be stable and constant in both steady state and short circuit. The process of electrical power system analysis consists of:

1. Load flow analysis.
2. Short circuit analysis.
3. Transit analysis.
4. Harmonics analysis.
5. Motor starting analysis.
6. Relay coordination study.



IV. Load Flow Analysis

The process of power system analysis is the basis to determine if the system is efficient or not. In addition to calculating the electrical power, voltage drop and the angle.

Using the electrical system analysis, we can calculate the sizes of needed transformers, cables, etc.

Through this analysis, we can choose best places to support the system with capacitors or selecting the best connection spot of alternative power supplies, to reduce electrical losses that are caused by induction and other loads, and improve the power factor.

The situation that is to be considered exists in the electrical distribution system. A Backward/Forward Sweep Load Flow technique was chosen to analyze all the system coefficients (i.e., P, V, and Q).

In summary, this method depends on assuming that the voltage is 1.p.u., and calculate the power and losses, then voltage can be calculated from the below equations. 15 buses and 33 buses systems were analyzed using Matlab simulation and ETAP.

A Load flow technique to solve distribution networks based on sequential branch numbering scheme by considering committed loads is presented [14].

Table 1. Result summary of load flow 15 node.

BRANCH		P LOSS (KW)	QLOSS (KVAr)
FROM	TO		
1	2	37.72	36.90
2	3	11.34	14.01
3	4	2.05	2.40
4	5	0.06	0.04
2	9	4.77	4.89
9	10	0.39	0.27
2	6	0.11	0.08
6	7	0.47	0.32
6	8	0.06	0.04
3	11	2.18	0.04
11	12	2.18	1.54
12	13	0.6	0.41
4	14	0.07	0.05
Total losses		**60.35**	**58.39**

V. CASE STUDY

Baghdad city power supply is provided from six main substations 400/132kv, which in turn supply many substations of 132/33kv, (132/33/11kv) most of these 33/11kv substations are equipped with transformers of 31.5MVA.

This work is based on small portion of Baghdad power grid and it is situated in south-east of the city as illustrated in Fig (5). An 11 KV feeder from Al-Khalij substation supplies the area. The distribution system is radial with 14 buses, and total of 25 MVA load.

Fig. 5. AL. khalij substation.

The main objective of this work is to evaluate effective method to penetrate a wind generation farm consisting of 5 wind turbines with a capacity of 2 MVA each. A comparison is made of penetrating the wind farm in distribution and in transmission system.

Below are the main steps of this study:

1. Modeling the system in MATLAB Simulink using sim-power system package.
2. Integrating wind energy source with smart-link (Back to Back converter) and directly and comparing both cases based on voltage profile and minimization of losses.
3. Testing effective placement of wind turbine: (comparison of penetrating to transmission system and distribution system).
4. Calculating losses and voltage profile based on forward- backward sweep load flow method for all aforementioned cases.
5. Economic assessment of DC-link for integrating wind farm.

