A STUDY ON CONTROL STRATEGIES FOR DIFFERENT SOLAR GRIDS

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Abstract

Ever-rising concerns on climatic changes and accelerated depletion of fossil fuels raised by the world needs an immediate action to accelerate the clean energy generation with available renewable energy resources (RES). Hence the involvement of alternative energy sources is growing at a faster pace. There are many renewable sources like solar, wind, hydro, geothermal, etc but only a few pertain the adequate potential. Alternative from solar energy for daily needs is one such platform which has immense potential and is universally accessible with least environmental effects. Solar photovoltaic (PV) is a promising solution for extracting solar energy. Along with the growing dependence, there is a thriving need for the development and advancement of the technologies presently on the deck. This is a platform which needs the ultimate attention in the current scenario. This paper focuses on the analysis of the available trends in inverter technology for grid tied solar PV systems to make it fast and reliable thereby reducing losses and mitigating harmonics. Some of the inverter control strategies will be discussed here to improve the overall efficiency of the system by modifying synchronous reference frame (SRF) technique. The adaptive dc link technology is being focussed in all the topologies as it helps in reducing the switching losses in the system.

Keywords: *Solar PV, SRFT, Adaptive DC Link,*

INTRODUCTION

Solar power generation has shown a humungous rise in the last decade. The role of inverter in the photovoltaic power generation system as a power conditioning circuit has taken the most important place. The function of inverter is not just of converting dc to ac but also to maintaining output power quality matching the necessary standards, protective functions and control of power. The power conversion equipment is needed to be cost effective, efficient and reliable and should be able to work efficiently over a wide range of input voltage variation, as the intensity solar radiation is never constant. The International Energy Agency has classified the PV applications in four categories viz. Off grid domestic, Off grid non domestic, grid connected distributed and grid connected centralized. The first two categories are standalone systems while the rest two are grid connected systems. The inverters, often known as grid connected PV inverters or grid tied inverters have to produce electrical output which matches always with the voltage, frequency and phase of the grid. This requires an accurate and effective method of control of inverters. Some basic inverter topologies for single stage and multistage inverters have been discussed here and then comparison of three basic methods of control of grid interactive inverters is discussed.

Different Inverter Topologies

Here we discuss the basic inverter topologies of inverter for single stage and multiple stage inverters. The single stage inverter topology consists of one stage of power conversion for stepping up the low dc voltage available from the PV panel and modulating the sinusoidal load current or voltage. Figure 1(a) shows single stage and Figure 1(b) multi-stage inverters.

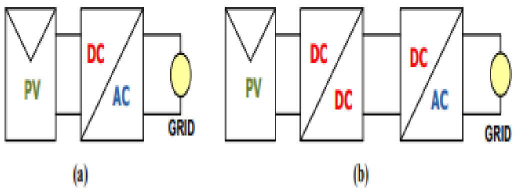


Fig -1: (a) Single stage inverter (b) Multistage inverter

The single stage inverters are classified as buck, boost and buck-boost. Further they are classified as four switch and six switch inverters depending upon the number of switches the inverter uses. The choice of the type depends upon the requirement of particular application. As seen in Figure 1(b), in a multistage inverter, the boost and isolation are carried out in the first stage while inversion is done in the second stage. Each stage can be controlled individually or synchronously. The multi-stage inverters are classified as dc-dc-ac, dc-ac-dc-ac and dc-ac-ac topologies. In the dc-dc-ac topology, the first stage gives elevated dc with tolerable ripples as input to the second stage which is a simple buck inverter.

Inverter Control Techniques

Some of the prominently used inverter control strategies for SPV system have been discussed in this section. Grid synchronization is one of the major area to be concentrated upon on design and development of grid supportive solar PV systems. To achieve normal operation and control of voltage source converter the phase and frequency of grid need to be determined. A phase locked loop (PLL) distinguishes the phase and frequency value of the utility voltage and develop a synchronized output signal. Conventional PLL does not have the ability to cancel out the double frequency ripple of input signal, to overcome this delay an enhanced PLL was proposed (EPLL). Phase differences are provided by the EPLL to compare actual current with different components of current to generate firing pulses. This system helps in attaining unity power factor (pf) and balancing both linear and non-linear loads.

