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Efficient Operation of Solar Power Grid using Single Stage Single Phase Inverter

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ABSTRACT

PV Panel is connected to a single phase inverter which is connected to a Grid voltage. In this project the issue of control strategies for single-stage photovoltaic (PV) inverters is addressed. We used controllers and they have been implemented and an experimental comparison between them has been made.A complete control structure for the single-phase PV system is also presented. The main elements of the PV control structure are: - a maximum power point tracker (MPPT) algorithm using the incremental conductance method; we also used a battery that is connected inorder to charge or discharge purposes.

KEYWORDS: Single Phase Inverter, Battery, Capacitor, PV Panel, MPPT, Grid Voltage, PLL, Low pass filter, Unit Delay, PI and PR controllers, Integrator, Charging and Discharging, Sine PWM

1. INTRODUCTION

Single phase inverters have broad applications such as photovoltaic(PV) power generations and power supplies.However,the ripple power ,especially the second harmonic pulsating power,flows through the dc side of a single phase inverters,causing the 2w voltage ripple of the dc bus.The 2w ripple must be minimized or at least restricted to an engineering tolerance range.For this purpose,large dc-link capacitors are generally required,which leads to high volume,highweight,and low reliability.Alternatively ,extra circuits were introduced into single-phase invertersto buffer the 2w ripple power.In this Project, single phase voltage inverter connected to a grid and supply will be given by PV panel or Battery.

2.PVPANEL

- PV panel or solar panel is an assembly of photovoltaic solar cells mounted in a frame and a neatly organized collection of PV panels is called a photovoltaic system or solar array.
- Build of strings in parallel.
- Produce electricity directly from sunlight.
- DC to AC using inverter.

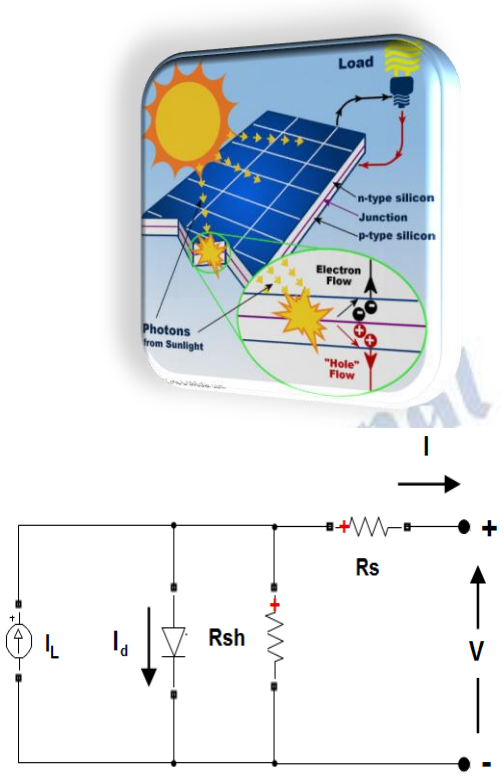


Fig 2.1 & 2.2 PV Panel & Circuit Diagram

3.ADVANTAGES OF USING PV PANEL:

- PV panels provide clean and green energy. During electric current generation with photovoltaic panels, there is no harmful greenhouse gas released in the environment.
- Solar PV is **eco-friendly**.
- The prices for solar panels are being quickly lowered and are projected to be further reduced over the next few years.
- The cost of installing and repairing PV panels compared to other clean energy systems was viewed as minimal and almost zero.
- PV panels are absolutely quiet and create no noise at all. They are therefore an ideal option for urban and suburban uses.

4. SINGLE PHASE INVERTER

The power circuit of a single phase full bridge inverter comprises four thyristors T1 to T4, four diodes D1 to D1 and a two wire DC input power source Vs. Each diode is connected in antiparallel to the thyristors viz. D1 is connected Single Phase Full Bridge Inverter is basically a voltage source inverter.