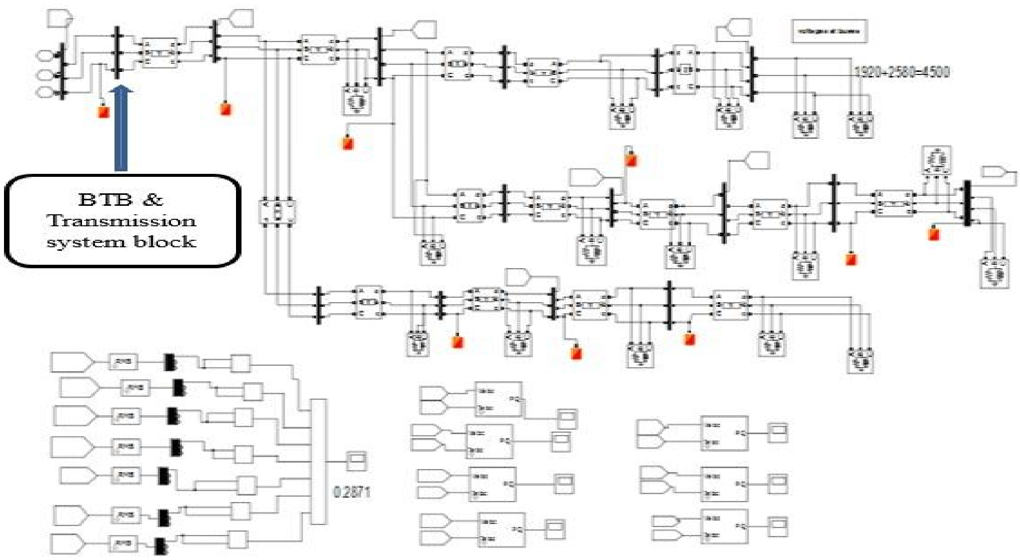


Fig. 6. Connect wind to distribution system.

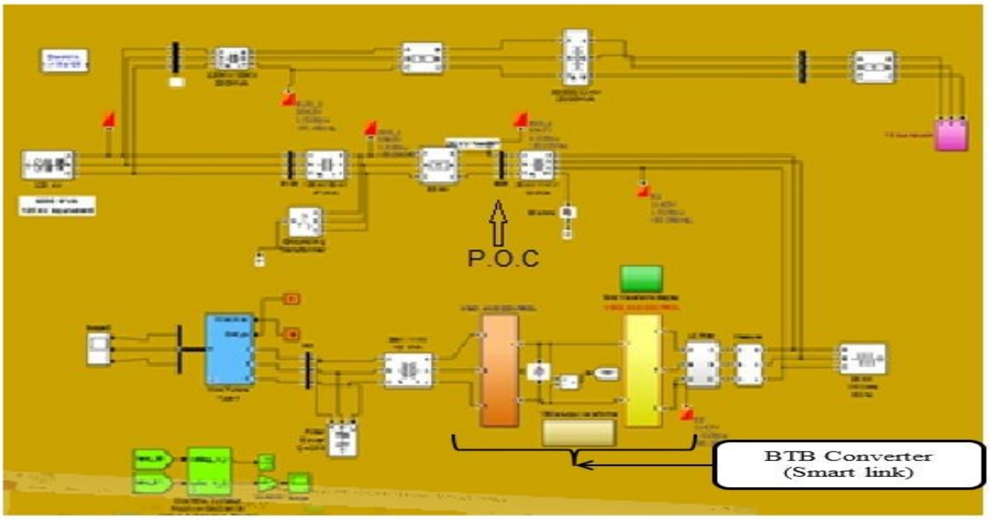


Fig. 7. Connect wind turbine to transmutation line.

International Journal of Electronics Communication and Computer Engineering
Volume 10, Issue 3, ISSN (Online): 2249–071X

VI. Results of Evaluation and Comparison

For selecting best possible method of integrating wind turbine to system, they are compared based on losses of the system and voltage profile. Power flow analysis using backward forward sweep method is used to find power losses and voltage profile of the system in this section result of two cases; wind turbine integrated to transmission system with and without back to back converters (smart-dc-link) is illustrated. System losses of a load curve for one full day is calculated for the two cases and comparison is made. Besides, voltage profile of a specific bus is compared for the two cases. Results are illustrated in the following graphs.

Table 2. Voltage Profile for both Cases of WT integrated in transmission system.

