

# Design of AC-DC-AC Power Electronic Converter for PMSG Based WECS

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## ARTICLE DETAILS

### Article History

Published Online: 15April2019

### Keywords

WECS, PMSG, boost converter, P.E converter.

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## ABSTRACT

wind energy performs one of the most important energy sources due to energy crisis and developing issues on global warming. For researches in power electronics, one of the hugest tough hassles is to develop WECS in order that the electrical energy from wind turbine is transformed to the utility line with better efficiency and better high-quality. The development of latest WECS goes back to the year 1971 but it is current decades that have indicated fast development in the field. This paper includes a design of equivalent power electronic controller for a permanent magnet synchronous generator (PMSG) based wind energy conversion system in MATLAB for independent and grid linked operation. In which output of PMSG is fed to the load through AC-DC-AC controller. The output frequency and voltage of PMSG is unstable caused by stochastic nature of wind and isn't match with the grid frequency. In order to put it into grid we have need of power electronic interface. The effects are made to maintain the variable output of PMSG to the constant voltage and frequency. The sine PWM approach is presented for the same.

## 1. Introduction

The wind is consequence of sun energy. The exterior of the earth cools and heats unequally, produce atmospheric stress zone which causes air to float and additionally rotation of earth makes wind. The wind has ability to exert a pressure put together to generate movement utilized inside the WECS. Wind energy era is showing wide development in growing nations like India. As a result of technological judgment of wind sources in the course of India, wind power has come out as a feasible and worthwhile example for power generation. Also research proposed that smaller scale WECS are more productive and profitable. Two types of generator are used in system i.e. asynchronous generator and synchronous generator. In synchronous generator, for large and small scale wind mills power generation, Permanent magnet synchronous generator (PMSG) is the favorable and reliable methods. The amplitude and frequency of PMSG output cannot directly linked with the grid hence to meet the amplitude and frequency requirement additional conditioning i.e. power electronic interface is needed. Advantages of PMSGs are brushless construction, light weight and small size, high reliability, high efficiency, less frequent maintenance, excessive electricity density, low acoustic noise, power compatibility.

There are many different topology interfaces between PMSG and the load in which two are greatest common topology. The first topology is as single switch mode rectifier and inverter and second topology designed as back to back PWM converter. The first configuration is more beneficial than second configuration because it has more system cost and complexity also. It causes more losses due to lot of switches and existence of electromagnetic interference which causes

voltage stress. Considering permanent magnet synchronous generator utilization, three phase diode bridge rectifier use along with boost converter are more inexpensive. An easy AC-DC-AC converter for wind energy generation systems to link with the grid is used having advantages of cheaper cost and control of generator load.

This paper offers an effective topology for small scale wind power conversion system using PMSG and AC-DC-AC power electronic converters. In this system single switch rectifier and inverter topology is used, using diode bridge rectifier (uncontrolled rectifier) variable PMSG output is transformed to variable DC and with the help of boost converter it is converted into constant DC, this constant DC output of boost converter is transformed to AC with the help of single phase PWM inverter and then fed to the load to meet amplitude and frequency requirement.

## 2. System Configuration and Description

### A. Proposed model of the system

The proposed diagram is shown in fig 1. It shows that variable wind machine is connected to the PMSG. A constant speed machine is able to extract significantly less energy than variable speed wind machine. Wind speed changes continuously due to its stochastic nature which makes the output of PMSG unstable. In this system, these variable output frequency and voltage is transformed into constant output frequency and voltage with the help of diode bridge rectifier, boost converter (dc-dc converter) and PWM inverter. This inverter is fed to the load. The LC filter is used to ripple out oscillations as well as smooth waveform.

