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STATCOM based Power Quality Improvement in Hybrid Power System

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ABSTRACT—The utility load now faces new demands in relation to power quality, voltage stabilization, and effective energy use as a result of the increased use of distributed energy sources in the electricity system. The sources of renewable energy that are regarded as being the most reliable are wind and solar. Due to the unpredictability of the wind and solar irradiance availability, however, the solitary operation of either photovoltaic or wind energy systems does not offer a highly stable source of electricity production. As a result, a variety of wind and solar power generation systems can create a very promising and dependable supply of electricity. A hybrid wind and photovoltaic system model has been presented in this paper. The distant users of this type of technology can benefit much from it.

In remote or island locations where grid integration is not very cost-effective, this kind of technology is quite helpful and advantageous. But connecting power electronics to DG systems results in very serious power quality issues, like harmonic production and reactive power adjustment, which disrupt the power distribution system. In this paper hybrid wind-PV generation system simulation model is given. Analysis is done on the system's performance in grid connected mode. Total harmonic distortion (THD) calculations at various wind speeds were used to assess the power quality of the wind-SPV hybrid system. Utilizing STATCOM has enhanced the power quality of this hybrid system.

Keywords—Total Harmonics Distortion(THD), STATCOM, Hybrid system, Distributed Generation(DG),Solar Photo Voltaic(SPV).

I. INTRODUCTION

The use of sustainable energy sources for the production of electricity can only be a feasible alternative to fossil fuels in light of the recent rising worries over environmental problems brought on by fossil fuels. Air flow and sunlight are two abundant sources of renewable energy. These two are regarded as the leading renewable energy sources. On the other hand, the main drawback of sunlight and air movement is that they cannot supply constant irradiation or constant speed air movement, respectively. Therefore, it cannot be used independently when a constant supply of electricity is needed. A new development in renewable energy technology is the blending of various energy sources with energy storage devices. Stand-alone wind and Solar Photovoltaic are two possible hybrid pairings.Since it makes use of the advantages of both solar and wind energy systems, the wind-SPV hybrid generation (WSPVHG) system with grid integration may be a viable option for producing electricity[2]. A hybrid system can lower the cost of electricity while still delivering high-quality power. Along with all of its advantages, the hybrid system also has some drawbacks, such as protection, synchronization, and power quality issues, but we will only focus on the latter here [1]. Voltage sag, harmonics, and power factor can all be used to assess the quality of power. In this study, we compute harmonics to evaluate the hybrid wind-PV system's power quality [9].This essay follows with descriptions of the hybrid system in part II and D-STATCOM modeling in section

II. HYBRID RENEWABLE ENERGY SYSTEM MODEL

A hybrid renewable energy system is one in which the system's electrical load must be supplied by two or more different power producing sources. Given that it makes use of the advantages of both solar and wind energy systems, a wind-PV hybrid generating system with grid integration could be a viable option for producing electricity [3]. This combination will provide the finest solution in standalone as well as grid connected mode to satisfy the growth in load demand. The grid-connected mode increases overall system efficiency and reliability while lowering costs. During

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both sunny and overcast days, the grid draws sustainable energy from the hybrid wind-PV system and delivers it to the connected loads. The following are the main benefits of HRES: reduction in peak load, decrease in transmission line losses, supply in remote places, and overall a reliable power system [10]

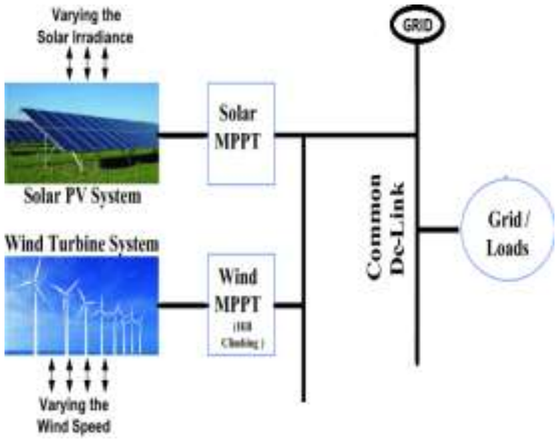

Figure.1 system model integrated with PV& WECS

a) Modeling of wind energy system

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

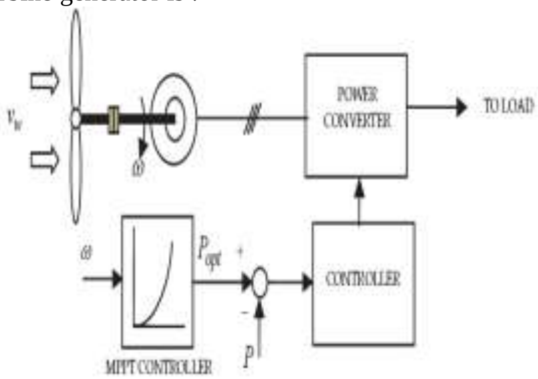

Figure 2.modelling of WECS with MPPT

$$P_i = 0.5 * \rho * C_p * A_s * V^3$$

Where P_i is the power generated by WTG, ρ is the air density, A_s is the area in sq.mt swept by the wind, V is the wind speed in m/s and C_p is the coefficient of performance. The coefficient of performance depends upon the ratio of tip speed to wind speed also known as tip speed ratio [4].