BUS NO.	Voltage without BTB in PU	Voltage with BTB(PU)
1	1	1
2	0.952	0.97
3	0.947	0.968
4	0.946	0.967
5	0.944	0.967
6	0.949	0.968
7	0.945	0.966
8	0.943	0.965
9	0.943	0.965
10	0.944	0.964
11	0.945	0.963
12	0.944	0.963
13	0.942	0.965
14	0.957	0.967

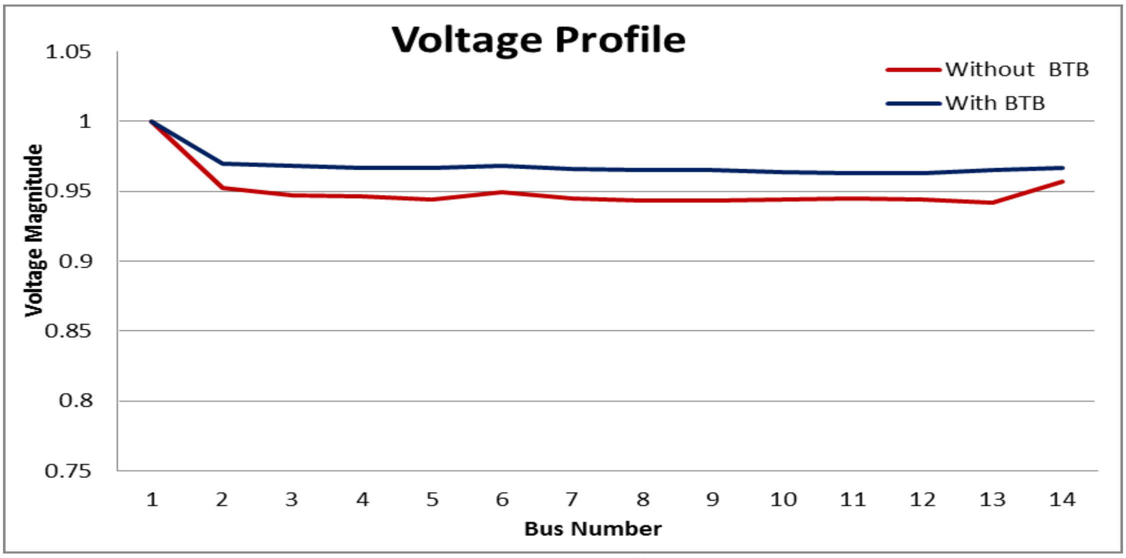


Fig. 8. Voltage profile.

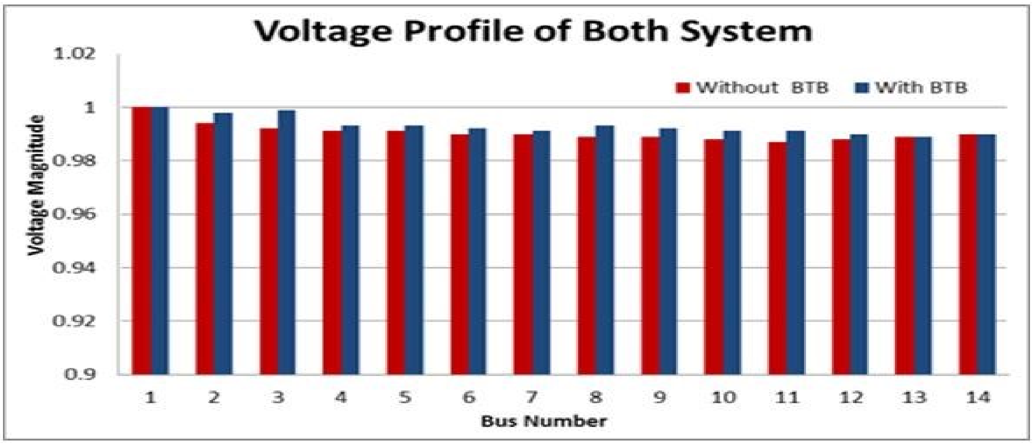


Fig. 9. Voltage profile of both systems.

Table 3. Losses with and without BTB.

