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Power Quality Control for Mixed Renewable Energy Systems

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Abstracts

Electrical energy is one of the famous and easiest used forms of energy. Electrical energy can be converted to many forms of energy. With the development of technology, the dependency on electrical energy has been increased greatly nowadays. Such as Computer and telecommunication networks field, railway network banking, post office, life support system are a few applications that just cannot run without electricity. In this article, we will discuss the power quality issues for distributed generation systems based on renewable energy sources, as an example solar and wind energy. A brief explanation about the power quality issues is conducted here. This article starts with the power quality issues, followed by discussions of basic standards. A brief study of power quality in the power system, which includes the systems with dc and renewable sources is done in this article. In addition to the power quality monitoring techniques and its possible solutions for the power quality issues for the power system are briefly discussed. Later we will go through the analyzing step for the methods of mitigation of these problems using custom power devices, such as D-STATCOM, UPQC, UPS, TVSS, DVR, etc., for microgrid systems. As an example, renewable energy systems, such as the station can be an efficient choice due to their several advantages, whereas the spinning reserve can enhance the power quality in traditional systems. Finally, we will discuss the power quality in dc systems. Two Main advantages for a DC system, are Simple arrangements and higher reliability. Even though it faces many power quality issues such as instability and poor detection of faults

Keywords

D - Statcom, P-V System, SVC, Hybrıd System, Statcom, Power Quality

INTRODUCTION

Nowadays electrical energy is one of the most efficient and popular forms of energy in our modern time and it is heavily dependent on the electric supply. Electrical energy is used also in various fields and which are indispensable in our daily life for home uses such as lighting, heating, and operation of household electrical appliances and all other fields such as industry, communications, and scientific fields. The usage of electrical supply has been increased nowadays due to the Urban and industrial expansion [1]. Electrical energy is one of the types of energy found in nature. Electrical energy can be obtained from nature by lightning strikes and friction, but this is difficult and economically ineffective. But electrical energy can be generated in many other ways, including chemicals, such as batteries, or by converting kinetic energy into electrical energy by moving a conductive wire in a magnetic field, as in electrical generators, or by a thermocouple [2]. In batteries, the electricity generated is of constant current. In generators, the electricity generated is mostly alternating current, and electricity can be continuous. The process of generating or producing electrical energy is the process of converting energy according to the available energy sources in the demand centers. For electrical energy according to the quantities required for this energy, which determines the types of power plants as well Types of consumption, fuels, and their sources all affect the type and location of the plant and its energy [3]. At the same time, the quality of the power supplied is very important due to the efficient functioning of the end-user equipment. Most of the commercial and industrial loads demand high-quality uninterrupted power.

If we want to go in deep we have to describe what the main definition for power quality is, power quality refers to the electrical system's ability where it can create a perfect power supply that has a pure noise-free sinusoidal wave shape [4]. Many issues may affect power quality which may appear in transmission lines and distribution systems, some of these problems example: harmonics, transients, sudden, switching operation, voltage fluctuations, and frequency variation. One of the most important power quality issues is voltage stability which requires regulation. Usually, the Voltage regulation is affected by the unbalance of reactive power and the time constant of the excitation system [5].

POWER QUALITY

It determines the suitability of electrical power for consumer devices. As the synchronization of the voltage with the current allows the electrical systems to operate in the desired way without significant losses in performance or age [6]. This term is used to describe the electrical power needed for any electrical load, and the ability of the load to work properly. Without proper capacity, the device or electrical load may fail to

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function, failing completely or not working at all. There are many reasons why the quality of the electrical power is poor.

The extent of the electric power quality can be described to the extent:

- Continuity of service.
- Voltage Value difference.
- Current & transients efforts.
- Harmonics in the current and voltage wave.

