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DESIGN AND PERFORMANCE ANALYSIS OF GENERALISED INTEGRATOR-BASED CONTROLLER FOR GRID CONNECTED PV SYSTEM

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ABSTRACT:

This article discusses the design and control of a single-phase grid-connected photovoltaic (PV) system. A 5-kW PV system is designed and integrated at the DC link of an H-bridge voltage source converter (VSC). The control of the VSC and switching logic is modeled using a generalized integrator (GI). The use of GI or its variants such as second-order GI have recently evolved for synchronization and are being used as phase locked loop (PLL) circuits for grid integration. Design of PLL circuits and the use of transformations such as Park's and Clarke's are much easier in three-phase systems. But obtaining in-phase and quadrature components becomes an important and challenging issue in single-phase systems. This article addresses this issue and discusses an altogether different application of GI for the design of compensator based on the extraction of in-phase and quadrature components. GI is frequently used as a PLL; however, in this article, it is not used for synchronization purposes. A new controller has been designed for a single-phase grid-connected PV system working as a single-phase active compensator. Extensive simulation results are shown for the working of integrated PV system under different atmospheric and operating conditions during daytime as well as night conditions. Experimental results showing the proposed control approach are presented and discussed for the hardware set-up developed in the laboratory.

Keywords - PV array, MPPT, single-phase filter, voltage source converter, generalized integrator**.**

I INTRODUCTION

The continuous use of fossil fuels has significantly affected the environment and caused of pollution and global warming. To fulfill the increasing demand of energy in daily life, renewable based energy resources widely used in the last several years. Among them, Photovoltaic (PV) Solar Energy is widely useful because it is pollution free, maintenance free and abounded in nature [1]. In PV Solar System,

PV Solar cell converts the sunlight into the electricity by the photovoltaic effect. PV Solar Panels are used in many applications, such as, battery chargers, solar powered water pumping systems, grid connected PV systems, solar hybrid vehicles and satellites. Photovoltaic (PV) devices and storage battery sources produce low voltages, so a dc–dc boost converter is generally required to adapt the voltage level for the grid-connected inverter. This dc–dc converter, in addition to boosting, also regulates the inverter input voltage and sometimes isolates the low- and high voltage circuits [2]. A Generalized Block Diagram of Grid connected PV System is shown in Figure 1. PV Solar cells are made from crystalline silicon which is connected series and parallel combination to form PV solar panels. And connection of PV solar Panels in series and parallel are form a PV solar array [3]. The PV solar array generates the DC Power which are varies with solar radiation level, In the morning and late evening periods, the solar radiation level is low, due to that the output power of PV solar panel is lower than rated level and during noon, the output power is maximum due to presence of higher solar radiation level. To harvests maximum power, Maximum Power Point Tracking (MPPT) System is used [4][5]. The output DC power is converted into the AC form, PWM based Inverter is used in practice. The design and Simulation of each component are presented in next section.

II.LITERATURE SURVEY

Jaime W. Zapata et al., —In order to increase the conversion efficiency in photovoltaic (PV) systems, different configurations and topologies were developed. Depending on the application, the converters used for grid connection are built using one or two conversion stages. The advantages of the converters with a DC-stage are mainly the distributed maximum power point tracking algorithm per PV string or PV module and, when required for grid connection, the possibility of voltage elevation. However, the conversion efficiency is lower than configurations with a single stage as the central inverter. Therefore, the proposed work presents a Partial Power DC-DC converter (PPC) which process part of the entire system power and the remaining power is directly supplied to the output side. A topology is proposed and the details of its operation are explained based on the operating principle. Simulations are performed in order to evaluate the converter performance.