Unlike Single Phase Half Bridge Inverter, this inverter does not require three wire DC input supply. Rather, two wire DC input power source suffices the requirement. The output frequency can be controlled by controlling the turn ON and turn OFF time of the thyristors in antiparallel to T1 and so on

5.IMPORTANCE OF SINGLE PHASE INVERTER IN PV GENERATION

- To remove the ripples by connecting PV Panel to the single phase inverter and grid voltage
- To increase the efficiency of power
- To bring the unity power factor between Grid voltage and Inverter Output voltage
- Battery is connected to the PV panel, to get the supply when PV panel is OFF.

6.MAXIMUM POWER POINT TRACKING

The task of the MPPT in a PV energy conversion system is to continuously tune the system so that it draws maximum power from the solar array regardless of weather or load conditions. Since the solar array has non ideal voltage-current characteristics and the conditions such as irradiance, ambient temperature, and wind that affect the output of the solar array are unpredictable, the tracker should deal with a nonlinear and time-varying system.

The incremental conductance algorithm has been chosen as a MPPT strategy in this paper. This algorithm has advantages compared to perturb and observe as it can determine when the MPPT has reached the MPP, where perturb and observe oscillates around the MPP.

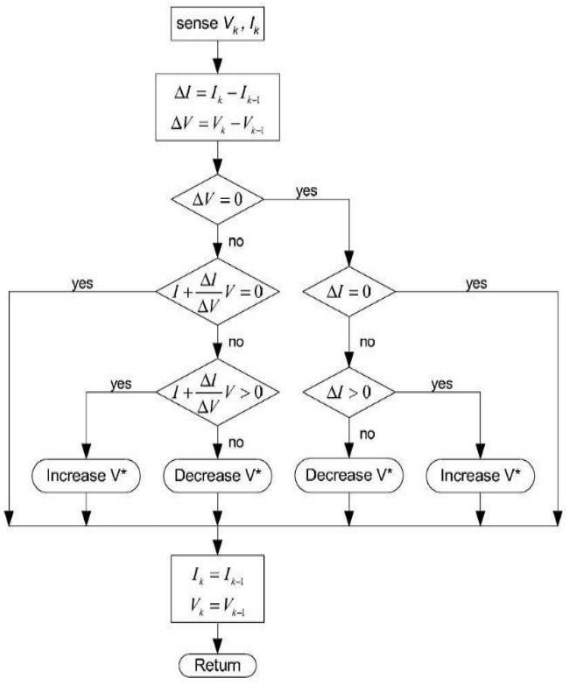
Also, incremental conductance can track rapidly the increase and decrease of irradiance conditions with higher accuracy than perturb and observe.

One disadvantage of this algorithm is the increased complexity when compared to perturb and observe. This increases the computational time and slows down the sampling frequency of the array voltage and current. The Vk and Ik are the momentary voltage and current of the PV array and Vk-l and Ik-i are the previous voltage and current, respectively. The dP/dV term can be replaced by I + (AI/AV) * V . The output of the MPPT is the dc voltage reference (V*8).

MPPT algorithms are typically used in the controller designs for PV systems. The algorithms account for factors such as variable irradiance (sunlight) and temperature to ensure that the PV system generates maximum power at all times. Assumptions of this

method is output conductance ratio of change is equal to change in ratio of output Instantaneous negative conductance we have P=VI

The Flowchart of the incremental conductance algorithm is shown in Fig:



Incremental conductance:

This algorithm, shown below, compares the incremental conductance to the instantaneous conductance in a PV system. Depending on the result, it increases or decreases the voltage until the maximum power point (MPP) is reached. Unlike with the P&O algorithm, the voltage remains constant once MPP is reached.

7.BLOCK DIAGRAM

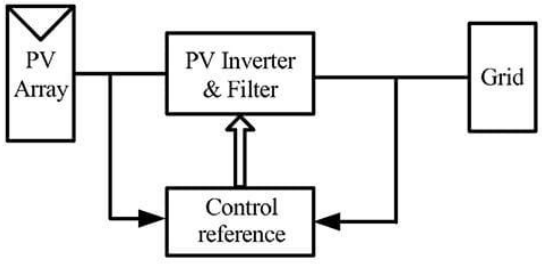


Fig .7.1 schematic diagram of the panel grid system

The purpose of power electronics in PVPS is to convert the dc current from the PV panel into ac current to the grid, with the highest possible efficiency , the lowest cost and to keep a superior performance. The basic interfacing is in fig7.1.

