TEST Engineering & Management

*January - February 2020*
*ISSN: 0193 - 4120 Page No. 4638 - 4644*

# 4A PMSG based Flexible Input WECS for Grid using Power Converter and MFT Device

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***Article Info***
***Volume 82***
***Page Number: 4638 - 4644***
***Publication Issue:***
***January-February 2020***

***Article History***
***Article Received****: 18 May 2019*
***Revised****: 14 July 2019*
***Accepted****: 22 December 2019*
***Publication****: 23 January 2020*

***Abstract:***
Frame work of wind energy conversion system(WECS) using permanent magnet synchronous generator(PMSG) is proposed in this article. The system proposition combines a diode rectifier, converter and a pulse width modulator (PWM), Medium Frequency Transformer (MFT) with current source converter (CSC). In this system proposition, an additional control freedom is broached to quantify the DC link current for empowering the system operation in full range. Further Active power control by d-axis and reactive power control by q-axis is exercised by grid voltage orientation method. Ascertainment of phase angle for utility voltage is espied using Phase Lock Loop (PLL) in d-q synchronous reference frame. This system proposition scheme ensures the concrete benefits of minimum cost, well quality power conversion result for the variable speed of WECS.

***Keywords:*** *Current source converter, permanent magnet synchronous generator, medium-frequency transformer, wind energy conversion system*

## I. INTRODUCTION

Series-interconnected Offshore wind farm arrangements are encouraging frame work on account of biggish and exorbitant offshore stations can be ostracized. This concept is based on a dispensed HVDC converter to onshore wind farms. The system proposition incorporates the wind turbines which is interconnected in series [1].A new control scheme to permanent-magnet synchronous generator is found in [2]. In [2], a current-source converter is occupied which arches the generator and grid to WECS. A new scheme for permanent magnet synchronous generator is introduced from the off shore wind form. Here cascaded PWM CSC is engaged at generator and grid. The composition of PWM CSC to on shore grid equalizes the number of wind form generators. [3]. Juxtaposition of series and parallel current source WECS is proposed in [4]. A catenation of off shore wind farm is made to the grid using HVDC with CSC. The circulation of system converters empowers the speed governance of generator [5]. CSC with MFT topology is proposed as the assured converter framework to medium voltage high power PMSG wind energy system. Further, it has the merits such as uncomplicated arrangement, opt grid wave, considerable power factor, and trust worthy short circuit protection of grid. From this point of view, important types of CSC oriented medium-voltage PMSG with WECS are examined [6]. The spotlight of the power converter technology at WECS will fall on the grid incorporation and congruity of the wind power in power transmission system. For long period, the confrontations for minimum cost of energy, trustworthiness, and responsible grid unification are the pushing technological advancement of WECS. In addition, it facilitates feasibilities with reference to the power transfer arrangement, drive train, generator, PEC configurations, as well as semiconductor devices [7].

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## II. CONFIGURATION OF PROPOSED SYSTEM

### A. Block diagram of proposed system:

The diagram of the system proposition is depicted in Fig. 1. The various blocks of this proposed system are defined as follows:

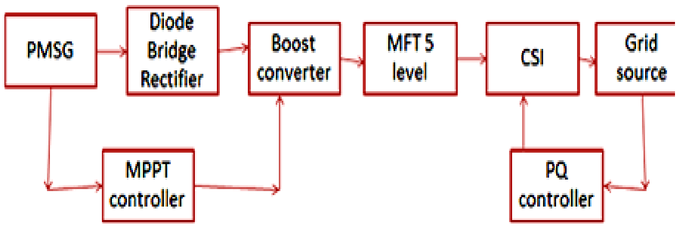


Fig. 1. Block diagram of PMSG system.

**Permanent Magnet Synchronous Generator (PMSG):** It is wind generator that consists of permanent magnet on rotor and armature coils on stator. Change over of wind energy into electrical energy is executed by PMSG.

**Diode Bridge Rectifier:** It is a full bridge three phase converter. It changes AC form of current into DC form of Current.

