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Hybrid Renewable Energy System using Ultra Sparse Matrix Converter

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ABSTRACT

Ultra-Sparse Matrix based Hybrid Energy system presented in this work. The Wind Energy System connected to the Ultra Sparse Matrix Converter for the conversion of the Three Phase AC to DC output. The advantages of the Proposed System including Voltage transfer ratio and the obtained power factor is discussed in this paper. The Proposed System simulated and verified using the Simulink Tool.

Keywords: 2-Mass Drive Train, Wind Energy Conversion System, Ultra Sparse Matrix Converter, Photovoltaic System.

1. INTRODUCTION

The Ultra Sparse matrix converter has the advantage of reduced number of switching devices compared to the existing Very Sparse Matrix Converter and reduces the driver circuit needed to run the AC systems. These types of converters used for driving the AC systems effectively. The Very Sparse Matrix Converter consists of the 12 Transistors and 30 diodes in comparison with the 9 transistors and 18 diodes in the Ultra-Sparse Matrix Converter [2]. The Indirect Matrix Converter classified into Conventional Indirect Matrix Converter (CIMC), Sparse Matrix Converter (SMC), Very Sparse Matrix Converter (VSMC), Ultra Sparse Matrix Converter configurations (USMC), Inverter Link Matrix Converter (ILMC), Multi-Step Commutation, Zero DC-Link current commutation.By using the Quasi-Z-Source Matrix Converter for the Back-to-Back Converter configurations, the voltage transfer ratio improved in the AC-DC-AC circuit configuration [1].

The Ultra Sparse Matrix Converter is proved to be efficient compared to the existing topologies due to the reduced complexity of the switching scheme. Sparse Matrix Converter is best suited for Aircraft actuators and Elevator Drive Applications and Unidirectional Power Flow applications. The AC-AC convertersare broadly classified into Converters with DC Link Storage, Hybrid Matrix Converters, and Matrix Converters.The Wind Energy System used in the system consists of the 2-mass drive train model using the Permanent Magnet Synchronous Generator. The Pitch Angle Controller used to control the torque of the Permanent Magnet Synchronous Generator.The Output of the Wind Generator fed to three legs of the Ultra Sparse Matrix Converter System.

The wind energy system implemented as either Vertical axis wind Turbine or Horizontal Axis Wind Turbine, whereas the vertical axis wind turbine, has the advantage of maximum torque compared to the Horizontal Axis type.Hybrid Matrix Converters also used for the Reactive Power Compensation by injecting a certain amount of harmonics to the Power source and the load by implementing the bidirectional switches [3].

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2. PROPOSED ULTRA SPARSE MATRIX CONVERTER

The Proposed System consists of the Wind Energy System connected to the Ultra Sparse Matrix Converter Circuit. The Ultra Sparse Matrix Converter consists of three switches S_1, S_2; S_3 controlled using the space vector modulation based controller. The output of the Converter connected to the Load. The Photovoltaic System connected to the DC side of the Matric Converter System. The ultra-sparse matrix converter system consists of 12 Diodes and three switching devices in comparison to the existing system with Very Sparse Matrix Converter System with 24 Diodes and six switching devices at the rectifier side. Fig 1 shows the entire structure of the Proposed Converter System with Photovoltaic and the Wind Energy Systems. The DC voltage fed to the hybrid system via a DC link capacitor [4]. Vienna Rectifier has several advantages including the Lower Total Harmonic Distortion, elimination of the Position Sensor and the reduction in the computation time [5].

