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GRID INTEGRATION OF PV SYSTEM USING EFFECTIVE SYNCHRONIZING METHOD

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Abstract

Grid-connected renewable is progressively developed in recent years, in photovoltaic systems. As the number of Distributed Power Generation Systems linked to the utility network grows, in terms of safe running, power quality, and islanding protections, severer and original standards are main issues. It is critical to better control the Distributed Power Generation System in order to meet the grid connection requirement. Synchronization of the injected current and frequency with the grid is mandatory. The synchronization algorithm is based on a synchronous reference frame (SRF) based phase locked loop (PLL) system that detects positive phase sequences. To ensure the correct creation of the reference signal, grid linked converter controllers are utilized for fast and accurate detection of the phase angle, amplitude and frequency of the utility voltage. PLL algorithms are a promising method for grid synchronization and monitoring in many grids connected PV system. Over the years, a variety of synchronization techniques have been proposed to overcome issues such as unbalanced conditions and frequency fluctuation. Because Second Order Generalized integrator (SOGI) is resonance at its fundamental frequency, avoids filtering delays, and is straightforward to construct. In this work, the SOGI PLL technique will be utilized to match the frequency and phase angle of the solar system output to a single-phase grid connected system, as well as continuous operating load, for experimental results. Further in future, this technique can be compared by other method of synchronization by changing few components of system model.

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1. Introduction

Recently, Photovoltaic panels are becoming more affordable, and enhanced PV technology in solar systems are allowing more Photovoltaic power generation systems to be connected to medium-voltage and high-voltage networks. However, grid-connected PV generation units may have a significant detrimental influence on the entire system because they cannot operate like traditional power plant with synchronous generator [1]. So, many components and subsystems are used in grid connection of solar PV system regulation. Because of emerging applications such as grid integration of small-scale renewable energy sources, vehicle to grid and grid to vehicle connections, low power rating in interruptible power supplies, and small-scale power quality conditioner, single phase power converters have also received a lot of attention [2]. The synchronization portion is the most difficult part of any single-phase converter system, with the goal of ensuring a seamless connection to the utility and analyzing grid conditions. Utility grid and synchronized power system work together to track the power angle of grid input values, to detect frequency variation, to eliminate harmonic components of signal and to respond to utility grid changes in less time.

The basic block diagram of grid connected PV system with grid synchronization and current controller is as shown in Figure 1. A deviation from the prescribed limits indicates an abnormal condition that may necessitate the PV system being disconnected from the grid. The detection of the grid phase angle can also be employed for anti-landing detection method [4]. These are divided into two categories: frequency domain and time domain. Due to their simplicity and durability, the PLL method is the most prevalent synchronization mechanism for grid-connected inverter applications [3].

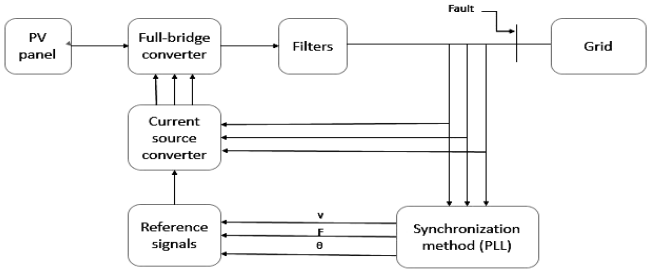

Figure 1. Block diagram of grid connected PV system.

A benchmarking of the most regularly used PLL approaches that could lead to the development of new PLLs as well as the enhancement of existing PLLs. As a result, the best synchronization system will ensure a good, dependable control of the vaccinated current, as well as good, reliable, and stable operation of the overall grid-connected inverter system [5]. Recent advances in single phase synchronization method is analyzed, Brief analysis in islanding method and its type is discussed in section, advances in PV inverter is reviewed in [6].

The dq-PLL method, commonly known as SRF-PLL, is standard algorithm synchronization method that is employed here. This approach is simple to use, but it is sensitive to imbalanced grid power, which might result in errors when measuring frequency and phase [7]. A large amount of study has been done to solve this problem, which may find in [8].In this paper, grid synchronization method is proposed using SOGI-PLL technique for different frequency source of generating stations and transmission line.