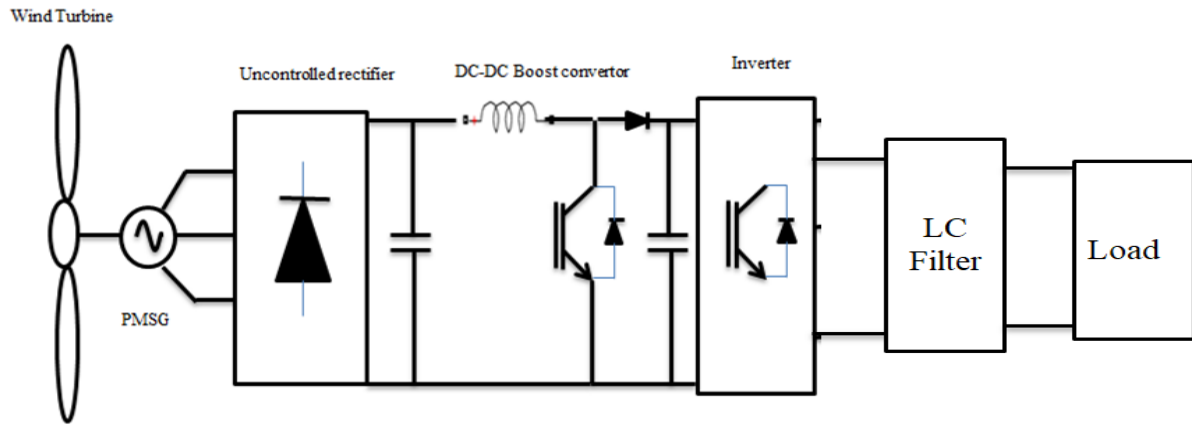


Fig 1. Block diagram of the system

**B. Simulation Model of the proposed system**

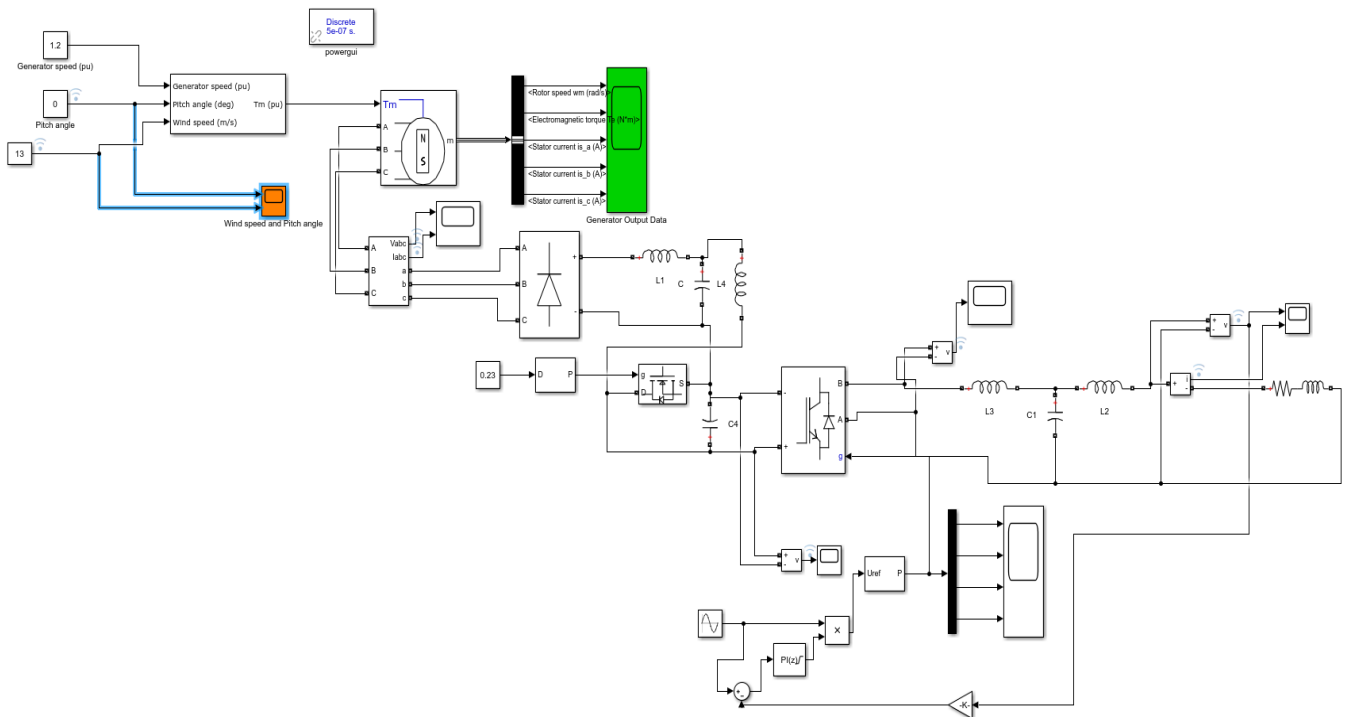


Fig 2 Simulink model of AC-DC-AC converter in MATLAB

AC-DC-AC converter for PMSG based wind turbine simulink model done in MATLAB given in figure 2. As shown in figure Wind turbine which has wind speed 13 m/s, pitch angle 0 and generator speed 12 pu is connected to diode bridge rectifier, boost converter (DC-DC converter) and a three phase PWM inverter with R load.

**C. Permanent magnet synchronous generator**

The PMSG is normally constructed with magnet (high-energy, rare-earth magnet such as neodymium-iron-boron) attached to the rotor. It is specially used in low speed operation in renewable power applications; it is attractive choice because it has more conversion efficiency, generally because magnet is present. It is of simple design, sturdy and reliable. The

mechanical friction is low in contrast to the machine because absence of brush gears and does not require gear box also it does not require an extra DC supply for the excitation circuit. These are light in weight, small size and more power to weight ratio as like it has numerous benefits. The disadvantage of permanent magnet required for PMSG are quite costly due to rare earth magnet and at high temperatures and high current magnet get demagnetized [7].

400 W, 12V PMSG generator is used having stator resistance 0.00018  $\Omega$  and armature inductance 0.835 H. The simulation result of the generated output voltage waveform and generated output current waveform is as shown in fig 3 and fig 4

