International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319-6734, ISSN (Print): 2319-6726
www.ijesi.org ||Volume 9 Issue 3 Series.II || Mar.2020 || PP 74-78

Fuzzy Logic Control Implementation on Matrix Converter for Grid Connected System

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ABSTRACT: *Among the all renewables, wind is the cost effective energy resource. This paper describes the usages and information of a matrix converter for Doubly Fed Induction generator (DFIG) based grid connected wind turbine systems. The use of DFIG has the advantages of Inexpensive small capacity PWM Inverter and Complete control of reactive and active power. And no need of permanent magnet .Such system also results in lower converter costs and lower power electronics losses compared to a system based on a fully fed synchronous generator with full rated converter. The main merit of the DFIG is its capability to deliver constant voltage and frequency output of a simulation model has been developed using MATLAB/Simulink environment. The system comprises a wind turbine, a DFIG, and a 3-phase matrix converter which acts as an interface between the wind turbine system and the electric power grid .The proposed system consists of matrix converter which is fed by DFIG generator based wind turbine. The matrix converter is single stage converter which converter fixed AC to variable AC converter .The switching pulses given to the matrix converter plays an important role in getting the desired output voltages. The proposed system uses fuzzy based controller for giving the desired pulses to the converter.*

KEYWORDS: *Doubly Fed Induction Generator (DFIG), Matrix Converter (MC), Pulse Width Modulation (PWM), Wind Turbine.*

Date of Submission: 14-03-2020 Date of Acceptance: 31-03-2020

I. INTRODUCTION

Fossil fuel has long been used in power sector. They produce harmful gases; therefore Renewable energy has been on the rise. This is due to number of environmental benefits such as wide availability and no greenhouse gas emission. However the increased use of these renewable poses a number of challenges to the electric power system when it is integrated to the grid .Doubly Fed Induction Generator (DFIG) will be more suitable for the WECS.The main merit of the DFIG is its capability to deliver constant voltage and frequency output A matrix converter is a one stage converter which consists of 9 bidirectional switches arranged in such a way input phase to its corresponding output phase. Matrix converter facilitates bidirectional power flow with improved input, output voltage and current waveforms. Matrix converters are the one which handles variable voltage and variable frequency drives in a reliable way Matrix converters are direct ac to ac power converters with motoring and regenerative power flow capability. One approach to describing some basic features of matrix converters is from the perspective of power topology and control principles .Matrix converters have several advantages. For example, a steady state ac input source can be converted directly into a variable voltage and variable frequency output by a bidirectional switches that controls the current flow in the two directions between the power grid and a motor .This unique feature makes it possible to operate motors in a motoring mode and a regenerative modes easily.

Also, the significant energy produced is a cost saving and are possible in an applications that requires frequent regenerative operation. Unfortunately, the complex controls and a lack of commercially available bidirectional power switches in a matrix converter had delayed the widespread use of the matrix converters, but these obstacles are slowly being overcome .Another advantage is that matrix converters does not contain ac to dc conversion circuits such as diode rectifiers–in the main power flow, thus large dc electrolytic capacitors are not required. Generally, the electrolytic capacitors are heavy and have a relatively shorter life span than the other power components in the converters. Thus, the matrix converters can eliminate the downtime which is needed for replacing defective electrolytic capacitors.

II. LITERATURE SURVEY

J.W. Kolar, T. Friedli, F. Krismer, and S. D. Round (2008) presents, in this paper, the known voltage and current DC-link converter systems, which are used to implement an AC/AC converter, are thus presented initially. According to this knowledge and the modulation methods in space vector, we show that their connection to the family of indirect matrix converters have finally given a connection towards the direct matrix converters. The discussions which have been made for the extended matrix converter circuits are given and a new unidirectional three-level matrix converter topology has been proposed.

The various topological connections of the converter circuits had directly lead to an adaptability of the modulation methods. These make the readers much familiar with the space vector modulation of voltage and current DC- link converters to be simply incorporated and identify new modulation methods. And the comparison of the converter concepts, with respect to their fundamental, topology-related characteristics, complexity, control and efficiency, then follows. Furthermore, by taking the example of a converter which covers a typical operation region in the torque-speed plane (incl. holding torque at standstill), the necessary of the silicon area of power semiconductors is thus calculated for a maximum junction temperature. This paper concludes with the proposals for the subjects in the area of matrix converters for further research.