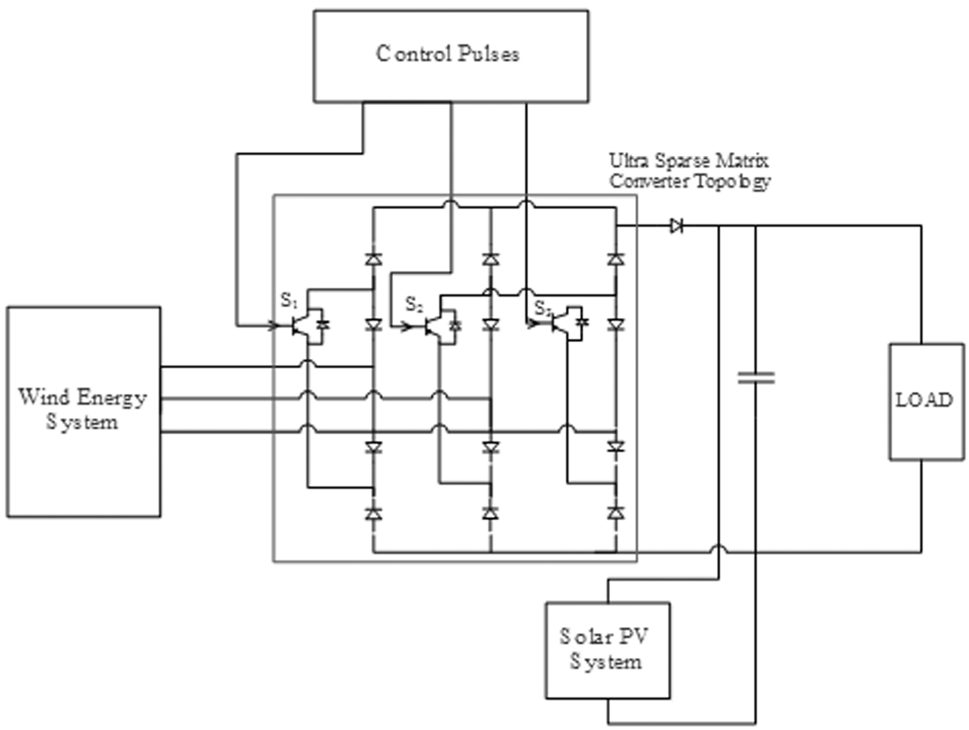

Figure 1: Proposed Hybrid Matrix Converter Topology with Photovoltaic and Wind Energy System

2.1. Parameters of Proposed System

Table 1 shows the control parameters of PV and the Wind Energy Systems for the Proposed Matrix Converter System. The Photovoltaic System maintained at the Standard Test Conditions. The Wind Energy System should be limited to the value of 25 m/s due to the Betz Limit.

Table 1
PV and Wind Systems Parameter Specification

Parameters	*Value*
Irradiance Level	1000 W/m^2
Temperature	25 °C
Wind Speed	10 m/s
PV Voltage	65-70 V
Wind Energy OutputVoltage	50-55 V
Net Output Voltage	137 V

2.2. Gate Pulse to the Proposed Matrix Converter Circuit

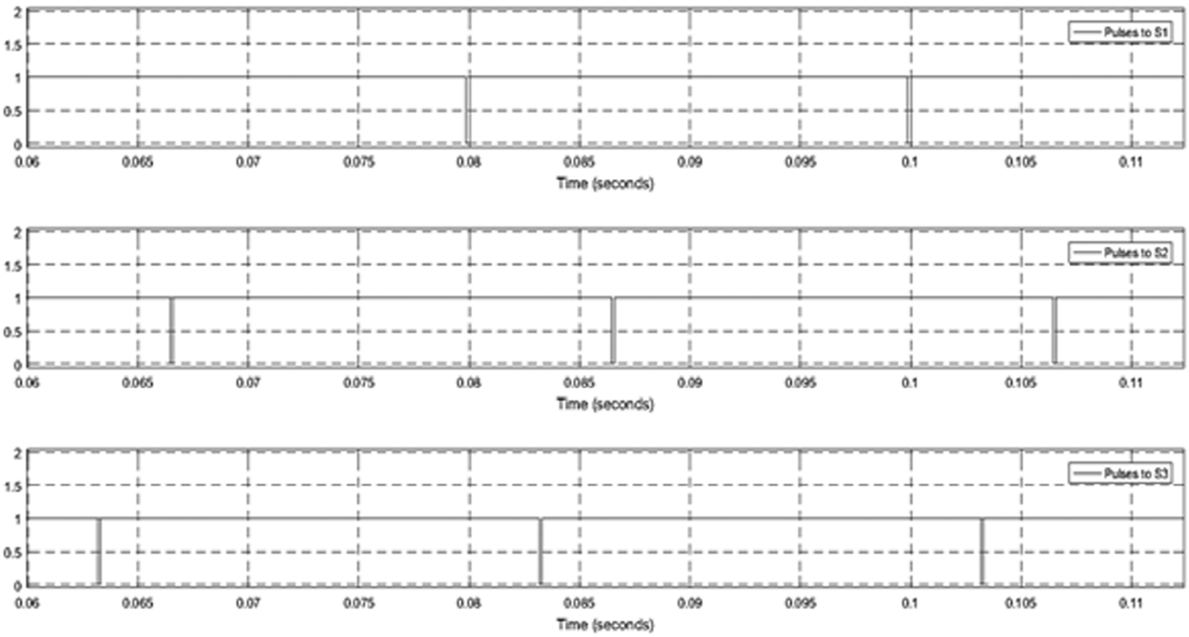

Figure 2: Gate pulse generation for the Switches S_1, S_2, S_3.