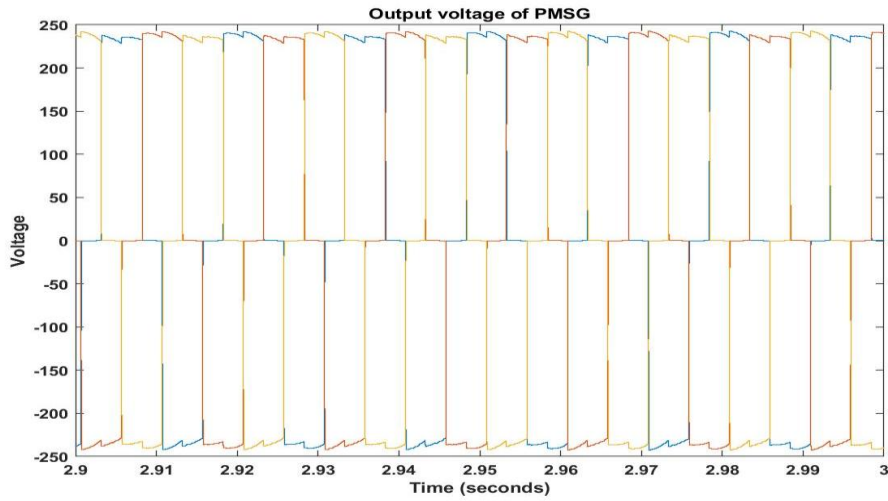


Fig 3. Generated output voltage waveform for PMSG

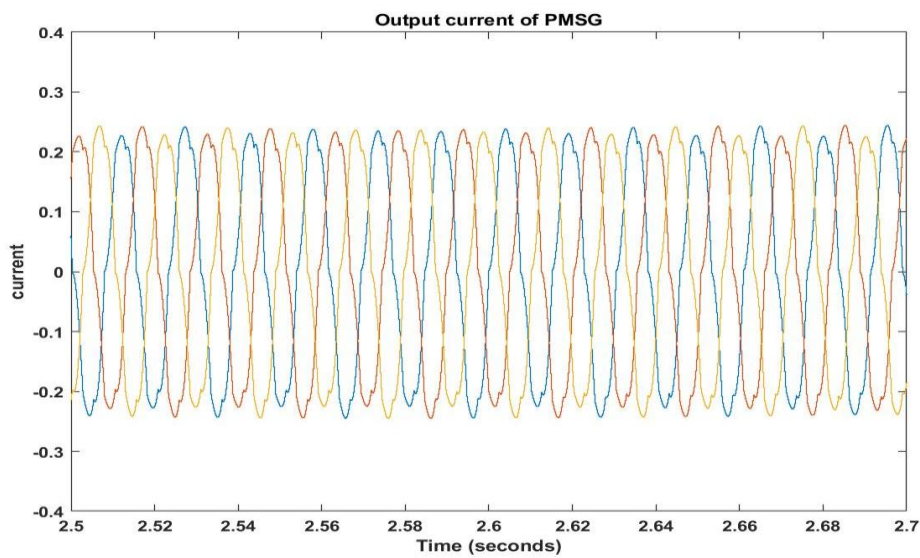


Fig 4 Generated output current waveform for PMSG

**D. Three phase diode rectifier**

The diode bridge rectifier is simple, higher efficiency than any other rectifier (half and full wave rectifier), use of low filter, inexpensive and rugged used in power electronic application. The diode bridge rectifier poor facet is that the output is not

proper, ripple is present in its output and it cannot operate in bidirectional power flow.

The diode bridge rectifier having snubber resistance 1e6 is used. The power developed from PMSG is of voltage 200V then it is stepped up to 250V and generated voltage waveform of 250V is as shown in fig 5.

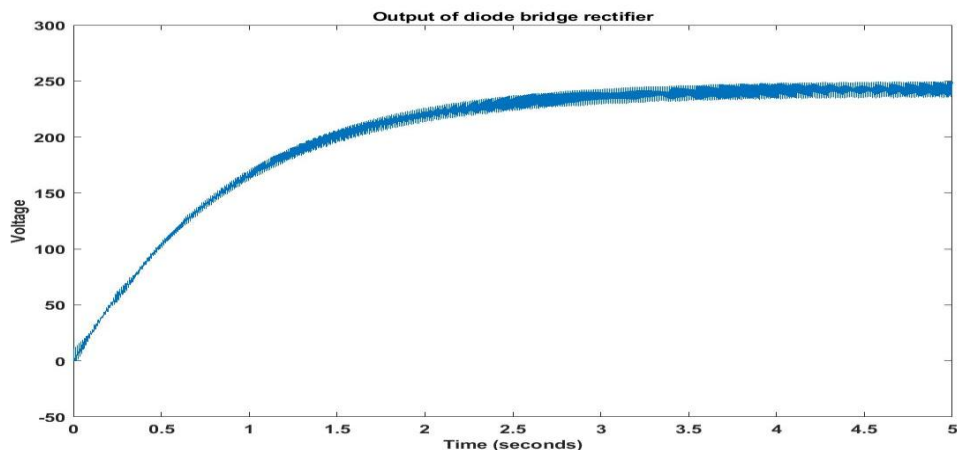


Fig 5 Output voltage waveform of diode bridge rectifier

**E. Boost converter(DC-DC Chopper)**

A boost converter which used to step up the input voltage i.e. input voltage is smaller than the output voltage. When transistor is ON, current is stored in the inductor, diode become reverse biased and remains off. When transistor is off, capacitor is charged because inductor releases its energy and fed to the load via diode. The output voltage of the boost converter is given by

$$\frac{V_0}{V_S} = \frac{1}{1-D}$$

Where  $D = T_{ON}/T$  is duty cycle of the transistor

The continuous inductor current will persist if

$$L > \frac{(1-D)^2 DR}{2f}$$

The minimum value of the capacitor should be as

$$C_{min} = \frac{DV_0}{(\delta V_0)RF}$$

DC-DC boost converter parameter of duty ratio 0.23, switching frequency 5KHz, inductance 0.0063H, capacitance 800e-6 F are used. The generated dc-dc boost converter output voltage with reduced oscillations as shown in fig 6

