International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 07 | July 2021 www.irjet.net p-ISSN: 2395-0072

Power Quality Improvement in Grid Connected Renewable Energy Sources

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Abstract - The objective of this project describes the power quality analysis of grid connected Renewable energy sources. Here, three various systems are taken as PV-Battery system, DFIG based Wind turbine, to show the importance of DFIG and its in-built converters. In Hybrid system, DFIG Grid Side Converter (GSC) of has been also utilized as an inverter of the System which reduces the cost of one converter. The total harmonic distortion (THD)is evaluated in grid side. The DFIG has two controllers Rotor side control and Gride side control. These two converters have the capability to maintain constant rotor speed, controls DC link voltage, inverter AC-DC-AC is implemented using vector control method. In solar PV MPPT technique and boost converter is used to maximize the power and fed to the three -phase pulse width modulation (PWM) inverter. Simulation study of the proposed system is carried out with MATLAB Simulink

Key Words: Power quality, Microgrid, Doubly-fed Induction Generator (DFIG)

1.INTRODUCTION

Due to tremendous increase in demand of electricity and to maintain continuity of supply in important regions such as Shopping malls, Railways, Industries etc . when a fault occurs in the main grid its voltage and frequency collapses due to which the major portion of the load lost its supply.
Microgrid is combination of sources and loads and it is small-scale power grid that can operate independently and dependently requirement of our load demand. DFIG is currently the system of choice wind turbines. It has many advantages such as reduces harmonics , variable speed. It's in built converters have back to back connection so closed operation is possible[2] Solar energy is free energy from the sun and the energy converted to electricity using photovoltaic cells. The DC is converted into AC. The voltage is increased using boost converter to maximize the power and fed to the PWM inverter. Power quality is the steady voltage supply where the frequency of the supply remains close the rated value. Without power quality issues the control strategies are implemented in DFIG based wind turbine using PI, PID controllers. To maintain constant supply to the grid. In the solar MPPT technique is used in mostly of the systems. The various power quality issues The various power quality issues occured while sending power to the grid to compensate the issues vector control method implemented.Vector control strategy is proposed to improve power quality and proper load sharing to the grid.

1.2 PV System with MPPT control

A photovoltaic cell is a semi-conductor device that converts light to electrical energy by photovoltaic effect. Photovoltaic systems that use batteries as the only storage system and in which the voltage varies slightly only due to the state of charge**.** An MPPT, or maximum power point tracker is an electronic DC to DC converter that optimizes the match between the solar array , and the battery bank or utility grid.
The universal formula to calculated the electricity generated in output of a solar system is

E = A * r * H * PR

E = Energy (kWh)
A = Total solar panel Area (m2)
r = solar panel yield or efficiency(%)
H = Annual average solar radiation on tilted panels (shadings not included)
PR = Performance ratio, coefficient for losses (default value= 0.75)

Table -1: System parameters for PV system

Parameter	Value
Maximum power	8KW
Open circuit voltage	128V
Short circuit current	14.4A
Boost inductor	5mh
Boost switching frequency	24 KHZ

1.3 PV system with Battery storage using Bidirectional converter

Bidirectional converter is used to allow current in both directions energy flow from battery to grid and vice-versa. Due to climatic conditions or lightning battery is used to sending power to grid and when the load requirement is fulfilled sending back to the battery.

