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Modeling and Performance Analysis of a Solar-Wind Hybrid Power System

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Abstract: In this paper desining simulation and modelling of PV/windhybrid system is presented to meet grid characteristics. The system is designed using PV station and wind farm that are integrated with five- level CHB MLI. The CHB MLI converts the dc output of wind and solar system into AC which can easily integrated with the grid. The wind and solar system utilizes maximum power point algorithm to extract maximum power during variable environmental conditions. At solar side a DC-DC boost converter is also connected to regulate the solar DC output. A wind generator is designed using permanent magnet synchronous generator. The system has been tested for various operating conditions like variable wind speed and solar radiations and the at all variations the PCC voltage is always constant which is the design consideration of the proposed work. This shows the effectiveness of the designed hybrid system.

I. INTRODUCTION

The exhausting natural/conventionalsourceshas compelled for therenewable energy sources (RES)to exploit for generating energy.Among numerous RES like solar, geothermal, tidal, wind, etc., photovoltaic and wind are in great attention because they are abundantly available and is considered as the utmost promising power technologies for producing electricity. In this paper the above mentioned two resources are integrated to form a microgrid in a way to energies a remotely located area and also to feed power to the utility grid. Traditionally integrated non-conventional system of electricity generation obtained from different sources is collected at a common DC bus [1] [2] [3] [4], or are connected electrically through power converters to extract maximum energy. This section discusses about how technological advancement helps in harnessing the power of RR and the work which has been done in this field. Permanent magnet synchronous generator (PMSG) is considered as a decent alternative for the wind generator on account of its high control thickness and consequently little size, low upkeep, as proposed [4] for wind power generation frame work. The diode rectifier-based arrangement is straightforward and effortlessly controllable. They have utilized different sources additionally like energy units and water electrolyser, all associated with the DC connection of voltage source inverter (VSI). In addition, (MPPT) calculation for wind vitality requires position detecting of PMSG rotor. A basic bother and watch technique for MPPT for Wind Power generation System (WPGS) is depicted in [5]. Besides, some adjustment of the ordinary system is likewise proposed. This strategy is exceptionally basic and savvy as it doesn't require any mechanical sensor. A mechanical sensorless MPPT strategy is likewise depicted in [6]. In any case, that technique is tremendously confused and includes part of computations. Utilization of an enlistment generator as little hydro generator is portrayed in [7]. As proposed by Scherer et al. [8], the enlistment generator is a decent alternative for independent little power supplies on account of its minimal effort and high unwavering quality. Author have developed a non-straight model of smaller scale wind generation utilizing movable speed drive and the recurrence and voltage of the framework is likewise kept up utilizing senator on the turbine and a VSI, separately. Singh and Rajagopal [9] have proposed a diverse strategy for controlling recurrence of a little hydro age utilizing an incorporated load controller. In addition, an Adaline-based control calculation is proposed for voltage direction what's more, relieving power quality issues as a result of non-direct or unequal burdens. A four-leg voltage source converter (VSC) based voltage and recurrence controller is proposed in [10] for WPGS in a separated appropriation framework. An Efficient phase lock loop (EPLL) based control calculation is utilized for recurrence estimation and power quality change for a four-wire arrangement of burdens. The self-energized induction generator (SEIG) has a poor voltage recurrence. There are various controllers proposed in the literature. Distinctive kinds of load controllers for recurrence direction in a SEIG-based age framework are talked about in [11– 15]. In the event that there are non-straight loads, at that point the symphonious streams stream in the dispersion lines and in the generator windings. This builds the misfortunes and necessities the de-rating of the machine. These power quality issues can be relieved to build the framework effectiveness as examined in [16, 17]. Researchers have chipped away at a half and half framework control and activity. These are incorporated coordinating distinctive vitality sources to make a crossover microgrid to supply nearby loads. [18] have worked toward various leveled control of a microgrid having numerous sources. The sources they have considered are wind, smaller scale hydro, sun based PV, energy component and ultra-capacitor. They have either imitated or coordinated the accessible source and the total topology is executed. In the work proposed a hybrid PV/Wind generation system is designed to meet the grid requirement. The systems intermittency has been taken care by MPPT controller and DC-DC converters helps in maintaining the constant DC output. The CHB MLI converts the dc output of wind and solar system into AC which can easily integrated with the grid. A wind generator is designed using permanent magnet synchronous generator. The system has been tested for various operating conditions like variable wind speed and solar radiations and the at all variations the PCC voltage is constant due to the designed controller.

