SSR Mitigation with a New Control of PV Solar Farm as STATCOM (PV-STATCOM)

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1. INTRODUCTION

Energy management is, nowadays, a subject of great importance, because of the need of facing petroleum shortage and earth global heating. However such a management has to deal with many problems arising from the nonlinearities that may appear, like the behaviour of power converters or the enforcement of constraints of the different components of the system, or from the difficulty in selecting, among a set of sources able to produce energy, the one that will give energy to a set of loads. The sources and loads are of different types and are usually distributed around the main grid. Moreover the prediction about how the system may react as well as the
choice of sources must be made in real-time to avoid any power outage. Loads also have a stochastic behaviour which can be partially forecast and can be situated also very far from the source location, which adds the transmission losses. In the end each source has its specific characteristics such as production cost, environmental constraints, capacity, etc, that must be accounted for in the source selection. Finally, the stability issues of a power network with many distributed generation units of significant rating are still an open problem.

The goal of this study is to present a system able to self regulate a heterogeneous set of power sources and loads organized as a coherent group of entities that is called micro grid, in order to optimize several criteria such as: cost and efficiency without any interruption of the load supply, which is a mandatory constraint. Indeed, if the amount of produced energy is not enough to supply the energy demanded by the loads, the system has to supply the difference with the energy available on the grid which is generally more expensive. The sources in a micro-grid can be photovoltaic arrays (PV), wind turbines (WT), Fuel Cell (FC) systems, batteries or super capacitors (SC). The last two components can also be regarded either as loads since they can store energy from other components or sources since they can provide energy to the loads when necessary. Each source has an autonomous behavior, its own characteristics and interacts with the other sources in order to fulfill the system goals. For example, a photovoltaic array generates power from solar radiation and its production can be supposed to be null when no solar
Radiation is available. As for the FCs it can be assumed that it can supply power at any time depending on the amount of available hydrogen, but limiting its starts and stops to avoid

the reduction of the fuel cell lifetime: the best is to start fuel cell if it is supposed to work for long time spans (several days). The Multi-Agent Systems (MAS from now on) paradigm has been chosen for the design of the energy management system. Each entity is modeled as an autonomous agent able to interact and with its own mechanism for decision making. The characteristics of the source type have been taken into account and each entity collaborates with other agents in order to globally optimize the given criteria. The problem is distributed (geographically), open (new sources/loads can enter/exit the system), dynamic (changes happen during the life of the system both in its parameters and in available system components). This study is structured as follows. Section II presents the background needed in terms of problem description and MAS principles. Section III details the architecture of the system and section IV shows some experimental results and section V concludes