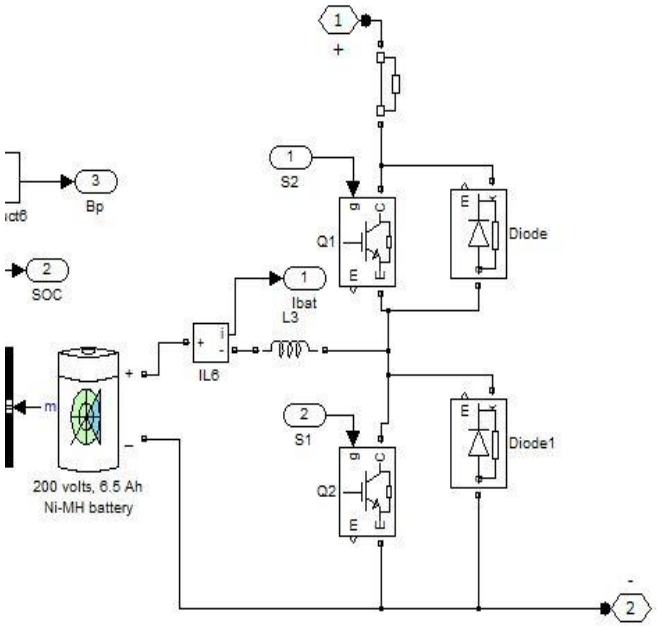

FIG.1 Simulation model battery with bidirectional converter

3.WIND TURBINE

3.1 DFIG based wind turbine working

Wind is abundant energy source in the earth. The energy Come from wind is kinetic energy is converted into electrical energy using generators. DFIG based wind turbine is used for this purpose. This turbine has several advantages like harmonic compensation and active and reactive power control used.

Table -2: *Wind turbine parameters*

Parameters	*Value*
Nominal wind speed	12m/sec
Wind system power	20KW
Pitch angle	45 degrees

DFIG has two back-to-back converters. They are Grid side converter and Rotor side converter the whole system is used to generate power and send to the utility grid. Here, GSC is AC-DC converter circuit which is used to provide a regulated DC voltage to the inverter maintain a constant DC link voltage. RSC is DC-AC inverter, it is used to provide controlled AC voltage to the rotor. The closed loop operation.

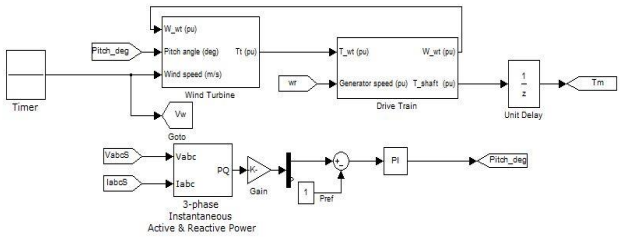

FIG.2 Simulation model of wind energy conversion system

3.2 Control strategy implemented in DFIG system

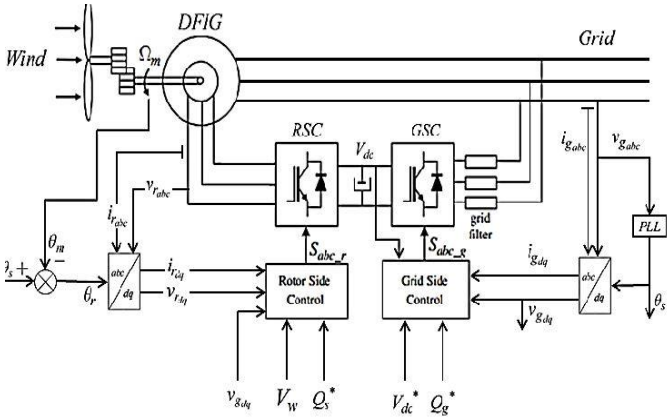

Fig. 3. Vector control of DFIG with grid and rotor side converters.

A vector control is applied to both sides of converters to control the stator active and reactive power are controlled By controlling direct and quadrature axis currents. The three-phase stator currents are measured and this measurement provides the corresponding voltages and the rotor velocity is also measured. The 3-phase currents are converted to 2-axis system for simple mathematical calculations. This conversion provides the variable voltages. The 2-axis system is rotated to align with the rotor flux using a transformation angle with respect to the stator reference axis. Error signals are formed using reference values for each. Error signals are input to the PI and PID controllers. The output of the controller provides voltage with respect to dq-axis. These controllers estimating the modulating signal compared with fixed frequency these signals given to the PWM generator

through converters. The calculations are used in method using park transformation method. This method is most preferable for the simple calculation purpose. PLL(phase locked loop) is used to detect the phase angle of the grid voltage injects current into the grid in phase with voltage to get unity power factor operation.

