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MODELING AND SIMULATION OF GRID-CONNECTED SOLAR PHOTOVOLTAIC SYSTEMS WITH D-STATCOM

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ABSTRACT:

Photovoltaic systems have been increasingly used in the generation of electrical energy because of the cost of energy produced from fossil fuels is rising day to-day and there by photovoltaic energy becomes a promising alternative source for fossil fuels. The most important operational requirement in power network at both transmission and distribution levels. Whenever there is a penetration of photovoltaic cell power to the low voltage distributed grid. Power quality is the major problem that occurs between grid to end user transmission lines This paper presents grid connected PV-system with stationman a day's FACTS device is very useful for the compensation and control of active power in transmission and distribution power system network. This will improve the stability of system under faulty condition and under varying condition. By using MATLAB simulation, I-V and P-V characteristic are shown. The basic control strategy which are used in this paper is dual close loop control. In this there are two control loop one is called outer control loop also called voltage control another is inner control loop also called current control loop Which are used for active and reactive power compensation. Here P&O algorithm is used for solar MPPT. Which are easier and accurate and it requires less parameter compared to others.

1.0 INTRODUCTION:

In the recent years a number of changes have been observed in electrical power networks which aim at the increasing share of distributed energy sources (DESs) in total energy production. Main factors influencing the common application of DESs are costs and efficiency. Although investment costs are still high, energy produced from DESs may be cheaper than the one from conventional energy sources. Different types of DG technologies are in use today. They can be grouped dependently on the fuel applied: micro turbines, fuel cells or reciprocating engines are based on gas, photovoltaic's, wind or hydro sources use renewable energy. Optimization of DG sources efficiency requires interconnection to the electrical power network, converting energy available at the moment and transmitting it into the grid. It can be presumed that the integration of considerable number of DERs into the grid may cause difficulties with maintaining the required power quality (PQ). DERs may generate

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disturbances such as voltage variations, asymmetry or harmonics. The problems may be heightened by disturbing loads if they are installed in the grid. The total apparent (complex) power that is injected into a transmission line is made up of two components, namely active and reactive. The active power P component is the part of energy that is converted into physical energy form. Micro-grids are the centralized alternative to distributed one to supply electrical energy to homes in isolated communities. The main advantages are relative lesser maintenance cost and best exploration of the installed power. Photovoltaic solar panels are becoming accepted as an important mean of power generation. And, the production rate will reach tens of giga watts in the next 40-50 years. Within the category of renewable energies and compared to wind conversion, this Photovoltaic (PV) conversion approach is silent, modular, easily transportable and quickly installed. Photovoltaic systems (cell, module, and network) require minimal maintenance..

SYSTEM DESCRIPTION

The system is studied on a single machine infinite bus system. Rating of generator is 25 MVA supplying power to 25 KV transmission line network. In this transmission network PV-Starcom is connected in the midpoint of transmission line. The transmission network has two segment T1 and T2 active power from requirement of load and level of solar power injection. Because solar PV power generation depends on the irradiance and temperature. During the night time solar PV is disconnected from the STATCOM and STATCOM will take some amount of active power from the grid for the charging and discharging so that it can maintain the DC-link capacitor voltage. And now STATCOM will supply completely reactive power to the network during the night time.

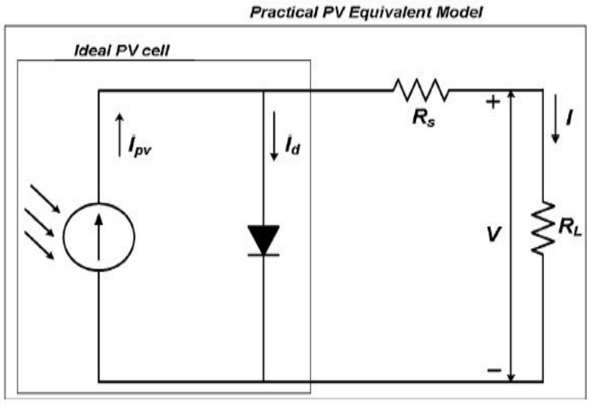

Figure 1: solar PV Cell

PHOTO VOLTAIC:

Photovoltaics (PV) is a term which covers the conversion of light into electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon studied in physics, photochemistry, and electrochemistry. A typical photovoltaic system employs solar panels, each comprising a number of solar cells, which generate electrical power. PV installations may be ground-mounted, rooftop mounted or wall mounted. The mount may be fixed, or use a solar tracker to follow the sun across the sky. The operation of solar PV generates no pollution. The direct conversion of sunlight to electricity occurs without any moving parts.

2.0 SIMULATION THEORY:

MATLAB (**mat**rix **lab**oratory) is a numerical computing environment and fourth-generation programming language.

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Developed by Math Works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, and Fortran. Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing capabilities. An additional package, Simulink, adds graphical multi-domain simulation and Model-Based Design for dynamic and embedded systems

SIMULINK

Simulink, developed by MathWorks, is a commercial tool for modeling, simulating and analyzing multi-domain dynamic systems. Its primary interface is a graphical block diagramming tool and a customizable set of block libraries. It offers tight integration with the rest of the MATLAB environment and can either drive MATLAB or be scripted from it. Simulink is widely used in control theory and digital signal processing for multi-domain simulation and Model-Based Design

We can build customized functions by using these blocks or by incorporating hand-written MATLAB, C, Fortran, or Ada code into the model. The custom blocks can be stored in their own libraries within the Simulink Library Browser.

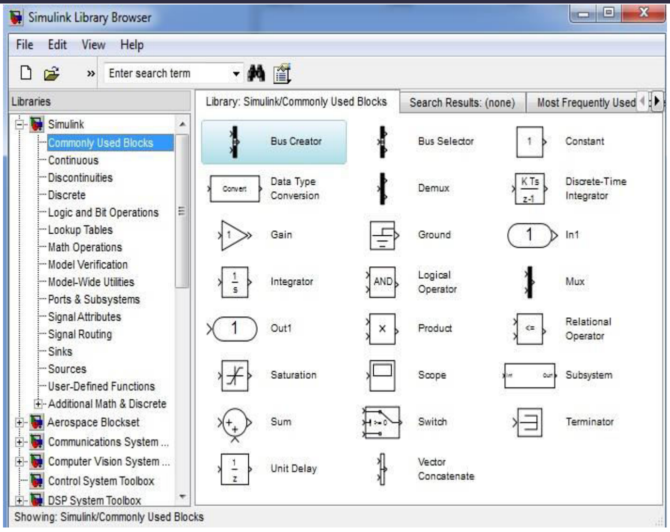

Figure 2. Commonly used blocks

Simulink add-on products let you incorporate specialized components for aerospace, communications, PID control, control logic, signal processing, video and image processing, and other applications. Add-on products are also available for modeling physical systems with mechanical, electrical, and hydraulic components

MANAGING SIGNALS AND PARAMETERS:

Simulink models contain both signals and parameters. Signals are time-varying data represented by the lines connecting blocks. Parameters are coefficients that define system dynamics and behavior. Simulink helps to determine the following signal and parameter attributes.

- Data type—single, double, signed, or unsigned 8-, 16- or 32-bit integers; Boolean; enumeration; or fixed point

- Dimensions—scalar, vector, matrix, N-D, or variable-sized arrays
- Complexity—real or complex values
- Minimum and maximum range, initial value, and engineering units

If we choose not to specify data attributes, Simulink determines them automatically via propagation algorithms, and conducts consistency checking to ensure data integrity