Control Structure of PV Inverter

The fundamental types of control can be classified into two types: voltage control and current control. Voltage amplitude and frequency of inverter gets synchronized with each other, when it is connected to the grid. The classical current control is classified as active power and reactive power control method. The grid frequency is tracked by a phase locked loop (PLL). The inverter assembly circuit with control strategy. The voltage and current of the grid is taken as reference and it is transformed to mathematical equation with current control structure and given as duty cycle to the inverter

Modeling Of Pv Panel

Due to the fact the VoIP mobile has become easily the most fundamental part of the PV technique, true simulation of an VoIP mobile is necessary for acquiring a productive PV technique. A number of experiments are conducted previously on PV module modelling in addition to topological definitions which can be employed in isolation or in conjunction having a grid. For great filming of the PV collection, the topology platform has to be picked closely. You'll find several different types of PV cells out there from the literature, for instance, suitable version, two-diode version, along with also single-diode version. An perfect version of this PV module might also be clarified by way of a photo-generated current-source Iph as well as also a diode in parallel, as stated by the legislation of mathematics. Even the p-n intersection of this PV module is closely characterized as diode D, and latest by way of this diode i-d is your speeding present during the p-n intersection as a result of diffusion mechanism. This really could be the simplest version, as it's thought to be loss less. Nevertheless, the setup of the PV module isn't precisely represented via this version.

Table: Types of PV cells

SL. No.	Types of PV Cell	Properties
1	Mono-crystalline	∗ Made up of a single material called silicon. ∗ Most efficient in power generation in good weather conditions. ∗ Energy conversion efficiency is 12-15%.
2	Poly-crystalline	∗ Made up of a material called Poly-crystalline silicon which is composed of a number of small silicon crystals. ∗ It is also efficient in good light conditions. ∗ But, it has less embodied energy than mono-crystalline. ∗ Energy conversion efficiency is 11-14%.
3	Thin-film	∗ Made up of materials like CdTe, CIGS, CIS, Amorphous Silicon (a-Si). ∗ It is efficient even in poor light conditions. ∗ Very low embodied energy. Most environmental friendly. ∗ Energy conversion efficiency is 6-12%.

Inspire of how the activity of a two-diode product ardently reflects a physical PV module, the version is equally both more nonlinear rather intricate. It's extremely intricate to analyses mathematically. The setup of one diode PV module is significantly much more straightforward than this of the two-diode version, in spite of how it's nonlinear. Like a consequence, analyzing this version is significantly much more straightforward than simply just minding the two-diode version. It frequently responds readily to some alterations while inside the machine's functional parameters.

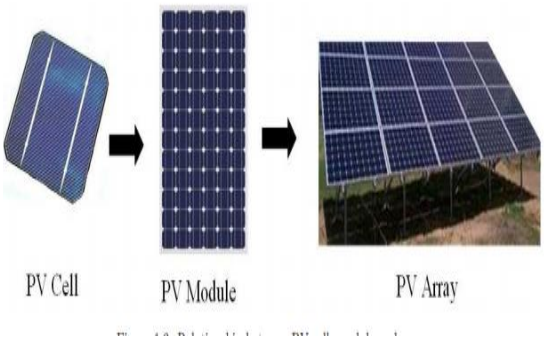


Figure: Relationship between PV cell, module and array

MAXIMUM POWER CONTROL USING MPPT

But just an MPPT that has a fantastic monitoring algorithm for locating the MPP at a brief length of time plus also an effective control may create the made PV electrical strength usable for useful utilization. Like a result, MPPT exploration is necessary for improving the operation of both all PV cells. Back in earlier times much analysis was dedicated to improving the overall durability and strength of PV programs. Inspite of the simple fact PV electricity transformation to electric power is just one among the quickest climbing engineering in a variety of nations, PV programs have downsides like substantial construction outlays, inadequate vitality conversion operation, and strength production irregularity as a result of ecological addiction on Due to the fact the operation quality of your PV panel has been light, solar irradiance and temperature have a noticeable impact in the change of its own output signal PV electrical strength price. Like a effect of the doubt and randomness of both PV electrical energy manufacturing, the operation of the PV electrical strength apparatus varies considerably. The highest power purpose of PV cells, particularly, fluctuates somewhat using solar irradiance and fever. The typical energy generating functionality of advertisement PV panels is exceptionally very lower.

