ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1041

Hybrid Solar PV and WECS Power Quality Improvement by STATCOM

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Abstract:- The increasing integration of off-grid energy sources in the utility load has ended up resulting in elevated standards regarding power quality, voltage stabilisation purposes, and efficient energy use. The electrical network Wind and solar energy have been considered to be among the most reliable renewable energy sources. However, the self-sufficient operation of either photovoltaic or wind energy systems does not offer a highly consistent source of electricity production owing to the unpredictability of the wind and solar irradiance availability. As a result of this, a variety of solar and wind power generation systems have the ability to produce a very reliable and promising electrical supply. In the present study, a hybrid wind and photovoltaic panels system model has been provided. This specific type of technology possesses plenty of possibilities for its users from afar. This particular kind of technology is highly beneficial in inaccessible or offshore locations where integrating with the grid is not very cost-effective. Nevertheless, integrating power electronics to dissipated generation (DG) systems brings substantial issues with power quality, which include reactive power adjustment and harmonic development, which throws off the system for power distribution. The present study proposes a simulation framework for a hybrid wind-photovoltaic generation system. The system's efficiency in grid-connected mode is assessed. Calculations of total harmonic distortion (THD) at various speeds of wind were used for assessing the wind-SPV hybrid system's power quality. This hybrid system's power quality has been enhanced owing to its employing of STATCOM

***Keywords:-** Total Harmonics Distortion (THD), STATCOM, Hybrid System, Dissipated Generation (DG), Solar Photo Voltaic (SPV).*

I. INTRODUCTION

Particularly in light of the current upsurge in worries concerning the ecological problems caused by fossil fuels can the adoption of renewable energy sources for the production of electricity be an acceptable substitute to fossil fuels. Two ubiquitous sources for green energy are airflow and the sun. These are believed to constitute the two most important renewable energy sources. On the contrary, the primary disadvantage of the sun and airflow is the failure to deliver uninterrupted air flow or consistent radiation exposure, respectively. Therefore, it cannot be functioned on its own energy when an ongoing supply of electricity is needed to function. Coupling multiple energy sources with devices for storing energy is a recent breakthrough in renewable energy technology. Two prospective blends are solar photovoltaic and stand-alone wind. This wind-SPV hybrid generation (WSPVHG) technology with integration into the grid incorporates the positive aspects of wind and solar power systems, rendering it a possibly viable means for producing electricity [2]. Costs of electricity are capable of being minimised employing a hybrid system. While upholding an exceptionally high level of power production. Furthermore to all of its advantages, the hybrid system has downsides as well, notably as concerns with the synchronisation, protection, and power quality, but this latter issue is the only one to be addressed here [1]. Electricity factor, harmonics, and voltage sag may all be employed to gauge the quality of the electricity. In the present research, the power quality generated by the hybrid wind-photovoltaic system is assessed using harmonic simulation [9].The work extends with portions on D-STATCOM modelling and part II representations regarding the hybrid system.

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II. HYBRID RENEWABLE ENERGY SYSTEM MODEL

A system based on hybrid renewable energy is one which happens the ability to obtain power through two or more distinct sources for the purpose to fulfil the electrical load. A grid-integrated wind-photovoltaic hybrid generating system might represent an effective means of producing power due to the fact that it leverages the positive aspects of both wind as well as solar power [3]. As a way to cope with escalating demand, this combination is going to provide an ideal alternative across independent and grid-connected configurations. Additionally to conserving costs are incurred, the grid-connected approach boosts overall system reliability as well as effectiveness. The hybrid wind-photovoltaic system feeds the grid adequate sustainable energy which it uses to supply electricity to attributed loads on both warm and overcast days. The primary contributor advantages associated with HRES are outlined below: decreased peak load, lower transmission line losses, disconnected supply, and an all over sustainable power system. [10]

