Improvement in Power Quality of Matrix Converter Interfaced Wind Turbine Emulator

Naveen Sen, Prof. S.N.A. Jaaffery

Abstract— **We have seen that the nominal power of single Wind Energy Converter Systems has been steadily growing up and reaching power ratings close to 10 MW. In the power conversion stage, we found that the medium-voltage power converters are replacing the conventional low-voltage back-to-back topology. Due to this reason the Matrix Converters interfaced have appeared as a promising solution for Multi-MW WECSs due to their characteristics such as modularity, reliability and the capability to reach high nominal voltages. In 2009-10, the country imported 159.26 million tons of crude oil which amounts to 80% of its domestic crude oil consumption and 31% of the country's total imports are oil imports. The growth of electricity generation in India has been hindered by domestic coal shortages and as a consequence, India's coal imports for electricity generation increased by 18% in 2010. So in this paper I try to develop fuzzy-logic based control strategy to capture maximum wind energy and reduce harmonics for proposed wind generation system and then develops fuzzy control for indirect matrix converter under steady-state and dynamic conditions. With these assumptions finally try to validate the proposed wind generation system in simulation environment to validate the developed control algorithms under various balanced /unbalanced conditions. Finally evaluate the performance of the developed wind generation system and its controls under various balanced/unbalanced wind conditions. During investigating details the robustness of the steady-state and dynamic performance of the developed system under various balanced/unbalanced conditions using simulation software I presents the experimental performance evaluation of the developed matrix converter prototype with wind emulator.**

Index Terms— **Wind energy conversion system (WECS), Matrix converter, Wind emulator, space vector pulse width modulation (SVPWM), permanent magnet synchronous generators (PMSGs), wind farms (WFs).**

I. INTRODUCTION

Wind power is one of the most promising sources of renewable energy, and the application of wind turbines is one of the cheapest alternatives to reduce CO2 emissions from electrical power production. This paper addresses the mentioned problem and demonstrates how the power quality may be improved by using of matrix converter interfaced wind turbine emulator. The turbines are up-wind, horizontal-axis, stall-regulated machines. [1] Each turbine drives a dual-power, two-speed, asynchronous induction generator with an output of 150 kW at wind speeds of up to 7 8 m/s. In the wind farm, each wind turbine generator is equipped with a 0.69/15 kV step-up transformer. All transformers are connected to the local 15 kV network cable

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which consists of five radial feeders, of which two are connected to nine generators each. [2]

The wind energy conversion system consists of a horizontal-axis WT, a three phase PMSG and indirect matrix converter (IMC). The extracted power from wind is directly transmitted to the generator and is converted into electrical power. The generated power then fed to the utility grid through IMC.
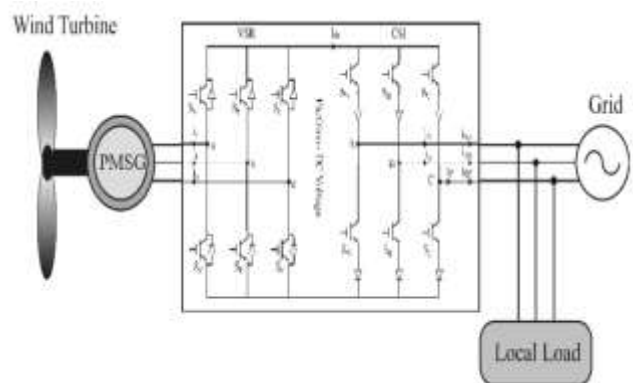

Figure 1: Projected Wind Energy Alteration System

IMC is used for interfacing with the grid, and SVPWM control is effectively used to achieve low harmonic characteristics.

