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DC Link Capacitor Voltage Stabilization of DFIG under various Fault Conditions

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Abstract- *Variable-speed Doubly Fed Induction Generator(DFIG) wind energy system is one of the main WECS configurations in today's wind power industry. The variable-speed operation is possible due to the power electronic converters interface, allowing a full (or partial) decoupling from the grid. For a DFIG based wind energy system, the rotor-side converter (RSC) controls the torque and active/ reactive power of the generator while the grid-side converter (GSC) controls the DC-link voltage and its AC-side reactive power. The stability of DC link capacitor voltage is very important in ensuring that a nearly sinusoidal voltage is delivered by the grid side converter which is used as inverter. The fluctuations in the DC -link voltage cut down the lifetime and reliability of capacitors in voltage source converters.The paper Deals with DC Link capacitor voltage stabilization under various types of faulty and load conditions. In this Paper Variable Voltage source has been taken which represents a Fault that occurs in source wide system. Due to this the Variable voltage source has been decreased to 0.5 Pu. So, Behaviour of DFIG system is studied in this paper. The analysis is performed for normal, unsymmetrical fault and load conditions on DFIG integrated with grid under MATLAB/ SIMULINK.*

Keywords- *wind energy conversion system (WECS), DFIG, PI controller, dc-link voltage, unsymmetrical fault, RSC, GSC*

I. INTRODUCTION

Over the last twenty years, renewable energy sources have been gaining great attention due to the cost increase, limited reserves, and adverse environmental impact of fossil fuels. Among them, wind energy is one of the fastest growing renewable energy sources. Wind energy has been used for hundreds of years for milling grains, pumping water, and sailing the seas. The use of windmills to generate electricity can be traced back to the late nineteenth century with the development of a 12 kW DC windmill generator.

Wind Electric Generator (WEG) of 2 MW Capacity is installed in suzlon (tamilnadu) is the largest power rating in India. Maximum WEG Installations are in tamilnadu of capacity about 1639MW. Maximum gross estimated Wind potential is in Gujarat of 9675 MW. Wind electric systems directly feeding to the local load are known as the Isolated wind energy system but the wind energy system that are connected to the grid are known as Grid connected system. Wind is not available all the time for the generation of electric power and power output of wind turbine is proportional to the cube of the velocity of the wind and the power output is optima for a particular wind velocity. So large WEG systems are connected to utility grid where they feed the power to grid.

Over the past decades, Doubly Fed Induction Generators (DFIGs) are the most popularly used for variable-speed wind power system .Variable speed operation and bidirectional power control are advantageous capabilities of this configuration. In addition, DFIG's power converter is rated for approximately 20-30 % of its rating.

DC-Link Model

The DC-Link model describes the DC-Link capacitor voltage variations as a function of the input power to the DC-Link. The energy stored in the DC Capacitor is

$$Wdc = \int P\, dtdc = \tfrac{1}{2} CVdc^2 \qquad (1)$$

Where C is the Capacitance, V_{dc} is the voltage, W_{dc} is the stored energy, and P_{dc} is the input power to the DC Link. The Voltage and energy derivatives are

$$DVdc = Pdc,\ dWdc = Pdc\ dt\ CV_{dc}\ dt \qquad (2)$$

The P_{dc} is calculated as $P_{dc} = P_{in} - P_c$ Where P_{in} is the input power from rotor-side converter and P_{dc} is the grid-side converter output power. The DC- Link voltage varies as P_{dc} and is a constant when P_{dc} =0.

II. MATLAB Simulink Model of DFIG Based Wind Turbine System

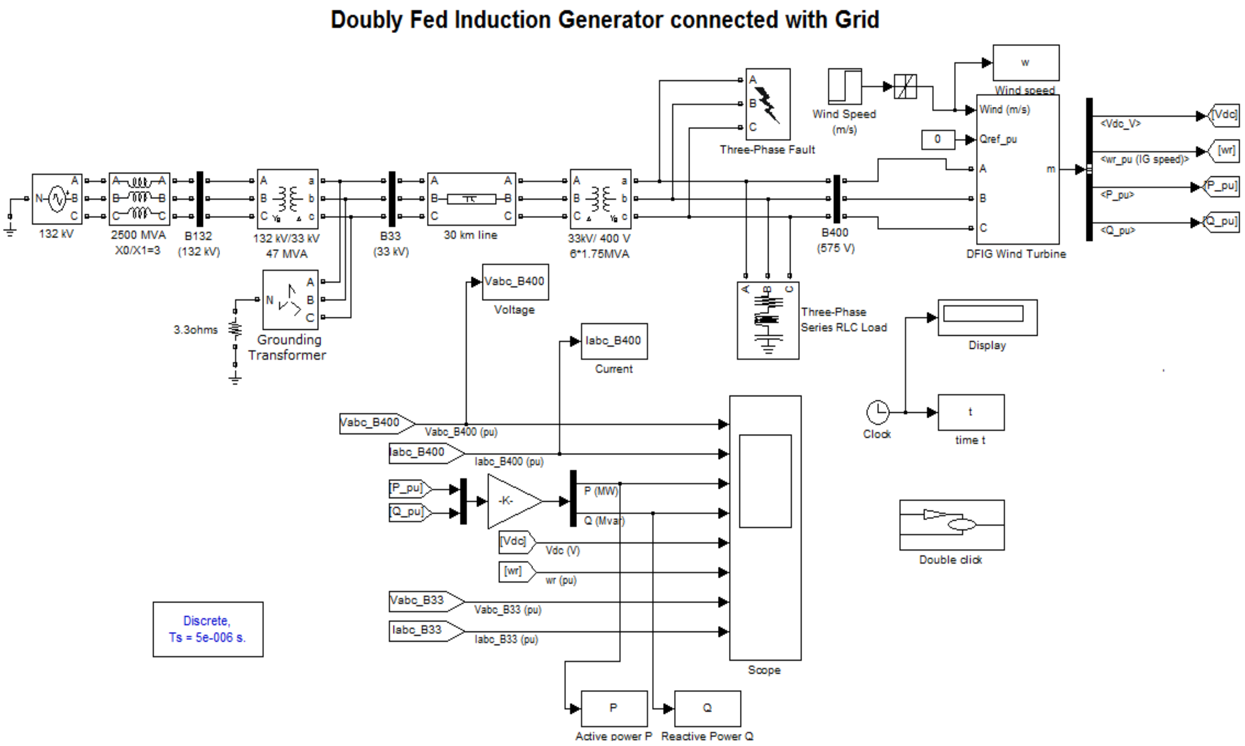
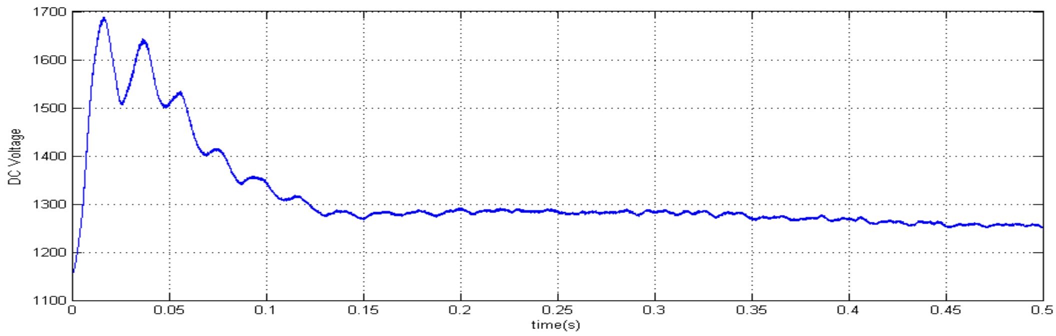