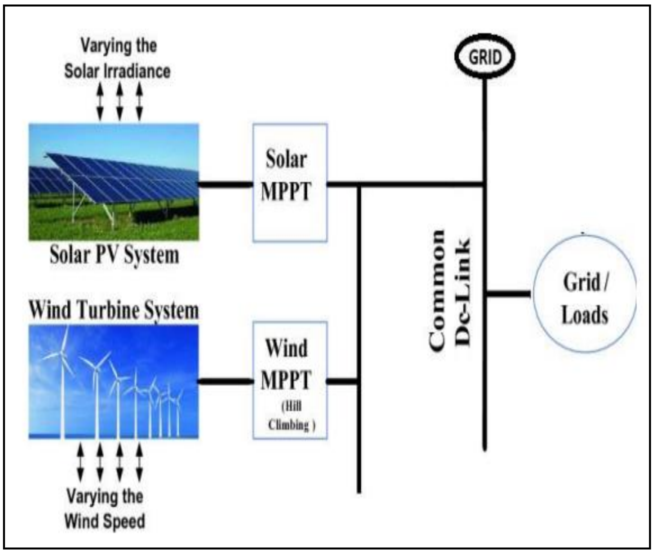

Fig 1 System Model Integrated with PV& WECS

➢ *Modelling of Wind Energy System*

The total quantity of power produced by a wind turbine generator is:

$$P_i \quad 0.5 * \dot{\rho} * C_p * A_s * V^3$$

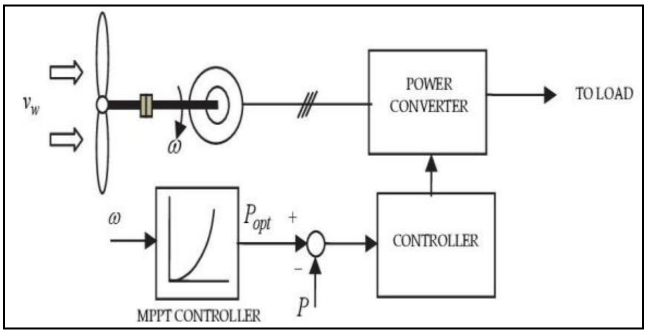

Fig 2 Modelling of WECS with MPPT

Where as is the area in square metres that the wind sweeps, V is the wind speed in metres per second, P_i is the power produced by wind turbine generators, and Cp is the coefficient of performance. The tip speed ratio, or the relationship between tip speed and wind speed, determines the coefficient of performance [4]

➢ *Modelling of PV System*

A solar photovoltaic (SPV) cell is the key element of a PV array. The SPV cells are coupled in series to produce an SPV module, and multiple SPV modules are put together to create an SPV array [1]. Fig. 1 demonstrates the approximate circuit for an SPV cell. The mathematical formula for simulating an ideal SPV cell is as follows:

$$I = I_{PV} - I_{0}\,(e^{qv/Akt} - 1) \qquad (1)$$

$$V = V_d - IR_S \qquad (2)$$

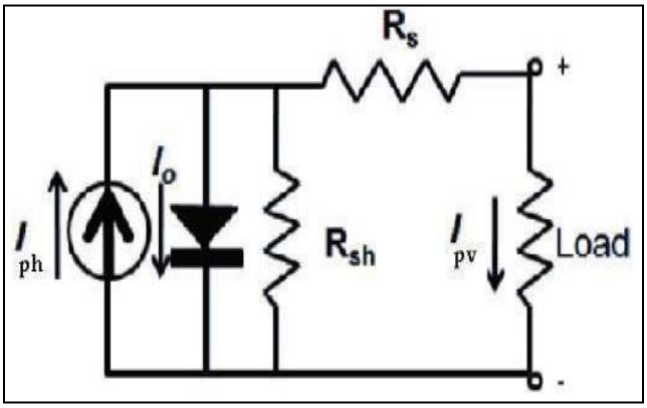

Fig 3 Equivalent Circuit of PV cell

Where I_o is the diode leakage current, q is the charge liberated by the electron, k is the solar irradiance current, and I_P V is the current produced by the sun. Being the Boltzmann constant, where T is the P-N junction temperature (in °K), V_d is the voltage across the diode, and an is the ideality factor of the diode. Fig. 3 displays a Simulink model of a PV cell generated via the previously mentioned equations.