**Boost Converter:** It consists of MOSFET switch, inductor and capacitor. It converts DC voltage to higher magnitude by governing the duty cycle of the MOSFET.

**Medium Frequency Transformer (MFT):** MFT's are the special type of transformers operating at high power (>50 kW) and high frequency (>1 kHz).The burden of implementing Single transformer is reduced with the help of single MFT design that helps to boost a single megawatt-level power.

**Current Source Inverter (CSI):** It consists of inductor in series with three phase inverter to produce AC output, which is to be synchronized with Grid supply. As a result of which it controls the active and reactive power flow from DC to AC side.

**Maximum Power Point Tracking (MPPT):** The purpose of MPPT is to control the wind generator and converter side to operate at the maximum operating voltage in respect of wind speed. This gives PWM signals from wind speed control action to boost converter.

**PQ controller:** PQ controller is generally used for controlling active and reactive power individually. If grid needs active power, then active power alone is given to the Grid supply. If grid needs reactive power then reactive power is given to Grid supply.

### B. Implementation analysis of proposed system

The topology in Fig 2 shows the proposed boost converter which is constructed on PMSG system. This layout is composed of a medium voltage PMSG, a boost converter, a three-phase diode rectifier, a CSI and a modular MFT –based converter which is joined to the grid via transformer.

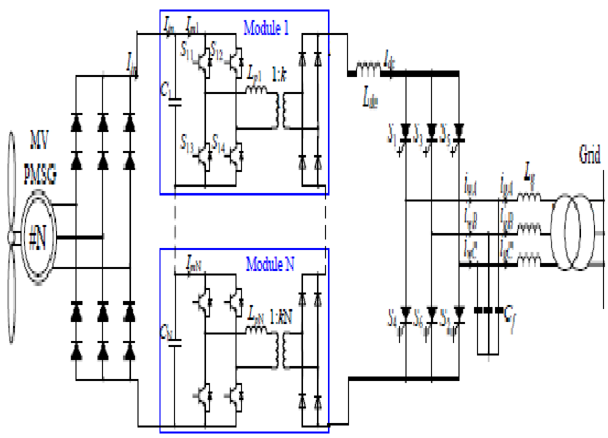


Fig. 2. Proposed system

Fig. 3 presents a boost converter, it converts DC voltage from low level to high level with the help of inductor connected with a series switch that aids in charging the inductor. The charged inductor current is then discharged to capacitor and it is stored for cycle. The operation of boost converter is presented in Fig. 4. From this, we can observe that when switch $S_1$is turned ON, inductor is charged, and when this switch $S_1$ is turned OFF, the inductor discharges via the capacitor. The switching of boost converter is controlled through the signal received through wind MPPT controller, which produces output signal according to wind speed. This boosted

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DC output is then fed to MFT; here voltage at higher level is controlled by splitting into 5 levels by using the capacitor series connection across boost converter output.