Wind Turbine Model:

A dynamic mathematical model of various components of the proposed wind generation system like indirect matrix converter, PMSG, and the adaptive fuzzy logic control system incorporating the perturbation and observation type MPPT to be used for controller design purposes. [3]
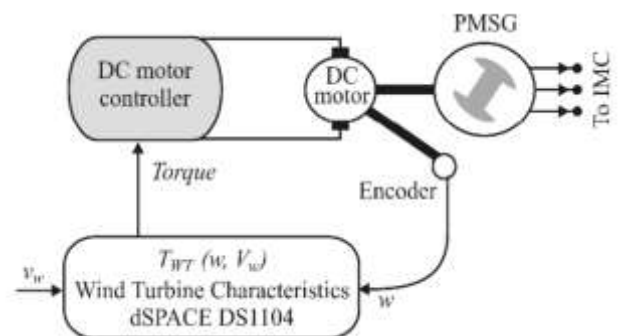

Figure 2: Wind emulate system

Indirect matrix converter which finds its suitable application for generation system is used to interface the PMSG by:

$$T_m = \frac{1}{2}\pi\rho \, C_p(\lambda) \, R_o^3 \, V_w^2$$

$$P_o = \frac{1}{2}\rho C_p A \, V_w^3$$

The power factor at the interface with the grid is also controlled by the indirect matrix converter to either ensure purely active power injection into the grid for optimal utilization of the wind generation system, and also assists in regulation of voltage and frequency at the grid.[4]

II. PROPOSED PERTURBATION & OBSERVATION TYPE MPPT

The SVPWM switching of IMC also helps in keeping the total harmonic distortion (THD) in load voltages to 2.6% for phase A, 3.2% for phase B, and 3.0 %, for phase C, which is below the acceptable limit of 5% as per IEEE-519 standards.
The procedure can be illuminated as below:

$$\text{Pertubtaion}: \omega_{ref}(t) = \omega_{ref}(t-1) + s\left|\Delta\omega_{ref}\right|$$

$$\text{Observation}: \Delta P_0 = P_0(t) - P_0(t-1)$$

A robust sliding mode controller has been used by the indirect matrix converter to track accurately and precisely the optimum angular frequency by regulating the switching frequency of the IMC. [5] The controller is designed on the basis of double integral state variables and state feedback law. This controller has been chosen due to better dynamic performance over wide range as compared to conventional controls;
more immune to effects of external disturbances and parameter variations; and more robust under load variations. [6]
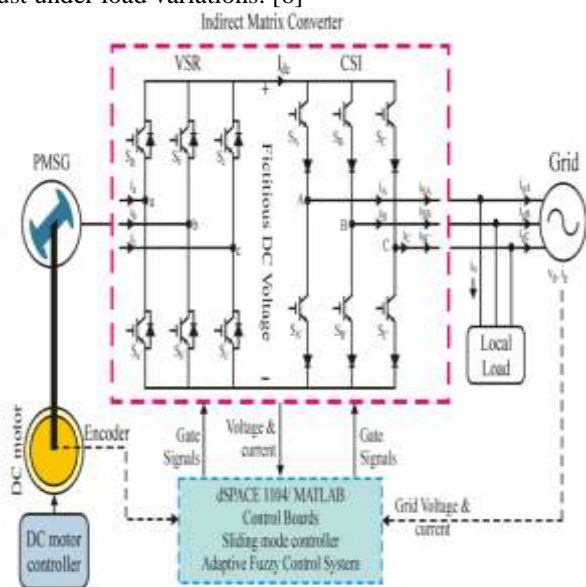
Figure 3: Overall Box Figure of the indirect matrix converter interfaced PMSG for wind energy conversion system

III. SIMULATION RESULTS AND DISCUSSION

The National Institute for Wind Energy's (NIWE) latest estimate for India's wind power potential is 302 GW at 100 meters. The major wind power states are Tamil Nadu, Gujarat, Karnataka, Maharashtra and Rajasthan.
The present study is conducted to compare the financial performance of dSPACE on the basis of ratios such as credit deposit, net profit margin etc. [7] The study found that dSPACE is performing well and implemented using

dSPACE DS1104 real time board. Considering the renewable energy potential in India, a rapid push is needed to meet this goal. About 70% of India's energy generation capacity is from fossil fuels, with coal accounting for 40% of India's total energy consumption followed by crude oil and natural gas at 24% and 6% respectively.
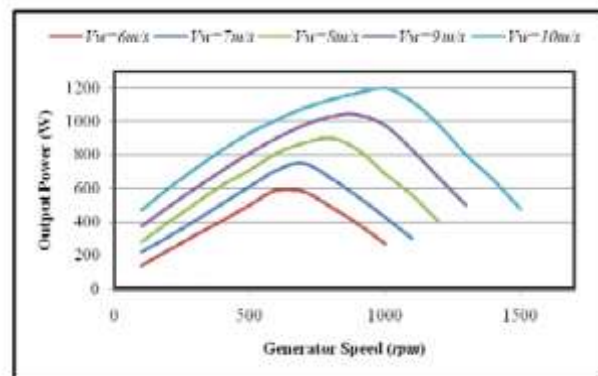
Figure 4: Experimental plot of generator speed versus output power for different wind speeds.