Sumitha T L et al., DC/DC converters which form interface between photovoltaic panels and the batteries/inverters is an integral part of any photovoltaic power plant. These converters regulate the charge provided by PV panels to the batteries/inverters. Therefore in this work, for PV architectures, DC/DC converter with partial power processing technique is proposed. This proposed topology is said to have the advantage of simplicity, high efficiency, low cost and high reliability. The high efficiency of the converter output will be achieved by having the input PV power fed forward to the output without being processed and only a portion of the PV power is processed by the converter depending on the voltage regulation requirement. Here Peturb and Observe

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MPPT controller algorithm will be used for locating maximum power points, at any sunlight conditions for extracting the maximum power from the PV module and transferring that power to the load. The performance of the proposed topology is analyzed with the help of MATLAB/Simulink model.

III MATHEMATICAL MODELING OF PV SOLAR CELL

A photovoltaic Panel consists of a number of photovoltaic cells connected in series and parallel configuration. It is important to understand the operation of a single photovoltaic cell, and then the operation of the module under different conditions is easier to understand. An ideal photovoltaic cell consists of a current source and a diode. An ideal model of a photovoltaic cell has an additional shunt resistance connected parallel to the diode and a series resistance is shown in the Figure.

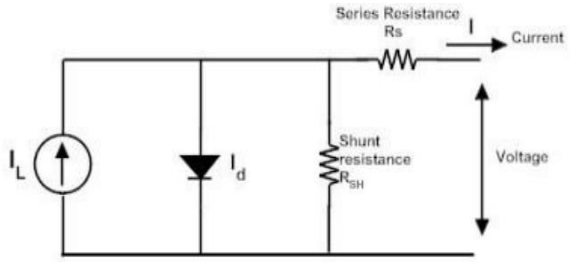

Figure 1. Equivalent circuit of PV Solar Cell.

The basic equation from the theory of semiconductors [6] that mathematically describes the I–V characteristic of the ideal PV cell is:

$$I = I_{ph} - I_d \quad \ldots\ldots (1)$$

$$I = I_{ph} - I_o\left[exp\left(\frac{qV}{kT}\right) - 1\right] \quad \ldots\ldots (2)$$

$$I = I_{ph} - I_o\left[exp\left(\frac{qV + IRs}{nkT}\right) - 1\right] \quad \ldots\ldots (3)$$

Where:

Iph=photo generated current, Io=reverse saturation current, V= terminal voltage, q is the electron charge, k is Boltzmann constant (1.38×10 -19 J/K) and T is the junction temperature in Kelvin (K) and n is the diode ideality factor In order to model the solar panel accurately we can use two diode model but in this project our scope of study is limited to the single diode model.

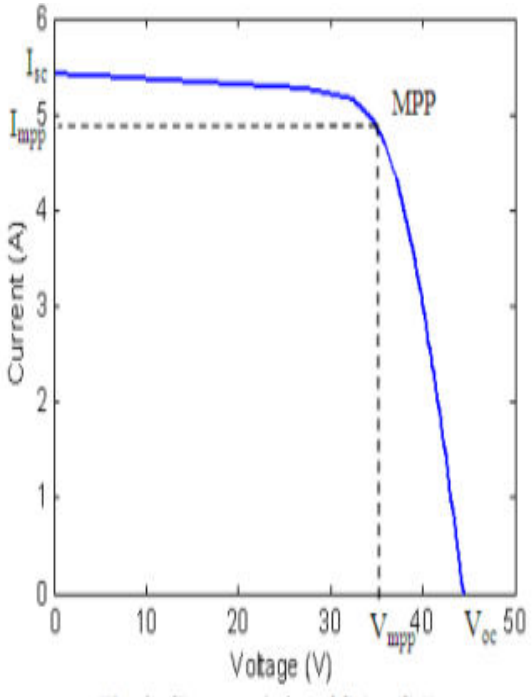

Figure 2 : Characteristics of Solar Cell

IV SYSTEM ANALYSIS

EXISTING METHOD:

The maximum power point (MPP) is proposed. As has been shown, there are many ways of distinguishing and grouping methods that seek the MPP from a photovoltaic (PV) generator. However, in this article they are grouped as either direct or non-direct methods. The indirect methods ("quasi seeks") have the particular feature that the MPP is estimated from the measures of the PV generator's voltage and current

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PV, the irradiance, or using empiric data, by mathematical expressions of numerical approximations. Therefore, the estimation is carried out for a specific PV generator installed in the system. Thus, they do not obtain the maximum power for any irradiance or temperature and none of them are able to obtain the MPP exactly. Subsequently, they are known as "quasi seeks

PROPOSED METHOD

In this proposed method proposes the design and control of a single-phase grid-connected photovoltaic (PV) system. A 5-kW PV system is designed and integrated at the DC link of an H-bridge voltage source converter (VSC). The control of the VSC and switching logic is modeled using a generalized integrator (GI). The use of GI or its variants such as second-order GI have recently evolved for synchronization and are being used as phase locked loop (PLL) circuits for grid integration. Design of PLL circuits and the use of transformations such as Park's and Clarke's are much easier in three-phase systems. But obtaining in-phase and quadrature components becomes an important and challenging issue in single-phase systems. This article addresses this issue and discusses an altogether different application of GI for the design of compensator based on the extraction of in-phase and quadrature components. GI is frequently used as a PLL; however, in this article, it is not used for synchronization purposes. A new controller has been designed for a single-phase grid-connected PV system working as a single-phase active compensator

Block diagram

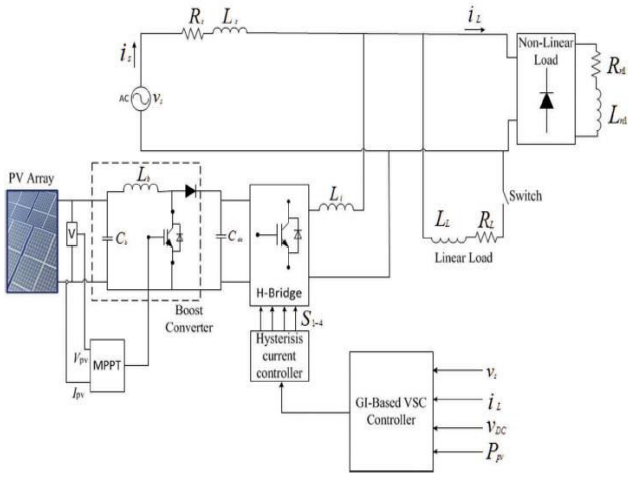

Figure 3: System configuration of single-phase double-stage grid-connected system.

V. METHODOLOGY

Grid-Connected Solar Photovoltaic (SPV) System

illustrates the schematic diagrams of the grid-connected PV system. Two-stage energy conversation systems are used in this work. The first stage of the energy conversion system consists of a PV array and a DC–DC converter, which boosts the relatively low SPV system voltage to match the inverter input voltage rating. The next stage consists of a voltage source converter (VSC) connected to the grid via an L-filter and a step-up transformer, to increase the inverter voltage to match the grid voltage [28]. The incremental conductance (IC) maximum power point tracker (MPPT) for the PV is implemented on the boost converter for extracting maximum power under normal condition. The "control without MPPT" controller is adopted under fault conditions. The inverter control scheme is modified to inject the required reactive current into the grid under fault conditions, by using the developed reactive power inject.