II. THE PV/WIND HYBRID POWER SYSTEM (PVW)

The system under study that isPVW hybridpower system is depicted in Fig. 1. The systemconsisting of PV station of 1.5MW rating and wind farm of 0.8 MW rating are designed together to constitute hybrid microgrid. The PV station andwind farm are integrated through main PCC to inject thegenerated power and enhance the system performance. The PV station is equipped with theDC-DC boost converter to regulate the output voltage, andaDC/AC converter is designed to generate synchronous AC power. The incremental conductance (IC) MPPT technique isimplemented in a way to extract the maximum power from PV system undervariable irradiance.

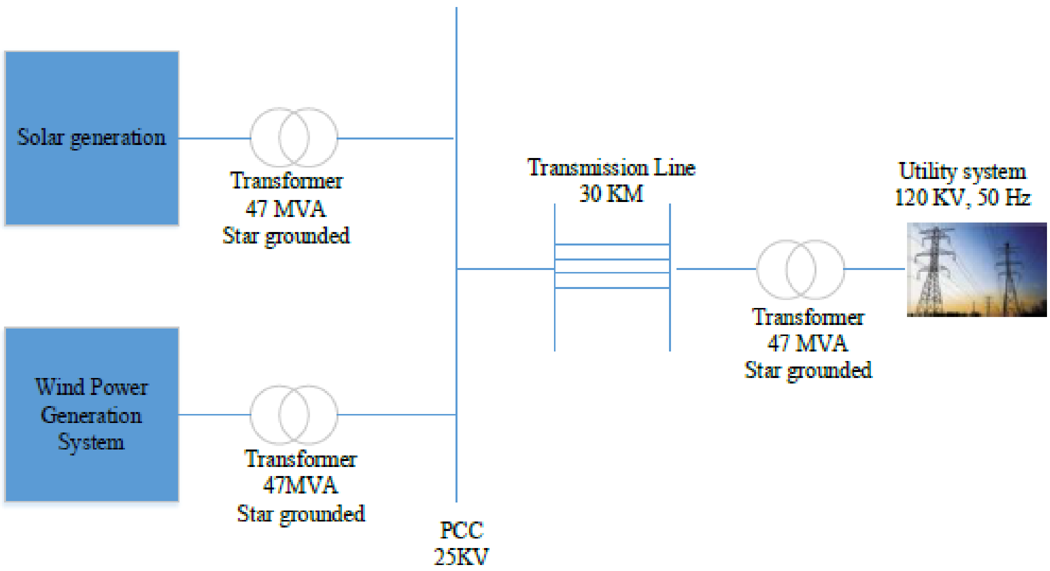

Fig 1: PVW integrated hybrid system

The modelled PV system is integrated with wind power generation system. PMSG is considered to design wind generation. The wind is equipped with rotor side converter (RSC) for maintaining the DC-busvoltage constant and also to generate synchronous AC output. Wind farm also employed with IC-MPPT technique.In addition,the wind farm is interconnected with the PCC-bus through 47 KV/25 KV ▲/Y transformer. The PVW system isso controlled so as to operate at unity power factor, and the injectedactive power is transmitted to the electrical grid through 30 Kmtransmission lines and 25 KV/120 KV Y/▲ transformer.

III. SIMULATION OF SOLAR SYSTEM

The PV system is designed using 50 series and 10 parallel modules. The PV and VI characteristics are presented n Figure 2. The variable solar irradiation is given in Fig.3 whose respective boost converter output is shown in Fig. 4. The output voltage and current of MLI inverter connected to PV system to convert DC-AC and synchronizing it is given in Fig.5. The design consideration in presented in Table 1.