7.1 SIMULATION OF PV PANEL CONNECTED TO SINGLE PHASE INVERTER TO GRID VOLTAGE

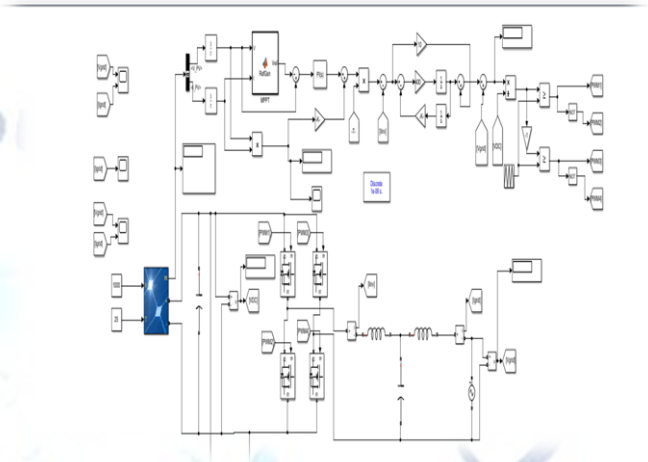


Fig.7.2 simulation of this project in matlab

A synchronous Reference Frame PLL (SRF PLL) is utilized for following the stage point if there should arise an occurrence of 3-stage signals which meets expectations in a comparable manner as a direct PLL with just distinction in the Phase Detector (PD) piece. It uses Park's Transformation of a 3-stage motion as the PD. To begin with square in the figure is Clarke's Transformation which deciphers a 3-stage voltage vector from the abc common reference edge to the αβ stationary reference outline. The second square is the Park's Transformation which deciphers the αβ stationary reference edge to a rotating frame.

8.PHASE LOCKED LOOP [PLL]:

- A phase-locked loop combines a voltage-controlled oscillator and a phase comparator as a feedback system to adjust the oscillator frequency or phase to track an or phase modulated signal.
- The main goal of PLL structure is to synchronize the output oscillated signal with a reference signal.

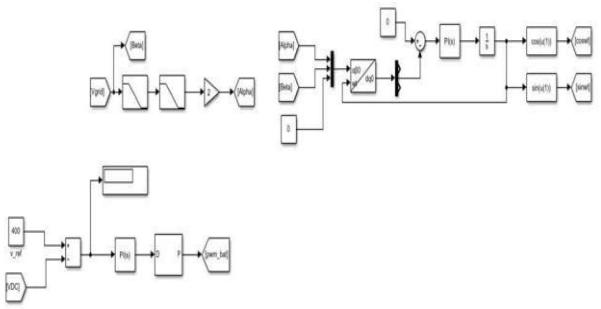


FIG.8.1 Simulink of PLL

- Reduce the errors.
- It is used for grid voltage monitoring.
- Phase detector
- Voltage Controlled Oscillator

8.2 PLL Structure:

A phase-locked loop combines a voltage-controlled oscillator and a phase comparator as a feedback system to adjust the oscillator frequency or phase to track an applied frequency-modulated or phase-modulated signal.

The PLL is used to provide a unity power factor operation which involves synchronization of the inverter output current with grid voltage and to give a sinusoidal current reference.

The main goal of PLL structure is to synchronize the output oscillated signal with a reference signal. PLL reduces the phase errors between the output and input frequency and phase difference between the two signals.

The PI controller parameters of the PLL structure are calculated in such a way that we can directly set the settling time and the damping factor of this PLL structure.

The PLL structure is also used for grid voltage monitoring in order to get the amplitude and the frequency values of the grid voltage.

The block diagram of a basic PLL is shown in the figure below. It is basically a flip flop consisting of a phase detector, a low pass filter (LPF),and a Voltage Controlled Oscillator (VCO). The input signal Vi with an input frequency fi is passed through a phase detector.

