Yashoda R. Perkar[1]
Dr. Jaydeep Chakraborty[2]

Enhanced Power Quality In Hybrid Power System With DSTATCOM For Grid Connection

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Abstract
The utility load is currently facing new challenges in terms of power quality, voltage stabilization, and efficient energy usage due to the increased utilization of circulated power sources in the power grid. Surrounded by the renewable power sources, wind and solar are considered the most reliable. However, relying solely on either photovoltaic or wind energy systems can lead to unstable electricity production due to the unpredictable nature of wind and solar irradiance availability. To address this issue, a Hybrid system of Solar and wind energy generation systems can provide a promising and dependable electricity supply. This paper presents a model of a hybrid system connected to the grid. This technology can greatly benefit remote users, especially in regions where grid combination is not cost-effective. Though, connecting power electronics to distributed generation systems can result in significant issue created by power quality like: production of harmonic and adjustment of reactive power, which can interrupt the distribution system. The paper contains a software simulation model of the hybrid power system and analyzes its performance in grid linked mode. The quality power of the hybrid system is evaluated by calculating the THD at various wind speeds. The utilization of DSTATCOM has enhanced the power quality of this hybrid system.

Key words: *THD, DSTATCOM, Hybrid system, Grid connection, Solar Photo Voltaic (SPV), Wind Power System*

INTRODUCTION

The recent concerns regarding environmental issues caused by fossil fuels have led to the exploration of sustainable energy sources for electricity production. Among these sources, air flow and sunlight are considered the most abundant and reliable renewable energy options. However, they have limitations in terms of providing constant irradiation and air movement speed, respectively, which makes them unsuitable for meeting the constant electricity demand. To address this issue, a new development in renewable energy technology involves combining different energy sources with energy storage devices.

One possible combination is the integration of wind and Solar Photovoltaic (SPV) systems, known as the wind-SPV hybrid generation (WSPVHG) system [2]. This hybrid system takes advantage of the benefits offered by both solar and wind energy, making it a promising option for electricity production. By integrating this hybrid system with the grid, it becomes a viable alternative that can reduce the cost of electricity while maintaining high-quality power [1].

However, it is important to acknowledge that the hybrid system also has its drawbacks, including issues related to protection, synchronization, and power quality. In this essay, we will specifically focus on the power quality aspect, which can be assessed through parameters such as sag voltage, harmonics interrupt, and power factor. To evaluate the quality power of the hybrid system, this study utilizes harmonics analysis [3].

In the following sections, this essay will provide detailed descriptions of the hybrid system (part II) and the modeling of D-STATCOM (section [insert section number]).

1.HYBRID RENEWABLE ENERGY SYSTEM MODEL:

A hybrid generating system through integration grid system is a promising solution for convention the electrical load demand. By combining the advantages of solar and wind energy systems, this hybrid system can provide reliable power in both standalone and grid-connected modes[4]. The grid integration enhances the overall efficiency and reliability of the system while reducing costs. Regardless of weather conditions, the hybrid system draws sustainable energy and supplies it to connected loads. The main benefits of this hybrid renewable energy system include a reduction in peak load, decreased conduction line losses, supply in remote areas, and overall reliability[5].

In this paper, the hybrid power system discussed involves of predictable sources and alternating renewable sources like wind and solar. Yet, the alternating nature of renewable power can cause fluctuations in voltage and current, which can negatively affect power quality. To address these issues, the system incorporates the D-STATCOM.

The D-STATCOM acting a critical role in changeable voltage by injecting reactive power. This helps mitigate voltage sags, swells, and flickers, ensuring a stable and consistent voltage profile. Additionally, the D-STATCOM improves the power factor of the system, leading to a reduction in overall system losses.