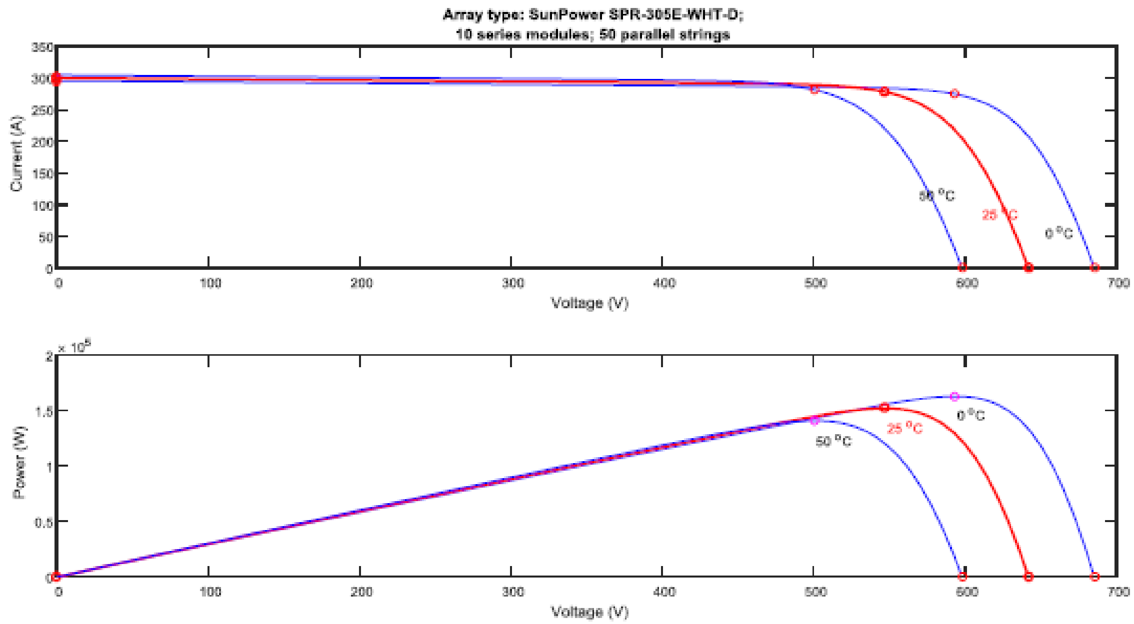

Fig 2:VI and PV characteristics of the designed system

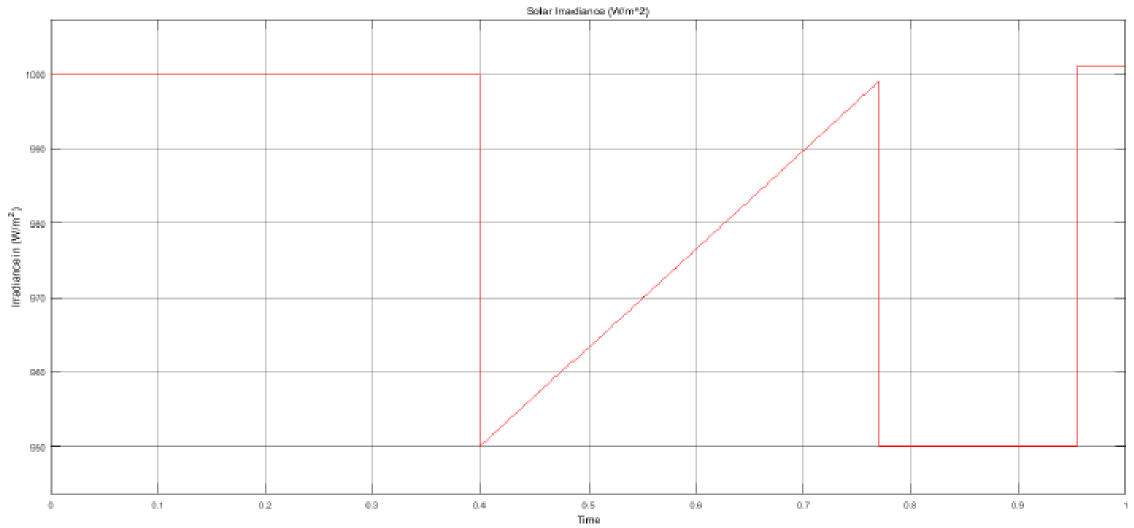

Fig 3:Variable solar irradiations.