➢ *STATCOM Modelling*

Considering practically all loads demand reactive power and electrical power systems usually have to cope with AC figures, reactive power correction represents one of the foremost issues with the quality of power [7]. To provide the correct voltage assistance to support variations in voltage in WECS, the flow of reactive power needs to be regulated [5]. During the voltage drop, the STATCOM is more capable to supply more capacitive reactive power. At the output terminals, a power electronics device commonly referred to as a STATCOM has the potential of either generating or absorbing reactive power. It is additionally capable of handling physical electricity when connected to a battery storage device [12].Unlike SVCs, low value inductive and capacitive components are sufficient for transmission lines for obtaining reactive power assistance

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[8]. The small form factor of the STATCOM, which lowers installation requirements for space, and its enhanced reactive power yield at low voltages are the primary benefits. Additionally, STATCOM imparts more effective damping properties from the dynamic stability standpoint [6]. In this study, the quality provided by the hybrid micro-power grid has been strengthened using the utilisation of STATCOM. Using a D-STATCOM positioned at the point of common coupling (PCC) may assist mitigate concerns about power quality pertaining to both voltage and current. For the purpose to balance and generate pure sinusoidal source currents, D-STATCOM injects the reactive and harmonic elements that make up the load current when using the current control mode. As a means to help protect the critical loads from noteworthy voltage disturbances, the PCC voltage was regulated in voltage control mode in accordance with a reference value [9].

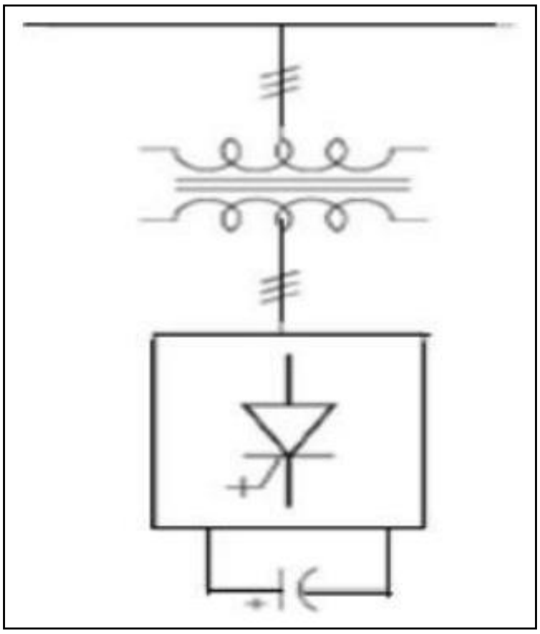

Fig 4 STATCOM Modelling

III. SIMULATION AND RESULTS

➤ *Simulation without Controller*

Fig. 5 illustrates an outline for the developed hybrid generation system with a distributed inverter setup. In the envisioned structure, the wind and SPV systems are connected in parallel at the inverter output sides and have been simulated as two distinct generating systems with independent dc-ac inverters [11].