3.3 Simulation model of DFIG based wind turbine

Here the asynchronous generator is used for stable operation. Which reduces noise and mechanical stresses and improves power quality. DFIG uses stator flux linkage oriented control strategy , for variable speed operation DFIG based wind energy conversion system needs control of voltage source converter. The GSC and RSC acts as STATCOM devices to absorb the reactive power.

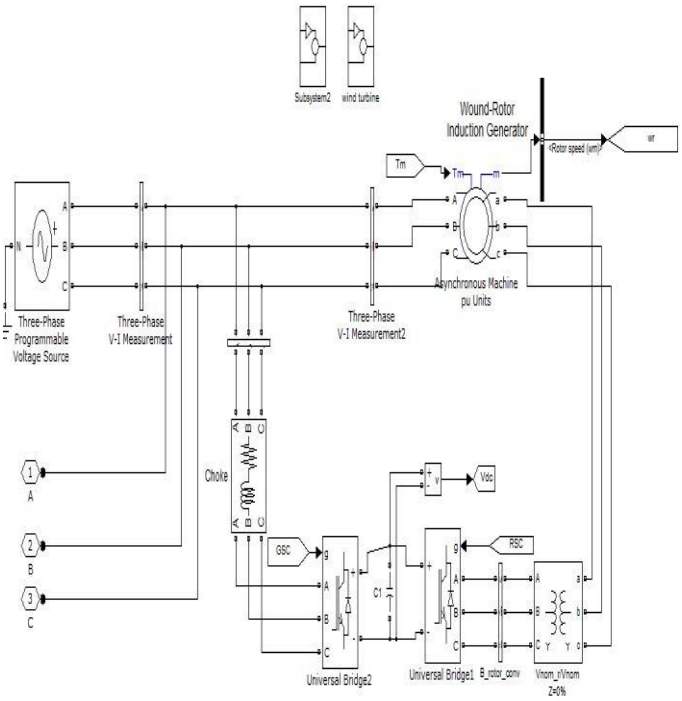

FIG. 4 Simulation circuit of wind system to grid

4 GRID-SIDE CONVERTER

The overall vector control scheme of the GSC, in which the control of the dc-link voltage Vdc and the reactive power exchanged between the GSC and the grid, is achieved by means of current regulation in a synchronously rotating reference frame.

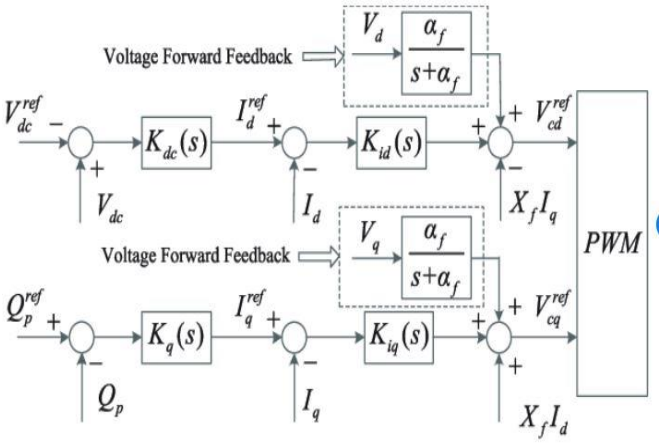

FIG. 5 Vector control of GSC

4.1 ROTOR -SIDE CONVERTER

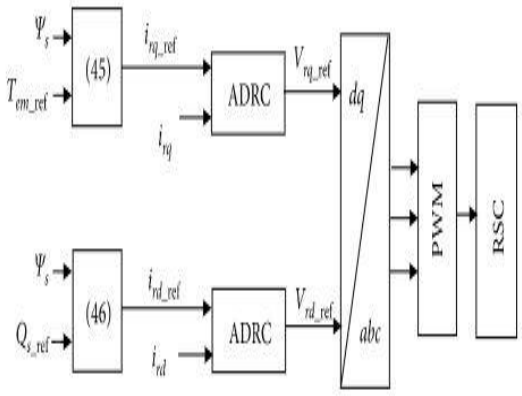

FIG. 6 Vector control of RSC

To control the generator rotor side converter is used.It controls the generator in terms of active and reactive power by ensuring minimum power loss during power conversion. The rotor side converter is made up of IGBT.