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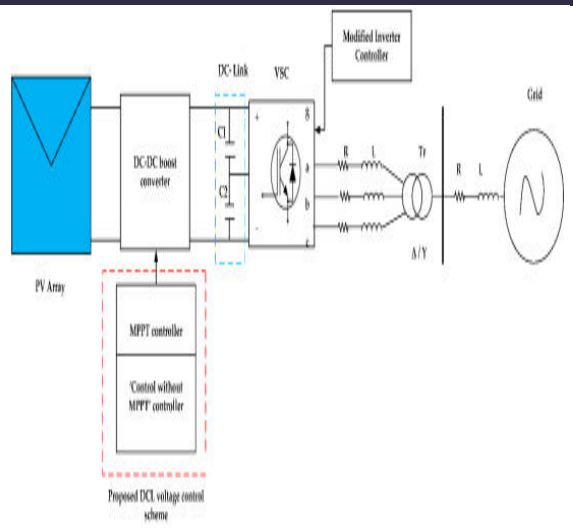

Figure 4. Schematic diagram of the grid-connected photovoltaic (PV) system. VSC: voltage source converter; DCL: DC-link; MPPT: Maximum power point tracking.

Direct Current–Direct Current (DC–DC) Boost Converter Mode:

As the voltage of PV arrays is not sufficient as input into the inverters, a DC–DC boost converter should be connected in order to increase the DC voltage under certain conditions. The structure of the boost converter is shown in Figure 2. The input-output voltage relationship of the DC–DC converter is (1):

$$V_{in} = V_o(1 - D)$$

where D is the duty cycle, Vin is the input voltage, and V0 is the output voltage.

$$V_{rip} = \Delta V_o / V_o$$

To reduce the ripple voltage, the pulse-width modulation (PWM) frequency of the pulse generator was reduced. However, we could not increase the frequency beyond a certain value because a higher Appl. Sci. frequency produces large energy losses in the circuit.

The proposed DCL control scheme is shown in Figure 4. During normal operating conditions, the incremental conductance (IC) MPPT method is applied to track the maximum power from the PV arrays. Under three-phase fault conditions, the inverter cannot inject the SPV system with the maximum power into the grid owing to the sudden voltage sag.

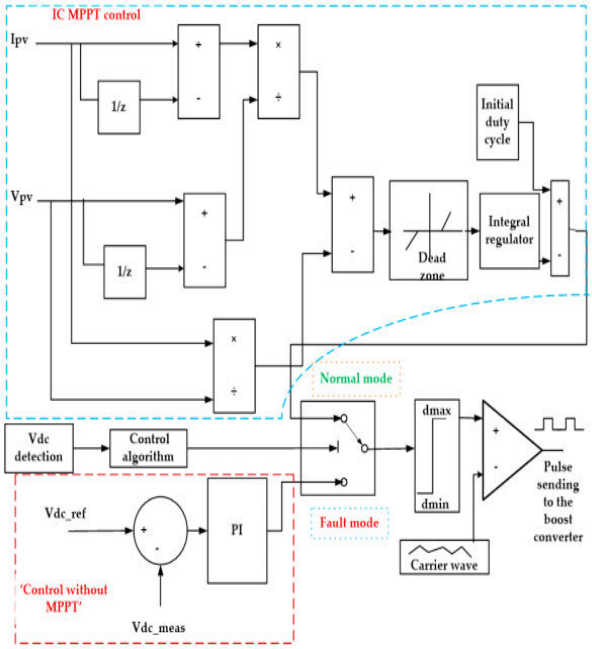

Figure 5. Proposed DC-link voltage control .

VI.RESULTS

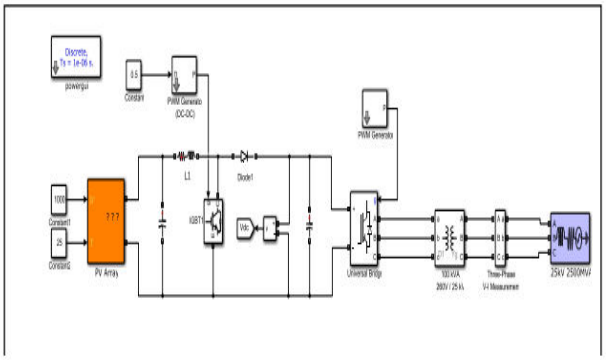

Figure 6. Simulation of Grid Connected PV System.