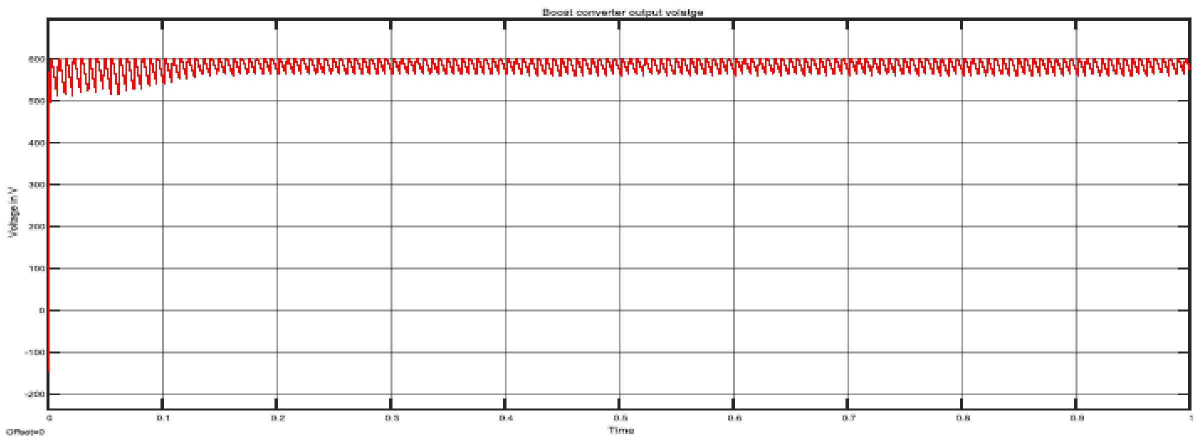

Fig 4: Boost converter output

Table-1 Design parameters

Parameter	Value
PV rating	1.5 MW
DC voltage output	600 V
switching frequency	5kHz
Boost converter inductor	150mH
Boost converter capacitor	100µF
Filter inductance	100mH
Filter resistance	0.01 ohm
Filter capacitance	1000 µF
Output voltage of DC/AC inverter	25KV
Output current of DC/AC inverter	600A
DC voltage of WPGS	90 V
AC voltage of WPGS	200V
Rating of WPGS	0.8 MW
Voltage at PCC	25KV