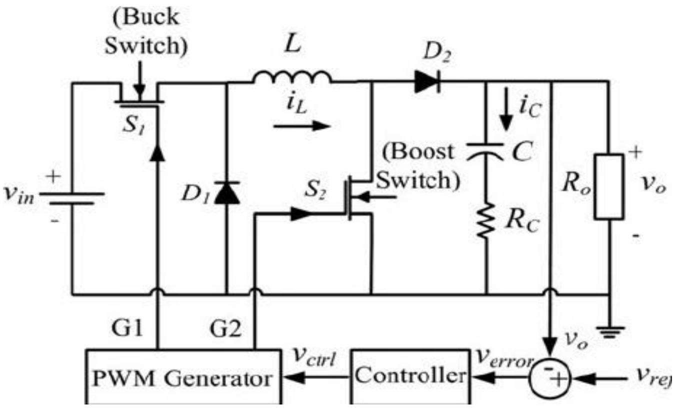


Fig. 3.Boost converter

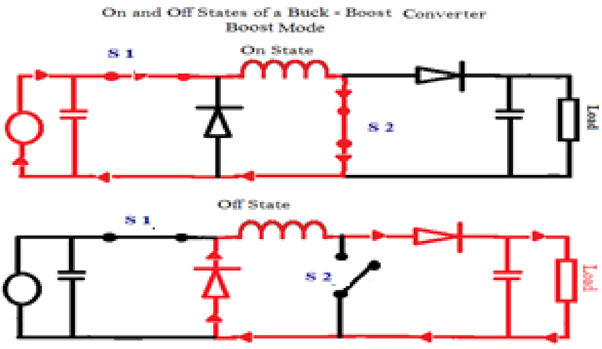


Fig. 4.operation of boost converter

This voltage is reduced to lesser voltage at individual capacitor, this helps in using transformers at lesser rating rather than a bulky single transformer.

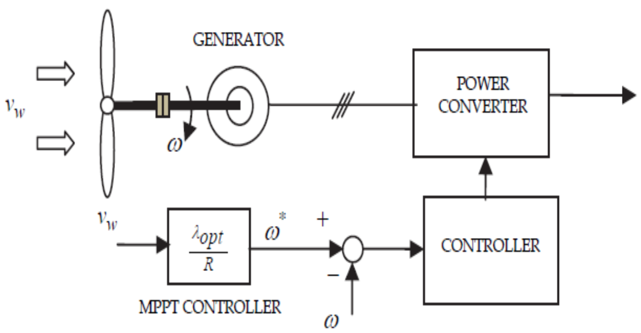


Fig. 5. Tie speed ratio of WECS.

The output from the transformer is given to the Grid via CSI.CSI converts DC supply to three phase AC supply. This CSI also controls voltage input to the Grid side, which inturn compensates the active and reactive power effectively. The control action is performed by means of PQ controller. This PQ controller is controlled by comparing experimental values with desired values. This error values are in turn calculated as PWM signals and then triggered the CSI inverter accordingly. In this way, the Grid connection of PMSG based WECS is effectively operated in a controlled manner.

Fig. 5 depicts the tie speed ratio of TSR and WECS control method that formulates generator's rotational speed in order of maintaining the TSR to an optimum value at which the maximum power will be extracted. To run this method wind and turbine speed are required to estimate besides the knowledge requirement of the optimum TSR of the turbine to extract power to the maximum in the system

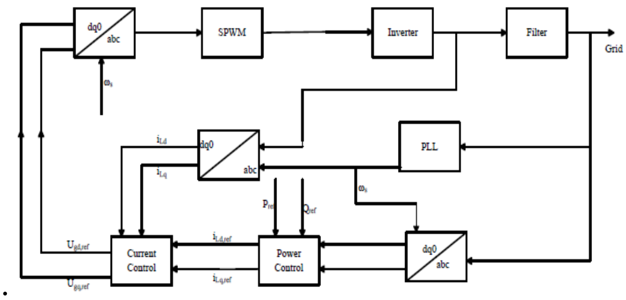


Fig. 6. PQ control theory

From the Fig.6, PQ controller furnishes the managing control of active power and reactive power. It uses a structure which contains the outer loop of power control and the interior ring of current control. PQ control is achieved in the synchronous rotation of d-q coordinate. The phase-locked loop (PLL) is responsible for tracking the grid frequency as the reference frequency of inverter. A timely tracking reference current produces the accurate reference voltage. Filter can filter out the higher harmonics to improve the quality of distributed power. (SPWM)Sinusoidal

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Pulse Width Modulation is obtained on the basis of the duty ratio of the PWM pulse width changes by sine law. Filtered sinusoidal output is achieved by the inverter.

## III. RESULTS AND DISCUSSION

Matlab/Simulink simulation verifies the performance of the proposed configuration. In Table I, System parameters are listed.