2. Literature Review

2.1 System description: The goal of power electronics in a PV system is to convert DC electricity from PV panels into AC current as efficiently as possible while keeping costs low. Basic control functions and auxiliary control functions are two types of control functionalities. The maximum power extraction is one of the basic control functions. The current and voltage management, as well as the detection of unintended is landing, require the most is synchronization. The right design of the current and voltage controllers, as well as the synchronization system, results in high power factor operating and harmonic reaction. The photovoltaic power source controller, which consist of a maximum power point tracking (MPPT) and a DC voltage controller, provides the current and voltage control reference signal. The maximum power extraction is handled by the MPPT algorithms [9, 10].

2.2 PV Modeling: PV cells are connected in series, parallel, or a combination of the two for increased power output and efficiency. String refers to the number of PV cells connected in series, whereas PV array refers to the number of strings connected in parallel. In case of series combination of

cells, open circuit voltage (Voc) become double and short circuit current (Isc) remain same. And in case of parallel combination of cells, short circuit current (Isc) become double and open circuit voltage (Voc) remain same. PV modeling is purely based on values of parameters.

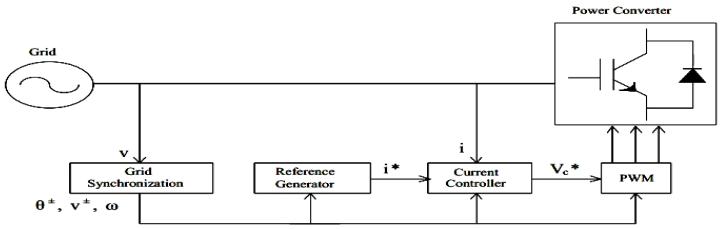

Figure 2. Block diagram of power converter controller.

2.3 Grid Synchronization method: Various grid synchronization challenges are discussed, and various estimation methods for phase angle, frequency, and harmonic estimation have been developed for grid connected converter synchronization. In [11], several synchronization methods for grid integration are proposed, as well as a current comparison and analysis of the approach, critical hurdles to smart synchronization method, and future feasible study.

3. Methodology

Voltage and current sensors of this array gives primary signal to the MPPT controller (from which maximum output adjusts the duty ratio in such a way that when this duty ratio is applied to the boost converter, it gives maximum electrical power output) and to the PLL synchronizer (from which this signal gets synchronize with grid voltage and current). Error values from PLL synchronizer given to the current and voltage regulator, such that this error signal will detect and compensate the error values and gives synchronized value of voltage and current to the inverter. Output from converter is fed to the inverter through DC link. Figure 3 shows the block diagram of grid connected photovoltaic system with modeled systematic arrangements used in this work.

In this, experimental performance is done in MATLAB Simulink model, model simulation time is 0.1 second. There are various subsystems connected with proper arrangement, each subsystem have their own working model. Main subsystem of this model is discussed.

PLL and measurements subsystem: These subsystems contain various blocks are: Phase Locked Loop (PLL), PLL drive, Dq transform.

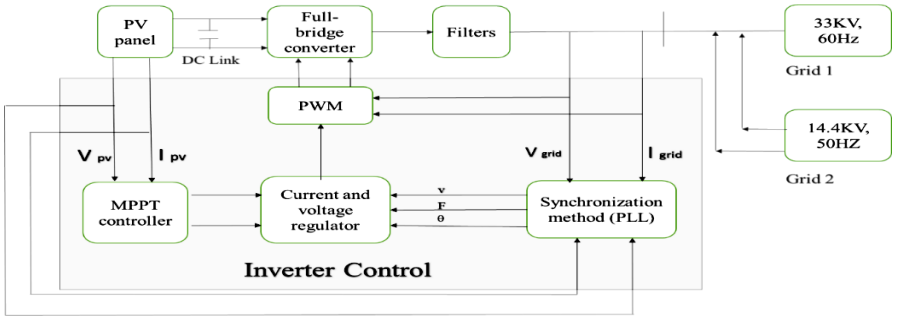

Figure 3. Block diagram of grid connected solar PV system model.

Phase locked loop: A PLL system typically consists of a Second Order Generalized Integrator (SOGI) type Phase Detector (PD), a Loop Filter (LF) performed by a PI controller, and a Voltage Controlled Oscillator (VCO). The fundamental block diagram of a PLL system, which is frequently used in grid-connected applications, is shown in figure 4.