3. SIMULATION RESULTS

Figure 2 represents the gate pulses to the switch S_1, S_2, $S_3$of the Ultra Sparse Matrix type Converter. The three pulses are phase shifted by an angle of 120° with each other. Figure 4 shows the AC output voltage waveform across the Wind energy system.

From the Figure3 the output AC voltage displaced by an angle of the 120°. The AC voltage then fed back to the Matrix Converter System to convert it into the DC. Space Vector Pulse Width Modulation realized using Clarke's Transform. Figure4 shows the Wind output voltage across the converter after the AC-DC conversion. Figure 5 shows the net output voltage from both the Photovoltaic and the Wind Energy Conversion

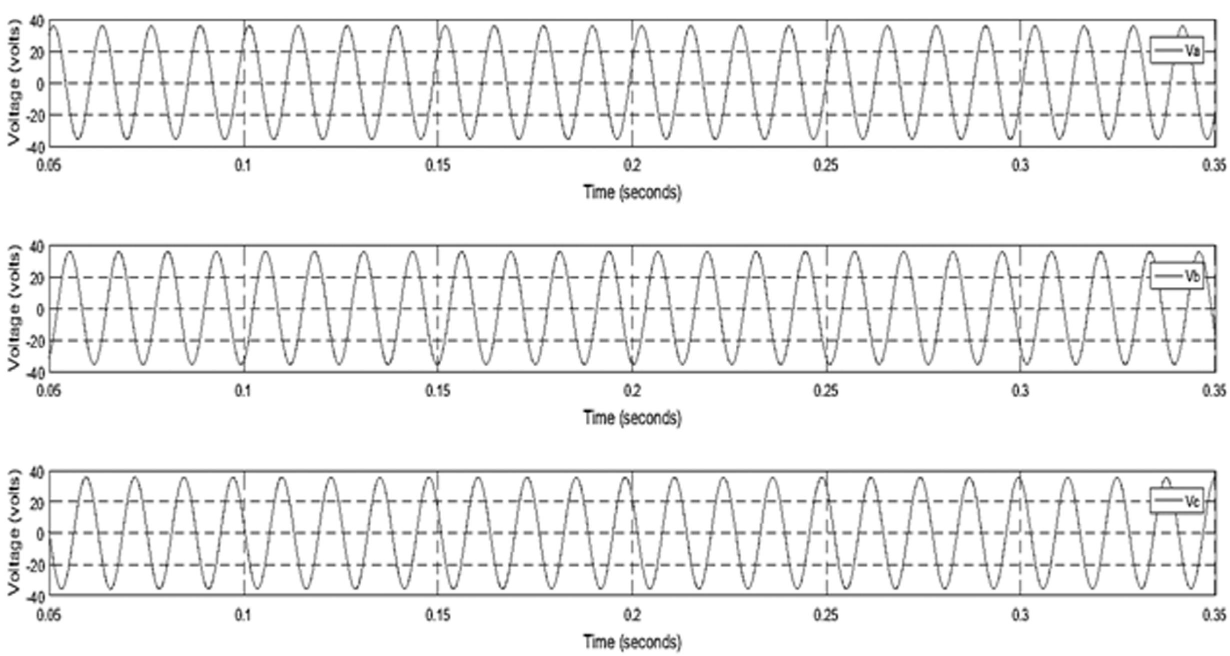

Figure 3: Output AC Voltage across the Wind Energy System

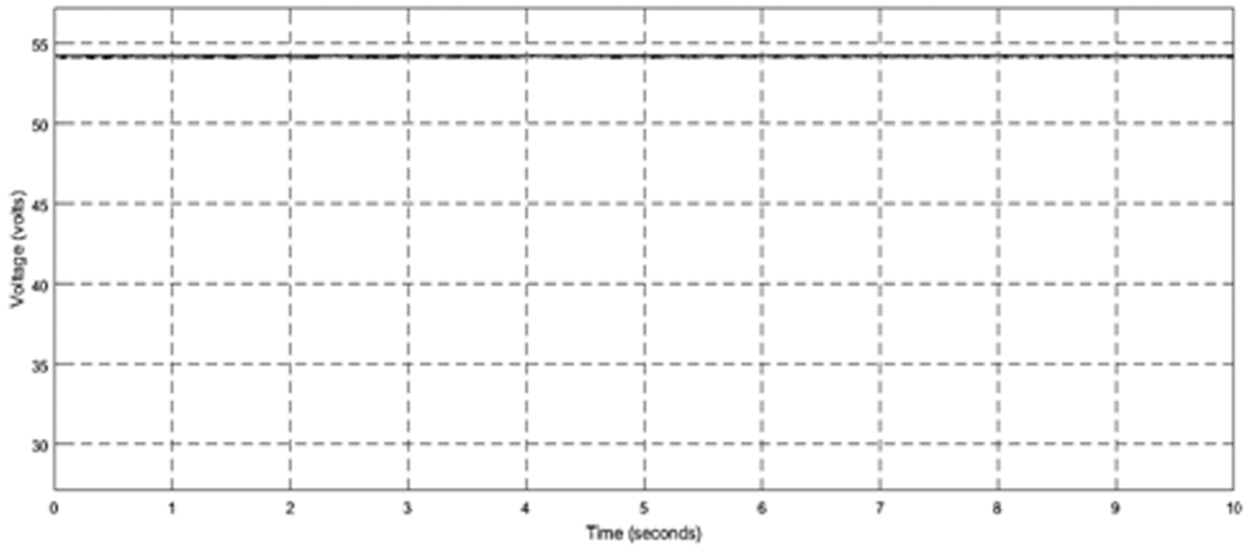

Figure 4: Output Voltage across the Proposed Converter

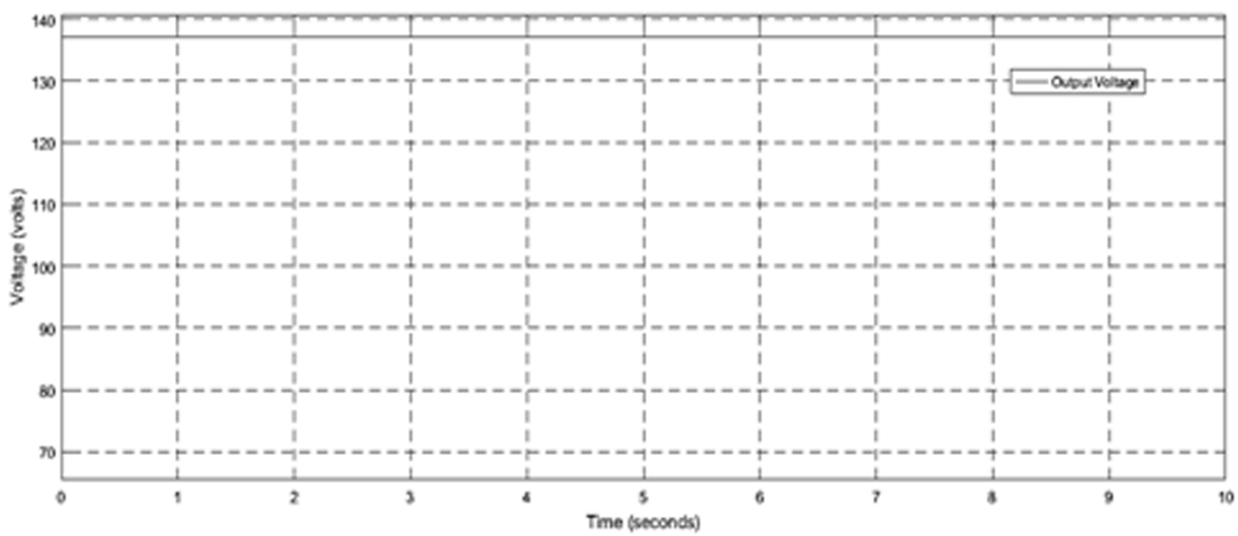

Figure 5: Net Output Voltage

Systems. The power factor across the Wind Energy System obtained at 0.98. Thus, from the Figure 5, the Output voltage obtained as 137 volts. In comparison to the existing system, the voltage transfer ratio obtained at 1.1% [3].Reverse Blocking switches are used for the Single stage AC-AC direct type Matrix Converters along with a magnetic coupler which uses only 7 switches for the control operation [6]. Also, realize AC-DC-AC type matrix converter using a switched rectifier inverter for the conversion of the three-phase AC to the single-phase AC output with high power density suitable for the Aircraft applications [7].

Further, the Voltage Boost Ratio improved by adding the Z- source before the inverter section of the matrix converter system [8]. The Clamp circuit used across with the DC link capacitor to protect the Converter circuit from the reverse overvoltagesto generate the sinusoidal input voltage and current [9].The direct AC-AC conversion also made possible by implementing the Three Level Buck – Boost Converters with lower THD and improved Power Factor and Bidirectional power flow also made possible [10].

4. CONCLUSION

The Proposed type of Sparse Matrix Converter has the improved voltage transfer ratio and better power factor compared to the very sparse matrix converter configurations. The Proposed type of converter realized using an inverter circuit and fed to the AC load. The Proposed type of converter is useful for the Remote Power Systems by feeding the output DC voltage to the High Voltage DC Transmission Systems.

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