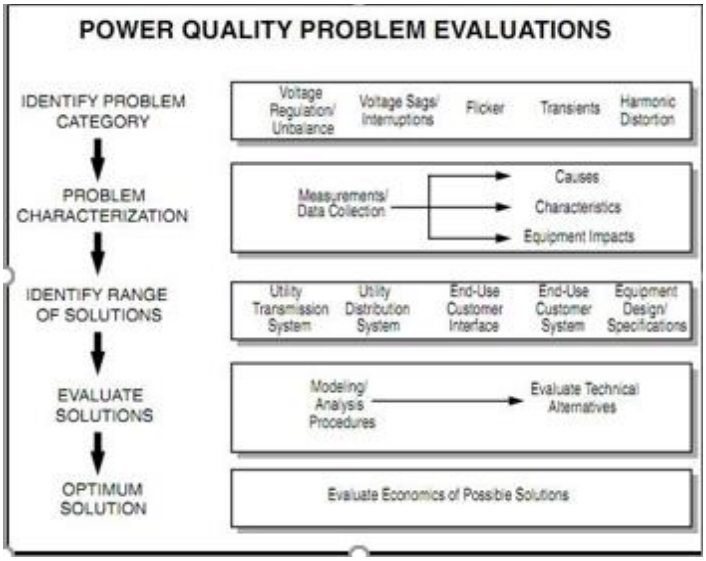

Fig. 1. Basic steps involved in a power quality evaluation

POWER QUALITY ISSUES

In the electrical power system, there are different kinds of power disturbance, they are classified as follows:-

A) Voltage sag (dip)

Description:- A huge decrease for the level of normal voltage between 10 and 90% of the nominal RMS voltage at the power frequency, for durations of 0, 5 cycle to 1 minute.

Causes: causes are the Faults on the transmission line where most of the time are on the parallel feeders. Also Faults in the consumer's installation. Finally, causes can be in the Connection of heavy loads and the startup of large motors.

Consequences: the Multifunction of information technological know-how equipment, namely microprocessor-based control structures such as (PCs, PLCs, ASDs, etc.) that may also lead to the process stoppage. The Tripping of the contactors and electromechanical relays will result in disconnection and loss of efficiency in electric rotating machines.

B) Very short Interruptions

Description: a full interruption of electrical supply for a duration from few milliseconds to one or two seconds.

Causes: Because of the opening and computerized enclosure of the protection devices to decommission an inaccurate section of the network. The foremost fault reasons are as the instance is: insulation failure, lightning, and insulator flashover. Consequences: Tripping of protection devices, loss of facts, and malfunction of records processing equipment. Stoppage of touchy equipment, such as ASDs, PCs, PLCs, if they're no longer organized to deal with this situation.

C) Long Interruptions

Description: Fully interruption for electrical supply for a duration of greater than 1 to 2 seconds.

Causes: Equipment failure in the power device network, storms and objects (trees, cars, etc.) putting strains poles, fire, human error, bad coordination, or failure of protection units.

Consequences: Stoppage of all equipment.

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1. Control of output voltage and power quality of a DC-DC converter for MPPT based PV system

In this area, we will discuss, the stand-alone solar PV device alongside with Cuk regulator which is designed. In addition to the consequences are analyzed the use of the MATLAB/Simulink program with distinctive irradiance levels. From the consistent kingdom analysis, we can conclude that it can be inferred that the system reaches maximum energy factor tracking in a quick time through altering the surrounding conditions. System efficiency will go on reducing by increasing insolation levels, from 800 to 1300 Watt (peak)/m2. The Efficiency is 90% when the insolation is 800Watt (peak)/m2 and 54.6% when insolation is 1300 Watt (peak)/m2. The Vmpp (voltage most strength point) will stay constant at 20 volt but Impp adjustments as the irradiance stage increases. It increases from 3.7 A to 6.1 A [11].