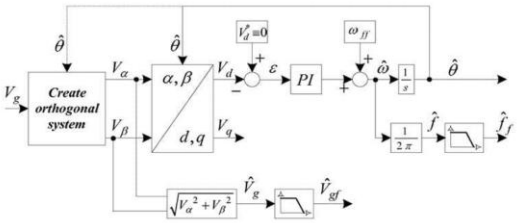


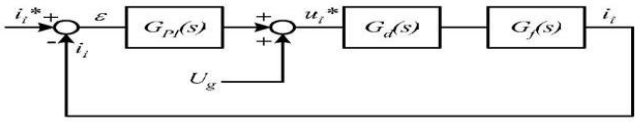
FIG 8.2 structure of PLL

9.GRID CURRENT CONTROLLER:

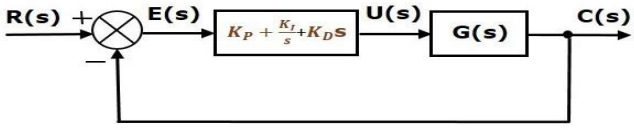
Classical PI control with grid voltage feed-forward (Ug), is commonly used for current-controlled PV inverters.

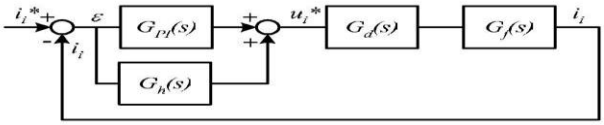
The Current loop of PV Inverter with PI controller:

$$u = \underbrace{K_p e}_{\text{Proportional Term}} + \underbrace{K_i \int_0^t e\,dt}_{\text{Integral Term}} + \underbrace{K_d \frac{d}{dt} e}_{\text{Differential Term}}$$



The Current loop of PV Inverter with PR controller:





GRID VOLTAGE AND GRID CURRENT:

The grid voltage and the grid current for PI ,PR+HC controllers are presented here.

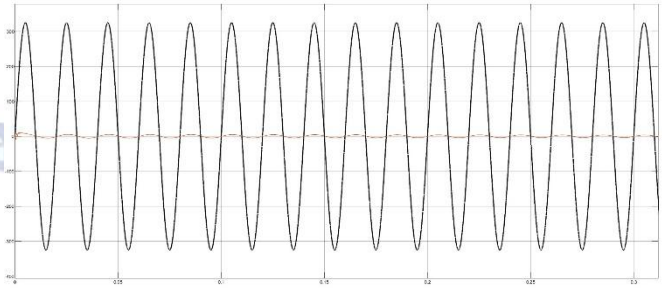


Fig: Vgrid and Igrid

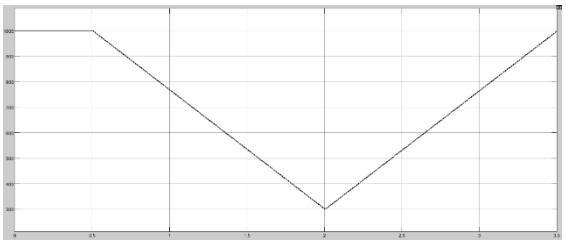


Fig: radiation and time graph

10.CONCLUSION:

The Single Phase Inverters are used because of their good efficiency, lower price and easier implementation. The Single phase Inverter connected to the voltage grid is connected to the PV panel which thus increases the efficiency of the power system. If MPPT had not been used, then the user would have had to input the duty cycle to the system. When there is change in the solar irradiation the maximum power point changes and thus the required duty cycle for the operation of the model also changes. But if a constant duty cycle is used then maximum power point cannot be tracked and thus the system is less efficient.

The dc-link capacitor is used to minimize the ripple power. Here the value of capacitor is 0.6mF.

The Low pass filters(LCL) are used inorder to remove the higher harmonics.The PI controller is used to calculate an error signal by taking the difference between the output of a system. The PLL is used to control the grid voltage.

Improvement in this project can be made by adding an extra circuit to remove Active power decoupling produced by the PV panel which reduces the size of the capacitor.

We can do active power decoupling based on Boost and Buck converter for Single Phase Inverter.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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