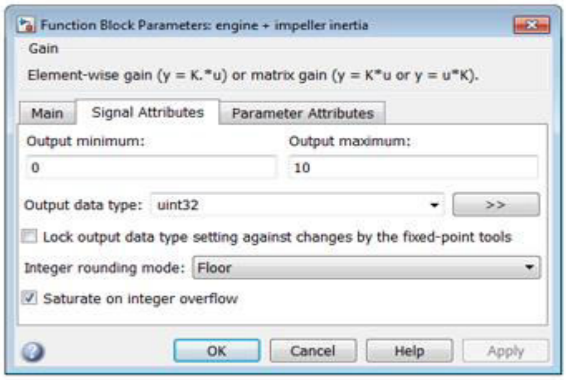

Figure 3: Signal Attributes tab

ANALYZING SIMULATION RESULTS

After running a simulation, we can analyze the simulation results in MATLAB and Simulink. Simulink includes debugging tools to help to understand the simulation behavior. We can visualize the simulation behavior by viewing signals with the displays and scopes provided in Simulink. We can also view simulation data within the Simulation Data Inspector, where we can compare multiple signals from different simulation runs. Scope is the block in Simulink by which we can measure and view the voltage, current, and power in electrical domain. Fig.3. shows the output of a multilevel converter through scope. Alternatively, we can build custom HMI displays using MATLAB, or log signals to the MATLAB workspace to view and analyze the data using MATLAB algorithms and visualization tools.

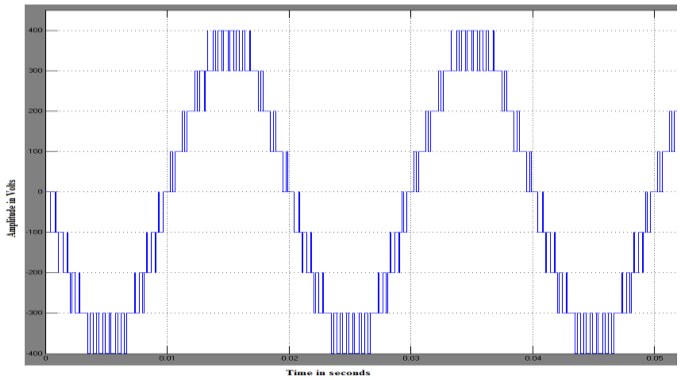

Figure 4. Multi-step waveform

SIM POWER SYSTEMS

Sim Power Systems™ provides component libraries and analysis tools for modeling and simulating electrical power systems. The libraries include models of electrical power components, including three-phase machines electric drives, and components for applications such as flexible AC transmission systems (FACTS) and renewable energy systems. Harmonic analysis, calculation of total harmonic distortion (THD), load flow, and other key electrical power system analyses are automated. Sim Power Systems was developed by Hydro-Québec of Montreal.

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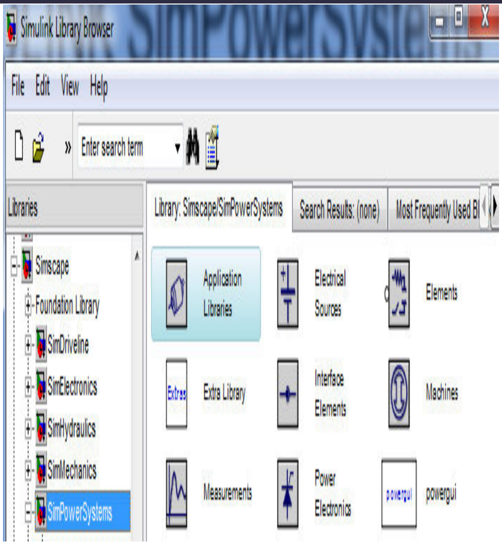

Figure 5: Sim Power Systems pane

MODELLING ELECTRICAL POWER SYSTEMS

With Sim Power Systems, we build a model of a system just as we would assemble a physical system. The components in the model are connected by physical connections that represent ideal conduction paths. This approach describes the physical structure of the system rather than deriving and implementing the equations for the system. From the model, which closely resembles a schematic, Sim Power Systems automatically constructs the differential algebraic equations (DAEs) that characterize the behavior of the system. These equations are integrated with the rest of the Simulink model. We can use the sensor blocks in Sim Power Systems to measure current and voltage in your power network, and then pass these signals into standard Simulink blocks