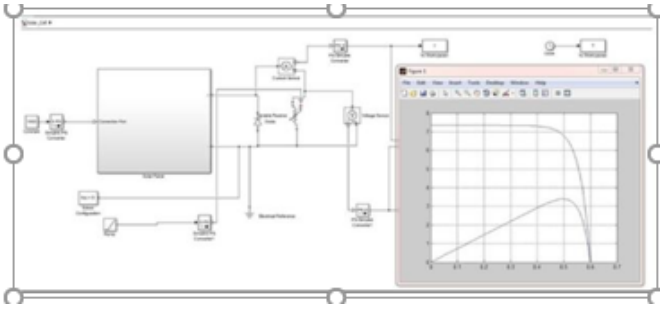


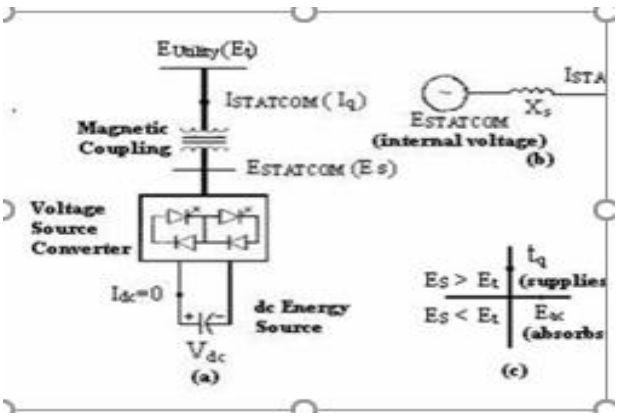
Fig. 2. Simulation for I-V curve

2. Modelıng of PV Solar Farm As Statcom

Nowadays, we are more often than not structured on non-renewable energy that has been and will continue to be a foremost reason for air pollution and different environmental degradation. To find, the suıtable and sustainable alternative is turning into more and more urgent because of these problems and the dwindling supply of petroleum. Perhaps, the biggest and largest challenge is in devising a sustainable future, which relies upon the integration and manipulates of renewable energy sources in grid allotted generation [2]. This section provides the modeling of the modern-day and voltage module of PV arrays and their characteristics.

- **Principle of the operation :**

A STATCOM is a managed reactive-power source. It offers the favored reactive-power generation and absorption completely by way of the ability of electronic processing of the voltage and modern waveforms in a voltage source converter (VSC). A single-line STATCOM energy circuit is shown in Figure 3 (a), where a VSC is connected to a utility bus thru magnetic coupling. In figure 3 (b), n this figure the STATCOM is shown as an adjustable voltage provides in the back of a reactance. The capacitor banks and shunt reactors are now not preferred to use in this case for reactive power and absorption[12]. The exchange of reactive power between the converter and the ac device can be managed with the aid of various the amplitude of the 3-phase output voltage, Es, of the converter, as illustrated in determine 3 (c If the amplitude of the output voltage is decreased below the utility bus voltage, therefore the modern flows from the ac system to the converter and the converter absorbs inductive- reactive electrical energy from the ac System. In other meaning, if the output voltage is equal to the ac device voltage, the reactive-power exchange becomes zero. In this case, the STATCOM is stated to be floating. Adjusting the segment shift between the converter-output voltage and the ac system [13].



(a) A power circuit; (b) an equivalent circuit; and (c) a power exchange

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Fig. 3. The STATCOM principle diagram:

The reactive and real-power alternate between the STATCOM and the ac system can be managed independently. Any mixture of real electricity generation or absorption with var era or absorption is attainable if the STATCOM is equipped with an energy-storage device of appropriate capacity, as depicted in Figure 3. With this capability, extraordinarily high-quality management techniques for the modulation of reactive and actual output strength can be devised to enhance the transient and dynamic system balance limits.

3. PV Array Simulation for Constant Insolation

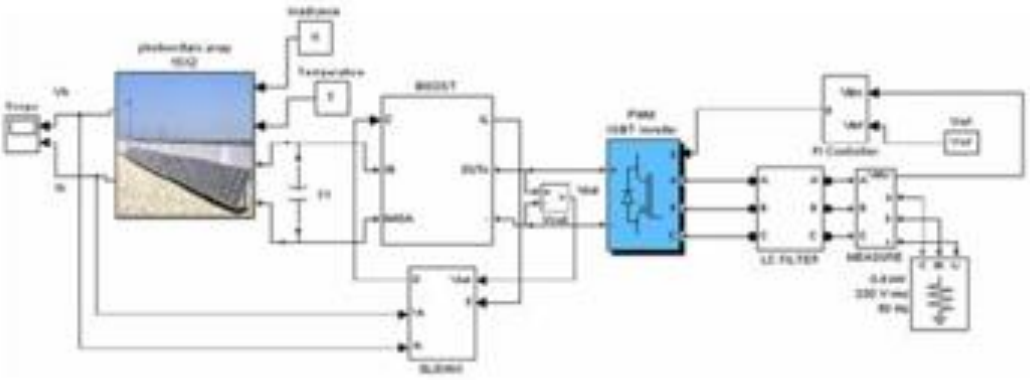

Fig. 4. Simulink block Diagram of the PV system connected to AC Load

The PV array combined with a DC-DC boost converter and DC-AC inverter for a steady insolation value of 1000 kW/m2 is simulated and the output voltage, output current, enter and output power of the inverter is obtained. The output voltage from the inverter offers a steady value of 158 W for regular insolation as shown in Figure 5.