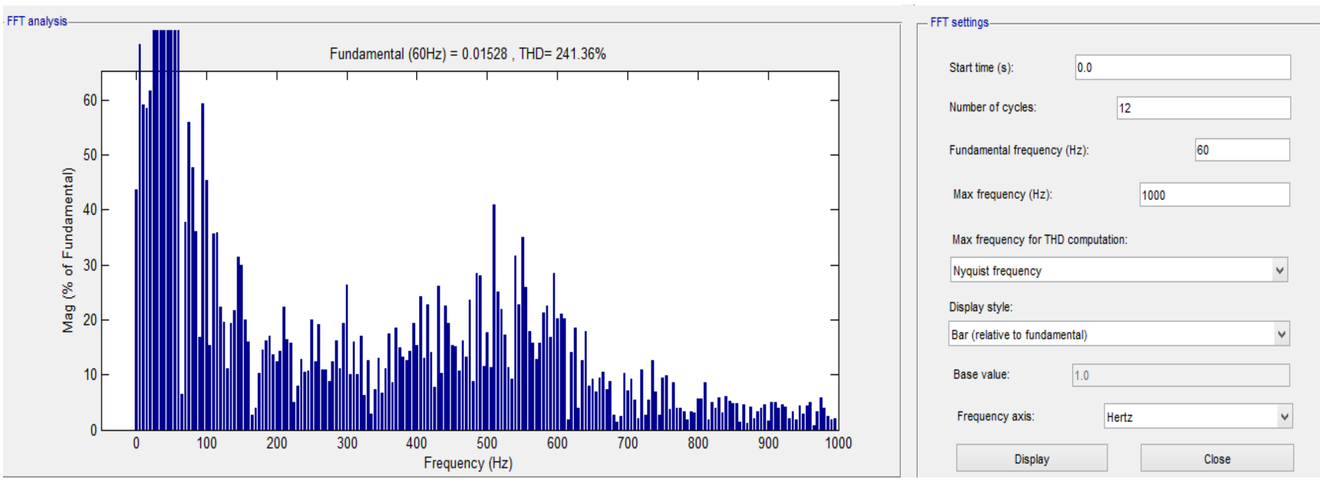
Figure 5. Matlab Simulink model of DFIG based wind turbine system

III.DFIG With and Without PI Controller under Faulty and Load Conditions (with FIXED VOLTAGE SOURCE)

1- DFIG With No Fault, No Load (without PI Controller)

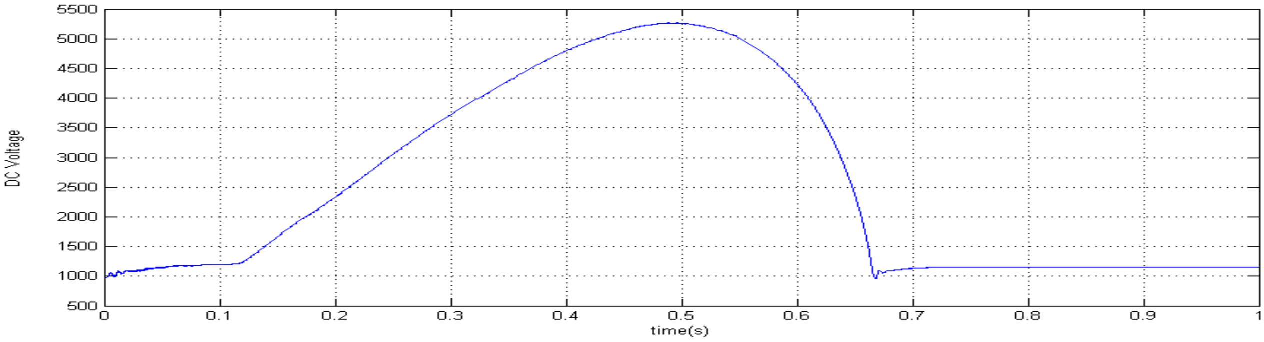


DC Voltage

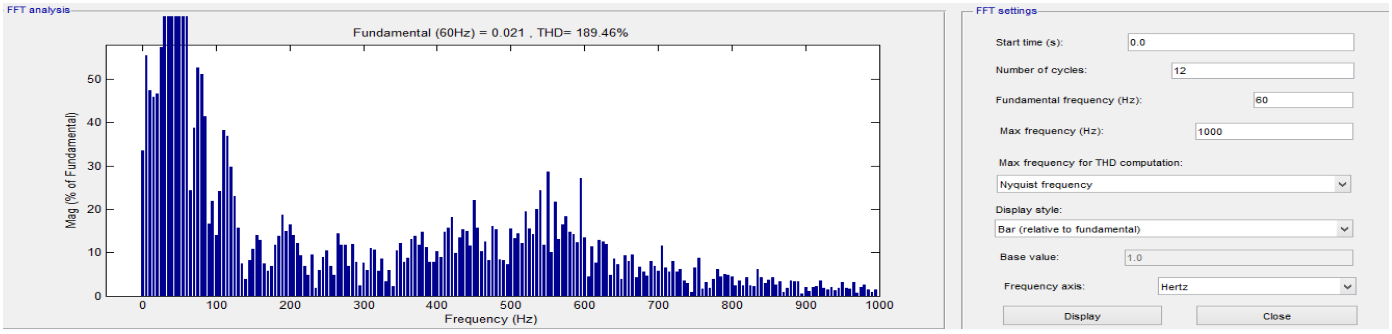


THD of Voltage at B400 (241.36%)

DFIG with No Load, No Fault (With PI Controller)