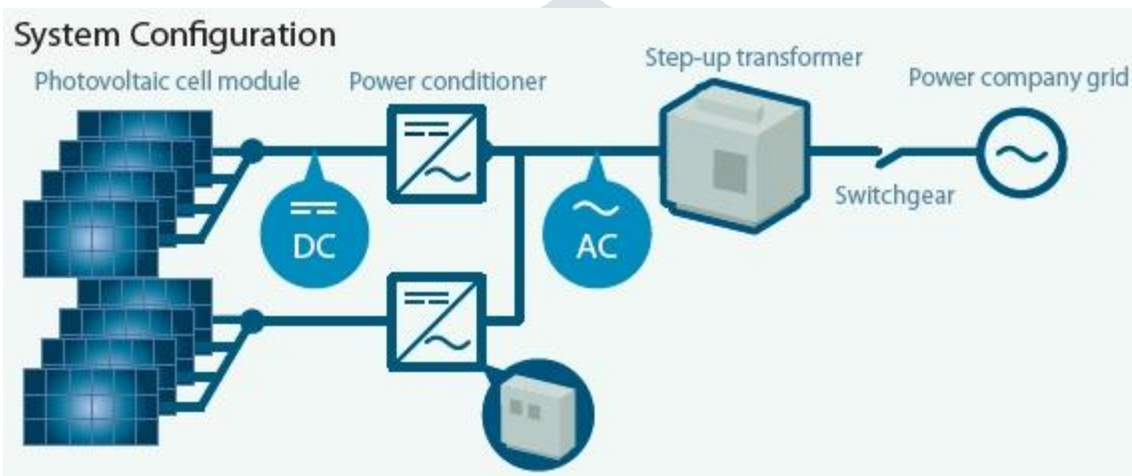


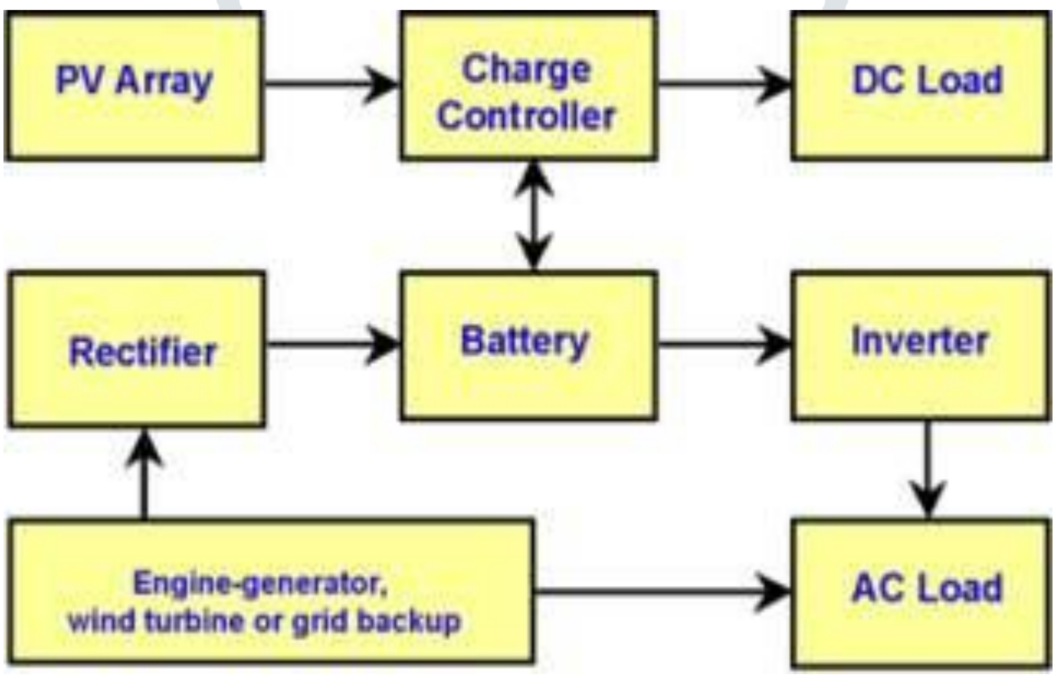
PHOTO VOLTAIC POWER SYSTEM DIAGRAM

Solar energy is produced by sun created through a thermonuclear process and this process creates heat and electromagnetic radiations. These electromagnetic radiations have the energy that reaches the earth. As solar energy is an indirect source of energy, we need two components: one the collector and other the storage device. The collector will collect the radiations coming from the sun and convert it in the form of electrical energy.

One the other hand we require storage unit since the radiations keeps varying throughout the day and during night hours there will be no radiations. There are three types of collectors like flat-plate collectors, Focusing collectors and Passive collectors. Most of the time we use flat- plate panel which is a combination of array of solar cells arranged in a simple plane.

The output of these panels depends upon the size of panel, intensity of radiations and the cleanness of the panel. A solar cell or PV cell converts solar energy into Electrical energy by the photo voltaic effect. When the sunlight is incident upon a material surface, the electrons present in the valence band absorb energy and, being excited jump to the conduction band and become free.

These highly excited, non-thermal electrons diffuse, and some reach a junction where they are accelerated into a different material by a built-in potential (Galvani potential). This generates an electromotive force, and thus the light energy is converted into electric energy. An Array of solar panels is used to generate electricity. The output of solar panel will be connected to the storage device and inverter for converting the obtained direct current into three phase alternating current. The 3 phase AC power is then given to meet the load demand or fed to grid. Practical problem of generating power from the sun would be the expense of the silicon material that converts light to electricity, and the large tracts of land needed for solar farms. Now with the concept of floating solar we are enchasing the availabilities of water bodies in different regions. Since with this idea we do not have to utilize a large area, the problem of land for the solar plant can be easily solved. Also, keeping in mind the fact that land acquisition in India is not an easy task, this sort of an idea keep itself away from disputes. We all know, that during summers canals face the threat of drying up due to which irrigation problems arise. With floating solar, around 70% of the evaporation could be prevented which would in turn help in the retaining sufficient amount of waters in the canals and small river bodies. Also, algae formation in the water bodies can be reduced as the amount of sunlight entering into the water would decrease which in turn reduce the photosynthesis process to produce less algae in water. This makes water less contaminated and helps the aquatic life in sustaining .