RESEARCH METHODOLOGY

Design of power controller:

The power measurement module, the LPF, the droop controller, and also the voltage enhancer module, also as found at Fig. 1, then create up the power control assembled inside this report. Voltage and present in those heaps, that can be accumulated from the measurement module, which therefore are traditionally all utilized to find out the micro power's prompt active and reactive output power. Even the LPF could possibly be utilized to figure out the corresponding moderate induce. The frequency and voltage amplitude of this grid, respectively, therefore are both Pn and U0, and also the output ranked energetic power of micro power is currently Pn.

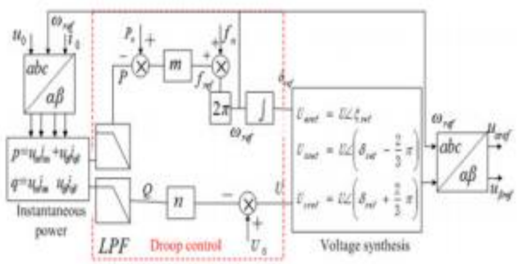


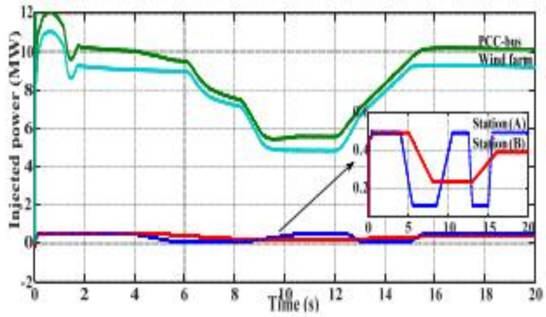
Figure: Schematic diagram of power controller

RESULTS

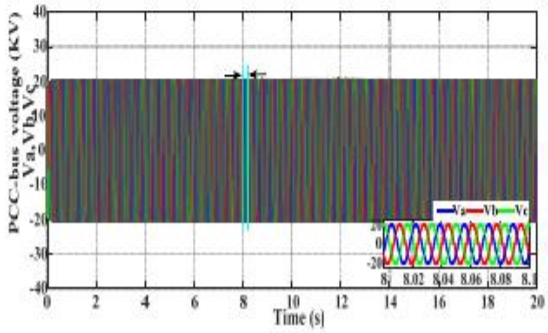
Injected Power from Hybrid System Larger than Plant Load

In this case, the generated power from PV stations and wind farms is greater than the plant's specific burden requested intensity. As a result, the mixture structure will take charge of the plant's essential heap, while the excess force will be injected into the electrical lattice, as seen in Fig. As a result, according to Eq., the half breed system adds power to the plant and electrical utility. The waveforms of three-stage load current are depicted in Fig. From 0 to 4 seconds, the specific burden requested force is 8 MW with 262.3 A.

The simple burden capacity is reduced from 8 MW to 6 MW with 202.8 A over the period of 4 to 8 seconds. The simple plant's power is reduced to 4 MW with 139.3 A from 8 to 13.5 seconds at that time. After a long time, the simple burden capacity has miraculously returned to 6 MW. Figure 1 portrays a constant burden voltage with no respect for the difference in simple burden strength.



(a) Power delivered to grid side (PCC-bus).

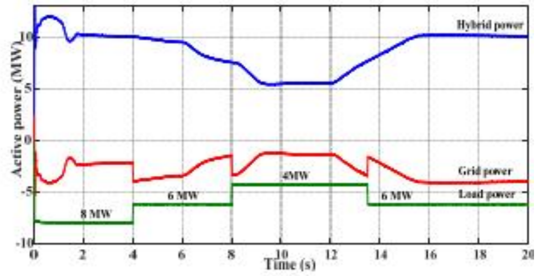


(b) Voltage of PCC-bus.

