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Voltage Sag Enhancement of Grid Connected Hybrid Pv-Wind Power System Using Battery and SMES Based Statcom

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Abstract
This project proposes a method to optimize voltage of Distribution Static Compensator (DSTATCOM) based on load compensation requirement using Reduced Switch Count Multi-Level Converter connected with Photo-Voltaic-Wind (PV-WIND) system. The proposed method is capable of compensating reactive power, unbalance and harmonics demanded by three-phase unbalanced and non-linear loads connected to the distribution side, leading to improvement of power quality. It is also capable of providing real power support to the load and thus prevents source from getting over loaded whenever required. The STATCOM control scheme for the grid connected PV energy generation system for power quality improvement is simulated using MATLAB/SIMULINK in power system block set. The effectiveness of the proposed scheme relives the main supply source from the reactive power demand of the load and the induction generator. The development of the grid co-ordination rule and the different technique have been used for improvement of power quality.
Keywords*: Distribution Static Compensator, Static Synchronous Compensator, Super MagneticEnergy Storage, Maximum Power Point Tracking, Photo Voltaic Wind System, Flexible AC Transmission System, Dynamic Voltage Restorer.*

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I. INTRODUCTION

To have sustainable growth and social progress, it is necessary to meet the energy need by utilizing the renewable energy resources like PV, biomass, hydro, co-generation, etc. In sustainable energy system, energy conservation and the use of renewable source are the key paradigm. The need to integrate the renewable energy like PV energy into power system is to make it possible to minimize the environmental impact on conventional plant. The integration of PV energy into existing power system presents a technical challenges and that requires consideration of voltage regulation, stability, power quality problems. The power quality is an essential customer-focused measure and is greatly affected by the operation of a distribution and transmission network. The issue of power quality is of great importance to the PV turbine.

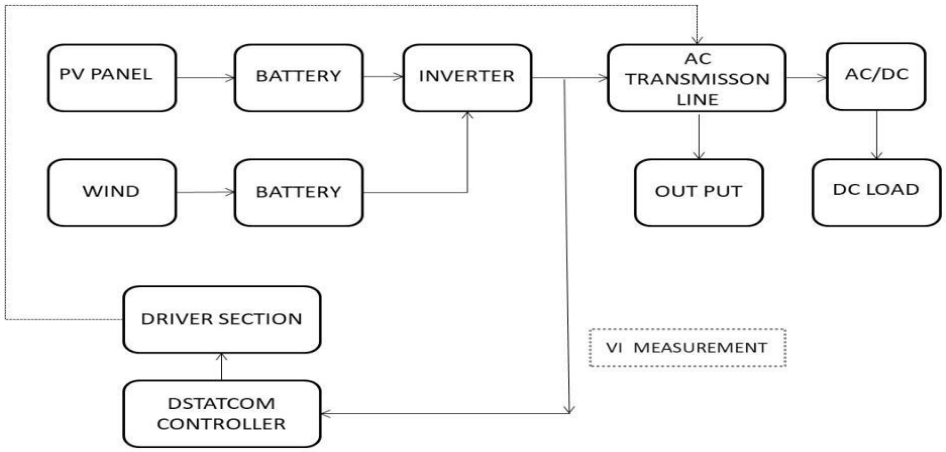
There has been an extensive growth and quick development in the exploitation of PV energy in recent years. The individual units can be of large capacity up to 2 MW, feeding into distribution network, particularly with customers connected in close proximity. Today, more than 28,000 PV generating turbines are successfully operating all over the world. In the fixed-speed PV turbine operation, all the fluctuation in the PV speed are transmitted as fluctuations in the mechanical torque, electrical power on the grid and leads to large voltage fluctuations. During the normal operation, PV turbine produces a continuous variable output power. These power variations are mainly caused by the effect of turbulence, PV shear, and tower-shadow and of control system in the power system