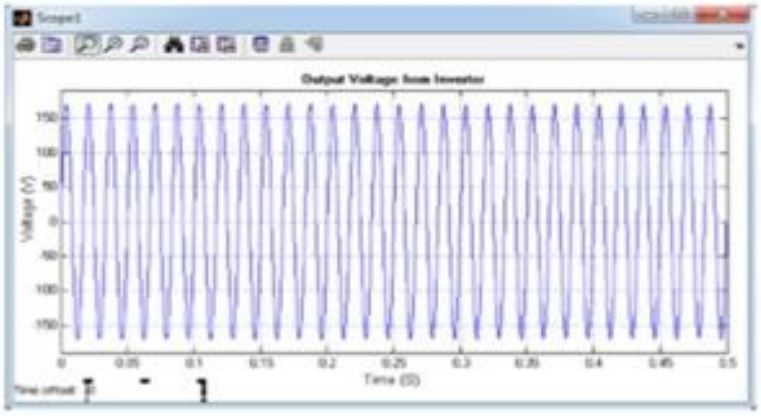

Fig. 5. Output Voltage of Inverter for constant insolation

4. Analysis and Simulation of Solar PV-Wınd Hybrıd Energy System with Statcom using Matlab-Simulink

Nowadays as the demand for electricity ıs ıncreasing, in different aspects, the power systems grow to be extra complex. The preferred methods which are used to forestall the voltage instability and collapse in developing and complex structures have now and then failed to meet the desires of the system. Today, with Flexible Alternating Current Transmission Systems (FACTS), the energy issues of complex and developing systems respond more rapidly and effectively. Besides, FACTS devices, when [4]. Used properly, make bigger the balance limits of strength systems and supply reactive power compensation by way of minimizing the voltage ripple ensuing from.

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5. Modellıng of PV-Wind Hybrid System with Statcom

A theoretical find out about and Simulink modeling should be performed before the actual implementation of these proposed systems. The Simulink model is in Figure 6. Firstly, in the system, a solar-wind hybrid model connected to the grid is modeled, and a STATCOM average model of +/-3 MVAR is linked between the load and the grid. Consequently, an everlasting magnet synchronous generator-based wind turbine and with the photovoltaic panel, a hybrid system with STATCOM is modeled [11].

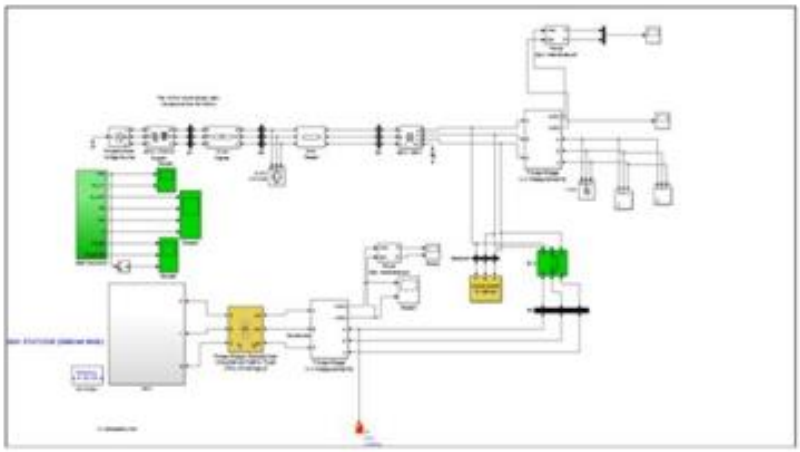

Fig. 6. Figure 6. Model of PV- Wind Hybrid System with Statcom

6. Simulation Of Svc And Statcom

A) Modelıng Of Svc

The center of attention of this chapter and research is a simulation of single section TCR/TSC Static Var Compensator and STATCOM in MATLAB/Simulink to solve voltage regulation and system dynamic overall performance deficiencies. A comparison of SVC and STATCOM has also been completed in this chapter. Transient Stability with SVC and SIMULINK model of IG with SVC and STATCOM are additionally presented in this chapter. SVC is a thyristor-based controller that presents fast voltage control to support electric power transmission voltages for the duration of right away after fundamental disturbances [8]. FACTS devices can modify the energetic and reactive strength control as properly as adaptive to voltage magnitude control concurrently by their quick control traits and their non-stop compensating functionality and so minimize glide of closely loaded traces and preserve voltages in preferred level.