[1*]Ph.D Research Scholar Electrical Engineering Indus Institute of Technology and Engineering, Indus University, Ahmedabad
[2]Associate Professor HOD Electrical Engg Department Indus institute of Technology and Engineering, Indus University, Ahmedabad

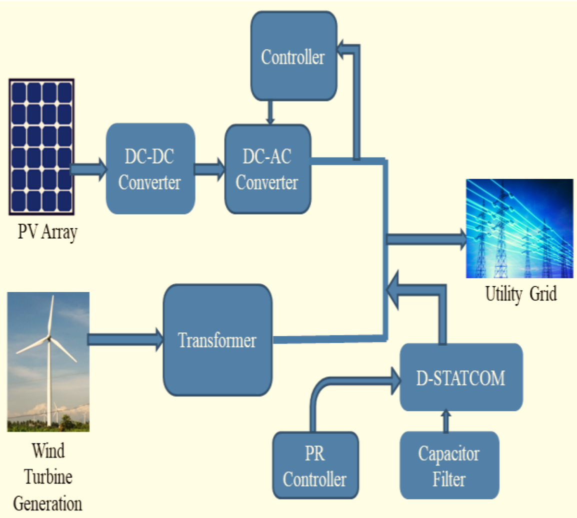

Figure 1 conventional D-STATCOM for hybrid power system

2.DEMONSTRATING SYSTEM

2.1Solar Energy System Modelling

The fundamental component of a PV array is a solar photovoltaic (SPV) cell. By connecting the Solar PV cells in series, a Solar PV module is formed, and multiple Solar PV sections are combined to create an Solar PV array [1]. Figure 2 illustrates the estimated circuit of a Solar PV cell. To simulate an ideal SPV cell, the following mathematical formula is utilized.

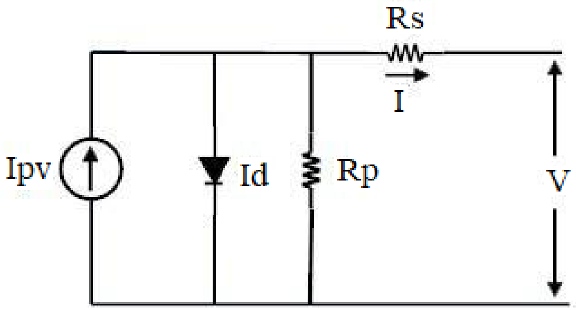

Figure 2 equivalent circuit of Solar Cell

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

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

The current generated by solar irradiance, denoted as Ipv, is influenced by various factors. These factors include the leakage current of diode (Io), the free electron charge (q), the constant value: Boltzmann (k), at the P-N junction temperature (T in oK), the across voltage the diode (Vdis), and the diode ideality factor (a).

3.2 Wind Energy Power System Modelling

The wind turbine generator produces a specific amount of power in the form of turbine power.

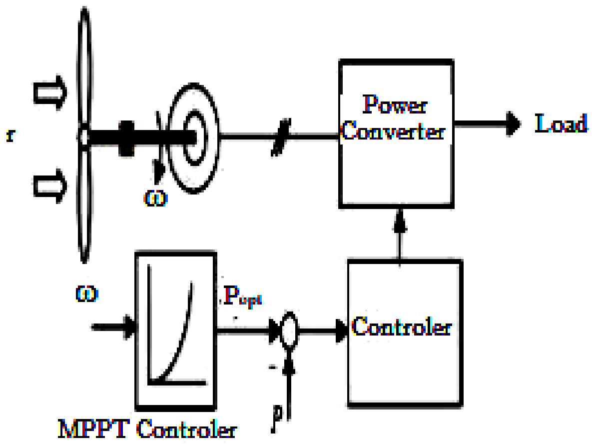

Figure 3 Block diagram of Wind Energy System

$Pi=0.5*\rho*C_p*A_S*V$ (3)

The power generated by a wind turbine generator (WTG) can be calculated using the formula: Pi = ρ * As * V * Cp. In this calculation, ρ represents the density of air, As is represent the area removed by the wind in square meters, V is represent the speed of wind in meters per second and Cp is the performance coefficient. The coefficient of performance is determined by the tip speed ratio, which is the ratio of the speed tip to the speed of wind [6].