Thus, the network needs to manage for such fluctuations. The power quality issues can be viewed with respect to the PV generation, transmission and distribution network, such as voltage sag, swells, flickers, harmonics etc. However the PV generator introduces disturbances into the distribution network. One of the simple methods of running a PV generating system is to use the induction generator connected directly to the grid system. The induction generator has inherent advantages of cost effectiveness and robustness. However; induction generators require reactive power for magnetization. When the generated active power of an induction generator is varied due to PV, absorbed reactive power and terminal voltage of an induction generator can be significantly affected. A proper control scheme in PV energy generation system is required under normal operating condition to allow the proper control over the active power production. In the event of increasing grid disturbance, a battery energy storage system for PV energy generating system is generally required to compensate the fluctuation generated by PV turbine. A STATCOM based control technology has been proposed

for improving the power quality which can technically manages the power level associates with the commercial PV turbines. The proposed STATCOM control scheme for grid connected PV energy generation for power quality improvement has following objectives

- Unity power factor at the source side.
- Reactive power support only from STATCOM to PV Generator and Load.

BLOCK DIAGRAM



The proposed Statcom model is located between source or point common coupling (PCC) bus and load bus which it is connected to sensitive load. The PCC bus is then connected to a 3P3W of 380 Volt 50 Hz low voltage distribution line. The DVR consists of injection transformers, filter circuit, active filter series, DC voltage sources and energy storage. The series active filter on DVR is controlled by UVTG method to maintain magnitude of voltage between PCC bus and load bus remain constant , balanced and distortion free. The UVTG method is also used to generate trigger pulses in PWM circuit of six pulses by the active series filter, so as able to generate injection voltage to compensate for sag/swell voltage on load bus.

PV PANEL:
The PV cell consists of one or two layers of a semi conducting material, usually silicon. When light shines on the cell it creates an electric field across the layers causing electricity to flow. The greater the intensity of the light, the greater the flow of electricity. ***Conversion of light energy in electrical energy is based on a phenomenon called photovoltaic effect.***

BATTERY (VALVE REGULATED LEAD-ACID BATTERY):
A **valve regulated lead–acid** (**VRLA**) **battery**, commonly known as a **sealed lead–acid** (**SLA**) **battery**, is a type of lead-acid battery characterized by a limited amount of electrolyte ("starved" electrolyte) absorbed in a plate separator or formed into a gel; proportioning of the negative and positive plates so that oxygen recombination is facilitated within the cell; and the presence of a relief valve that retains the battery contents independent of the position of the cells.

INVRTER:
A device that converts direct current electricity to alternating current either for stand-alone systems or to supply power to an electricity. An inverter **converts the DC voltage to an AC voltage**. In most cases, the input DC voltage is usually lower while the output AC is equal to the grid supply ...

STATCOM:
A Static Synchronous Compensator (STATCOM) is a fast-acting device capable of providing or absorbing reactive current and thereby regulating the voltage at the point of connection to a power grid. It is categorised under Flexible AC transmission system (FACTS) devices.

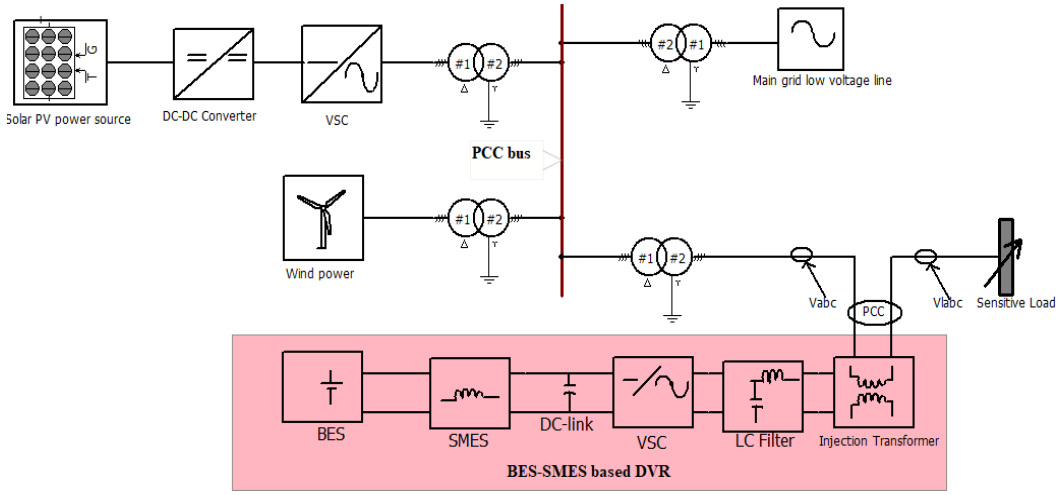
DSTATCOM:
DSTATCOM (distribution static compensator) is FACTS device used to solve all power qualityproblems which connected in parallel with system. The main function of D-STATCOM is**,** it generates or absorbs the reactive power at point of common coupling (PCC), so that power quality can be maintained.