Table -3 DFIG Parameters

parameters	values
DFIG voltage(rms)	320v
voltage	800v
frequency	50hz
R_S	9.5 ohm
R_R	10.7 ohm
L_S	5.45mh
L_R	6.32mh
L_M	2.25mh
J	0.003
DC link voltage	600v

5 FORMULAS

Wind power = K Cp $1/2\delta VA^3$

P = Power output, kilowatts
Cp = Maximum power coefficient, ranging from 0.25 to 0.45, dimension less (theoretical maximum = 0.59)
ρ = Air density, lb/ft3
A = Rotor swept area, ft2 or π D2/4 (D is the rotor diameter in ft, π = 3.1416)
V = Wind speed, mph
k = 0.000133 A constant to yield power in kilowatts. (Multiplying the above kilowatt answer by 1.340 converts it to horse- power [i.e., 1 kW = 1.340 horsepower]).

6. SIMULATION AND RESULTS

In this section we have simulated three hybrid systems namely PV-battery system, wind system, DFIG system

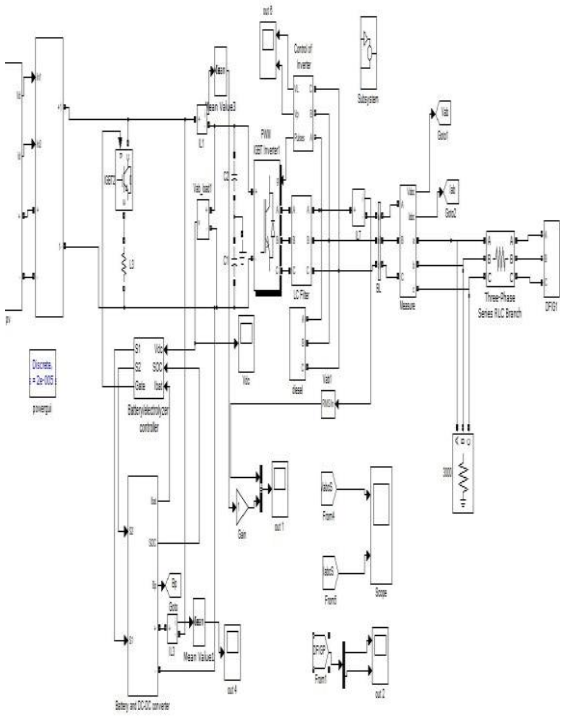

FIG.5 Simulation circuit of hybrid system (PV, battery, wind) with Grid

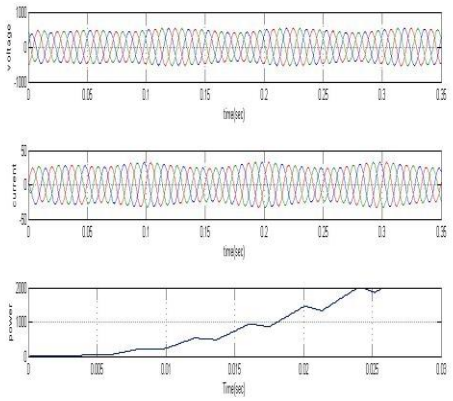

FIG.6 Simulation result of voltage and current waveform of Grid side converter in hybrid system

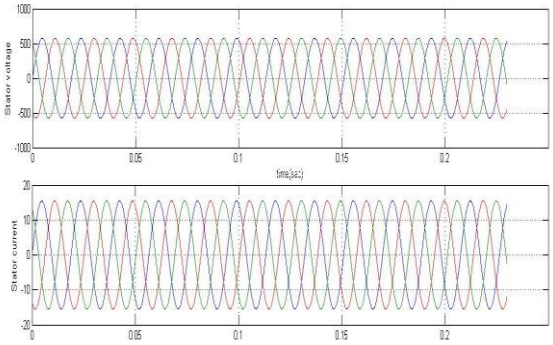

FIG.7 Simulation result of voltage and current waveform of Grid side converter in hybrid system