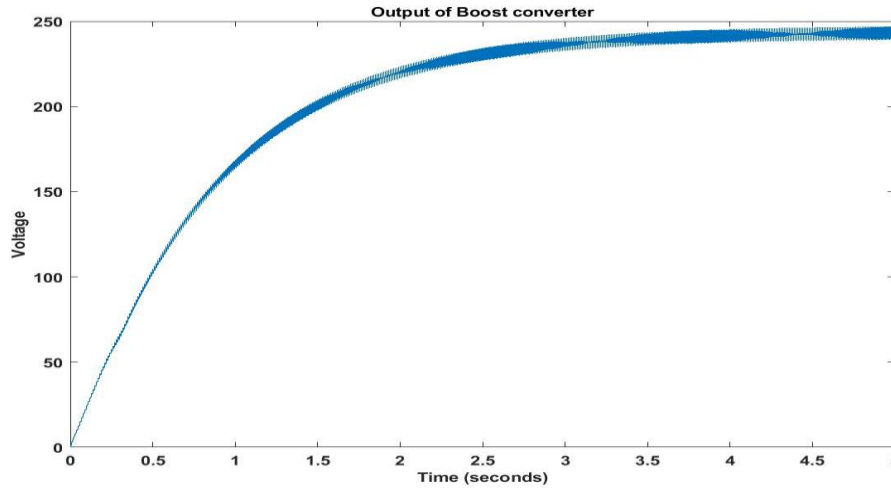


Fig 6 Output voltage waveform of boost converter

**F. Single Phase inverter**

The inverter must transfer power from a DC power source to AC power source or load with the required voltage and frequency. To decrease total harmonic distortion in the inverter circuit, output voltage control with incredible precision and filter requirement without external power device can be achieved using pulse width modulation technique. The output of boost

converter is supplied to single phase Inverter provides constant AC output. Usage of this inverter, main motive is to obtain desired shape and magnitude of the output.

IGBT switch is used having snubber resistance 1e5 is used. The generated output voltage of 250 V, 50 Hz and generated voltage with PWM switching is as shown in fig 7

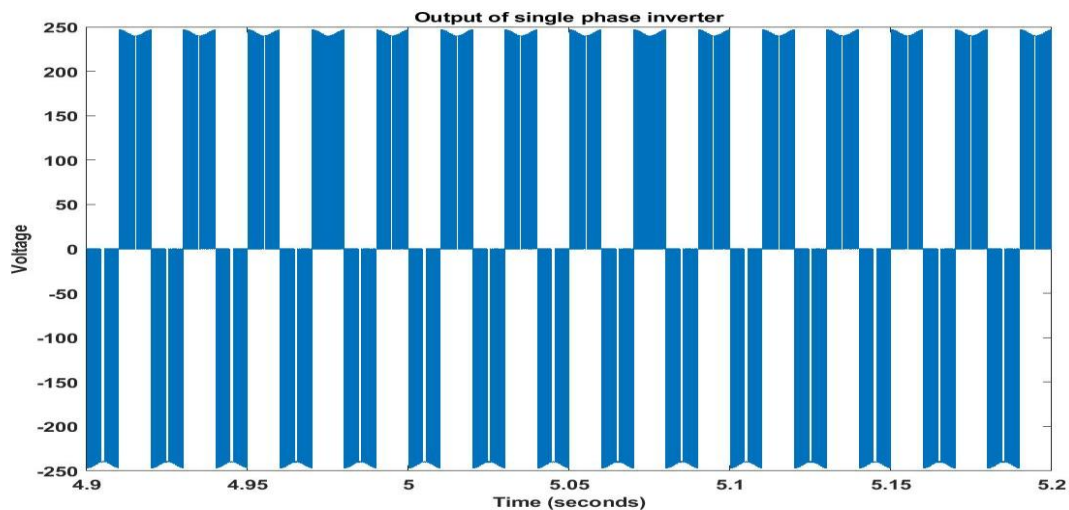


Fig 7 Output voltage waveform of single phase inverter

**3. Simulation result and analysis**

The generated voltage waveform of 230 V, 50Hz for power electronic converter based PMSG as shown in fig 8 and

generated current waveform having 0.4A for power electronic converter based PMSG as shown in fig 9