VI MEASUREMENT:
The Three-Phase V-I Measurement block is **used to measure instantaneous three-phase voltages and currents in a circuit**. When connected in series with three-phase elements, it returns the three phase-to- ground or phase-to-phase peak voltages and currents.

II. EXISTING SYSTEM

The FACTS is a concept based on power-electronic controllers, which enhance the value of transmission networks by increasing the use of their capacity. As these controllers operate very fast, they enlarge the safe operating limits of a transmission system without risking stability. Needless to say, the era of the FACTS was triggered by the development of new solid-state electrical switching devices. Gradually, the use of the FACTS has given rise to new controllable systems The FACTS is a concept based on power-electronic controllers, which enhance the value of transmission networks by increasing the use of their capacity. As these controllers operate very fast, they enlarge the safe operating limits of a transmission system without risking stability. Needless to say, the era of the FACTS was triggered by the development of new solid-state electrical switching devices. Gradually, the use of the FACTS has given rise to new controllable systems Poor Efficiency While Controlling SAG , SWELL. Complex Switching Technique . High Frequency Switches have been used which is leadsto high cost.

2.1 **BLOCK DIAGRAM**



DC-DC CONVERTER:
A ***DC-to-DC converter*** is an electronic circuit or electromechanical device that converts a sourceof direct current (DC) from one voltage level to another.

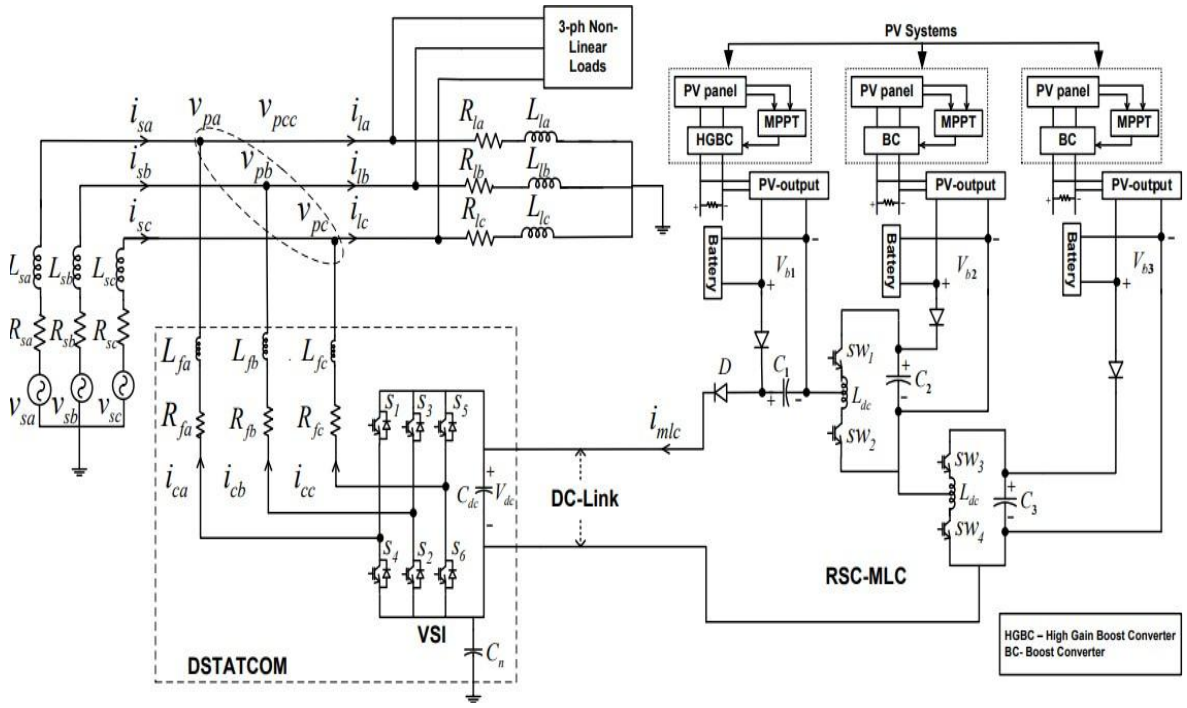
VOLTAGE SOURCE CONVERTER:
Voltage Source Converters (VSC) are **self-commutated converters to connect HVAC and HVDC systems using devices suitable for high power electronic applications, such as IGBTs**. VSCs are capable of self-commutation, being able to generate AC voltages without the need to rely on an AC system.