3.MODELLING OF D-STATCOM

As per power system generally deals with the quantities of Alternating Current (AC) and practically all the loads used demands reactive power, compensation of reactive power is a excessive power quality concern among others [7]. To deliver a required voltage support for the fluctuated voltage in WECS, the controlled of reactive power flow [8].
Throughout the voltage failure the DSTATCOM has a superior advantage to provide more capacitive reactive power.
A DSTATCOM is a power electronics method which is capable to produce or absorb reactive power at its output terminals. It is accomplished of handling the real power as well if associated with a battery storage device [9]. Different SVCs, it does not need high value of inductive and capacitive apparatuses to impart reactive power support to transmission lines [10]. The main benefits of the DSTATCOM are necessity of less installation area due to compressed in size and higher reactive power yield to low voltages. D-STATCOM also imparts better damping characteristics from other in the dynamic stability point of view [11].
The objective of this study was to enhance the power quality of the hybrid micro-grid by implementing D-STATCOM. By connecting a DSTATCOM at the common coupling Point, it is possible to address both current and voltage power quality concerns. When operating in regulator current mode, the D-STATCOM injects harmonic and reactive components into the load current to ensure balanced and pure sinusoidal source currents. On the other hand, when operating in voltage control mode, the Common Coupling Point voltage is controlled with respect to a base value to protect critical loads from significant voltage disturbances [12].

4.SIMULATION WORK AND RESULT

The DSTATCOM is linked at the PCC, where the suggested shunt controller is anticipated to whichever supply or consume the reactive power in order to uphold the complete system voltage stability

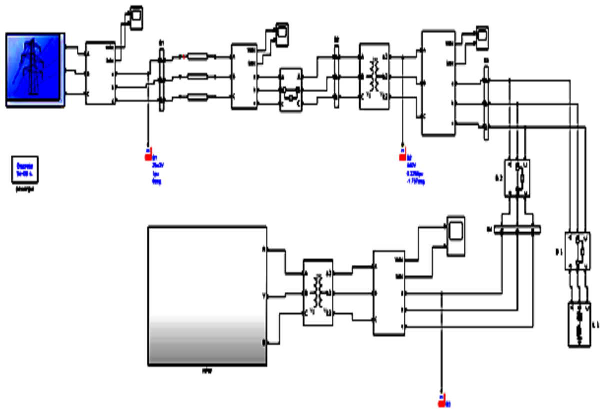

Figure 4 Schematic diagram of hybrid system with DSTATCOM

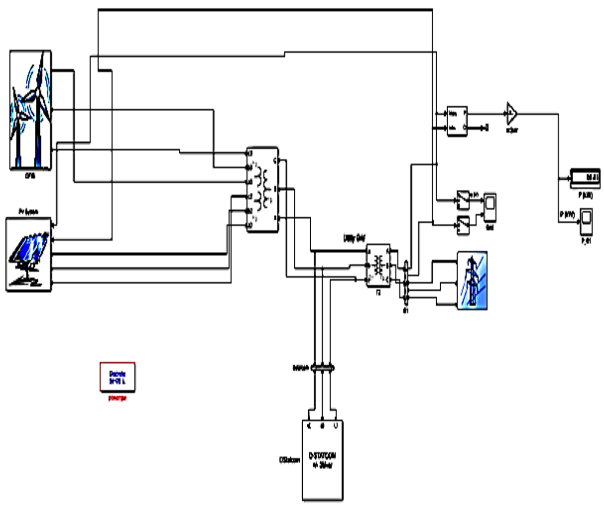

Figure 5 MATLAB Modelling of Hybrid System with D-STATCOM

The proposed system aims to address power quality issues effectively. The MATLAB simulation model is employed to depict this system. Within the simulink model, several blocks such as breaker, scope, and powergui are utilized. The scope block enables the display of signals generated during the simulation, while powergui is used to simulate the MATLAB Simulation Model in either continuous or discrete time.
In Figure 5, the MATLAB model of DSTATCOM is presented, highlighting its role in mitigating power quality problems. Figure 6 demonstrates the reduction of power quality issues achieved through the implementation of DSTATCOM.