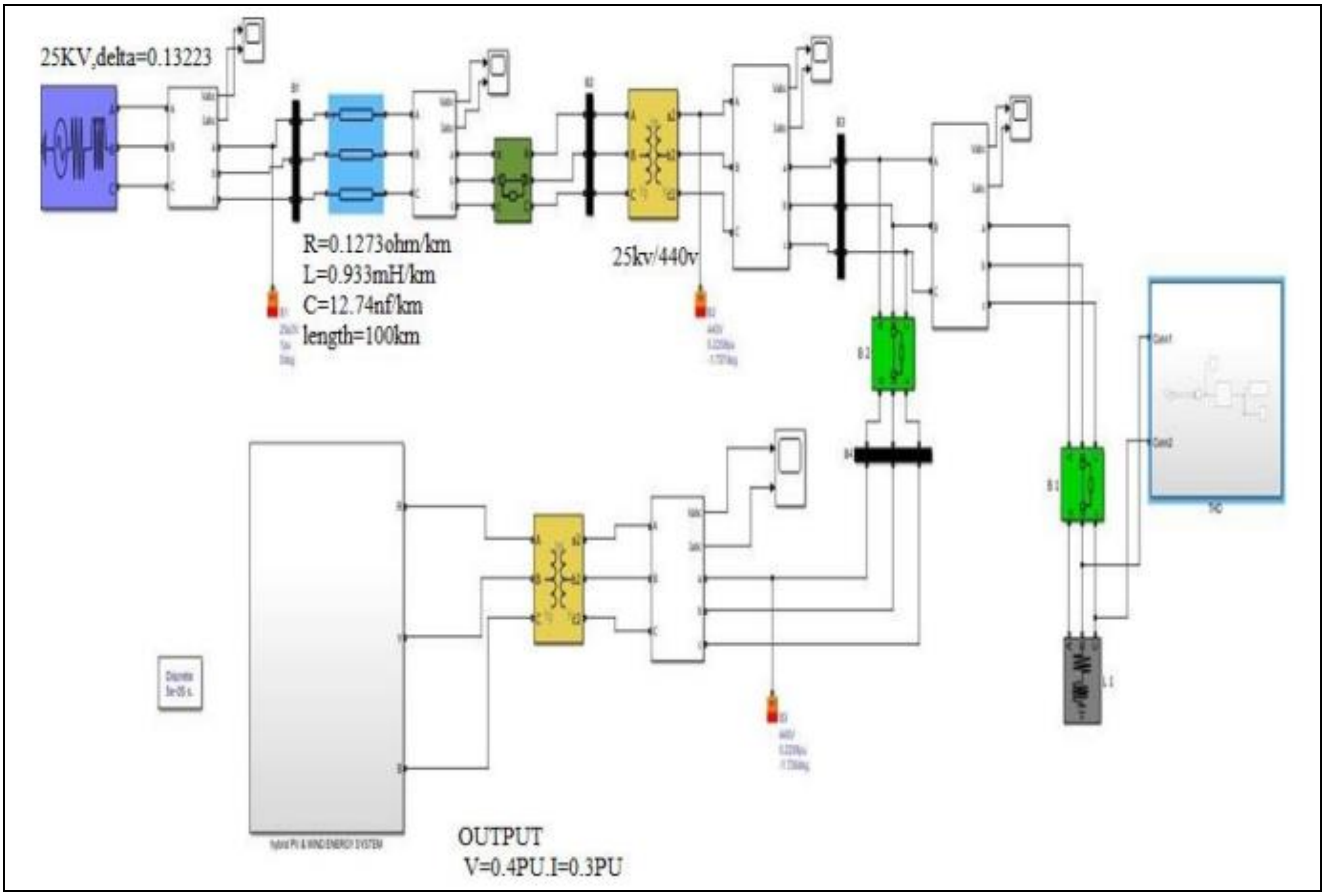

Fig 5 Matlab Simulation Model for Hybrid System Without Controller

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➢ *Results without Controller*