BATTERY ENERGY STORAGE:
Battery storage, or battery energy storage systems (BESS), are devices that enable energy from renewables, like solar and wind, to be stored and then released when customers needpower most.

III. PROPOSED SYSTEM

This project proposes novel voltage control, together with auxiliary damping control, for a grid-connected PV solar farm inverter to act as a STATCOM both during night and day for increasing transient stability and consequently the power transmission limit. This technology of utilizing a PV solar farm as a STATCOM is called "PV-Wind-STATCOM." It utilizes the entire solar farm inverter capacity in the night and the remainder inverter capacity after real power generation during the day, both of which remain unused in conventional solar farm operation This project was performed on the percentage of sag/swell load voltage, average THD of source voltage, and average THD of load voltage in each MPPT methods and disturbances scenario. Further more the results were compared and validated with IEEE 1159 and IEEE 519.

3.1 **CIRCUIT DIAGRAM**



There are two FLC method proposed in MPPT of PV system i.e. MPPT FM and MPPT-FS respectively. The MPPTFM/MPPT-FS helps single phase PV generate MPP in DVR-BES-PV system output. The DC output voltage of the PV is relatively low and then it is raised by a DC/DC boost converter at the appropriate voltage level in order to generate active power for BEScharging process. The BES has a larger storage capacity than capacitor,otherwise PV are used as an alternative DC voltage source to chargeBES when its capacity decreases.

CONFIGURATION OF FACTS-DEVICES:Shunt devices:
The most used FACTS-device is the SVC or the version with Voltage Source Converter
called STATCOM. These shunt devices are operating as reactive power compensators. The main applications in transmission, distribution and industrial networks are:

- Reduction of unwanted reactive power flows and therefore reducednetwork losses.
- Keeping of contractual power exchanges with balanced reactive power.
- Compensation of consumers and improvement of power quality especially with huge demand fluctuations like industrial machines, metalmelting plants, railway or underground train systems.
- Compensation of Thyristor converters e.g. in conventional HVDC lines.

Almost half of the SVC and more than half of the STATCOMs are used for industrial applications. Industry as well as commercial and domestic groups of users require power quality.Flickering lamps are no longer accepted, nor are interruptions of industry.

SVC:
Electrical loads both generate and absorb reactive power. Since the transmitted load varies considerably from one hour to another, the reactive power balance in a grid varies as well. The result can beunacceptable voltage amplitude variations or even a voltage depression, at the extreme a voltage collapse.

A rapidly operating Static Var Compensator (SVC) can continuously provide the reactive power required to control dynamic voltage oscillations under various system conditions and thereby improve the power system transmission and distribution stability.

Application of the SVC systems in transmission systems:

a. To increase active power transfer capacity and transient stability margin
b. To damp power oscillations
c. To achieve effective voltage control

SVC USING A TCR AND AN FC:

In this arrangement, two or more FC (fixed capacitor) banks are connected to a TCR (thyristor controlled reactor) through a step-down transformer. The rating of the reactor is chosen larger than the rating of the capacitor by an amount to provide the maximum lagging vars that have to be absorbed from the system. By changing the firing angle of the thyristor controlling the reactor from 90° to 180°, the reactive power can be varied over the entire range from maximum lagging vars to leading vars that can be absorbed from the system by this compensator.