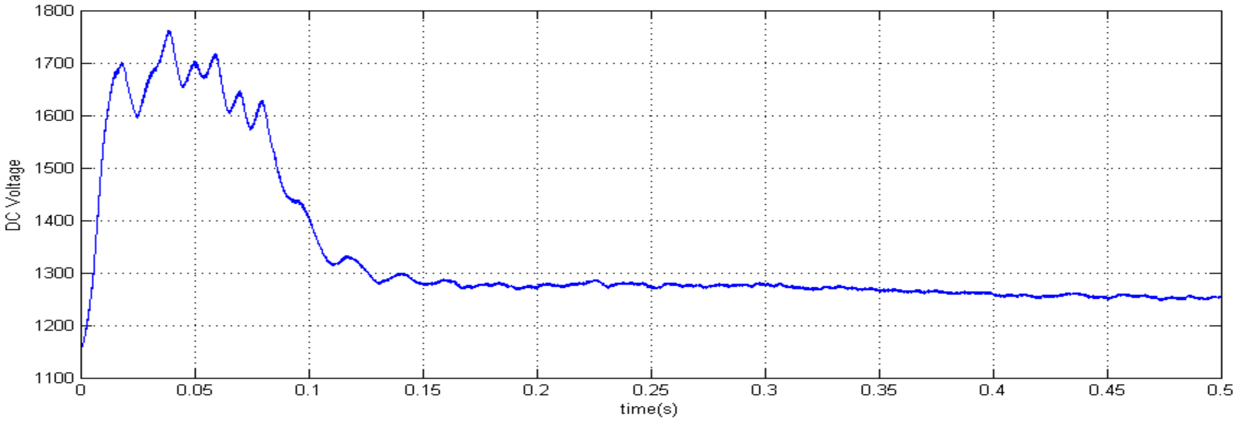


DC Voltage

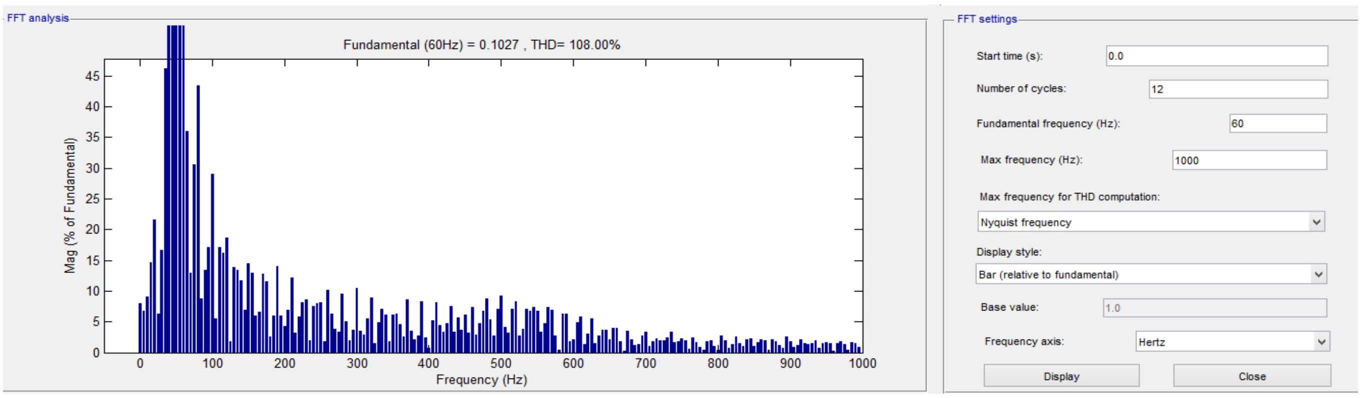


THD of Voltage at B400(189.46%)

2- **DFIG with no load and with phase A fault (without PI Controller)**

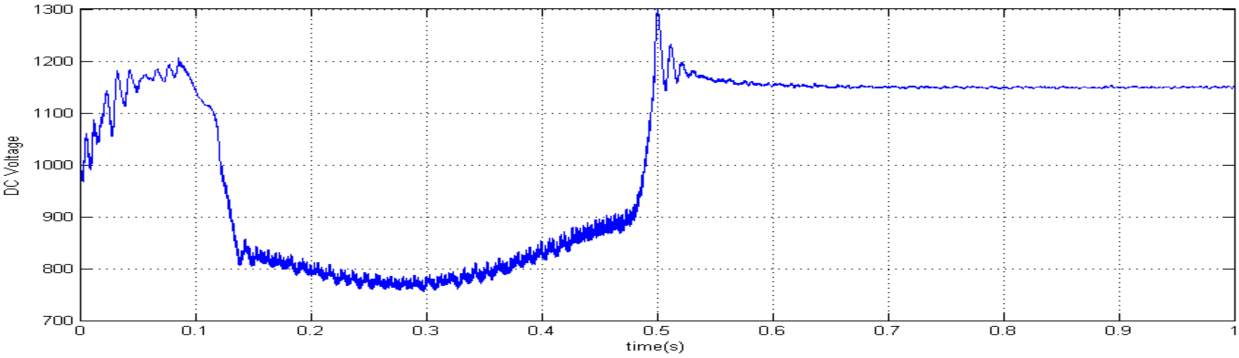


DC voltage

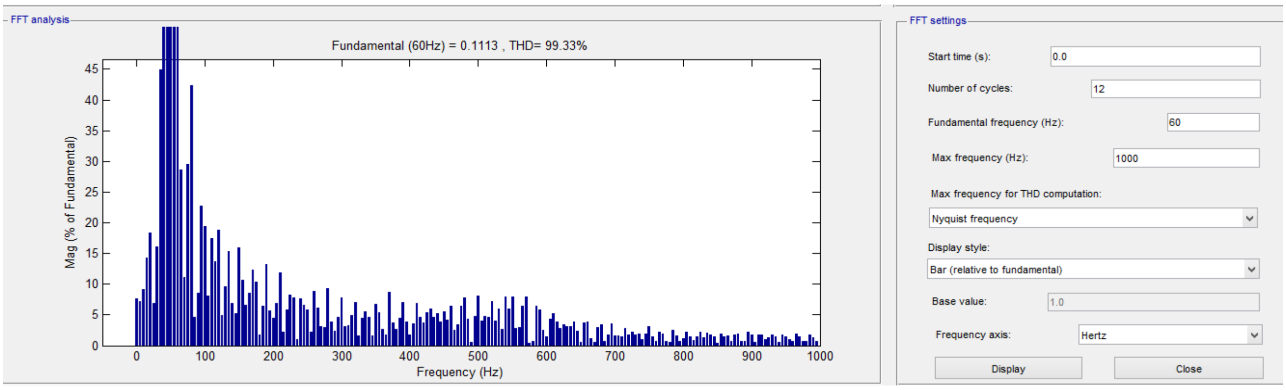


THD of voltage at B400 (108%)

DFIG with no load and with phase A fault (with PI Controller)

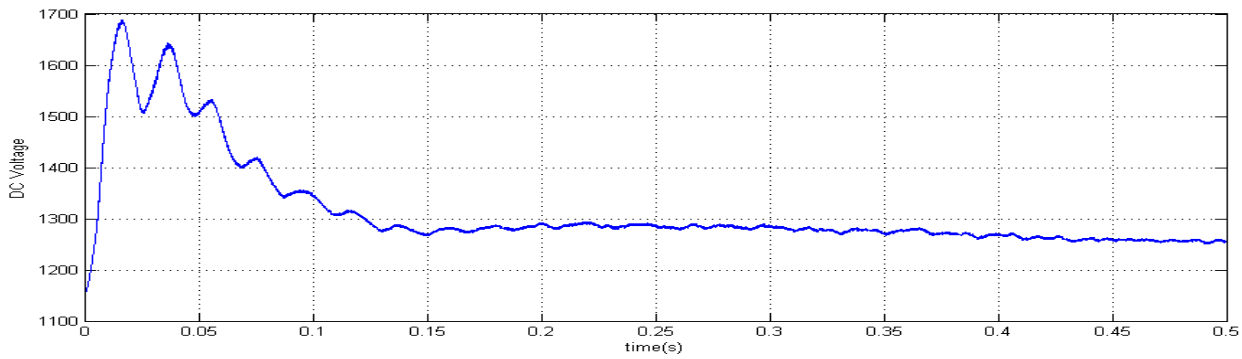


DC voltage

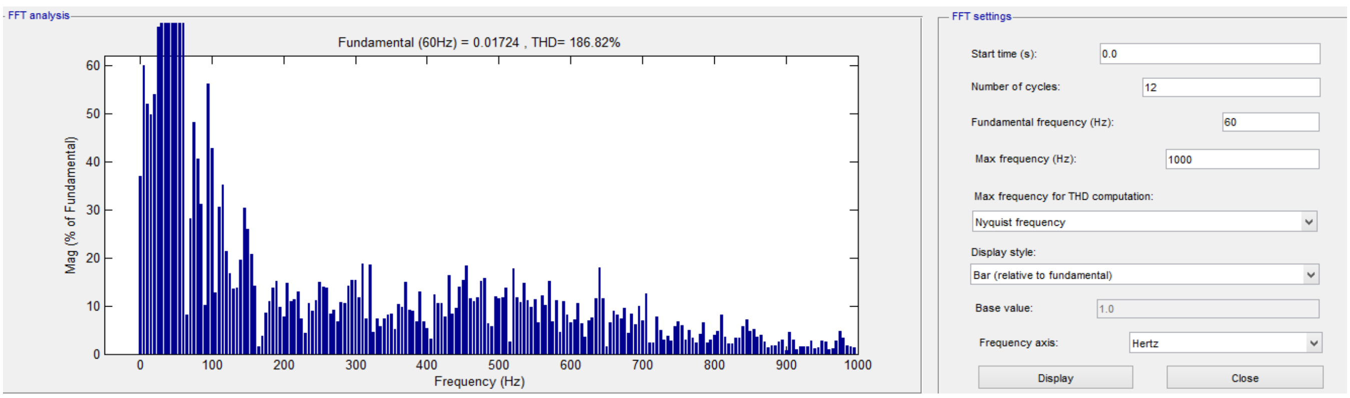


THD of voltage at B400 (99.33%)