He Liu, Mohamed Dahidah, R.T. Naayagi, Matthew Armstrong and James Yu Haojie Wang, Hai Sun (2017) this paper presents a novel modular multilevel DC/DC converter suitable for integrating the off-shore wind farm with the HVDC transmission system. Hereby, the converter which has been proposed consists of a wind farm-side three-phase MMC inverter and a series- connected rectifier linked by a special decoupled medium frequency transformer. The transformer thus decouples the three-phase input voltage to three isolated single-phase voltages with the 120-degree displacement. Zulqarnain Maira Xu David and Bo Yuwen (2011) at presents, this paper explores the option of autonomous controller for modular converter system. One of the most main challenges faced here in the design of autonomous controller is to ensure equal power sharing among the operating units without employing any communication between them. In order to enhance the system harmonic performance, control structure should enable interleaving of operational units under all conditions. Such an autonomous controller will thus greatly improve the system reliability/redundancy**.**

Doubly fed Induction Generator

The principle of the DFIG contains stator windings which are connected to grid and rotor winding, this rotor windings are connected to the converter via slip rings and back-to-back voltage source converter controls both the rotor and grid currents. Thus rotor frequency differs from the grid frequency (50 or 60 Hz). The converter which has been used here is used to control the rotor currents, is also possible to adjust the active and reactive power fed to the grid from the stator independently of the generator's turning speed. The control principles used here is either two-axis current vector control or direct torque control (DTC). DTC has turned out to have a better stability than the current vector control especially when the high reactive currents are required from the generator. The doubly-fed induction generator rotors are typically wound with 2 to 3 times the number of turns of the stator. This means that the rotor voltages will be higher and the currents are respectively lower. Thus the percentage ±30% is the operational speed range around the synchronous speed, the rated current of the converter is accordingly lower that leads to a lower cost of the converter. The drawback is that controlled operation outside the operational speed range of the generator is impossible because of the higher voltage than rated rotor voltage. Further, the voltage transients due to the grid disturbance (three phase and two-phase voltage dips) will also get magnified. In order to prevent this high rotor voltages (and high currents resulting from these voltages) from destroying the components like insulated-gate bipolar transistors and diodes of the converter, a protection circuit called crowbar is used.

MATRIX CONVERTER

The main advantages of matrix converter are the elimination of dc link filter present. Zero switching loss devices can transfer the input power to the output power without any power losses. But practically it does not exist. The switching frequency of the device decides the THD of the converter used in the process. Maximum power transfer which transferred to the load is decided by the nature of the control algorithm. Matrix converter has a maximum input and output voltage transfer ratio is limited to 87 % for sinusoidal input and output waveforms, which can also be improved. Further, the matrix converter requires more semiconductor devices than a conventional AC-AC indirect power frequency converter. Since the device called monolithic bi-directional switches is available they are used for switching purpose. Matrix converter is particularly very sensitive to the disturbances of the input voltage present in the system. This can be attenuated by intelligent control techniques and the fuzzy controller which has a least effect due to input side disturbance. In this chapter simulation of three phase matrix converter is obtained from a simplified simulation model.

SWITCHING CALCULATION OF MATRIX CONVERTER:

A 3 × 3 Matrix Converter (MC) consists of 9 bidirectional switches. These switches are thus connected in such a manner that, any one of the three inputs can be connected to any one of the three output phases. With these switches, MC can have 29 switching states, provided that there is no short circuiting in the input and no open circuit at the output. The switching pattern of bidirectional switches are S11, S21 and S31 of one row of the matrix converter and similarly it continues for a column.

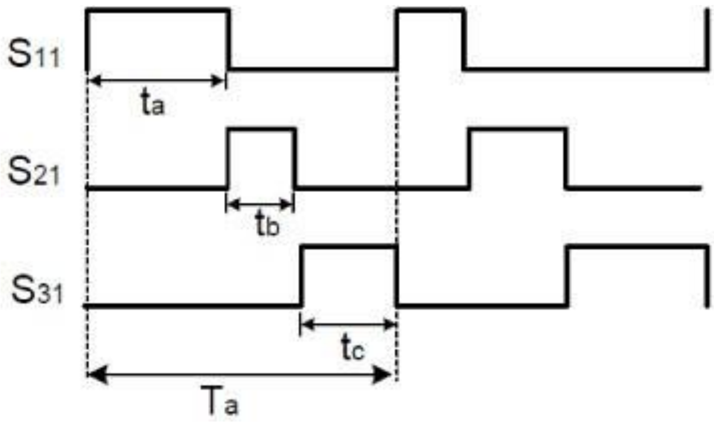

Fig 1.1 output waveform of matrix converter

Thus, the output voltage of one arm of the matrix converter is given by the formula:

$$v_{s1} = \frac{1}{Ta}[v_{s1}(t)t_a + v_{s2}(t)t_b + v_{s3}(t)t_c]$$

and the duty cycles associated to the times t_a, t_b and t_c are given by the formula:

$$m_a = \frac{t_a}{T_-} = \frac{1}{3} + \frac{2V_s}{3V_e}\cos[(w$$

$$m_b = \frac{t_b}{T_-} = \frac{1}{3} + \frac{2V_s}{3V_e}\cos[(w \quad \frac{2\pi}{3}$$

$$m_c = \frac{t_c}{T_-} = \frac{1}{3} + \frac{2V_s}{3V_e}\cos[(w \quad \frac{2\pi}{3}$$