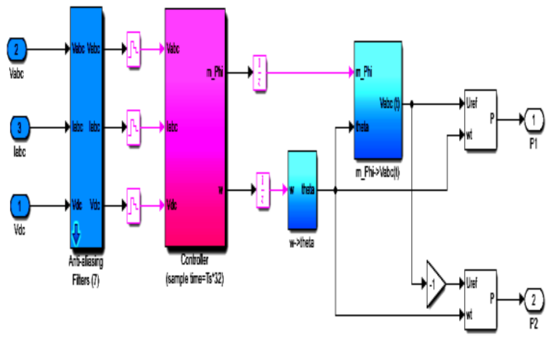

Figure 6 MATLAB Modelling of DSTATCOM Controller

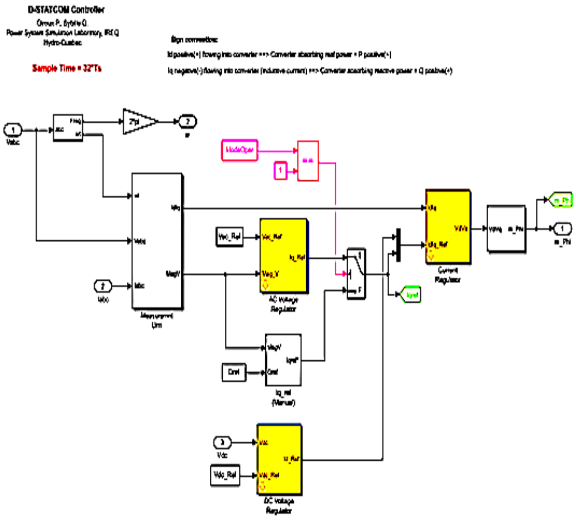

Figure 7 MATLAB Modeling with Connection

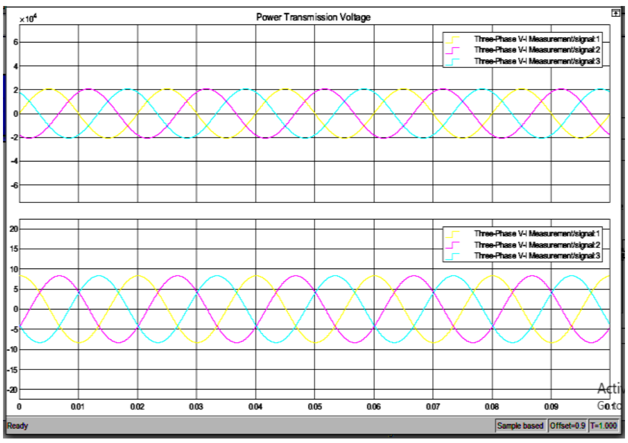

Figure 8 Grid Connection Output Result for using of DSTATCOM

5.CONCLUSION

The main objective of this paper was to develop and verify a controller for DSTATCOM that would effectively regulate voltage, compensate for reactive power, enhance power factor, and address unbalanced loads. The study primarily focused on implementing various techniques to improve power quality through the utilization of DSTATCOM. Additionally, an active power filter was employed to mitigate harmonic distortion.

The use of DSTATCOM was deemed necessary to minimize voltage imbalances, error voltage, and compensate for reactive power. By incorporating a distributed STATCOM, the inverter was able to uphold the desired power quality of the output voltage across the load. The MATLAB Simulation presented in this study demonstrated the significant enhancement in power quality achieved through the integration of DSTATCOM.

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