SVC USING A TCR AND TSC:

This compensator overcomes two major shortcomings of the earlier compensators by reducing losses under operating conditions and better performance under large system disturbances. In view of the smaller rating of each capacitor bank, the rating of the reactor bank will be 1/n times the maximum output of the SVC, thus reducing the harmonics generated by the reactor. In those situations where harmonics have to be reduced further, a small amount of FCs tuned as filters may be connected in parallel with the TCR.

SIMULATION AND RESULT

Matlab is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include Math and computation Algorithm development Data acquisition Modeling, simulation, and prototyping Data analysis, exploration, and visualization Scientific and engineering graphics Application development, including graphical userinterface building.

Matlab is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar nointeractive language such as C or Fortran.

The name matlab stands for matrix laboratory. Matlab was originally written to provide easy access to matrix software developed by the linpack and eispack projects. Today, matlab engines incorporate the lapack and blas libraries, embedding the state of the art in software for matrix computation.

Matlab has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, matlab is the tool of choice for high-productivity research, development, and analysis.

Matlab features a family of add-on application-specific solutions called toolboxes. Very important to most users of matlab, toolboxes allow you to learn and apply specialized technology. Toolboxes are comprehensive collections of matlab functions (M-files) that extend the matlab environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others.

The matlab system consists of five main parts:

Development Environment. This is the set of tools and facilities that help you use matlab functions and files. Many of these tools are graphical user interfaces. It includes the matlab desktop and Command PVow, a command history, an editor and debugger, and browsers for viewing help, the workspace, files, and the search path.

The matlab Mathematical Function Library. This is a vast collection of computational algorithms ranging from elementary functions, like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix eigenvalues, Bessel functions, and fast Fourier transforms.

The matlab Language. This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both "programming in the small" to rapidly create quick and dirty throw-away programs, and "programming in the large" to create large and complex application programs.

Matlab has extensive facilities for displaying vectors and matrices as graphs, as well as annotating and printing these graphs. It includes high-level functions for two-dimensional and three- dimensional data visualization, image processing, animation, and presentation graphics. It also includes low-level functions that allow you to fully customize the appearance of graphics as well as to build complete graphical user interfaces on your matlab applications.

The matlab Application Program Interface (API). This is a library that allows you to write C and Fortran programs that interact with matlab. It includes facilities for calling routines from matlab (dynamic linking), calling matlab as a computational engine, and for reading and writing MAT-files.

POWER QUALITY STANDARDS, ISSUES AND IT'S CONSEQUENCES

A. International Electro Technical Commission Guidelines

The guidelines are provided for measurement of power quality of PV turbine. The International standards are developed by the working group of Technical Committee-88 of the International Electro- technical Commission (IEC), IEC standard 61400-21, describes the procedure for determining the power quality characteristics of the PV turbine . The standard norms are specified.

1) IEC 61400-21: PV turbine generating system, part-21. Measurement and Assessment of power quality characteristic of grid connected PV turbine

2) IEC 61400-13: PV Turbine measuring procedure in determining the power behavior.

3) IEC 61400-3-7: Assessment of emission limits for fluctuating load IEC 61400-12: PV Turbine performance. The data sheet with electrical characteristic of PV turbine provides the base for the utility assessment regarding a grid connection.

B. Voltage Variation

The voltage variation issue results from the PV velocity and generator torque. The voltage variation is directly related to real and reactive power variations. The voltage variation is commonlyclassified as under:

- Voltage Sag/Voltage Dips.
- Voltage Swells.
- Short Interruptions.
- Long duration voltage variation.