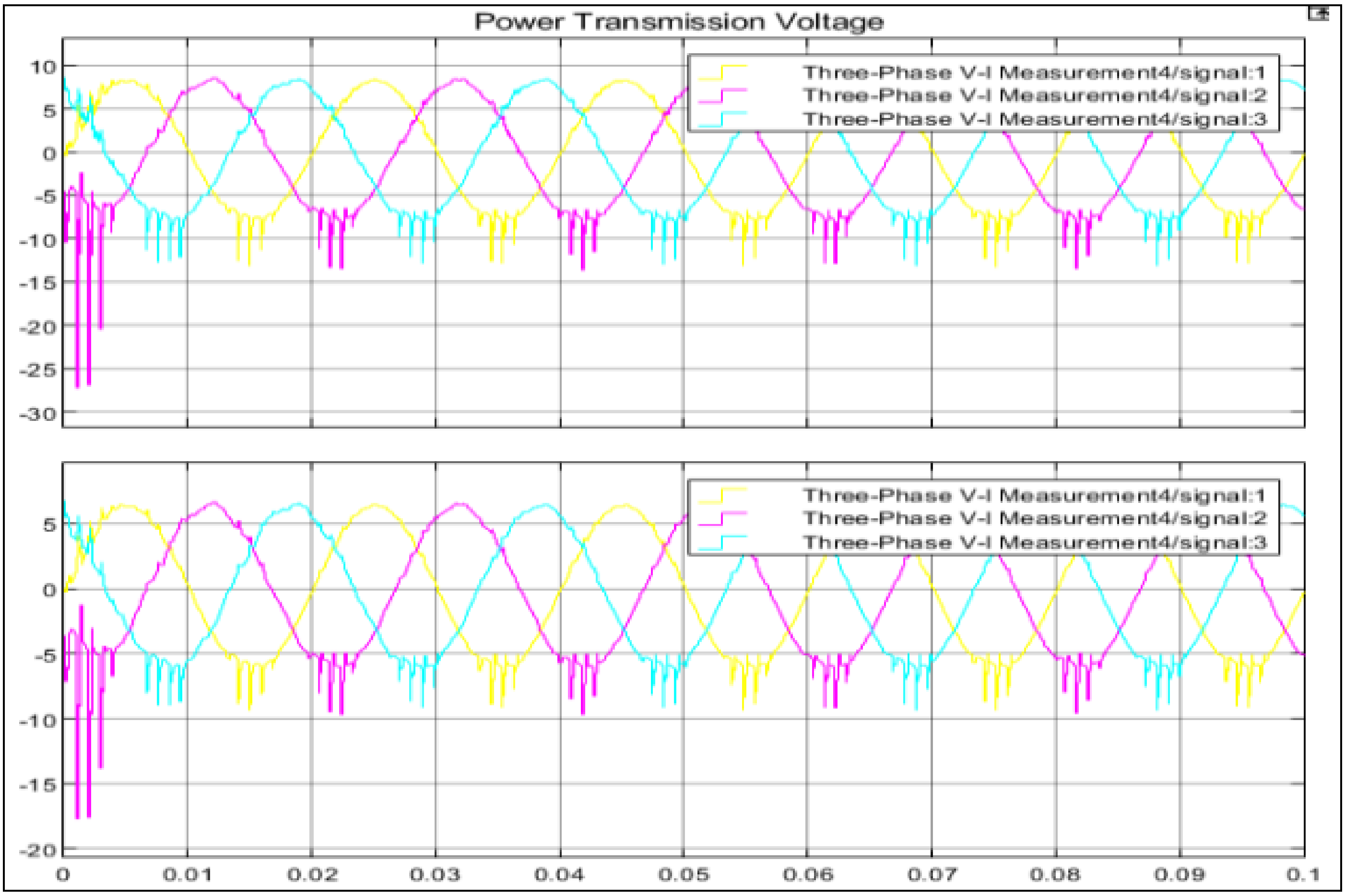

Fig 6 Hybrid Power System Output Voltage and Current

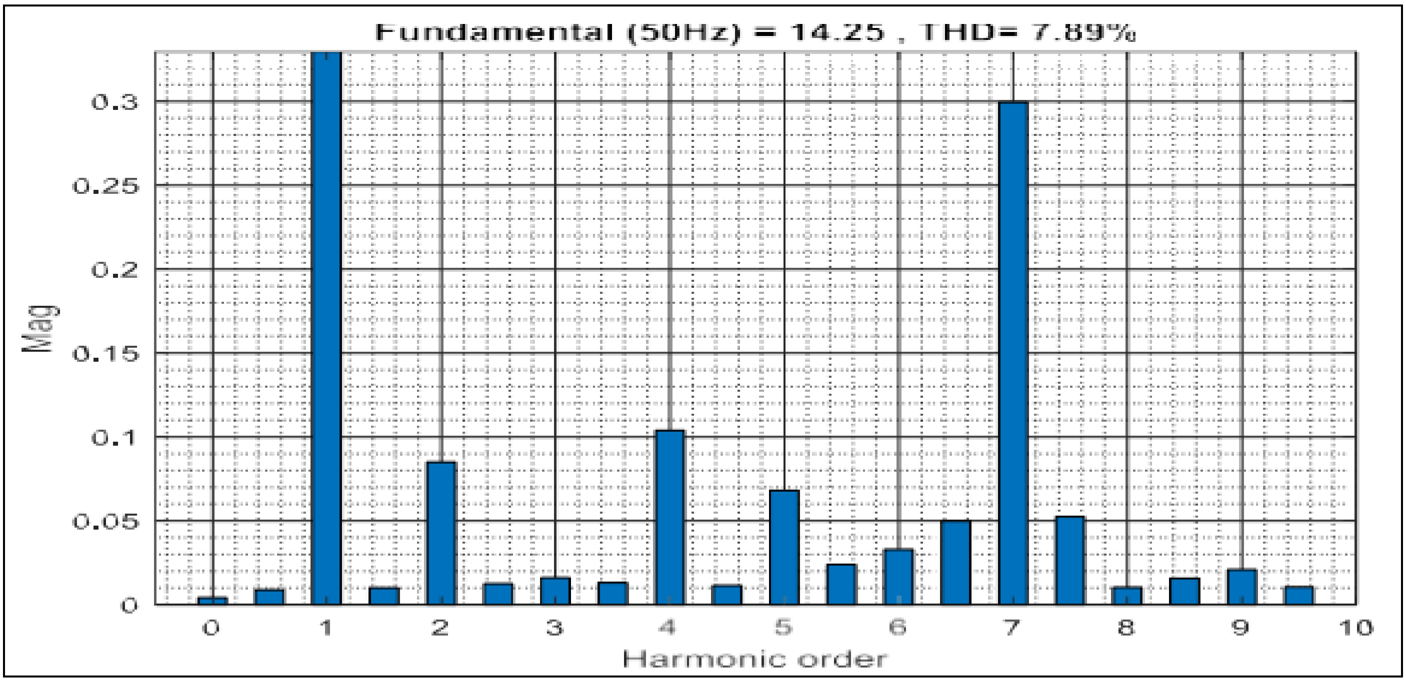

Fig 7 THD Graph for Hybrid System Line to Line Voltage

➢ *Simulation with Controller*

STATCOM has a connection at the shared coupling