b) Modeling of PV system

The basic part of a PV array is a solar photovoltaic (SPV) cell. A SPV module is created by connecting the SPV cells in series, and an SPV array is created by combining multiple SPV modules [1]. A SPV cell's approximate circuit is depicted in Fig. 1. The following is the mathematical formula used to simulate an ideal SPV cell:

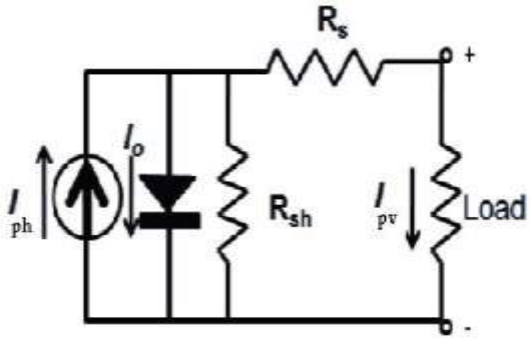

Fig.3 Equivalent Circuit of PV cell

$$I = I_{pv} - I_0 (e^{\frac{qv}{akT}} - 1)$$

$$V = V_d - IR_s$$

Where, I_{PV} is the current produced by solar irradiance, I_0 is the diode leakage current , q is the charge released by electron, k being Boltzmann constant, T is temperature (in ^oK) at P-N junction V_d is the voltage across diode and **a** is the diode ideality factor. A Simulink of a PV cell model made from above equations is shown inFig-3

c)Statcom modelling

Reactive power correction is one of the key issues with power quality because electrical power systems primarily deal with AC quantities and practically all loads require reactive power [7]. The reactive power flow needs to be managed in order to provide the appropriate voltage support for the voltage variation in WECS [5].The STATCOM has a higher advantage to deliver more capacitive reactive power during the voltage fall. A power electronics device known as a STATCOM has the ability to produce or absorb reactive power at its output terminals. If coupled to a battery storage device, it can manage real power as well [12]. For transmission lines to receive reactive power assistance, unlike SVCs, low value inductive and capacitive components are sufficient [8]. The STATCOM's key benefits are its small size, which requires less space for installation, and its better reactive power yield at low voltages. Additionally, from the perspective of dynamic stability, STATCOM imparts stronger damping properties [6].

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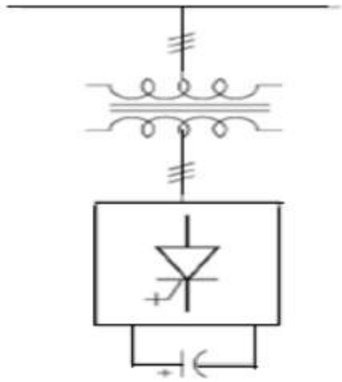

Figure.4. Statcom modelling

In this research, STATCOM has been used to improve the hybrid micro-power grid's quality. Power quality problems linked to both voltage and current can be reduced by using a D-STATCOM connected at the point of common coupling (PCC). When used in current control mode, D-STATCOM injects the harmonic and reactive components of the load current to balance and make the source currents pure sinusoidal. When used in voltage control mode, the PCC voltage was adjusted with regard to a reference value to protect the critical loads from severe voltage disturbances [9].

III. SIMULATION AND RESULTS

A) simulation without controller

The suggested hybrid generation system with a scattered inverter setup is seen in outline in Fig. 5. Both the wind and SPV systems have been represented as two independent generation systems equipped with distinct dc-ac inverters and are coupled in parallel at the inverter output sides in the proposed structure [11].