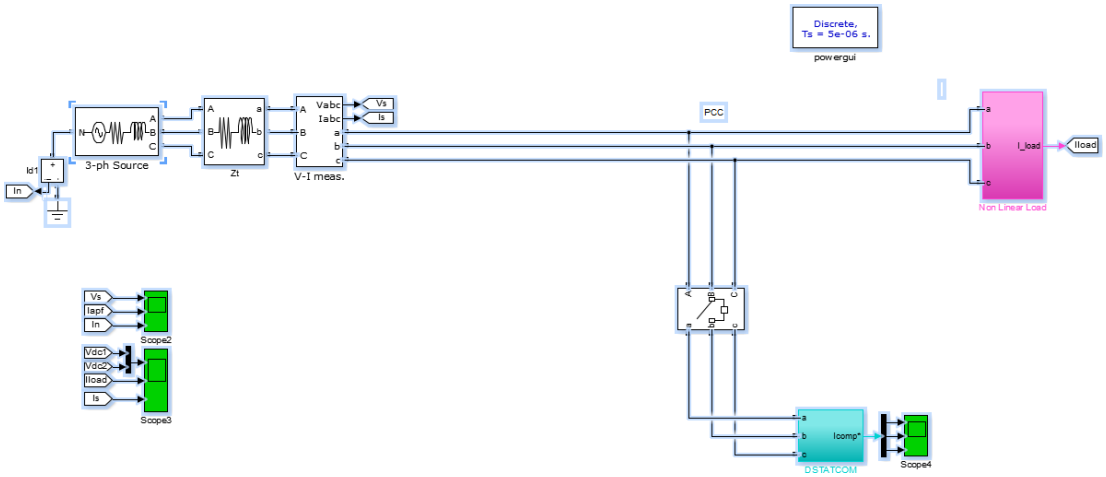
The voltage flicker issue describes dynamic variations in the network caused by PV turbine or by varying loads. Thus the power fluctuation from PV turbine occurs during continuous operation. The amplitude of voltage fluctuation depends on grid strength, network impedance, and phase-angle and power factor of the PV turbines. It is defined as a fluctuation of voltage in a frequency 10–35 Hz. The IEC 61400-4-15 specifies a flicke

C. Harmonics

The harmonic results due to the operation of power electronic converters. The harmonic voltage and current should be limited to the acceptable level at the point of PV turbine connection to the network.

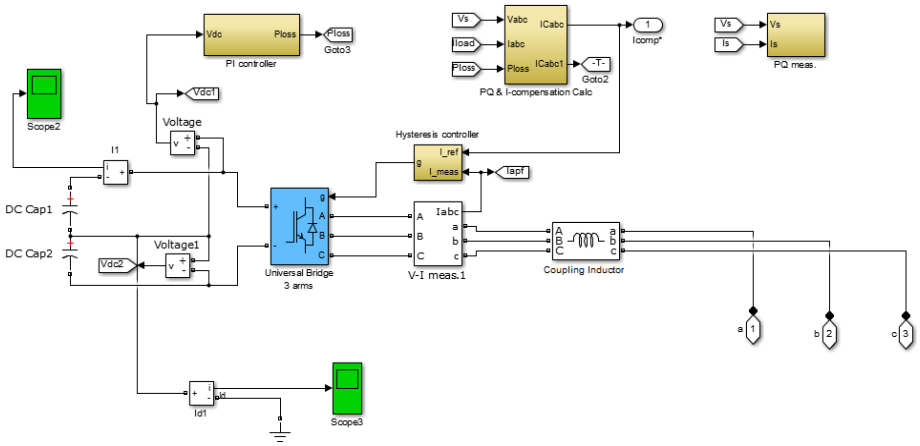
SIMULATION CIRCUIT

To test the performance of the proposed BES-SMES based DVR system for PV-wind hybrid energy sources with its parameters described . simulation is carried out using PSCAD/ EMTDC. For this simulation test, a fault is applied at the PCC bus for 50 millisecond time duration for symmetrical and asymmetrical conditions which produce symmetrical and asymmetrical voltage sags



DSTATCOM CIRCUIT

The DSTATCOM system is comprised of three main parts: a Voltage Source Converter (VSC), a set of coupling reactors and a controller. The basic principle of a DSTATCOM installed in a power system is the generation of a controllable ac voltage source by a voltage source inverter (VSI) connected to a dc capacitor (energy storage device). The ac voltage source, in general, appears behind a transformer leakage reactance. The active and reactive power transfer between the power system and the DSTATCOM is caused by the voltage difference across this reactance. The DSTATCOM is connected to the power networks where the voltage-quality problem is a concern. All required voltages and currents are measured and are fed into the controller to be compared with the commands. The controller then performs feedback control and outputs a set of switching signals to drive the main semiconductor switches (IGBT's, which are used at the distribution level) of the power converter accordingly.