3.1 Response during Steady-State Condition
The growth of electricity generation in India has been hindered by domestic coal shortages and as a consequence, India's coal imports for electricity generation increased by 18% and 519 standards.
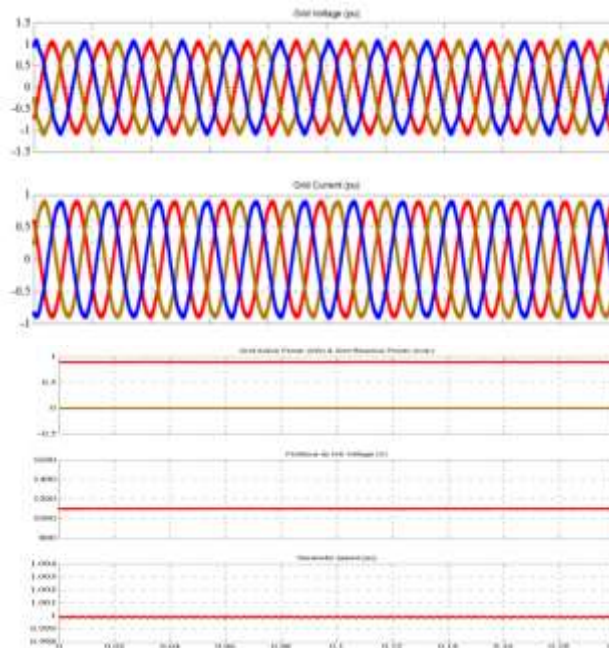
Figure: 5 Replicatedreplies during steady-state state. Grid voltage (pu), grid current (pu), grid active power (kW), grid reactive power (kvar), fictitious dc link voltage (V), generator speed (pu).

3.2 Response under Varying Wind Speed Condition
The system is affect the renewable energy integration. As per various grid codes, renewable energy plants must be able to ride through disturbances without disconnection. Voltage sag trip settings would allow the equipment to ride through during voltage sag as per IEEE Standard 1547a and this allows a plant not to trip if the duration of voltage sags is between default settings and maximum up to 12 m/s as given.
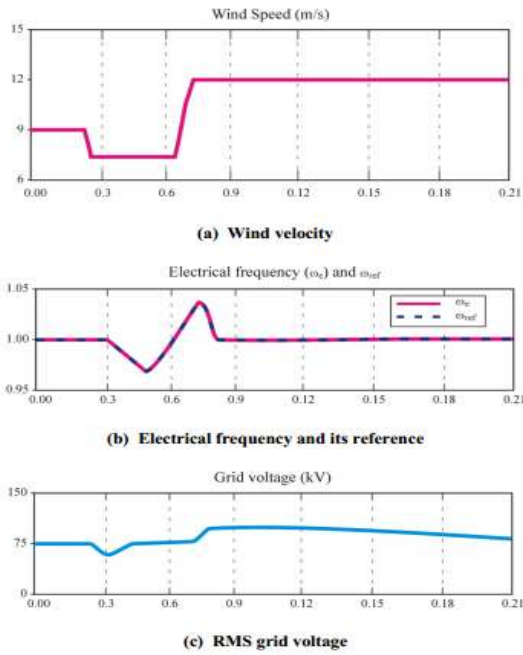
Figure 6: Replicated replies during modification in wind speed. (a) wind speed, (b) Electrical frequency and its reference, and (c) RMS grid voltage