3- DFIG with Load and No Fault (without PI Controller)

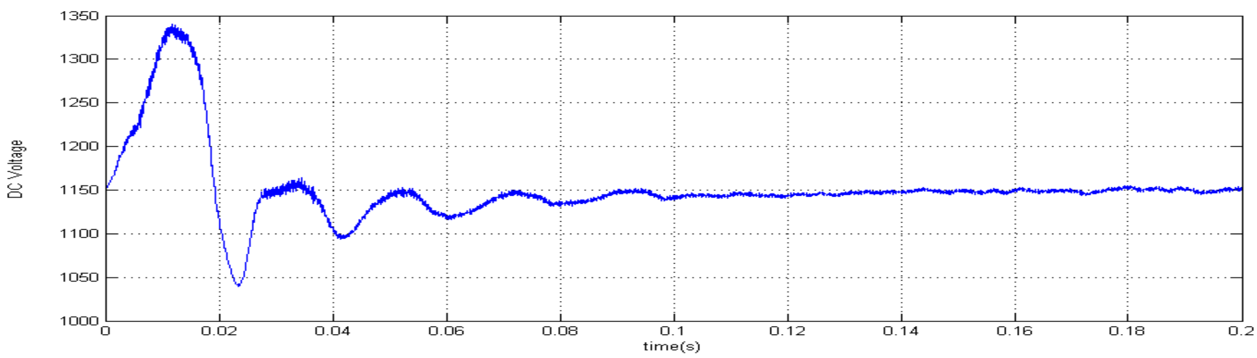


DC Voltage

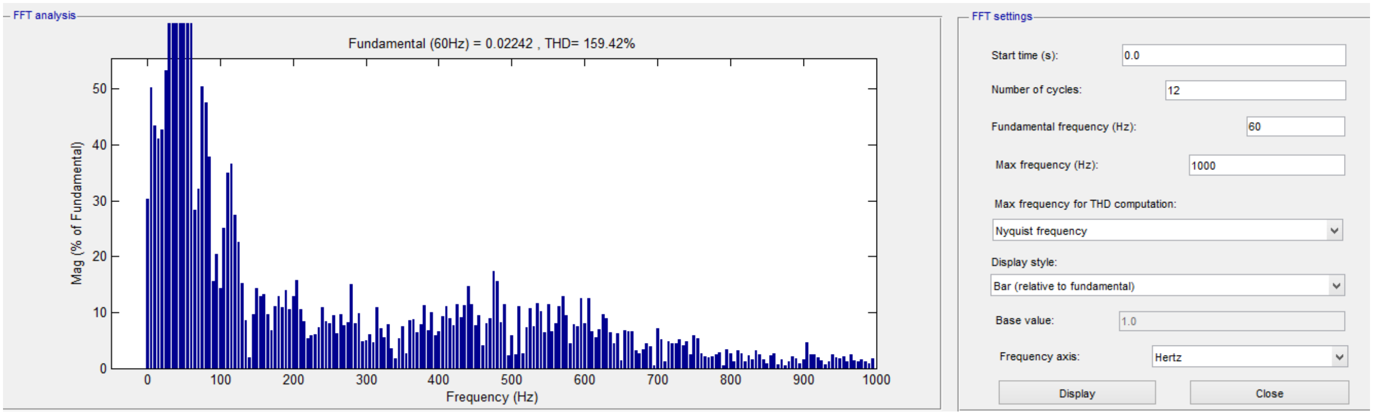


THD of voltage at B400(186.82%)

DFIG With load and no fault (with PI Controller)

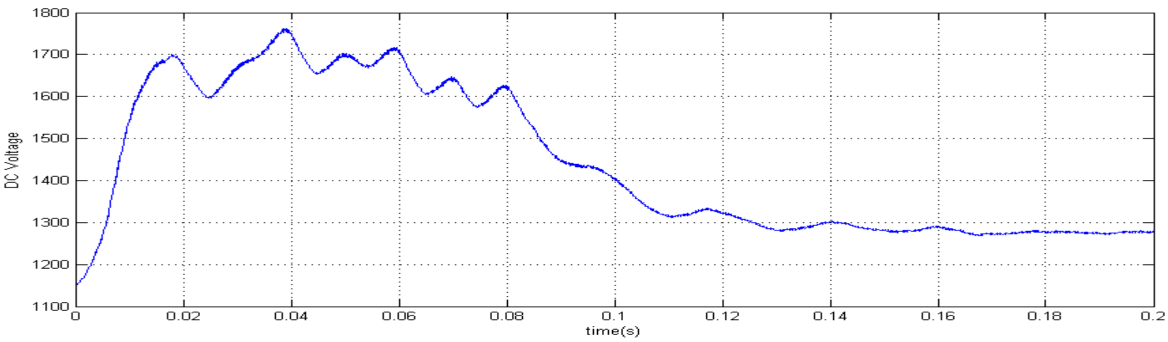


DC Voltage

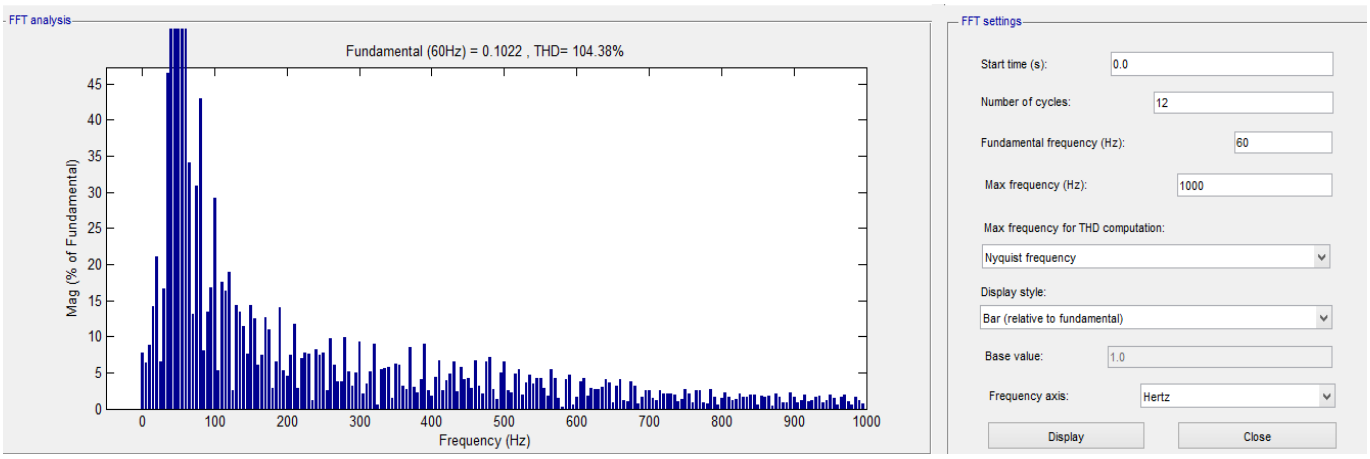


THD of voltage at B400 (159.42%)