Time	Load Demand(Mw)	Losses Value for without BTB(Kw)	Losses Value for With BTB(Kw)
12:00 AM	5.8	9.569324	5.454514406
1:00 AM	4	6.599533	3.761734073
2:00 AM	5	8.249417	4.702167592
3:00 AM	7	11.54918	6.583034628
4:00 AM	9	19.52501	11.12925615
5:00 AM	6	9.8993	5.64260111
6:00 AM	7.00	11.54918	6.583034628
7:00 AM	10	21.69446	11.93195104
8:00 AM	12	26.03335	14.31834125
9:00 AM	15	45.36501	23.58980392
10:00 AM	13	39.31634	20.44449673
11:00 AM	12	26.03335	14.31834125
12:00 PM	11	23.8639	13.12514615
1:00 PM	10	21.69446	11.93195104
2:00 PM	7	11.54918	6.583034628
3:00 PM	12	26.03335	14.31834125
4:00 PM	13	39.31634	20.44449673
5:00 PM	11	23.8639	13.12514615
6:00 PM	14	42.34067	22.01715033
7:00 PM	15	45.36501	23.58980392
8:00 PM	18	96.14684	49.99635789
9:00 PM	19	101.4883	52.77393333
10:00 PM	17	51.41368	26.73511111
11:00 PM	12	26.03335	14.31834125
12:00 AM	6	9.8993	5.64260111

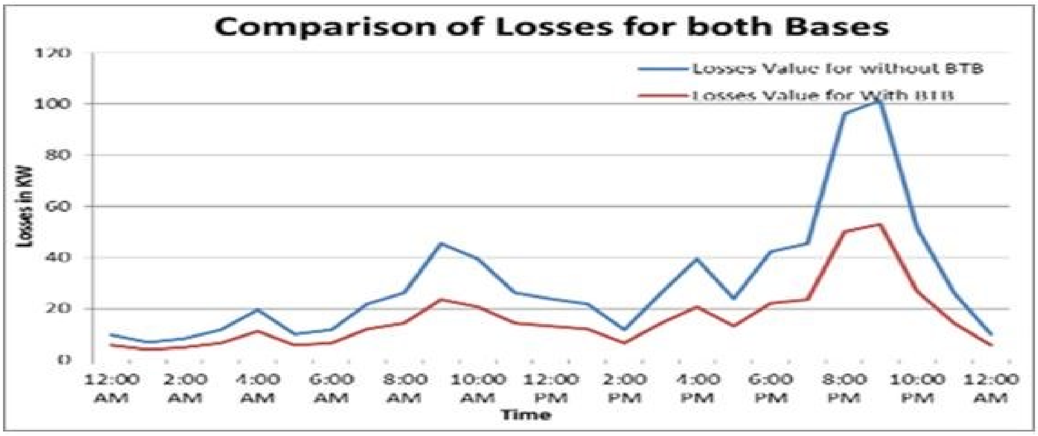


Fig. 10. Power losses.

VII. Conclusion

The project main objective is to integrate wind farm energy source economically to the conventional power grid system. It assesses penetrating wind turbine to the system in four distinct cases. A 14 buses power system with one main 11 KV main feeder is selected for the study. In the analysis procedure, wind turbine is connected to generation and distribution system with back-to-back converters as smart dc link as well as without back-to-back converters. According to the study result, back-to-back converter improves system condition considerably; it reduces losses to a major extent and improves buses voltage profile.

The results of comparison of all cases reflect that best location for integrating wind turbine is in distribution system with a dc-link (in this study back to back converter). Benefits of connecting renewable sources with back to back converter exceeds far more the investment cost as it will payback for its cost in less than 2 years by reducing losses and improving voltage profile.

The back-to-back converter connected in the system to reduce line current harmonics. It consists of a force-commutated rectifier and a force-commutated inverter connected with a common Dc–link.

This set has well known properties; the line-side converter may be operated to give line currents that are sinusoidal, for sinusoidal currents, the dc-link voltage should be greater than the peak main voltage, the dc-link voltage is regulated by controlling the power flow to the ac grid.

To increase the output power of a connected machine over its rated power, the inverter operates on the boosted dc-link.