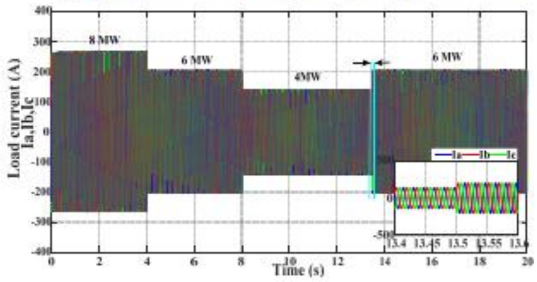
Graph Performance of PV-wind hybrid system at PCC-bus

Injected Power from Hybrid System Lower than Load Demand

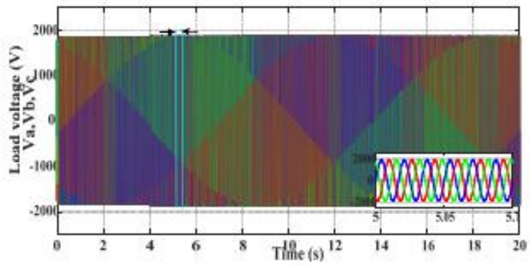
In this case, the infused power from the crossover framework is lower than the plant's specific requested strength. As depicted in Fig. 1, the electrical utility network in the assisted mixture power framework would take charge of the plant's specific demanded intensity. According to Eq. (2), the cross breed structure and electrical matrix can infuse power to the plant load in this manner. The waveforms of three-stage load current are depicted in Fig. From 0 to 7 seconds, the specific burden requested force is 12 MW with 392.2 A. The specific requested force is reduced from 12 MW to 10 MW with 325.9 A during the time period between 7 and 10 seconds. The simple requested force is then reduced to 8 MW with 262.3 A from 10 to 13 seconds. The simple burden capacity has abruptly returned to 12 MW after a long period of decline.



(a) power flow between hybrid system, grid and load.

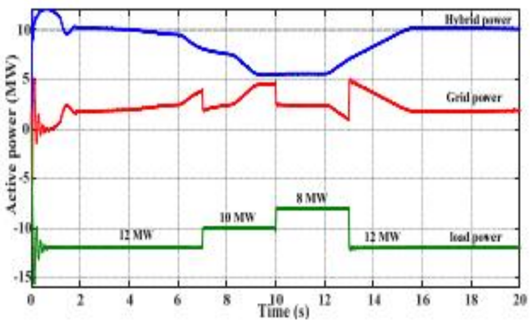


(b) Load current side (D).

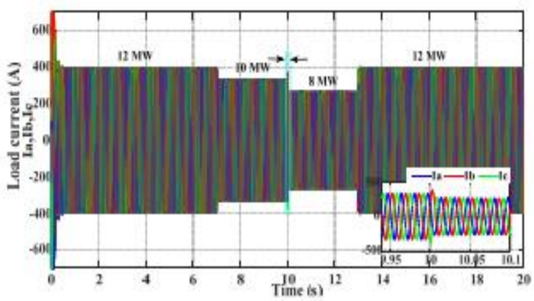


(c) Load voltage bus-B1.

Graph: Injected power from hybrid system greater than load demand for case 1



(a) Real power flow between hybrid system, grid and load.



(b) Load current side (D).

Graph: Injected power from hybrid system lower than load demand for case 2

Conclusion

Solar energy is critical for addressing environmental concerns as well as meeting energy demands. The popular production of MPPT algorithms to increase performance promoted the usage of solar panels for domestic energy production. The available MPPT techniques can be used to pick an MPPT technique for a specific application in grid tied or standalone mode of operations depending on the amount of control variables involved, forms of control strategies, circuitry, and implementations. Many recent hybrid MPPT strategies have been included in this study, as well as their advantages for mismatched conditions such as partial shading, non uniformity of PV panel temperatures, and dust impact. Perturbation and Observation, as well as Incremental Conductance, are basic approaches that are widely utilized in science, but they have slow monitoring and poor usage performance.

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