3.3 Response under varying load conditions

As far as markets and manufacturers are concerned worldwide, China became the largest markets with over 13.1 GW capacity installed in 2012, together with China (13 GW) and the EU (11.9 GW) sharing around 87% of the global market.
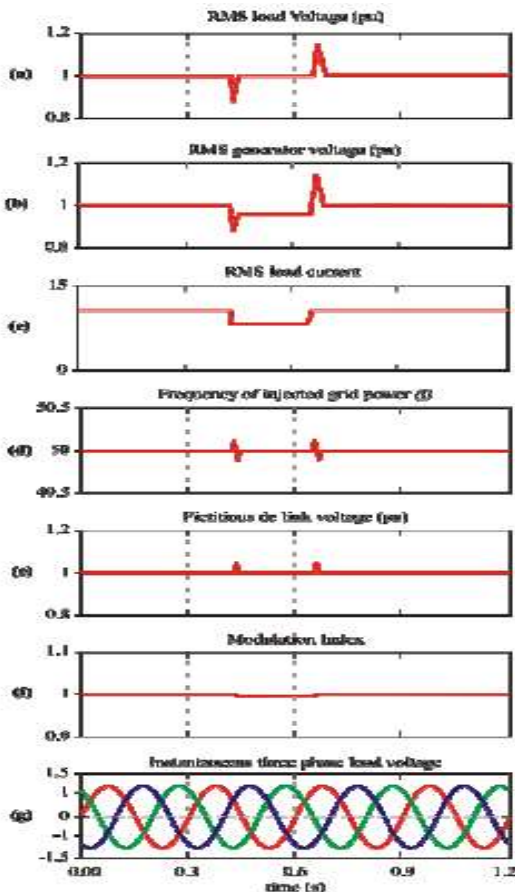

Figure 7: Response with proposed control

The development of wind power in India began in the 1990s by Tamil Nadu Electric Board near Tuticorin, and has significantly increased in the last decade. As of 31st March 2016, the installed capacity of wind power was 26.74 GW, spread across many states of India.

3.4 Response under Fixed -State Form

The steady-state capacity of various energy sources in India, as of 30th June, 2017 and total renewable energy installed capacity as of 30th June, 2017 (SourceMNRE). Therefore, wind power grows more significant than any other renewable for wind generation systems.
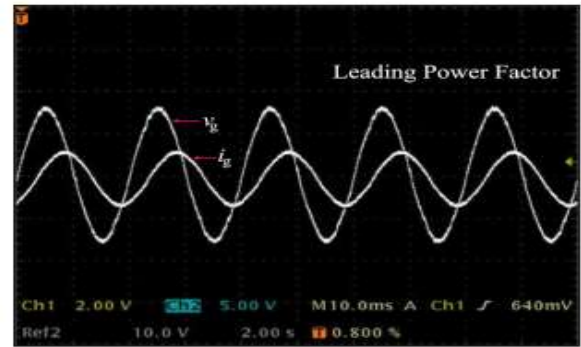

Figure 8: Leading pf operation

Figure 9: Lagging pf operation

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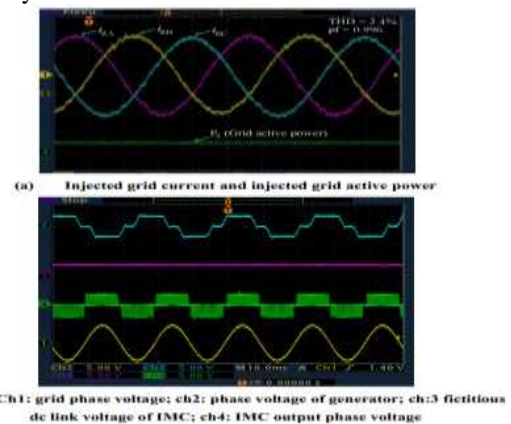

Figure 10: Experimental waveform during steady-state condition

IV. CONCLUSION

Adaptive fuzzy logic control strategy has been developed for indirect matrix converter based wind generation system for

achieving the maximum energy yield with reduced harmonics. Indirect matrix converter which finds its suitable application for generation system is used to interface the PMSG with the grid through business web portals. Theses technology strategies can up SEO of business. It can be said that after adopting better culture of technological enhancement e.g., Big Data, IoT, Semantic Web, one can enhance one's business with better economic changes. In this paper I have come

across at various strategies required for winning e-business and developed to adjust the turbine shaft speed and accordingly, control the active power injected into the grid to track maximum power for all wind speeds.

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