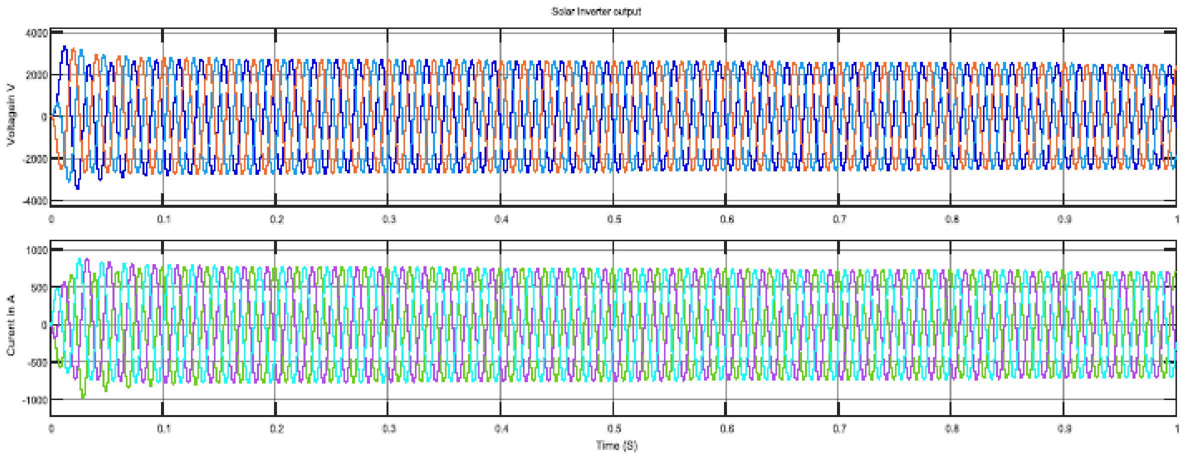

Fig. 5 Output voltage and current at Inverter side of PV system

IV. SIMULATION OF WIND SYSTEM

This paper presentssimulation model of PVW system with PMSG is considered to design the WPGS.The WPGS is equipped with rotor side converter (RSC) for maintaining the DC-busvoltage constant and also to generate synchronous AC output. Wind farm also employed with IC-MPPT technique to track maximum power at variable wind speed.In addition,the WPGS is interconnected with the PCC-bus through 47 KV/25 KV ▲/Y transformer. The PVW system is so controlled so as to operate at unity power factor, and the injectedactive power is transmitted to the electrical grid through 30 Kmtransmission lines and 25 KV/120 KV Y/▲ transformer with neutral grounded. The variable wind speed graph is given in fig.6. the respective DC output of the WPGS is given in Fig.7 and the RSC output designed using 5-level CHB-MLI is given in Fig 8.

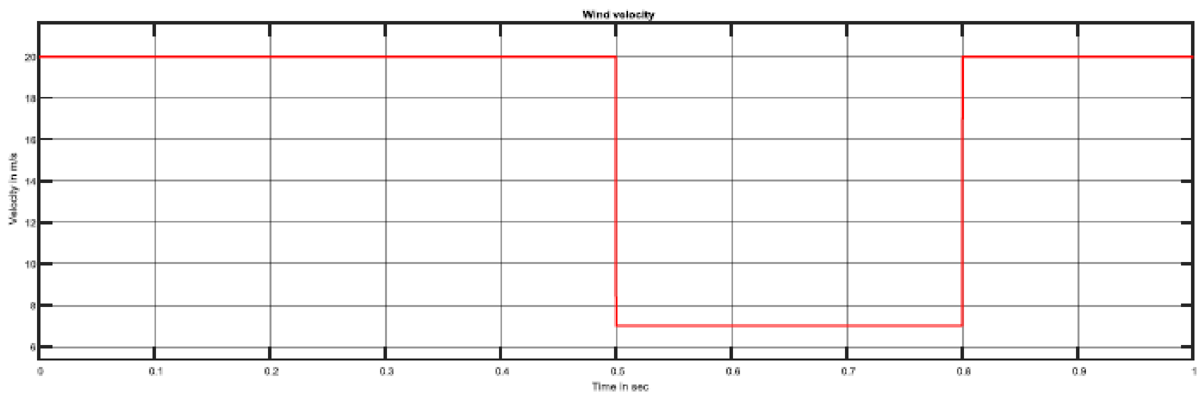

Fig 6: Variable wind speed.