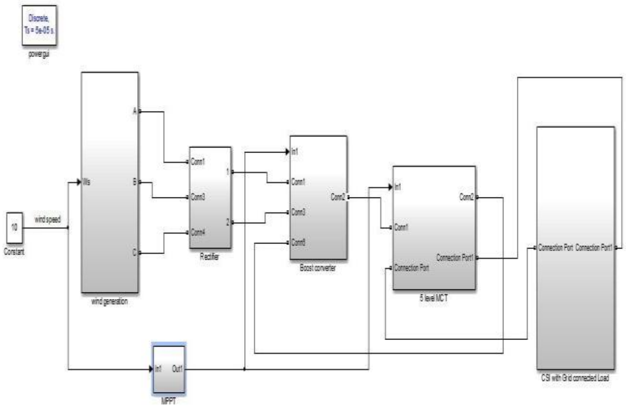


Fig. 7. Simulation model for PMGS system.

MATLAB simulink helps to simulate the Wind turbine and PMSG. Fig. 7 shows the simulation model of PMGS system. In wind generator sub system, three phase output is obtained from PMSG generator using the wind turbine as input. In rectifier subsystem, the three phase output from wind generator is given to bridge rectifier; here the three phase output is converted to DC output where the control parameter is only voltage parameter. After the DC output is given to converter the output voltage is boosted from low level to high level. Boosted output is given to 5 levels MFT circuit. So that the voltage level of individual transformer is reduced. The MFT output is rectified and it is given to the CSI inverter. In application side, ripple free current is considered as the vital part for synchronizing with the grid. So the CSI inverter is selected. Here, DC output is converted into AC output for synchronizing with grid source and the three phase load to recoup the grid active and reactive power by the generated source. In this way, the grid power compensation is successfully simulated.

Table I –System Paramters

| Parameters | Simulation | |
|---|---|---|
| | SI | pu |
| System Rating | | |
| Nominal power | 8.5KW | 1 |
| Grid voltage | 1250V | 1 |
| Frequency | 50Hz | 1 |
| PMSG | | |
| Nominal Voltage | 400V | |
| Synchronous inductance | 0.8mH | |
| stator resistance | 0.0425 ohm | |
| No. of pole pairs | 5 | |
| Generator side converter(MFT) | | |

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| | | |
|---|---|---|
| No. of modules | 5 | |
| turns ratio of transformer | 1/1 | |
| input Capacitance | 1000µF | |
| Grid side converter | | |
| DC link inductor $L_{dc}$ | 60mH | 0.6 |
| Grid side inductor | 0.5mH | 0.05 |
| Modulation scheme | SPWM | |

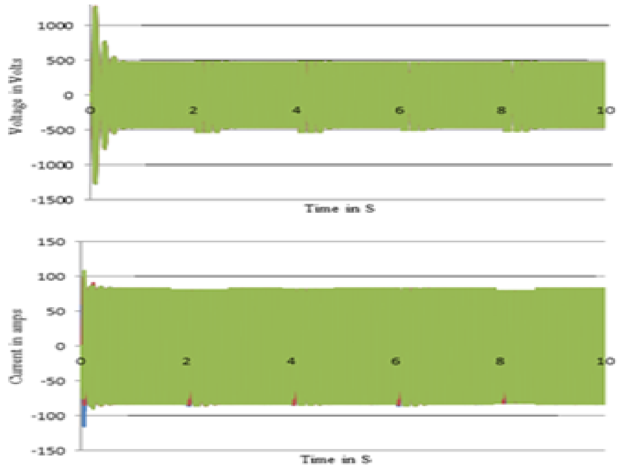


Fig. 8. Wind generator voltage and current

Fig.8 gives the detail about wind generator voltage and current. It generates 500V voltage and 80A current. This AC output is given to the rectifier circuit.