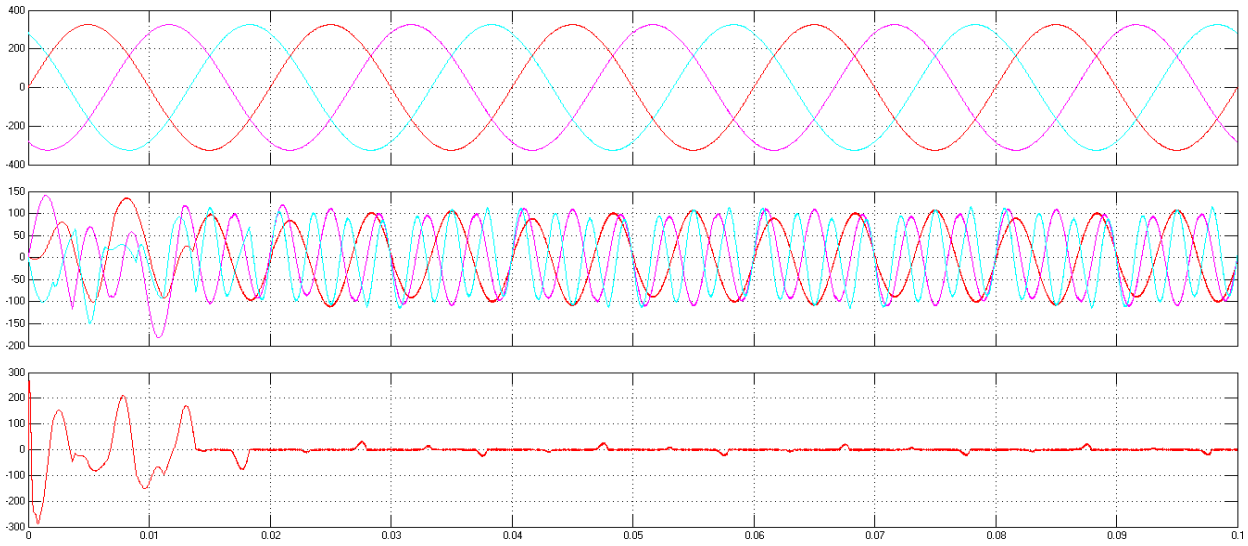


NON LINEAR LOAD

When there are nonlinear loads, **the current does not look like the voltage ona waveform**. Harmonics come from the loads so in this case we have current that is affecting the voltage. As we pull that current through the system, the nonlinear load creates current distortion, which then causes voltage distortion.