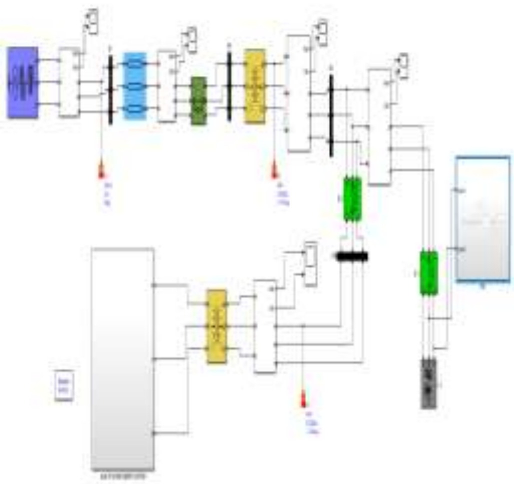

Figure 5. matlab simulation model for hybrid system without controller

B) Results without controller

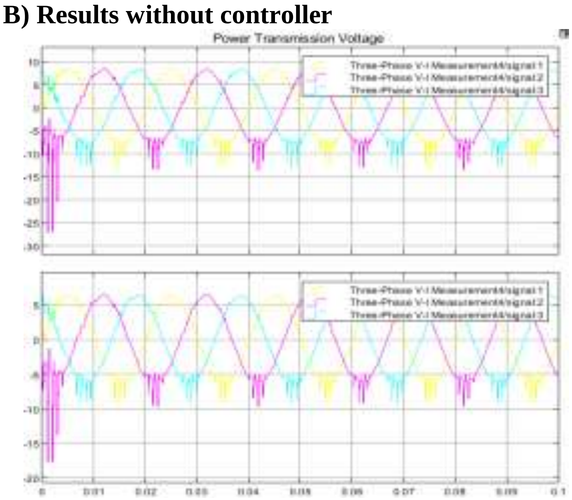

Figure 6.hybrid power system output voltage and current

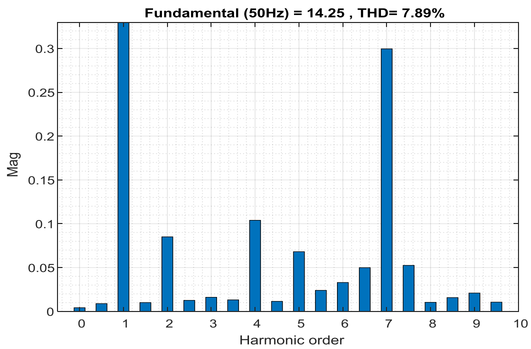

Figure 15. THD graph for hybrid system line to line voltage

B) simulation with controller

At the common coupling point, STATCOM is connected. To maintain the voltage stability of the entire system, the proposed shunt controller is meant to either deliver or absorb the reactive power.

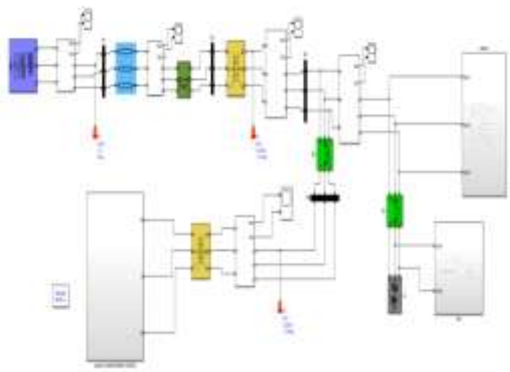

Figure 7. Simulation model for hybrid system with STATCOM controller

Results with controller

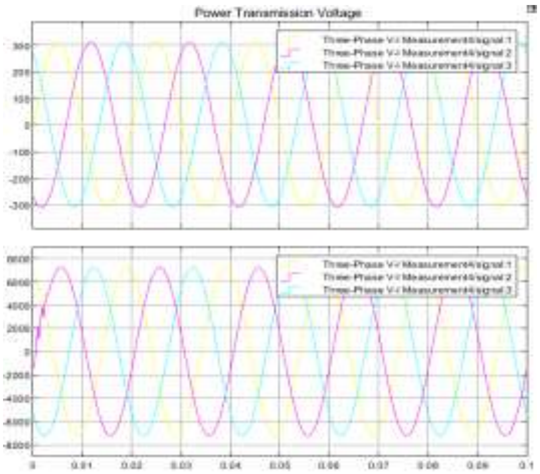

Figure 8.output voltage and current of hybrid system with STATCOM controller

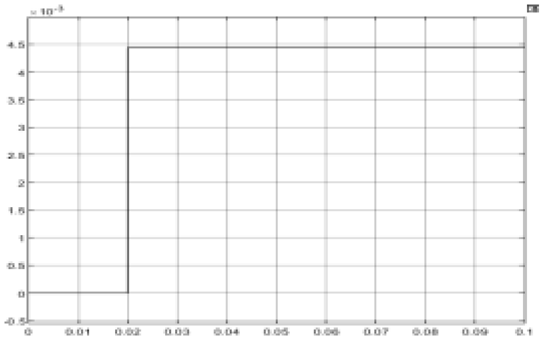

Figure 9.harmonic order with controller

IV. CONCLUSION

The goal of this effort was to improve the power quality of the proposed hybrid PV-wind system. Figure 7 illustrates the enhanced THD discovered by the FFT analysis in the presence of STATCOM. The STATCOM is incorporated into a hybrid power system simulation model. The outcome demonstrates that the total harmonic distortion (THD) is within the 7%. This shows that the suggested wind-PV hybrid generation model is operating satisfactorily.0.4%.

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