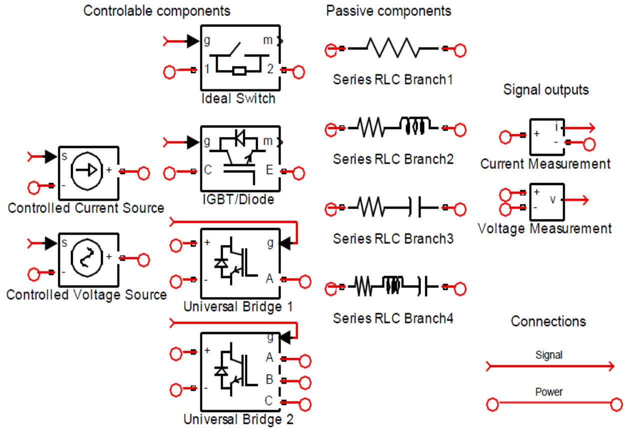

Figure 6. Sim power system Libraries

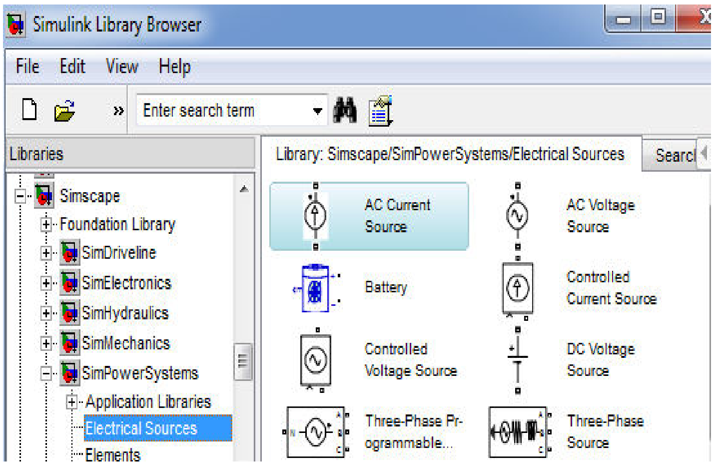

Figure 7. Block sets of electrical sources used in Sim Power Systems

4.0 SIMULATION AND RESULTS:

In this PV-module 88 parallel string and 7 series string are used and open circuit voltage of a single cell is 85.3V and short circuit current is 6.09. But the voltage at which maximum power occurs is approx. 85% of open circuit voltage and current. Power of a single cell at maximum power point is 414.8W. Maximum irradiance is 1000W/m2.Maximum power of solar PV module is 255 KV. Voltage and current of PV-module is 510V and 500 at maximum power point.

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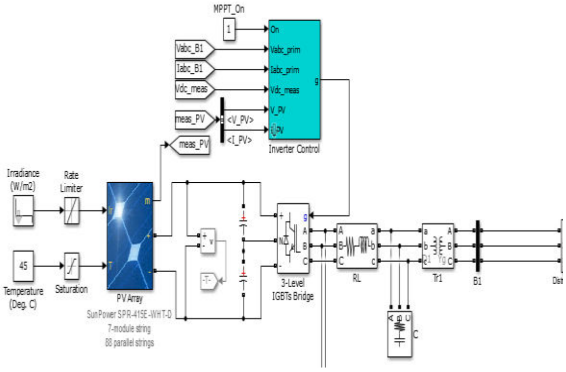