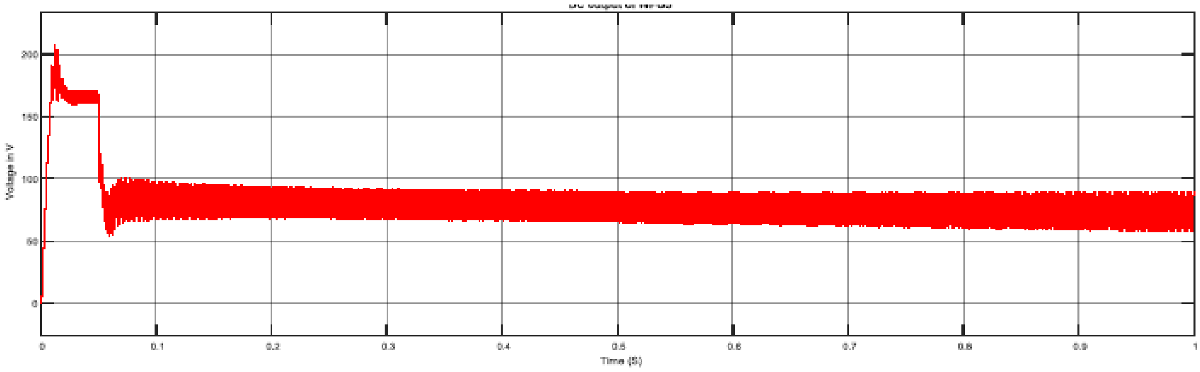

Fig 7: DC output of WPGS

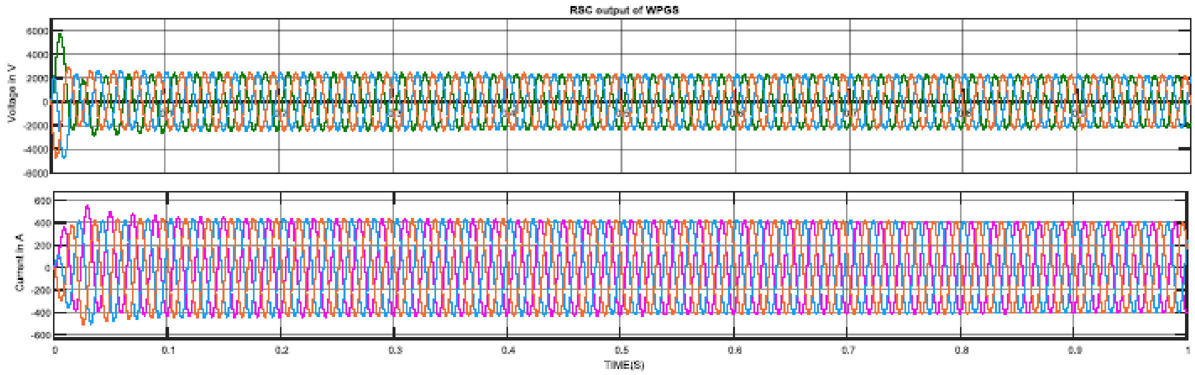

Fig 8: Simulation output of WPGS converter side.

V. RESULT ANALYSIS

In this section performance analysis of the proposed work has been presented. In the previous section result analysis of PVW system has been presented. It is observed that both PV system and WPGS give constant output both DC side and AC side at all wind speed and variable solar irradiation. This is the most important task when designing a PVW system since they are intermittent in nature and there output vary at variable environmental conditions. Another aspect of PVW system is that they must exhibit constant and synchronous characteristics with respect to utility system at PCC. The fig. 9 shows the voltage and current profile of the proposed PVW system at PCC. Fig. 10 presents the active power flow at PCC and fig. 11shows the power factor at PCC.

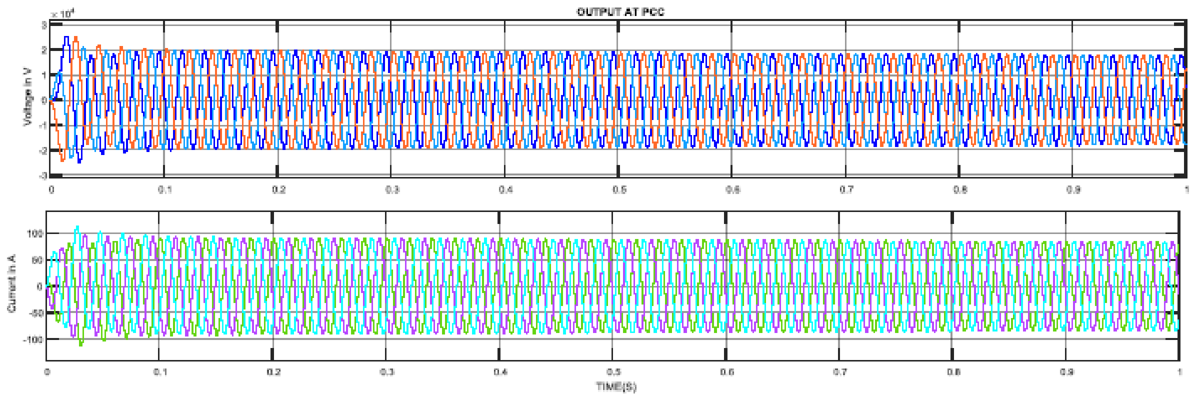

Fig. 9 Output voltage and current at PCC.