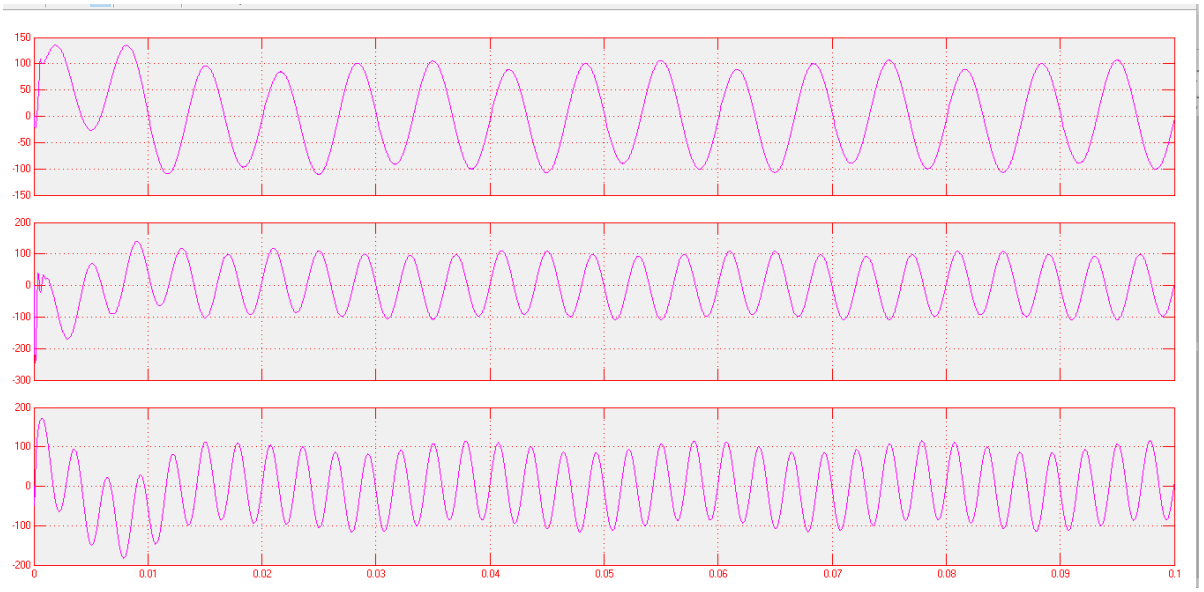
INPUT WAVEFORM

The voltage sags could happen not only due to a fault, but also due to the source fluctuation in the PV-wind power systems. Based on its' intermittent nature of the source, both PV and wind power system could produce symmetrical sag and if separate PV systems connected to the individual phases, asymmetrical voltage sag also will be produced. Whatever, the proposed BES-SMES based DVR will compensate the sag voltage whether it happened due to a fault or source intermittent. X-axis is the time and y-axis is the amplitude.



OUTPUT WAVEFORM

This project is reducing the distortion and improving the power quality,non-linear load connected to the power distortion side leading to improvement of power quality.



IV. CONCLUSION

The paper presents the STATCOM-based control scheme for power quality improvement in grid connected PV generating system and with non linear load. The power quality issues and its consequences on the consumer and electric utility are presented. The operation of the control system developed for the STATCOM-SOLAR in MATLAB/SIMULINK for maintaining the power quality is simulated. It has a capability to cancel out the harmonic parts of the load current. It maintains the source voltage and current in-phase and support the reactive power demand for the PV generator and load at PCC in the grid system, thus it gives an opportunity to enhance the utilization factor of transmission line. The integrated PV generation and STATCOM with IEEE Bus have shown the outstanding performance. Thus the proposed scheme in the grid connected system fulfills the power quality norms as per the IEC standard 61400-21.

REFERENCES

[1]. V.S. Karale, S.S. Jadhao, M. Tasare, and G.M. Dhole, "UVTG based Dynamic Voltage Restorer for Mitigation of Voltage Sag", In: Proc. of International Conf. on Computing Communication Control and automation, pp. 1- 6, 2016.

[2]. A. M. Munoz, D. Oterino, M. Gonzalez, F.A. Olivencia, and J. J. Gonzalez-de-la-Rosa, "Study of Sag Compensation with DVR", In: Proc. Mediterranean Electrotechnical Conf., pp. 990-993, 2006.

[3]. A. Kumar, N. S. Pal, and M. A. Ansari, "Mitigation of Voltage Sag/Swell and Harmonics using Self-Supported DVR", In: Proc. International Conf. on Power Electronics, Intelligent, Control and Energy Systems, pp. 1- 5, 2016.
[4]. N. Prakash, J. Jacob, and V. Reshmi, "Comparison of DVR performance with Sinusoidal and Space Vector PWM techniques", In: Proc. Annual International Conference on Emerging Research Areas: Magnetics, Machines and Drives, Kottayam, pp. 1-6, 2014.
[5]. A. M. Rauf and V. Khadkikar, "Integrated PhotoVoltaic-Wind and Dynamic Voltage Restorer System Configuration", IEEE Transactions on Sustainable Energy, Vol. 6, No. 2, pp. 400-410, 2015