Figure 8: Basic structure of PV-connected statcom

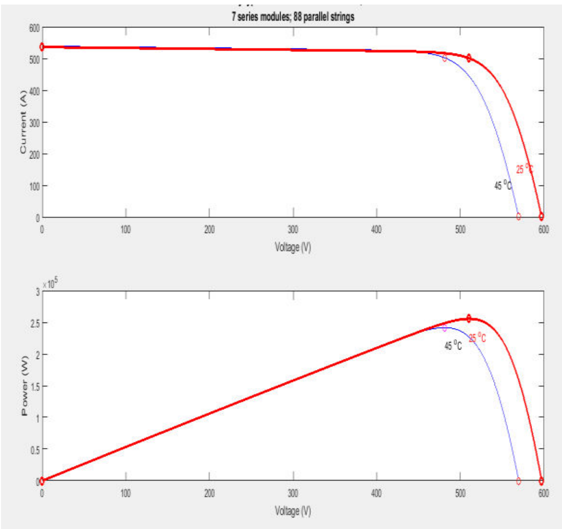

Figure: 9 I-V and P-V Characteristic of solar PV array

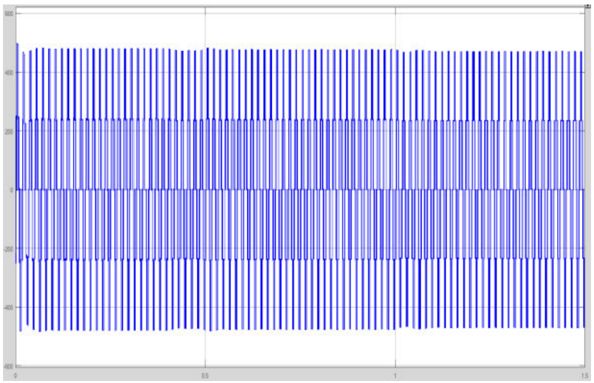

Figure 10: Output line voltage of inverter

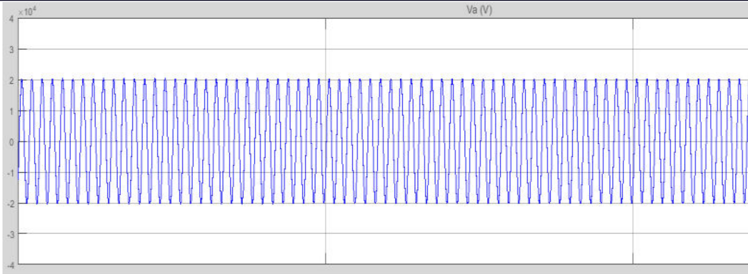

Figure 11-Voltage waveform at PCC

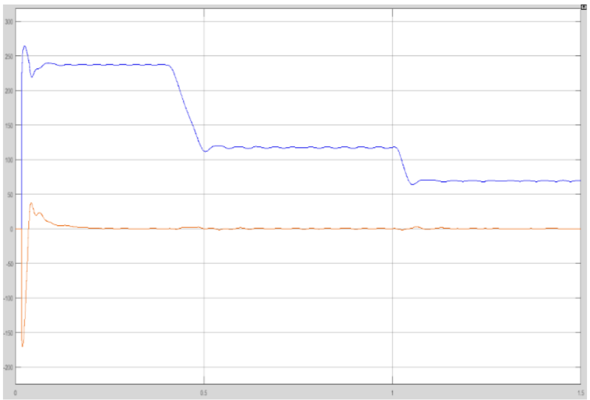

Figure 12: Output active and reactive power

CONCLUSION:

The Photovoltaic power system being integrated to low voltage distribution power grid near to consumer end by using Distributed Statcom to compensate the harmonics coming from the grid side Inverter and other side we have some loads in that, most of the non-linear loads inject harmonic currents to source side. In this paper we have studied and analysed the operation and performance of Statcom at various load conditions such as balanced & unbalanced linear & non-linear loads. This paper introduces a PV system that can be connected to a power grid, and its central concept is to use the system's stat com to generate as much active power as possible during the day, with the inverter's remaining capacity going toward compensating for reactive power. This paper's simulation findings demonstrate how the PV-power system's output decreases when irradiance rises, and the grid's power output rises, ensuring that the load demand is met optimally. The simulation and result contain all the data generated using Simulink in MATLAB. The ability to sell excess electricity to the grid during the day is a major benefit of grid-connected PV-stat com systems. This cutting-edge idea is also more sustainable, dependable, and low-maintenance than any other form of renewable power.

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