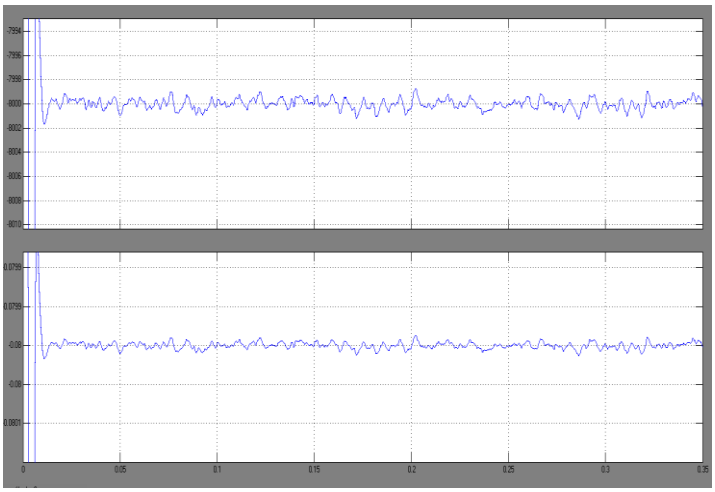

FIG: 8 Simulation result of active and reactive power waveforms in Grid side

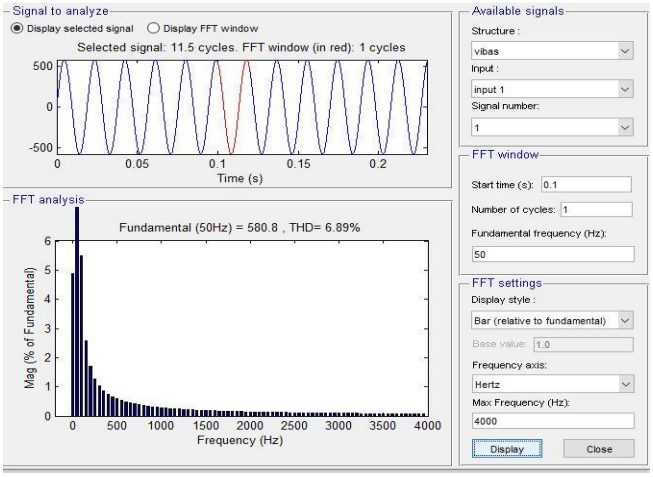

FIG.9 THD analysis of DFIG system voltage

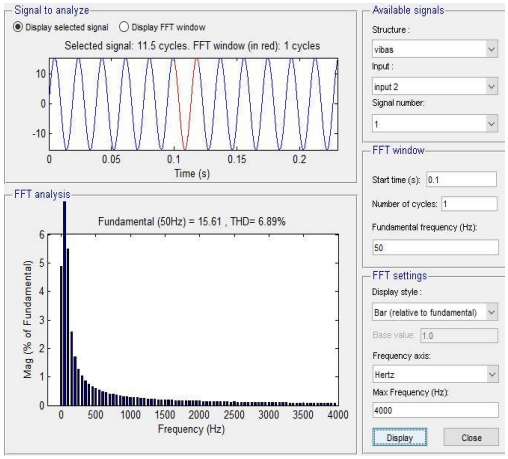

FIG. 9 THD analysis of DFIG system current

From the figures it has been observed that When hybrid system is connected to Grid the total harmonic distortion analysis as shown in fig 8, 9 respectively. The THD analysis of system is measured 6.89% in voltage and current. This can be achieved by DFIG and it's in-built converters.

7. CONCLUSION

From our comparative study it is been stated that, DFIG and it's in-built converters reduces the harmonics. In solar PWM inverter is used to reduce the lower harmonics and when the three systems are connected the grid side voltage and current is observed and THD of system is evaluated and hence power quality is improved.The performance of overall model found satisifactory.

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