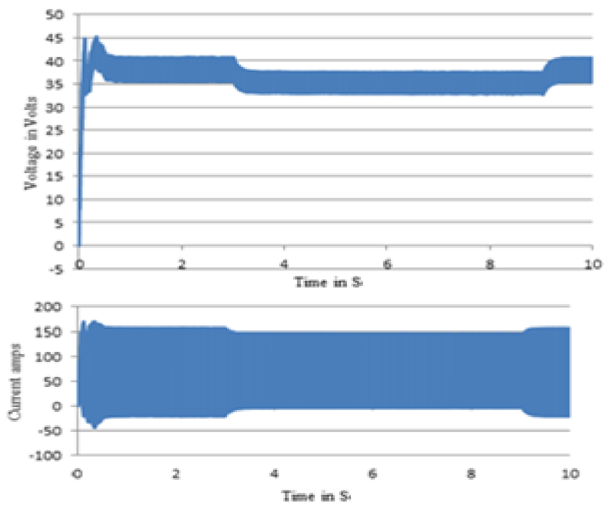


Fig. 9. Rectifier voltage & current

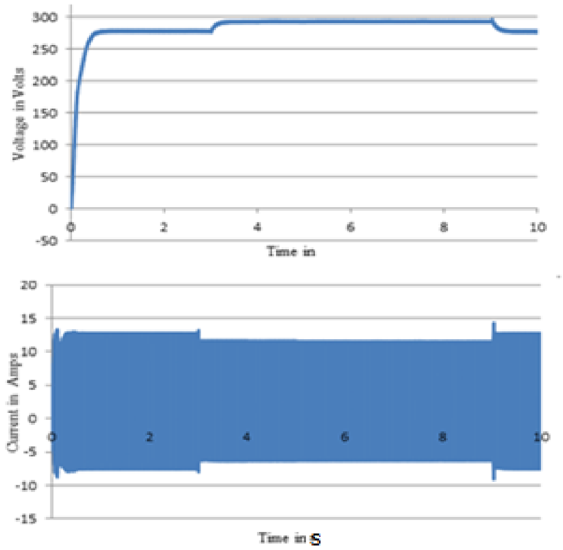


Figure.10. Boost converter voltage &current

Fig. 9 gives the output of rectifier voltage and current. In rectifier circuit, the output of wind generator is converted into DC output. Here 38V is obtained as constant DC voltage from rectifier circuit. This low level voltage (38V) is converted into high level voltage(300V) by the proposed system shown in Fig. 10.

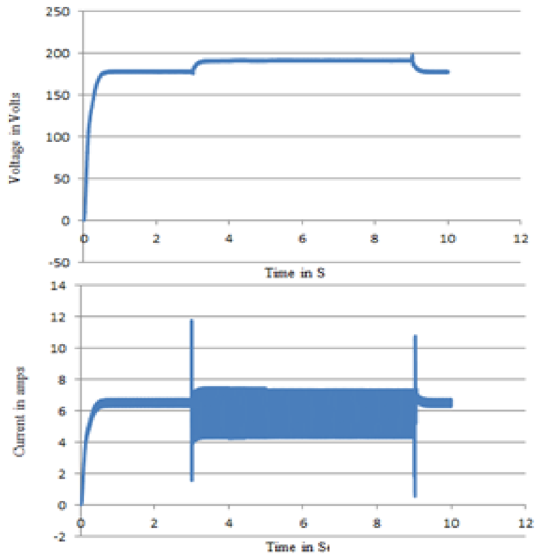


Fig. 11. MFT rectified voltage

In Fig. 11, total voltage is divided into 5 levels MFT circuit. Each individual transformer voltage is reduced to 220V.