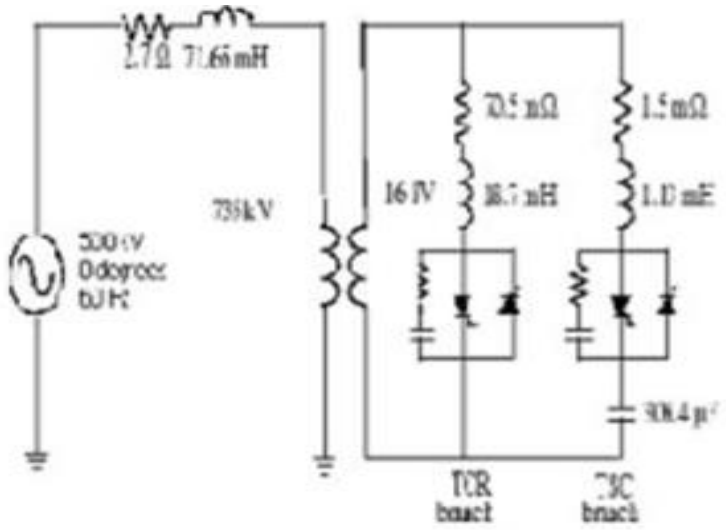

Fig. 7. Single Phase of a TCR/TSC SVC

In general, the two thyristors valve-controlled/switched ideas used with SVCs are the thyristor-controlled reactor (TCR) and the thyristor-switched capacitor (TSC). The TSC presents a ―stepped‖ response and the

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TCR presents a ―smooth‖ or always variable susceptance. A TCR consists of a constant reactor in sequence with a bi-directional thyristor valve. A thyristor switched capacitor consists of a capacitor in sequence with a bi-directional thyristor valve and a damping reactor. The thyristor swap acts to join or disconnect the capacitor for a quintessential range of half of the cycles of the utilized voltage. The capacitor is now not phase-controlled it is truly on or off. Because of this TSC (thyristor switched capacitor) will now not produce harmonic distortion. A reactor in the TSC circuit serves to restrict modern-day underneath challenging conditions, as properly as to tune the TSC circuit to a preferred frequency [14].

SIMULATION & RESULTS

A VSI based D-STATCOM is used to supply both reactive VAR and Harmonic current To the load, so the source current is sinusoidal and has a Unity power factor (UPF). A vector control method & SPWM scheme is used for closed-loop operation and pulse Generation, which have 2 controllers:

1. Voltage controller- used to maintain constant DC link voltage.
2. Current controlled-axis controller: supplies the harmonic current & draws little active current to meet the switching losses.