4- DFIG with load and with phase A fault (without PI Controller)

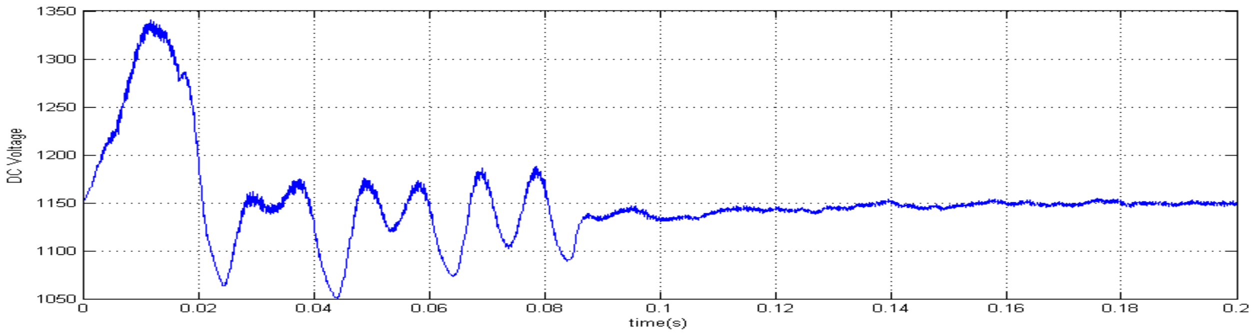


Dc voltage

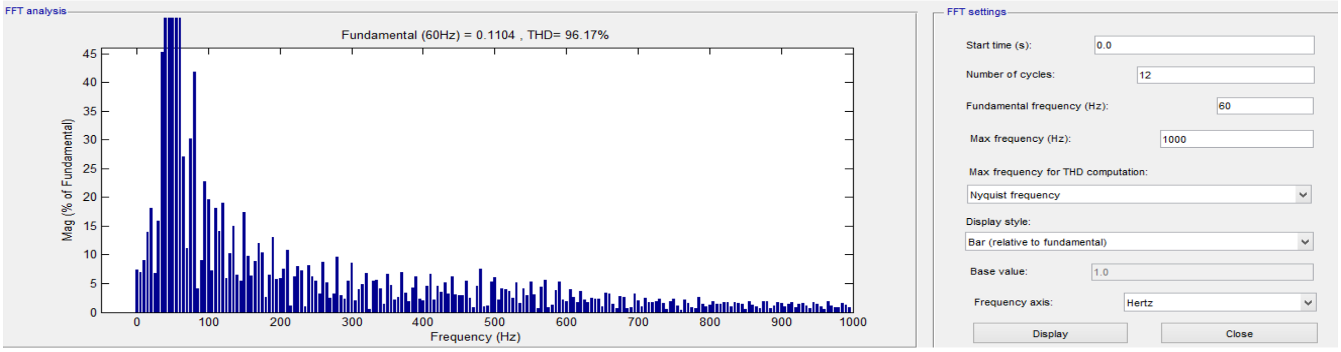


THD of voltage at B400 (104.38%)

DFIG with load and with phase A fault (with PI Controller)



DC voltage

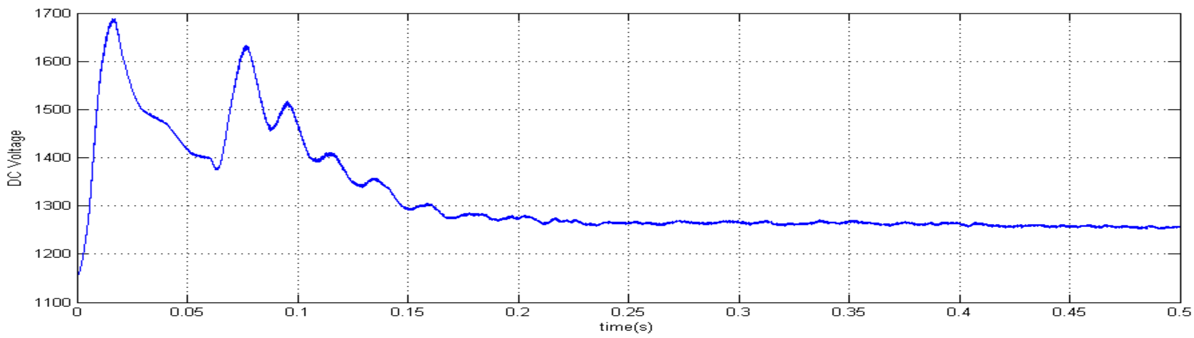


THD of voltage at B400 (96.17%)

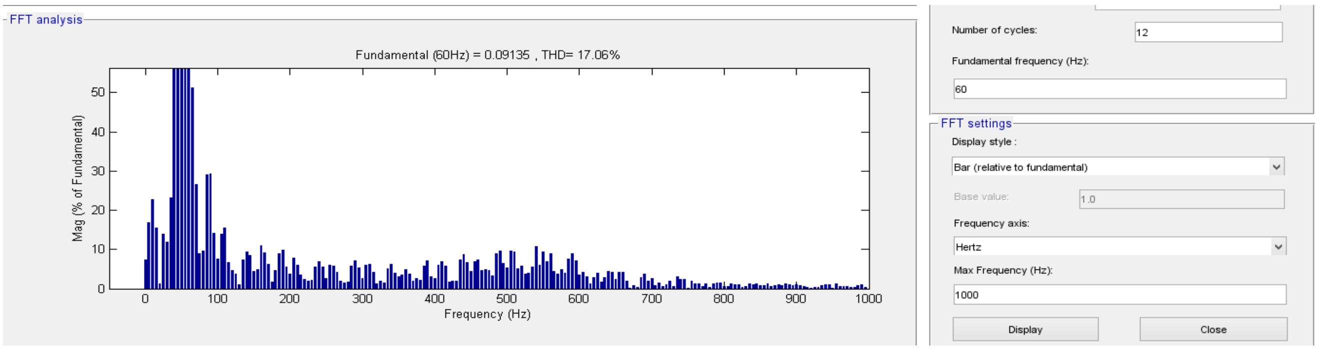
In the case of fixed voltage source, by all these results we can see that PI Controller is useful in reducing the DC link Capacitor Voltage Fluctuations and maintaining its stability as close as possible to the value of 1150V. And the Total Harmonic Distortions are also reduced when PI Controller is used.