point. The proposed shunt controller has been designed to either provide or absorb the reactive power for the purpose to help maintain the voltage stability of the entire system

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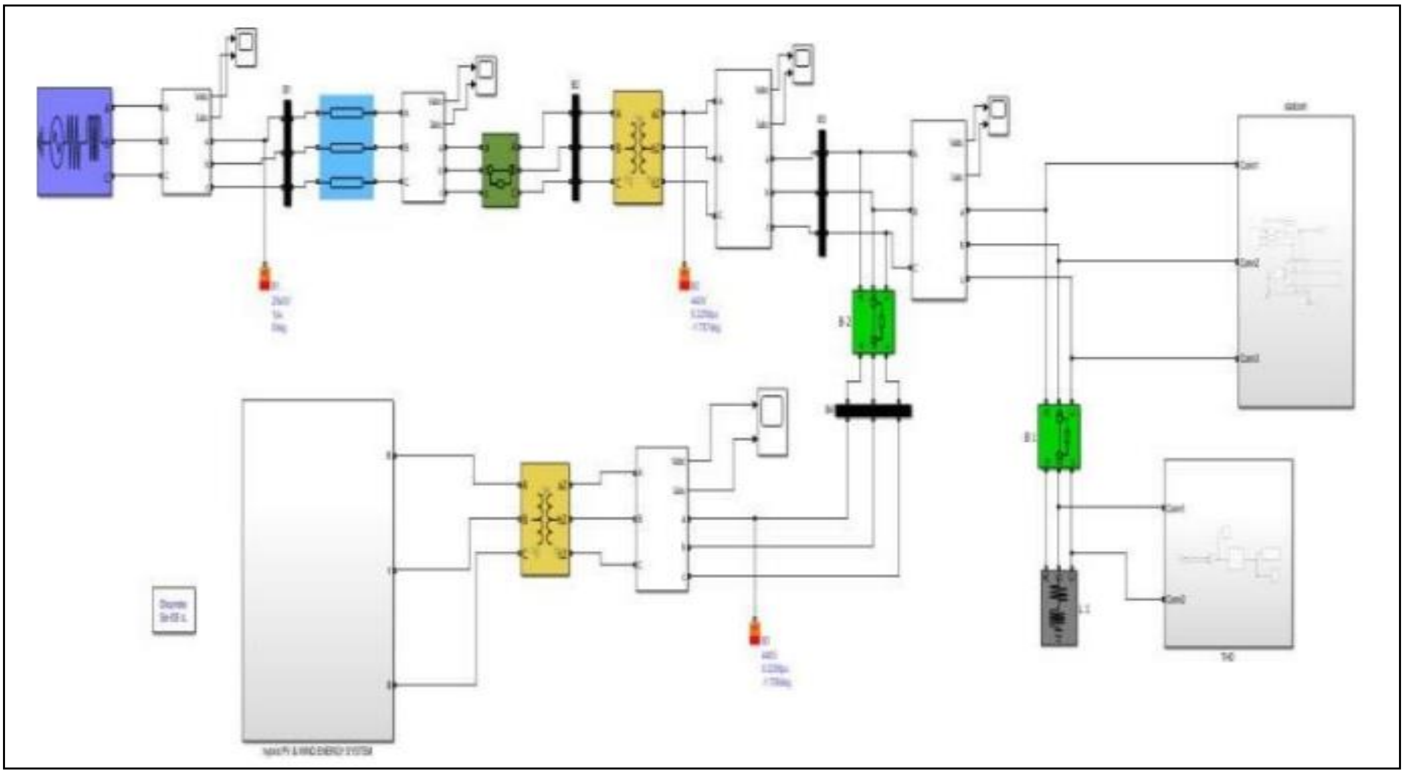