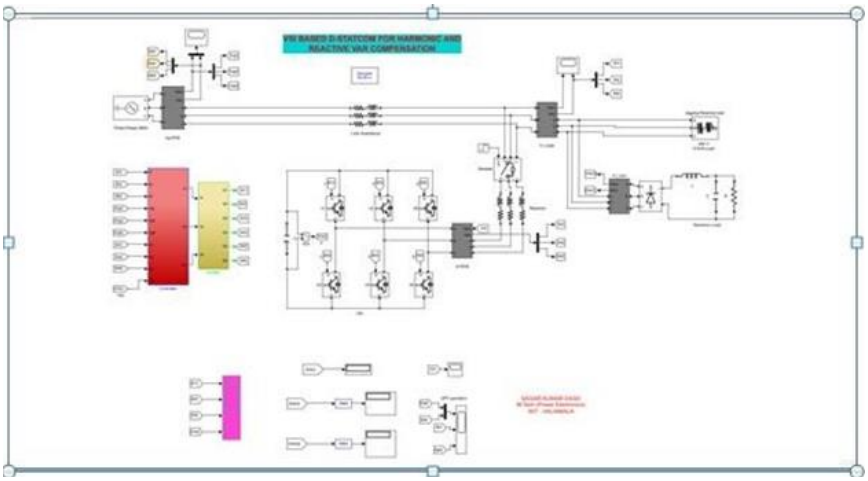

Fig. 8. VSI Based D-Statcom

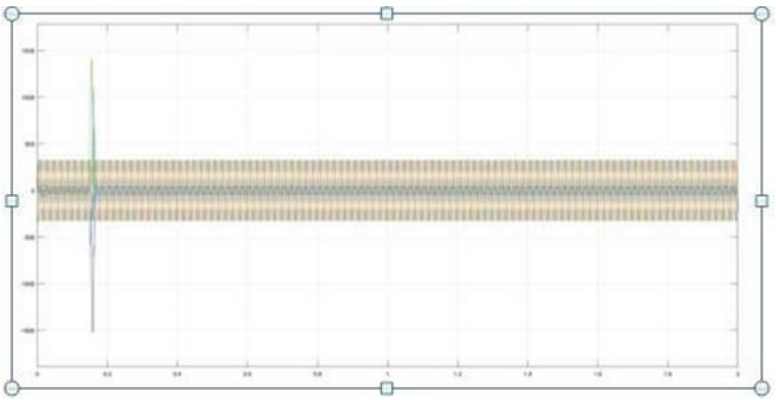

Fig. 9. Response of VSI Based D-Statcom

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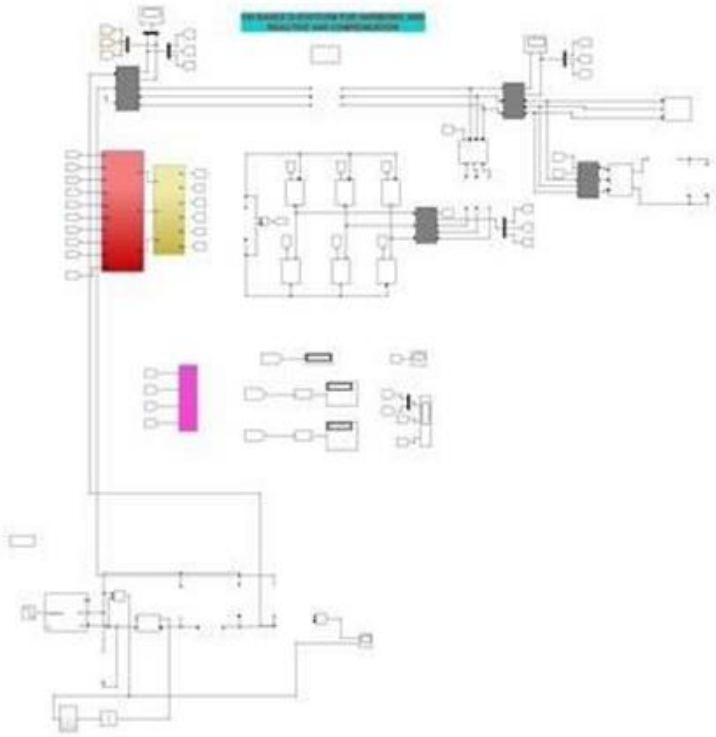

Fig. 10. D-Statcom Buck-boost convertor

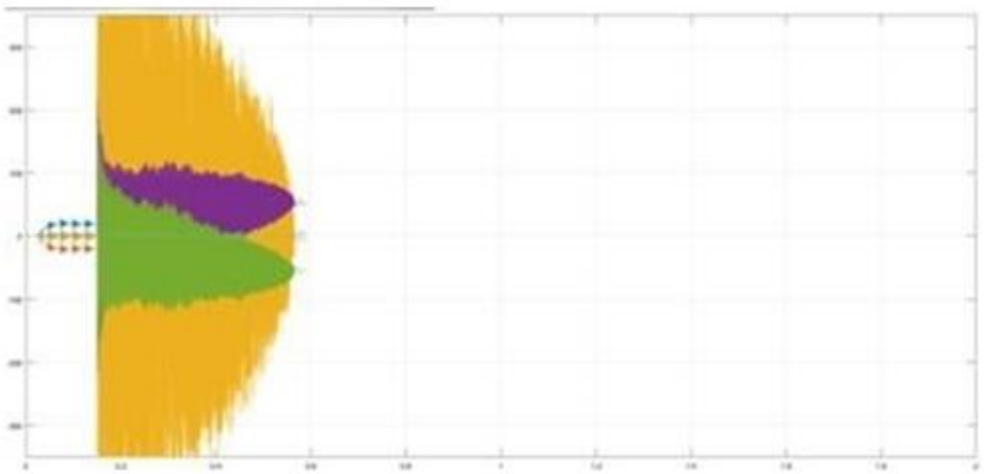

Fig. 11. Response of D-Statcom Buck-boost convertor

In this simulation, is connected Buck-boost converter for MPPT based PV. System to the D-Statcom Technique. To improve the effectiveness of a solar panel various control techniques are being used. MPPT algorithms result in extracting maximum power irrespective of all climatic conditions and also improve the efficiency by utilizing solar energy effectively. The main objective of the PV system is to accomplish maximum power in the generator