IV. DFIG With and Without PI Controller under Faulty and Load Conditions (with VARIABLE VOLTAGE SOURCE)

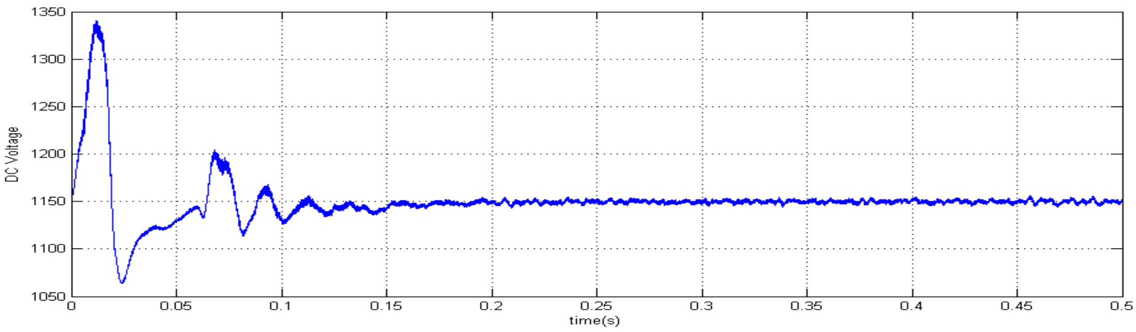
1- DFIG With No Fault, No Load (without PI Controller)



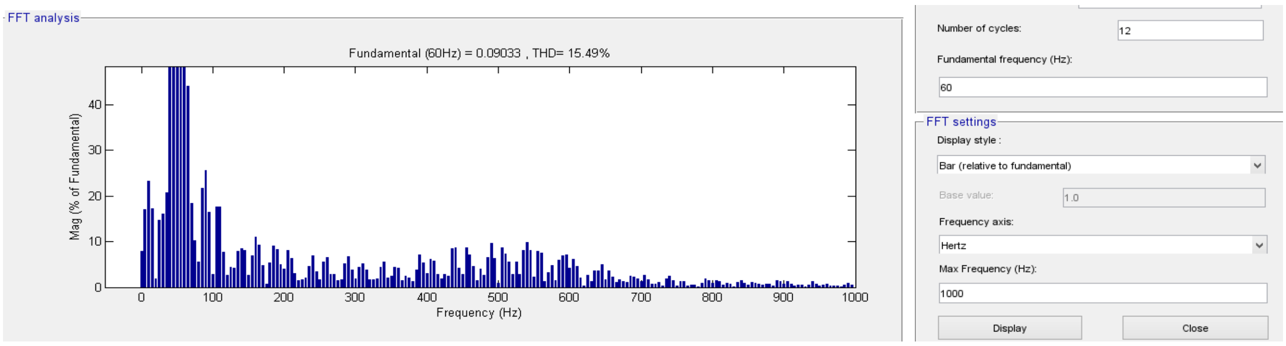
DC voltage



THD of Voltage at B400 (17.06%) DFIG with No Fault, No Load (with PI Controller)

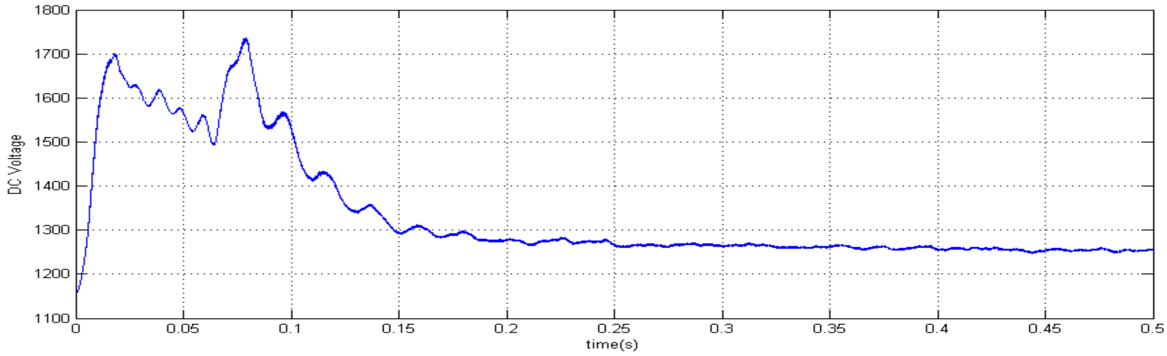


DC Voltage

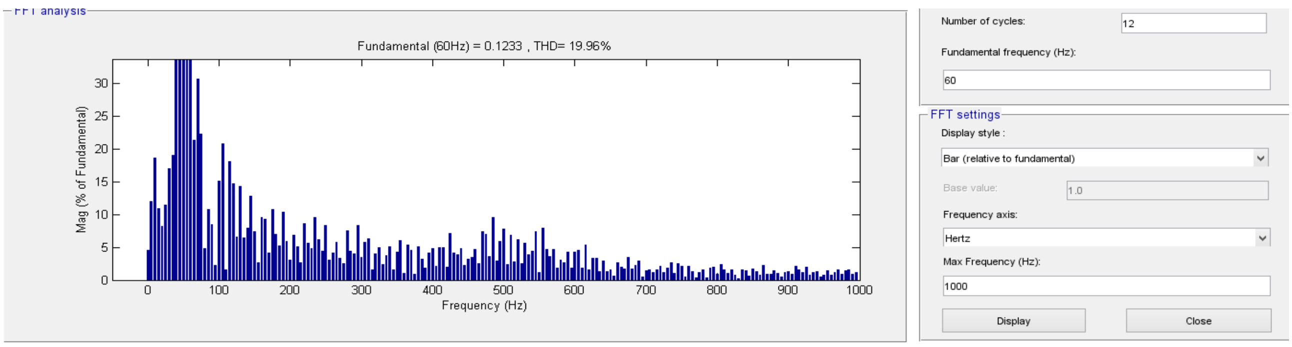


THD of Voltage at B400 (15.49%)

2- DFIG with no load and with phase Afault (without PI Controller)

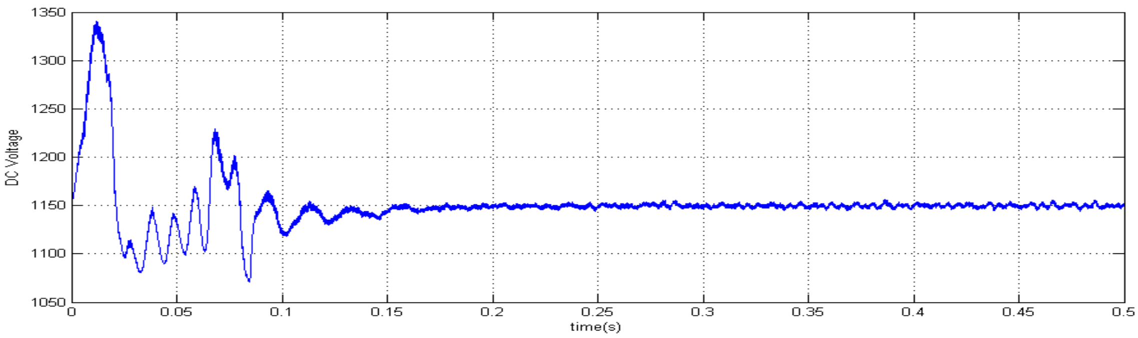


DC Voltage

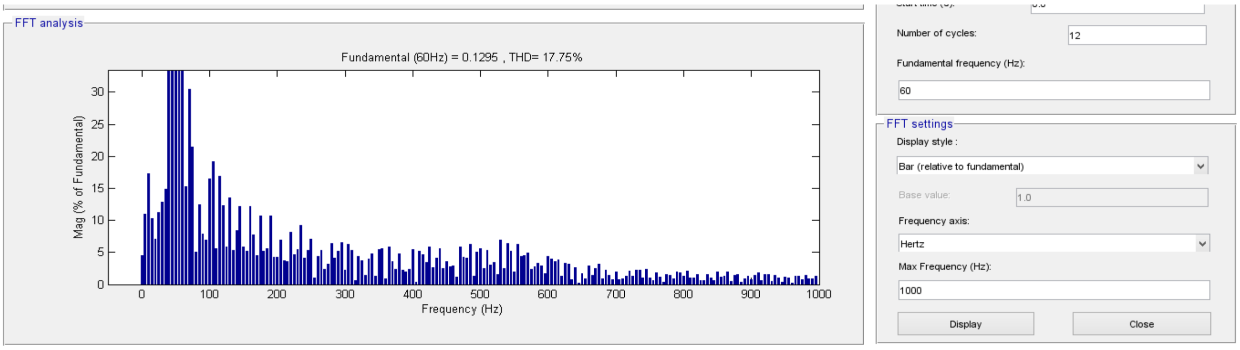


THD of Voltage at B400 (19.96%)