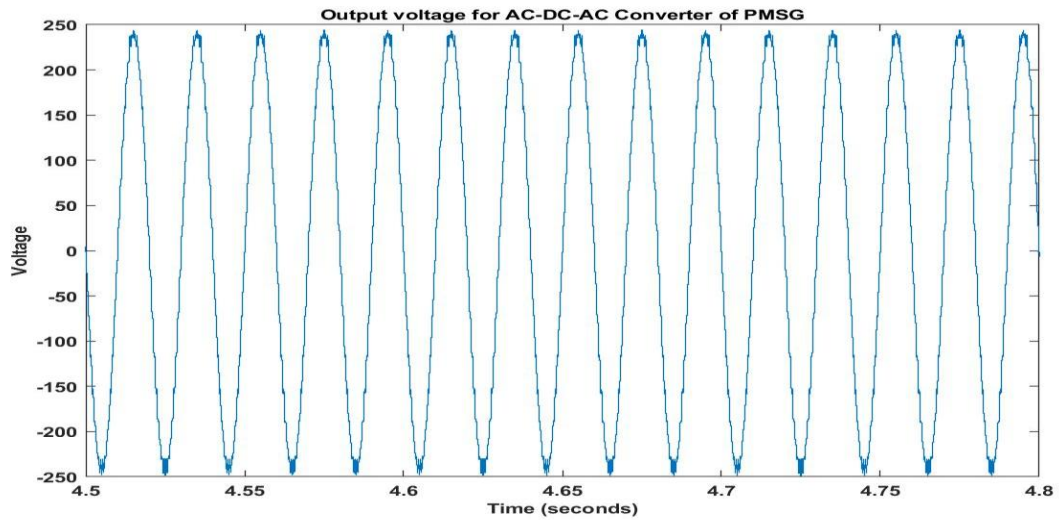


Fig 8 Generated current waveform of AC-DC-AC power electronic converter for PMSG based wind turbine

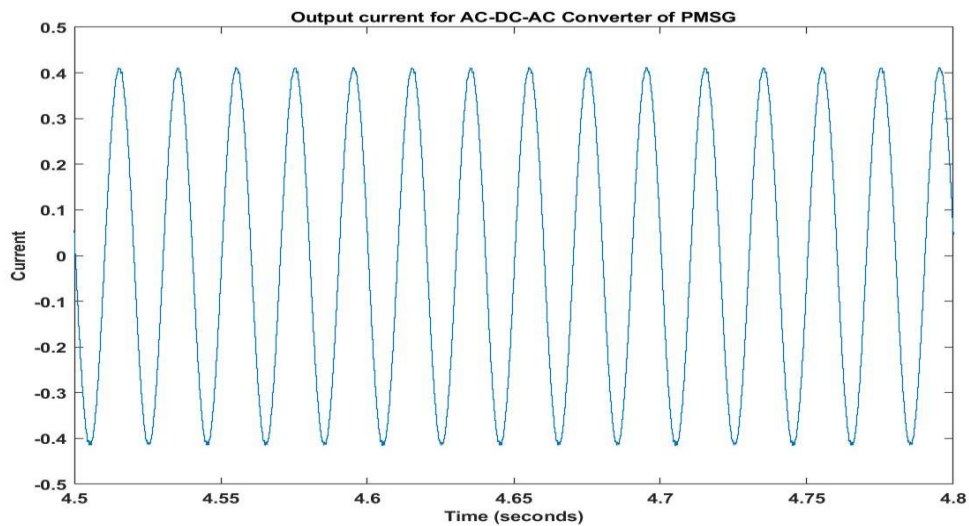


Fig 9 Generated voltage waveform of AC-DC-AC power electronic converter for PMSG based wind turbine

FFT ANALYSIS: The generated output voltage total harmonic distortion is the value of 26.77% shown in fig 10 and the generated output current total harmonic distortion is the value of 27.39% shown in fig 11