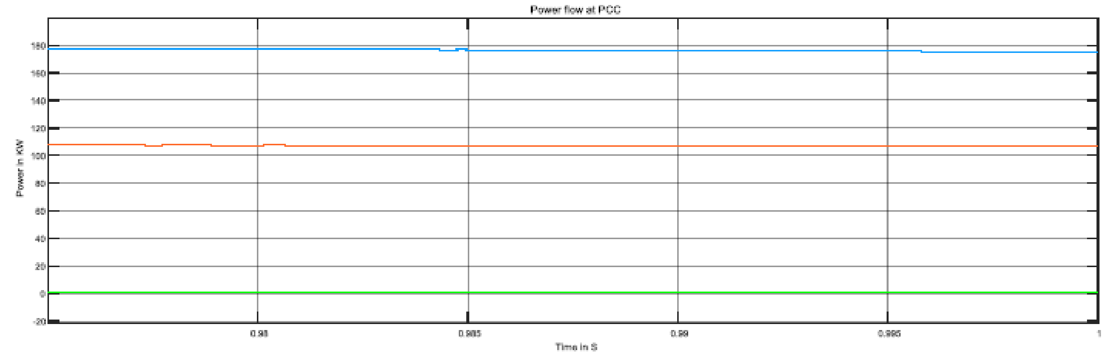

Fig. 10 Active power flow at PCC

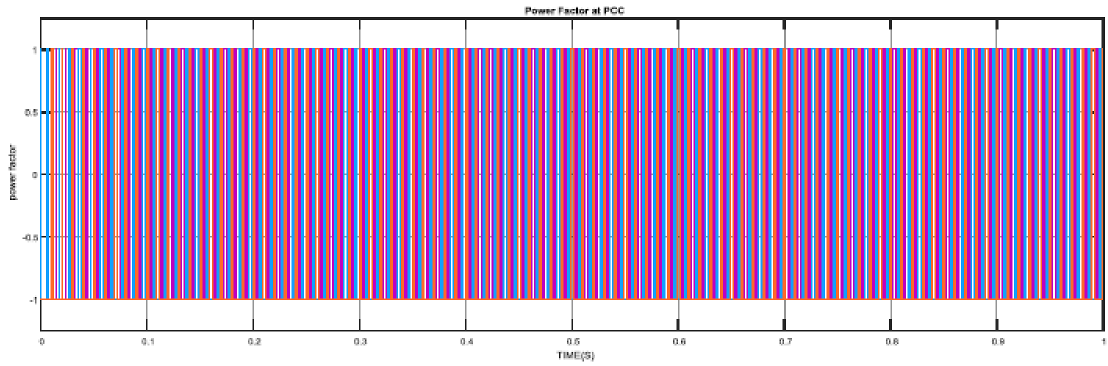

Fig. 11 Power factor at PCC.

VI. CONCLUSION

In this paper a control strategy has been presented for integrating PV-wind hybrid system. The simulation model in MATLAB 2016 for integrating PVW at PCC is developed. The system has been analysed dynamically for variable atmospheric conditions. At all dynamic operation of variable wind speed and sun irradiations, the system designed is stay constant. The DC as well as AC coupling of PVW is stable and synchronous at PCC. The system also operate at unity power factor. The hybrid powersystem consists of PV station of 1.5 MW rating and a WPGS of 0.8 MW rating that are integrated through PCC toinject the generated power and enhance the systemperformance. The incremental conductance MPPT technique isapplied for the PVW system to extract the maximum powerduring variation of the solar irradiance and wind speed.

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