DFIG with no load and with phase Afault (with PI Controller)

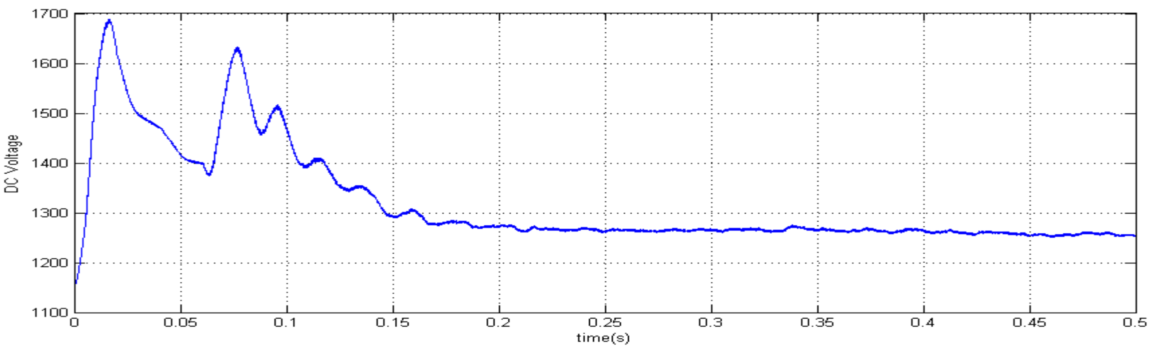


DC Voltage

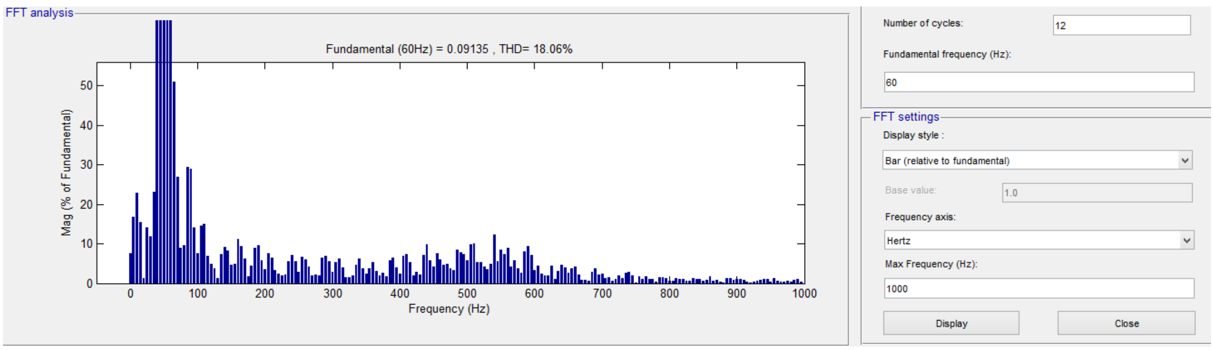


THD of Voltage at B400 (17.75%)

3- DFIG with load and no fault (Without PI Controller)

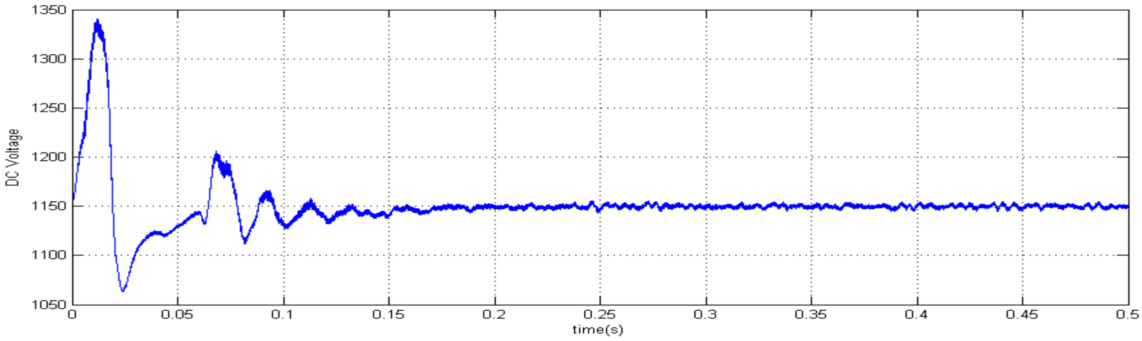


DC Voltage

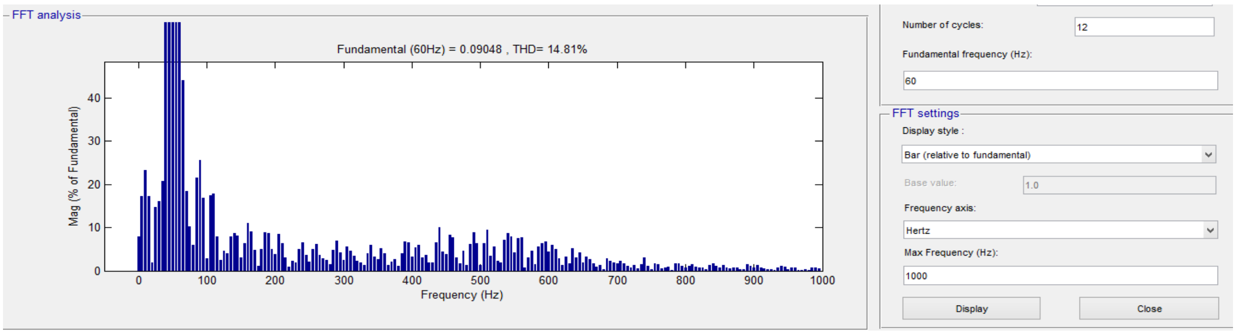


THD of Voltage at B400 (18.06%)

DFIG with load and no fault (With PI Controller)