PLL technique approaches have been proposed in a variety of ways. The T/4 Delay PLL, Inverse Part Transform (IPT) based PLL, Enhanced PLL (EPLL), and SOGI-PLL methods. Among these SOGI-PLL technique is used in this model. SOGI (Second order generalized integrator) is a phase detector circuit. Input voltage is converted into alpha beta component of voltage, this alpha beta voltage is converted into dq terms of voltage and this process is called park transformation. q component of voltage is shift to the reference voltage or it can be understood like q component is in phase with reference voltage such that its value becomes zero because of the sin component of voltage, d component or d axis is a cos component of voltage.

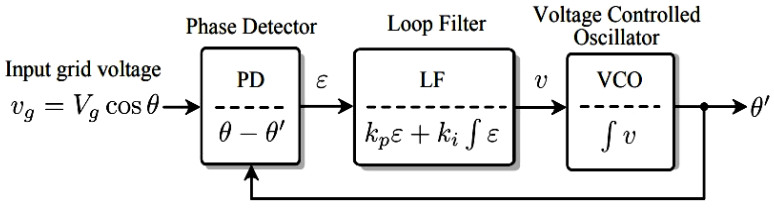

Figure 4. Basic block diagram of all PLL.

4. Results and Discussion

In Figure 5.1. Yellow waveform shows output grid voltage and also blue waveform shows output grid current. Transient distortion occurs in grid current for 0.03 second, and after that grid current settle down to normal value.

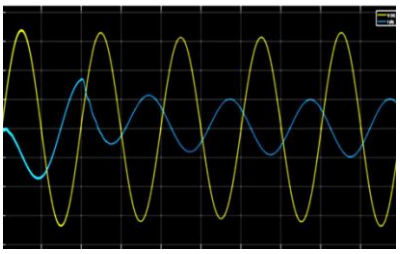

Figure 5.1. Output of grid voltage and current.

In Figure 5.2. Output waveform of utility grid is shown, when two different generating stations is connected, then after synchronization, frequency and amplitude of both grid become same.

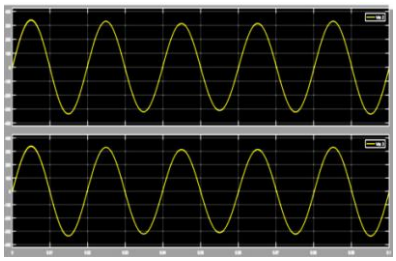

Figure 5.2. Output of utility grid 1 and utility grid 2 after synchronization.

In Figure 5.3. Waveform shows the output value of utility grid 1, when utility grid 2 is disconnected from the system. Upper waveform shows some distortion, this due to the noise of transmission system, which is settle down after 0.03sec.

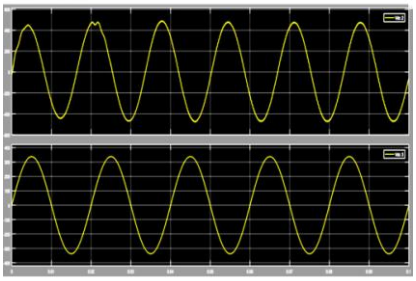

Figure 5.3. Output of utility grid 1 and utility grid 2 (disconnected from main grid) before synchronization

Figure 5.4 shows the output voltage waveform of utility grids, when grid 1 is disconnected from the grid. Each grid has their own voltage waveform at specified frequencies (grid 1: - 60Hz, grid: - 50Hz).

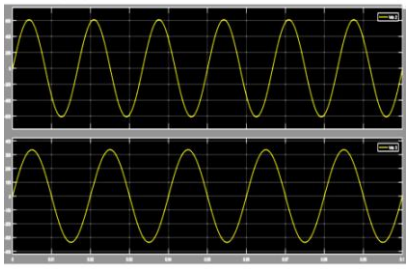

Figure 5.4. Output of utility grid 1 (disconnected from grid) and utility main grid 2 before synchronization.

4. Conclusion

This paper studies the performance of PV system connected to the utility grid which consist of a P&O tracker, PID controller, PV array, filter and inverter with VSC control and synchronizer. From the result discussion and simulation waveforms, it is concluded that SOGI-PLL is able to synchronize the different generating station at constant voltage supply and frequency and lock the system with grid at correct instant. MPPT tracker is able to maintain the DC voltage at constant level, current regulator is able to remove the reactive component grid current and thus able to maintain the unity power factor operation, reference generation through three level VSC control is achieved and the grid is synchronized with the PV system. Comparison of various methods of synchronization will be done in future in terms of THD, offset voltage, transient voltage etc., for better improvement in synchronization.

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