An important property of the back-to-back converter is the possibility of fast control of the power flow. By controlling the power flow to the grid, the dc-link voltage can be held constant.

The installation of a rapid control loop for the dc-link voltage makes it possible to decrease the size of the dc-link capacitor, with no effect to the inverter performance.

In fact, the capacitor can be made small enough to be implemented with plastic film capacitors.

References

[1] Al Ameri, A., Ounissa, A., Nichita, C., & Djamal, A. (2017). Power Loss Analysis for Wind Power Grid Integration Based on Weibull Distribution. Energies (19961073), 10(4), 1-16.
[2] Allison, J., Murphy, G. B., & Counsell, J. M. (2016). Control of micro-CHP and thermal energy storage for minimizing electrical grid utilisation. International Journal of Low Carbon Technologies, 11(1), 109-118.
[3] Anderson, J. (2017). Outlining the Renewable Energy Grid of the Future. Solar Today, 31(4), 26-27.
[4] Asaleye, D. A., Breen, M., & Murphy, M. D. (2017). A Decision Support Tool for Building Integrated Renewable Energy Micro grids Connected to a Smart Grid. Energies (19961073), 10(11), 1-29.
[5] Barbaric, M., & Loncar, D. (2016). Energy management strategies for combined heat and electric power micro-grid. Thermal Science, 20(4), 1091-1103.
[6] Beykverdi, M., Jalilvand, A., & Ehsan, M. (2016). Cooperative Energy Management of Hybrid DC Renewable Grid using Decentralized Control Strategies. Energies (19961073), 9(11), 1-18.
[7] Bohm, R., Rehtanz, C., & Franke, J. (2016). Inverter-based hybrid compensation systems contributing to grid stabilization in medium voltage distribution networks with decentralized, renewable generation. Electrical Engineering, 98(4), 355-362.
[8] Bollen, M.J., & Rönnberg, S.K. (2017). Hosting Capacity of the Power Grid for Renewable Electricity Production and New Large Consumption Equipment. Energies (19961073), 10(9), 1-28.
[9] Browne, A. (2017). The Tipping Point: Shifting Policy Focus from Renewable Energy Targets towards Grid Reform and System Integration. Renewable Energy Law & Policy Review, 8(1), 33-41.
[10] Cetinkaya, N. (2017). Improving of renewable energy support policy and a performance analysis of a grid-connected 1 mwp pv power plant in Konya. Selcuk University Journal of Engineering, Science & Technology / Selçuk Üniversitesi Mühendislik, Bilim Ve Teknoloji Dergisi (Selcuk University Journal of Engineering, Science and Technology), 5(3), 251-261.
[11] Chen, W., & Yin, H. (2017). Optimal subsidy in promoting distributed renewable energy generation based on policy benefit. Clean Technologies & Environmental Policy, 19(1), 225-233.
[12] Chicco, G., Cocina, V., Di Leo, P., Spertino, F., & Massi Pavan, A. (2016). Error Assessment of Solar Irradiance Forecasts and AC Power from Energy Conversion Model in Grid-Connected Photovoltaic Systems. Energies (19961073), 9(1), 1-27.

[13] Dyak, A.A., Abu-Lehyeh, E.O., & Kiwan, S. (2017). Assessment of Implementing Jordan's Renewable Energy Plan on the Electricity Grid. Jordan Journal of Mechanical & Industrial Engineering, 11(2), 113-119.

[14] S. Jamali, M.R. Javdan, H. Shateri and M. Ghorbani, "Load Flow Method for Distribution Network Design by Considering Committed Loads," Universities Power Engineering Conference, Vol. 41, No.3, September 2006, PP. 856-860.

AUTHOR'S PROFILE

Ihsan Mizher Baht
Currently PHD student in the electrical engineering department Craiova University-Romania, born in Baghdad 1978/12/13, he received his BSc in University of Technology Baghdad-Iraq, and Master degree in Osmania University - India. email id: imb121378@yahoo.com