Stand- Alone PV System

Advantages and disadvantages of using photovoltaic systems

Advantages:-

Reliability- Even in harsh climates, photovoltaic systems have proven their reliability. Often, photovoltaic systems are chosen for systems that must remain operational at all times. Photovoltaic systems may prevent costly or dangerous power failures in situation where continuous operation is critical

Low Maintenance Cost- It is expensive to transport materials and personnel to remote areas for equipment maintenance. Since photovoltaic systems require only periodic inspection and occasional maintenance, these costs are usually less than with conventionally fuelled equipment alternatives.

Saleable and modular- From providing milliwatts to power a calculator to acres of panels providing megawatts for grid connected supply on a commercial building roof or field, solar power products can be deployed in many sizes and configurations and can be installed quickly and almost anywhere in the world. As a distributed generation option, transmission and distribution costs are reduced.

Universal Applications- Solar PV is the only renewable energy technology that can be installed on a truly global scale because of its versatility and because it generates power under virtually all conditions, i.e. even in overcast light conditions

Disadvantages:-

Cost- Photovoltaic systems have a high initial cost. Each installation must be evaluated from an economic perspective and compared to existing alternatives. If the initial cost of the photovoltaic systems decreases and the cost of conventional fuel sources increases, photovoltaic systems will become more economically competitive

. **Variability of Available Solar Radiation**- Weather can adversely affect the power output of any PV system. If there is no sunshine there is no power.

Energy Storage- Some photovoltaic systems use batteries for storing energy which will be used at a later time. The battery increases the system's size and cost can make the system more complex.

Education- Photovoltaic systems use a new technology with which many people are unfamiliar. Few people understand its applicability. This lack of information slows market and technological growth.

Applications:-

Typical applications of PV in use today include:-

1. Stand-alone power systems for cottages and remote residences,
2. Remote telecommunication sites for utilities and the military,
3. Water pumping for farmers,
4. Emergency call boxes for highways and college campuses,
5. Street lightening ,
6. Grid Connected supply of Electricity,
7. Navigational aids for the Coast Guard

2. BRIEF LITERATURE SURVEY

1) **Peter P. Groumpos (1984)**
2) **N.Kasa, T.lida and H.lwamoto (2000)**

3) **Ying-Tung Hsiao, (2002)**
4) **Rafia Rawoof,(2015)**
5) **F. Cositore (2015)**
6) **Cheng Zhang, Zhenyang Hao (2017)**

2.1) Summary of Literature Review

1) **Peter P. Groumpos (1984)**:- as stand-alone photovoltaic (PV) energy systems have increased in size and diversity of loads, the importance of controls cannot be overstated. These systems represent "mini utilities" with the commensurate control requirements, albeit with the added complexity of not only the loads being variable, but also the energy source (sunlight received) being an uncontrollable variable. The first village stand-alone photovoltaic power system in the world, located in the remote Indian village of Schedule, Arizona, U.S.A., is used here as an example to show that stand-alone photovoltaic energy systems employing load management control are feasible and could play an important role in solving energy problems in developing areas of the world. The major components and control concepts of this photovoltaic energy system are reviewed. Performance considerations are briefly discussed along with research topics related to such systems. The foundation is thus laid for future generations of renewable energy system controls.
2) **N.Kasa, T.lida and H.lwamoto (2000)** :- A perturbation and observation method with a capacitor identifier is presented for maximum power point tracking (MPPT) in a photovoltaic power system. Usually, by increasing or decreasing the duty ratio of on-state of switching device, the maximum power point is tracked. The variation of duty ratio is determined by considering its circuit parameters. However, it is known that actual capacitance of an electrolytic capacitor in parallel with the photovoltaic array has 50% tolerance of its original value. If the variation of duty ratio is determined based on its nominal value, the performance of the MPPT is degraded. T~LIS, we must change variation of the duty ratio accordingly, based on its actual value. In the system presented, the model reference adaptive system is adapted to identify thc capacitor, so the capacitance can be accurately estimated and the variation of the duty ratio can be corrected by the estimated value. As a result, the high performance of the MPPT may be obtained. Experimental results are presented using a proposed power inverter using buck-boost chopper circuits.
3) **Ying-Tung Hsiao, (2002)**:- The electric power supplied by a photovoltaic power generation system depends on the solar radiation and temperature. Designing efficient PV systems heavily emphasizes to track the maximum power operating point. This work develops a novel three-point weight comparison method that avoids the oscillation problem of the perturbation and observation algorithm which is often employed to track the maximum power point. Furthermore, a low cost control unit is developed, based on a single chip to adjust the output voltage of the solar cell array. Finally, experimental results confirm the superior performance of the proposed method.