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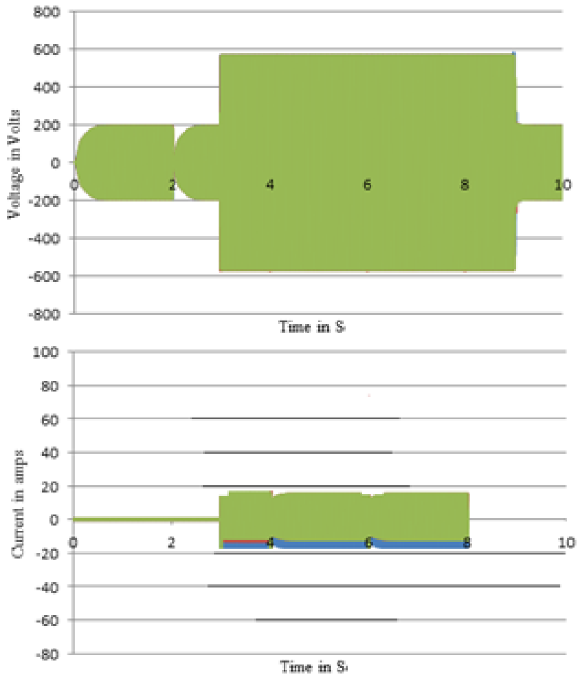


Fig. 12.CSI voltage & current.

In CSI inverter, DC output is converted into AC output to synchronize the grid, here the current plays a vital role to supply the grid in particular time interval of 3S to 9S shown in Fig. 12.

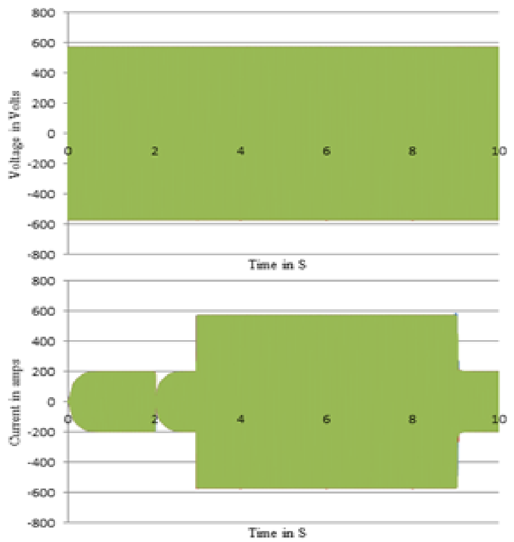


Figure13.Grid voltage and current

At that interval, the grid voltage and current is 440V and 30A as represented in Fig. 13. The Fig. 14 illustrates the grid active power and reactive power compensation at 3 S to 9 S intervals.

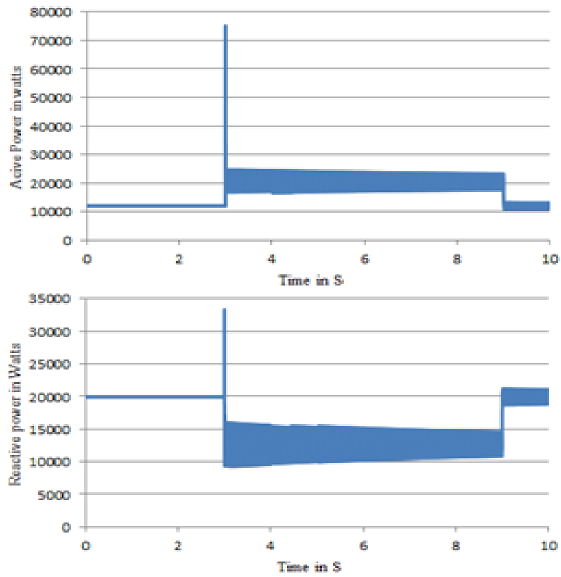


Fig14. Grid active and reactive power

## IV. CONCULSION

System proposition of MFT based WECS is presented for CSC positioned offshore wind farms. The recommended frame work comprises a medium voltage PMSG, a passive rectifier, a buck boost converter, a modular MFT based converter, and a CSI. It is particularized by no offshore substation, bulk power density due to the harmonization of a modular MFTs instead of a low frequency transformer, trust worthiness due to the implementation of a motile converter. Beyond from the conventional control objectives (MPPT, DC-link current and reactive power control) of a WECS, added attempt is forced to make sure an dispensed power and voltage sharing among the combining sections. The tendency of uncoupling between voltage/power balance control and the other control objectives is figured out well. Eventually, the performance of MFT-CSC system proves the converter performance in the wind energy conversion system effectively

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