Fig 7 Simulation Model for Hybrid System with STATCOM Controller

- *Results with Controller*

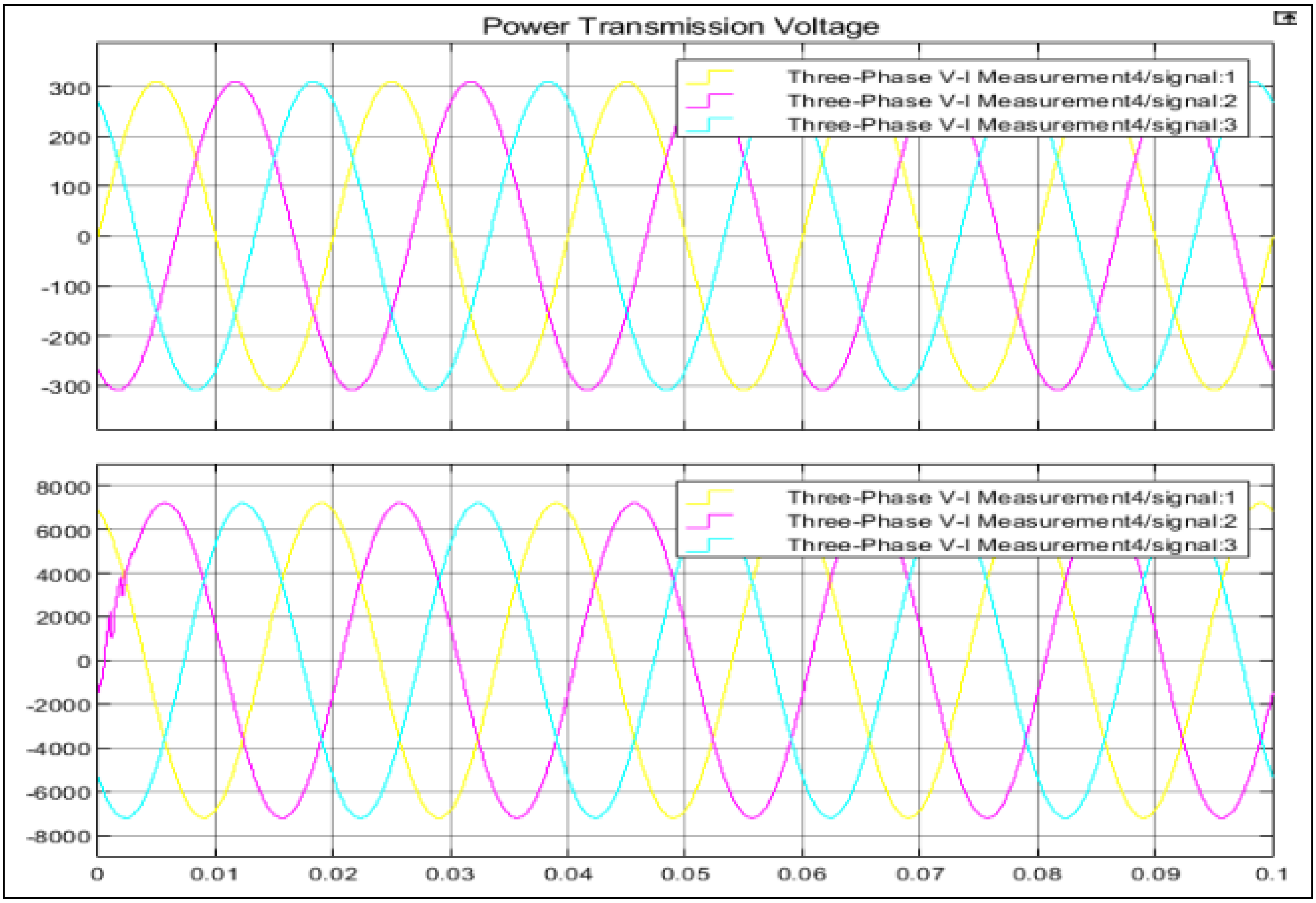

Fig 8 Output Voltage and Current of Hybrid System with STATCOM Controller

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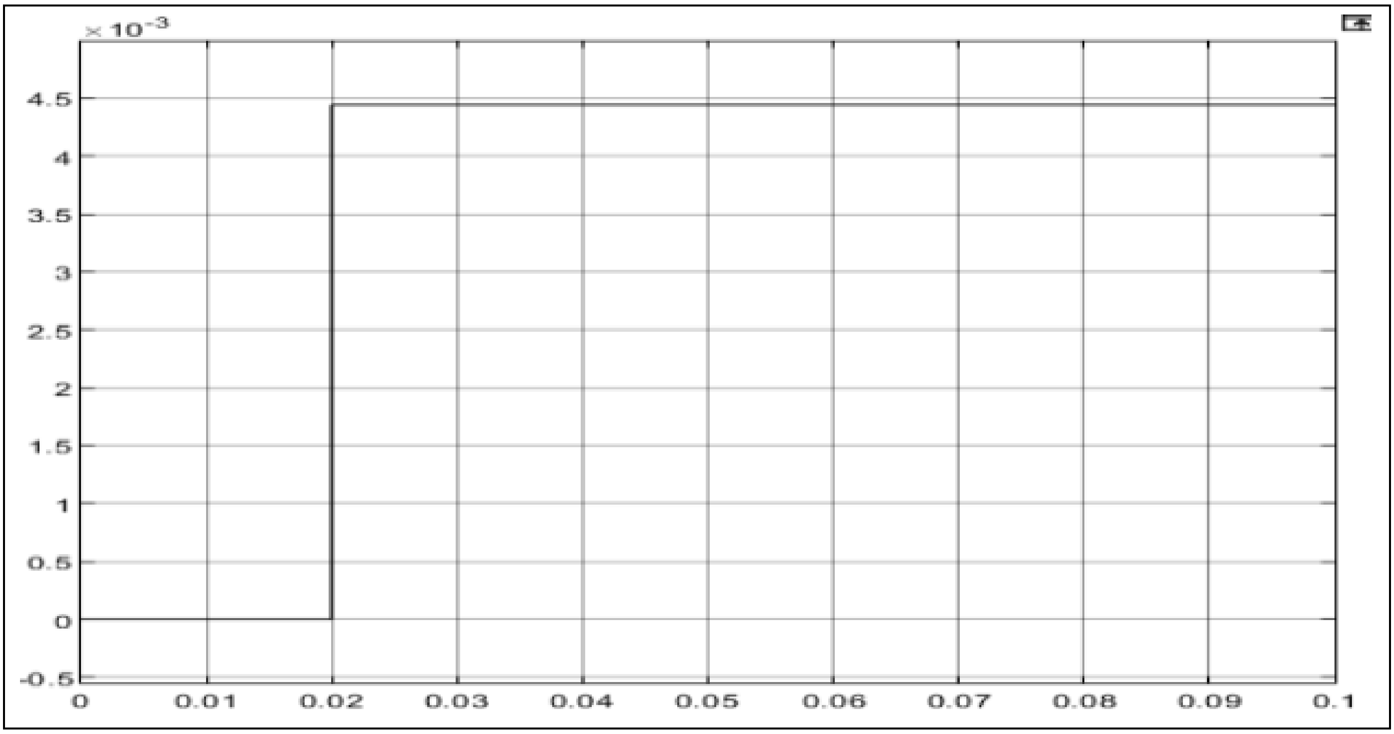

Fig 9 Harmonic Order with Controller

IV. CONCLUSION

Optimising the power quality of the proposed hybrid PV-wind system was the primary objective of this endeavouring. The streamlined THD obtained by the method of FFT analysis in the presence of STATCOM is shown in Figure 7. The simulation model for a hybrid power system incorporates the STATCOM. This finding suggests that the result has a lower than 7% of total Harmonic Distortion (THD). This demonstrate the fact that the envisioned hybrid wind photovoltaic Generation model accomplishes the envisioned outcome satisfactorily 0.4%

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