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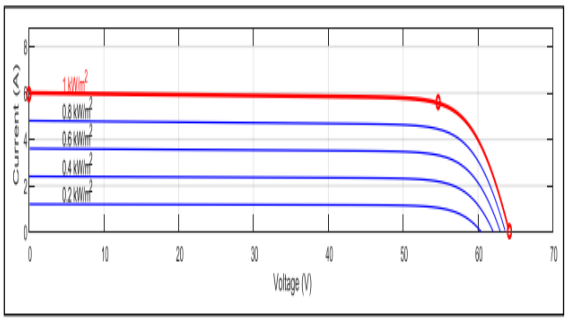

Figure 7. I-V Characteristic of Simulated PV Panel in Different Solar radiation.

The I-V and P-V characteristics of Simulated PV panel in different solar radiation level are depicted in Figure 5 and Figure 6, respectively. From this characteristic it can be notice that the Output of PV solar farm is varies with the different solar radiation level.

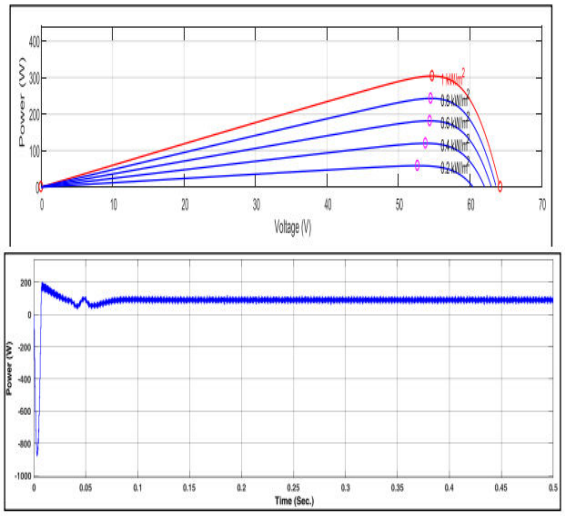

Figure 8. Output Power of PV Solar Farm.

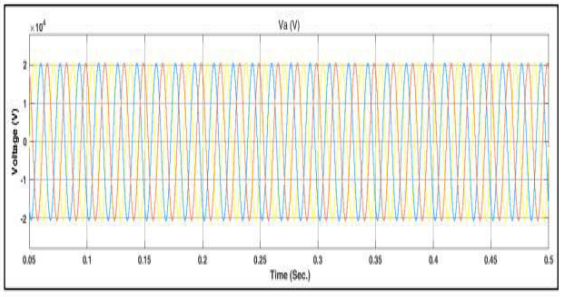

Figure 9. Grid Voltage Waveform

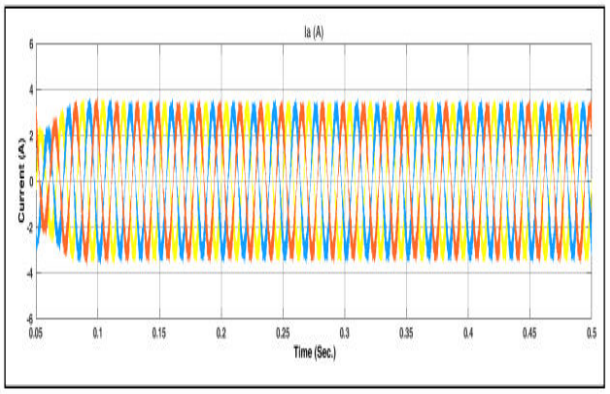

Figure 10. Output Current of PV Solar Farm.

VII.CONCLUSION

In this Paper, The Grid connected PV Solar Farm is simulated in MATLAB Environment. The design of the system is carried out for feeding 100KW power to the grid The Inverter is controlled in order to feed active power to the grid. The output of PV Solar arrays is depends on the Level of Solar radiation. In higher solar radiation level, the output of PV Array is Maximum.

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