Side. So DC-DC converters are a good solution to this problem to get better power conversion efficiency. In this converter, the input side and output side are detached by a capacitance- thus energy transfer side takes place through capacitive energy transfer.

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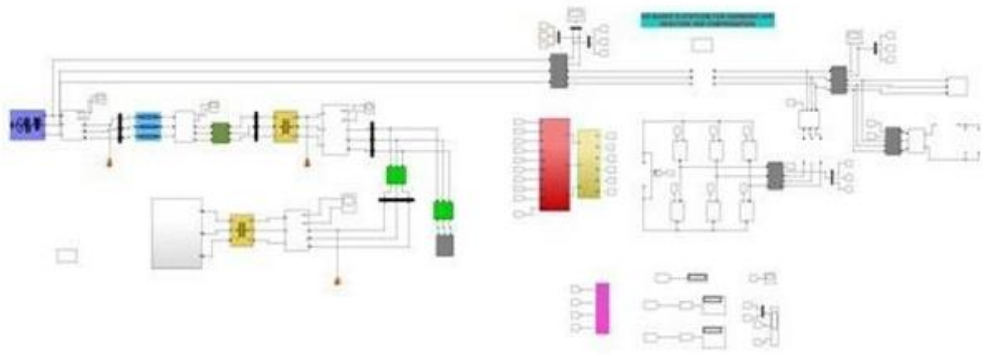

Fig. 12. D-Statcom Hybrid System

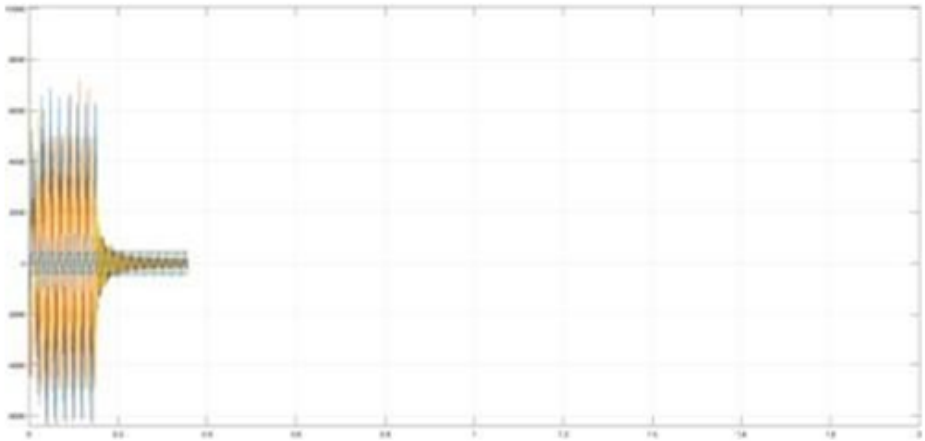

Fig. 13. Response of D-Statcom Hybrid System

In this simulation is connected The D-Statcom System with Hybrid System. One of the practices possible to provide these hybrids is a combination of grid-connected wind turbines and solar photovoltaic generators that together each could sit instead of the other one in a grid connection state when one of them cannot generate the required electricity for consumption by load properly.

CONCLUSION

The proposed methodology uses the combination of the 3-phase D-STATCOM in the mainline of Transformer secondary and single-phase active phase filter with the T-connected transformer in Feeder. This combination makes the size of D- STATCOM small and having a low KVA rating. The Hybrid D-STATCOM system is economical by using cost; small in size and simultaneous compensate reactive power, the load current harmonics, and the source neutral current. The Grid-connected PV generation will grow to be one of the famous generation technologies in the future. The simulation result shows that the PV system with DSTATCOM can output a different active power with different solar irradiance. Recognize the reactive power compensation, preserve grid-connected voltage steady and reduce total harmonic distortion of output current. This work is willing to make contributions to the development of renewable energy power generation systems and smart grids.

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