Simulation Model:

The simulink model of a Microcontroller is shown in Fig 5. Ideal switches have been used for the simulation process. The DFIG-based WECS simulation model using Microcontroller is shown in Fig 6. The whole system was modelled using MATLAB/Simulink environment. The rated power of the simulation model is 8.5kW, which can be used for smaller scale wind turbines. Nevertheless the matrix converter based system can be implemented in large scale power systems as well. Switching frequency of the MC is chosen as 6kHz and the model is discretized at a small time step i.e., 2µs. This model can observe the harmonics and the dynamic performance of the control system over a relatively short time period. The system consists of a variable speed wind turbine, a DFIG, and an MC with a line filter connected to the grid. The MC will control the output power of the DFIG and transfer a stable output power to the grid. The LC filter is to smoothens the harmonics due to the switching of the Microcontroller.

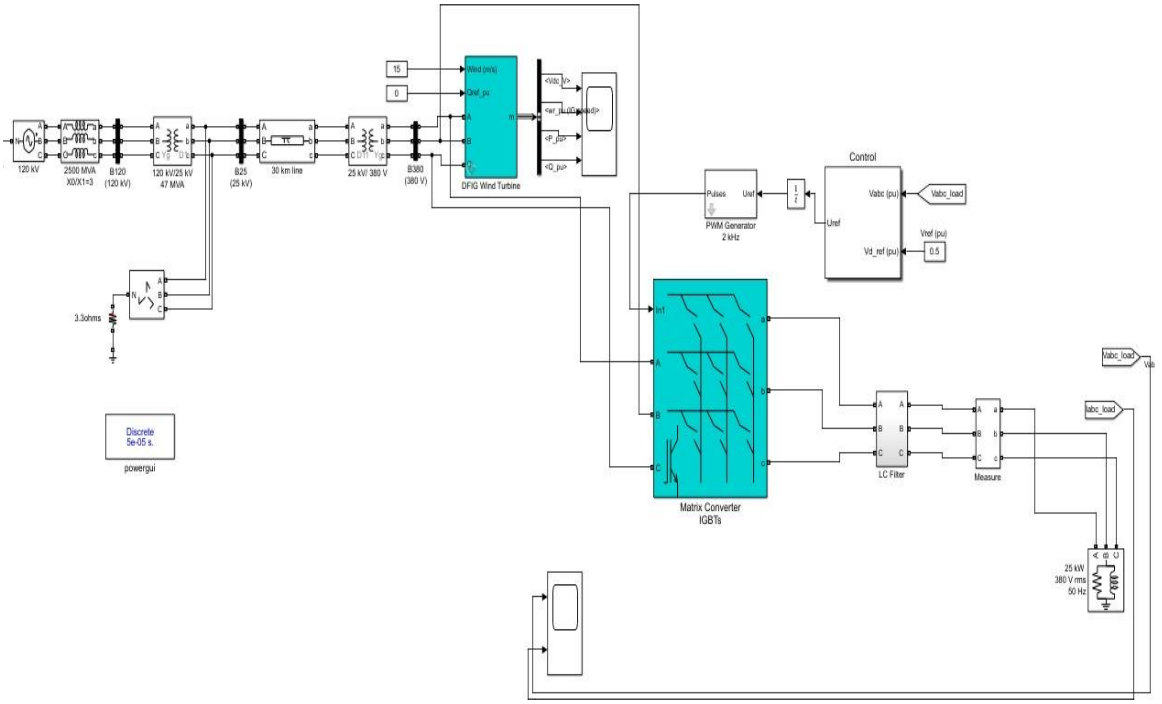

Fig 1.2 simulation model of matrix converter