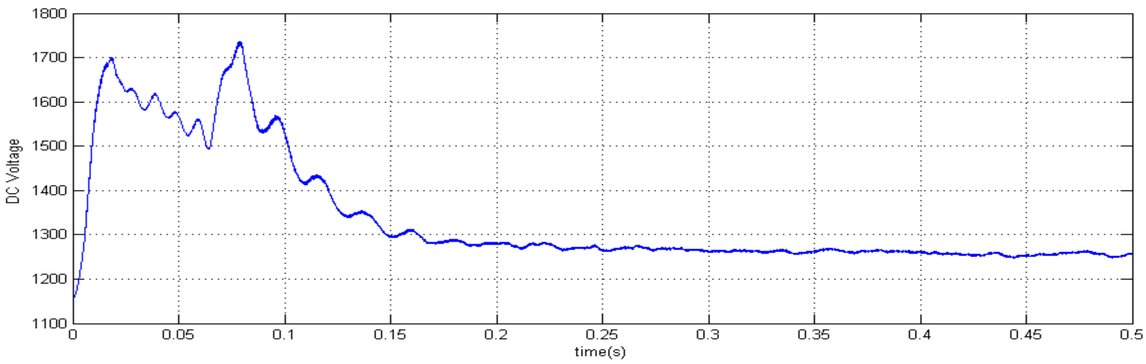


DC Voltage

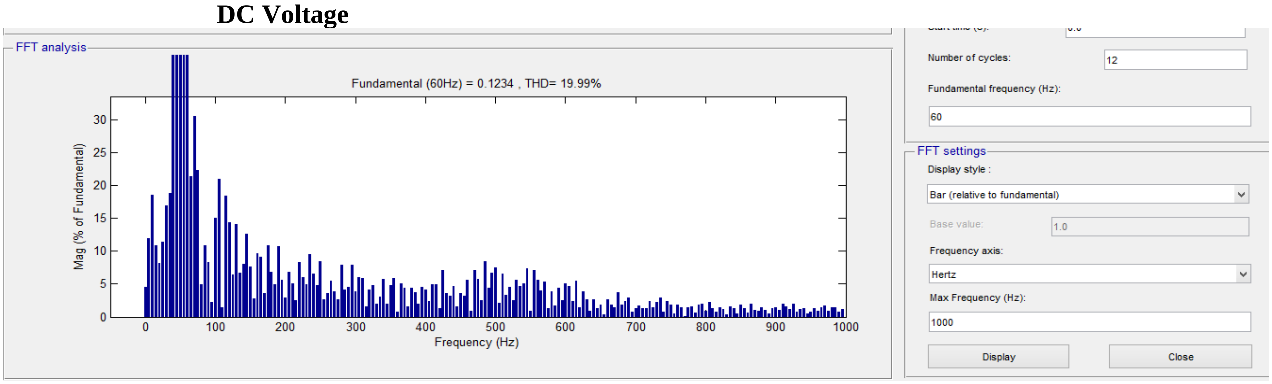


THD of Voltage at B400 (14.81%)

4- DFIG with load and with phase A fault(without PI Controller)

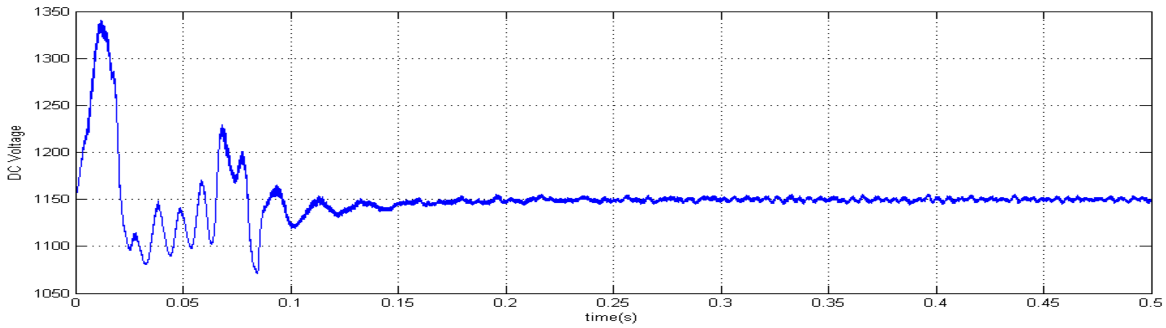


DC Voltage

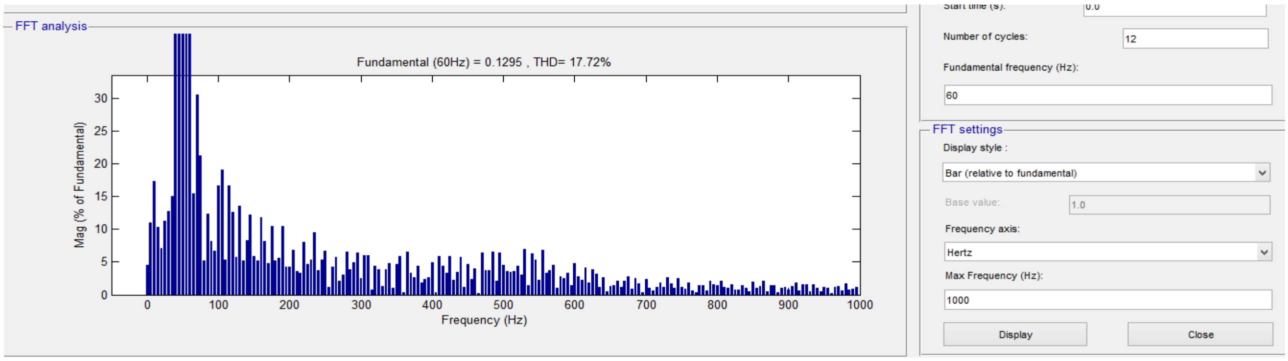


THD of Voltage at B400 (19.99%)

DFIG with load and with phase A fault (with PI Controller)



DC Voltage



THD of Voltage at B400 (17.72%)

In the case of Variable voltage source, by all these results we can see that PI Controller is useful in reducing the DC link Capacitor Voltage Fluctuations and maintaining its stability as close as possible to the value of 1150V. And the Total Harmonic Distortions are also reduced when PI Controller is used.

Table 1- FIXED VOLTAGE SOURCE

	VOLTAGE THD		
V_{DC} REGULATOR PI IN GSC [NO LOAD]	THD Without PI [no fault]	THD With PI [no fault]	
	241.36%	**189.46%**	
V_{DC} REGULATOR PI IN GSC [NO LOAD]	THD Without PI [with PH A fault]	THD With PI [with PH A fault]	
	108%	**99.33%**	
	THD Without PI [no fault]	THD With PI [no fault]	
V_{DC} REGULATOR PI IN GSC [ON LOAD]	**186.82%**	**159.42%**	
	THD Without PI [with PH A fault]	THD With PI [with PH A fault]	

V_{DC} REGULATOR PI IN GSC [ON LOAD]	**104.38%**	**96.17%**	

Table 2-RESULTS WITH A VARIABLE VOLTAGE SOURCE

V_{DC} REGULATOR PI IN GSC [NO LOAD]	THD Without PI [no fault]	THD With PI [no fault]	
	17.06%	**15.49%**	
V_{DC} REGULATOR PI IN GSC [NO LOAD]	THD Without PI [with PH A fault]	THD With PI [with PH A fault]	
	19.96%	**17.75%**	
	THD Without PI [no fault]	THD With PI [no fault]	
V_{DC} REGULATOR PI IN GSC [ON LOAD]	**18.06%**	**14.81%**	
	THD Without PI [with PH A fault]	THD With PI [with PH A fault]	
V_{DC} REGULATOR PI IN GSC [ON LOAD]	**19.99%**	**17.72%**	

V.CONCLUSION

The fluctuations in the DC-link voltage cut down the lifetime and reliability of the capacitors in voltage source converters.With continuously increasing penetration of the wind energy in the overall energy market, this issue is gaining significant prominence. The paper Deals with the DC Link capacitor voltage stabilizationof DFIG under faulty and load conditions. A Variable Voltage source has been taken here which represents a Fault that occurs in source wide system. Due to this the Variable voltage source has been decreased to 0.5 Pu. So, Behaviour of DFIG system has been studied in this paper.By comparing all the results it was found that PI Controller is useful in reducing the THD i.e. Total harmonic distortions and in also reducing the DC link capacitor Voltage fluctuations and in maintaining its Stability as close as possible to the value of 1150V. The simulation was performed for normal, unsymmetric fault, and load conditions on DFIG integrated with grid under MATLAB/ SIMULINK.

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