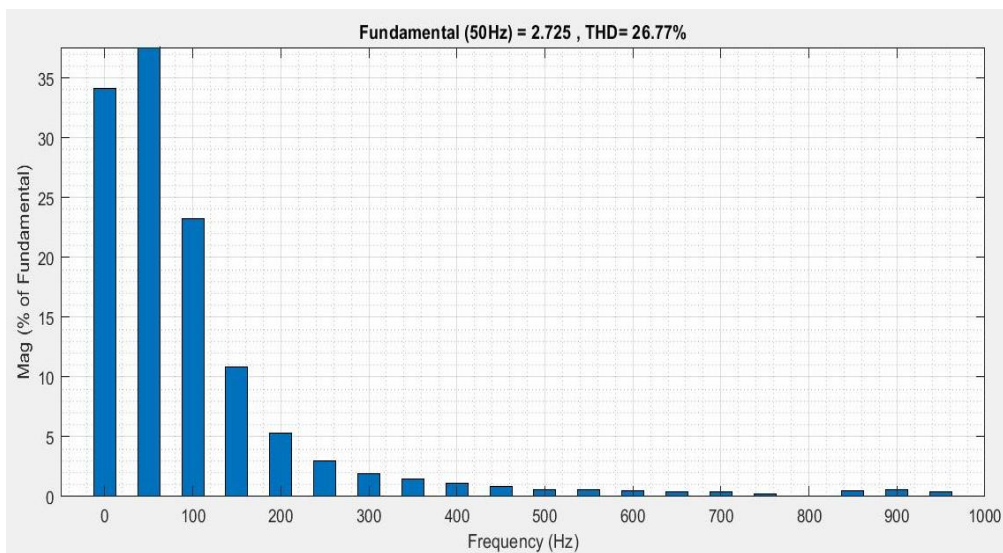


Fig 10 Output voltage THD

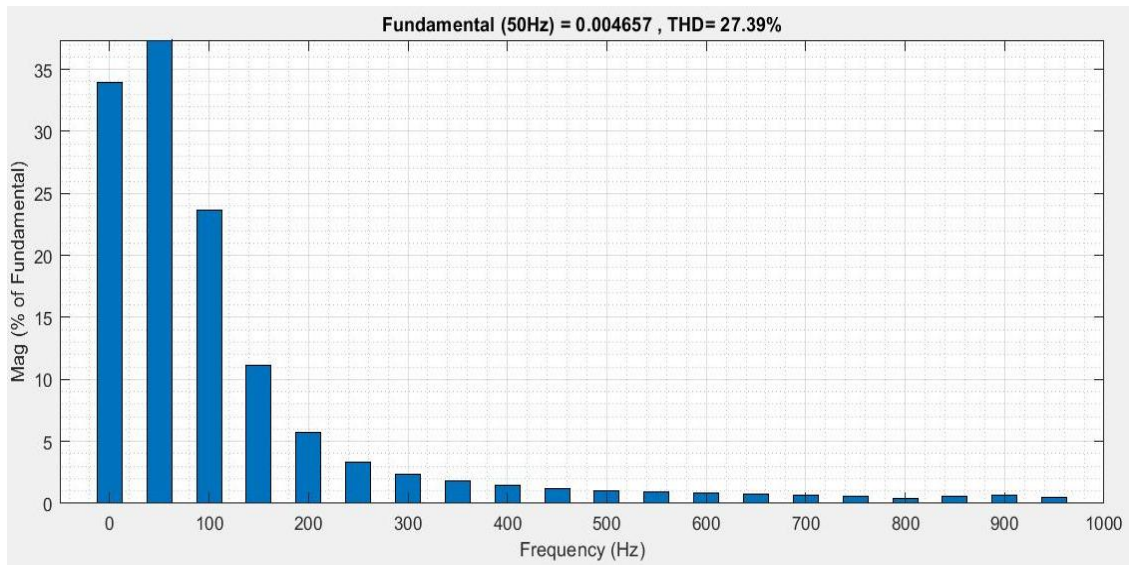


Fig 11 Output current THD

#### 4. Conclusion

The power electronic conditioning plays a very important role within synchronization of renewable power energy sources in to the grid and isolated consumers. Simulink model of AC-DC-AC power electronic converter of PMSG based WECS for grid connected application in MATLAB has been presented. Effective uses of PMSG based wind power conversion system

results in higher performance and also deliver AC power with required frequency and voltage which is definitely fitted to wind energy techniques. A power electronic interface consisting of diode bridge rectifier, boost converter and single phase inverter is used to maintain constant frequency and voltage to synchronizing generator to the grid.

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