III. SIMULATION RESULT

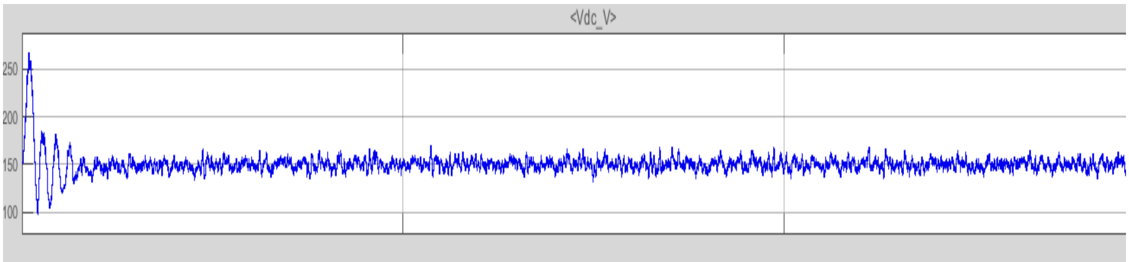

Fig 1.3 simulation result (voltage versus current)

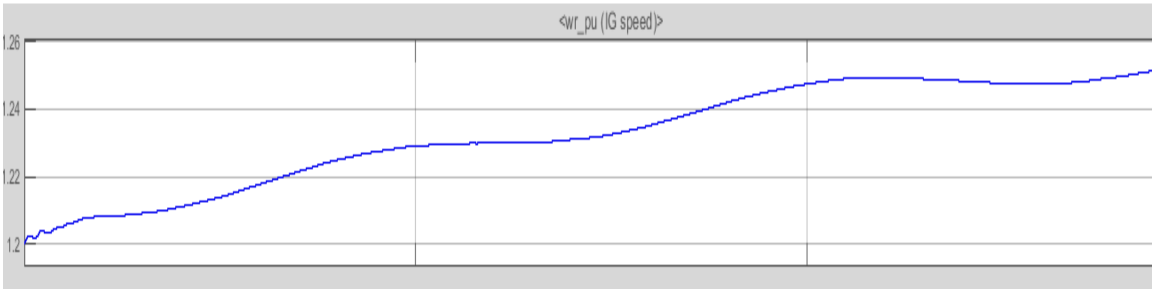

Fig 1.4 simulation result (speed curve)

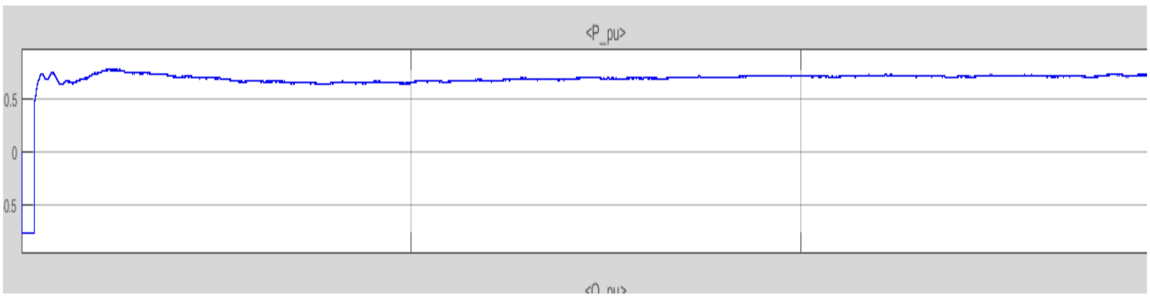

Fig 1.5 simulation result (real power versus current)

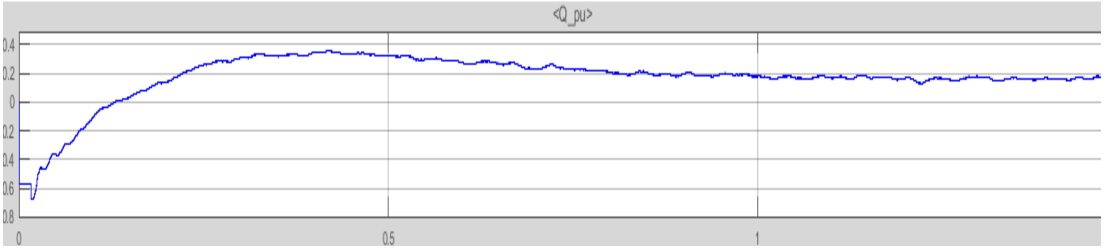

Fig 1.6 simulation result (reactive power versus current)

IV. CONCLUSION

This paper has presented a DFIG based WECS with a Microcontroller interface for grid integration. The system is modelled using the MATLAB/Simulink environment. The Microcontroller provides a controlled output voltage for variable wind speed without DC link elements. Microcontroller controls the terminal voltage and frequency of the synchronous generator so that the wind turbine can operate at its maximum power for all the wind velocities. Simulation results for dynamic wind velocities confirm that the MC is capable of operating well under transients, thus verifying its performance and suitability for a grid connected WECS.

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