4) **Rafia Rawoof,(2015):-** Modelling and simulation of grid connected power system, installed on rooftop of two block's connected through five (20kw) inverter to the LT distribution panel in those block. Mathematical model for PV array & two MPPT algorithm for capturing the maximum possible power under varying solar irradiance condition on matlab /simulink platform. This use two algorithm method (1)- P & O (Perturb & Observe),(2)- IncCond (INCREMENTAL CONDUCTANCE).Hence, algorithm are incorporated in control strategy used in DC-DC boost converter connected b/w PV array & inverter.hus, simulation result is varying o/p solar irradiance condition with actual power measurement made at corresponding irradiance. RESULT,- expected power generated increase as irradiance is increased .

   1-(P&O) – gave smooth response.

   2-(IncCond) – drop in duty cycle when irradiance is varied.

   Hence, (P&O) technology is preferred over (IncCond). Due to this result of simulation & actual measurement are equal. There is slight difference due to vary in PV module parameter available in Matlab/Simulink.

5) **F. Cositore (2015)**:- The paper discusses on a control algorithm applied to a hybrid PV power system. The hybrid power system is constituted by directly connecting an Electric Double Layer Capacitor (EDLC) device on the dc output bus of the PV Maximum Power Point Tracker (MPPT) converter. The aim of this paper is to propose a control approach applied to the dc power converter able to assure a double set-point regulation, which takes into account the operational constraints of both the PV power source and storage buffer. Control design is based on a cascade strategy. The controller parameters are synthesize basing on the State Space Averaging (SSA) method and low perturbation approach. A numerical simulator is set up in ®Matlab. The results of simulations aim to validate the features of the proposed approach.

6) **Cheng Zhang, Zhenyang Hao (2017)**:- An isolated grid-connected photovoltaic (PV) power system for household is proposed and the control strategy of the system is presented in this paper. The proposed PV system employs an interleaved boost converter as the first power processing stage, which can boost a low voltage of PV array up to a high dc-bus voltage. In the traditional isolated PV system, industrial low-frequency transformers are often used for electrical isolation. However, with the shortage of large volume, great weight and high noise, it is not suitable for household application. In this paper, dual active bridge (DAB) is used as the second power processing stage to achieve high-frequency isolation and a full bridge inverter is used as the third power-processing stage which can stabilize the dc-bus voltage and shape the output current. At last, a 1.5KW prototype has been built and verify the design presented in this paper.

3. PROBLEM FORMULATION

Module Sizing - No of modules required to meet energy requirement = Nm= selected module energy o/p at operating temperature peak sun hours of design tilt from insulation data chart. No of module required per string = Nsa = battery bus volt selected pv module power volt at STC

No of string in parallel =Np=Nm/Nsa

No of modules to be purchased = N=Nsa x Np

Battery Sizing - No of batteries in parallel = Na= Required battery capacity (considering an autonomy of 7 days and allowable depth of discharge of .8)/per ampere to hour capacity of seclected battery .

No of batteries in series =Ns=battery bus volt.(assumed)/ selected battery bus voltage from battery specification sheet.

Total no of batteries =Nb=no of batteries in parallel x no of batteries in series.

Inverter sizing -_From the load curve of the sample house if the maximum energy demand at peak hours is Wt(WATT) then for safety purpose the inverter should be 25-30%bigger in size.

Charge controller sizing -_T o select an appropriate charge controller , we need to calculate the controller input current and controller load current data.

Module short circuit current (Is) x Modules per string(Nsa) x Safety factor (Sf)= controller input current (ip).

Total dc connected watts (wdc)/dc system voltage (vb)=Max.dc lod current ie; controller load current (id).

4. PROPOSED METHODOLOGY

Work Methodology of Photo voltaic power system depends on few points as

1. Solar cell(Source of DC power)
2. DC to DC Boost converter
3. Inverter (DC to AC converter)
4. Filter

5. PRELIMINARY RESULT & DICUSSION

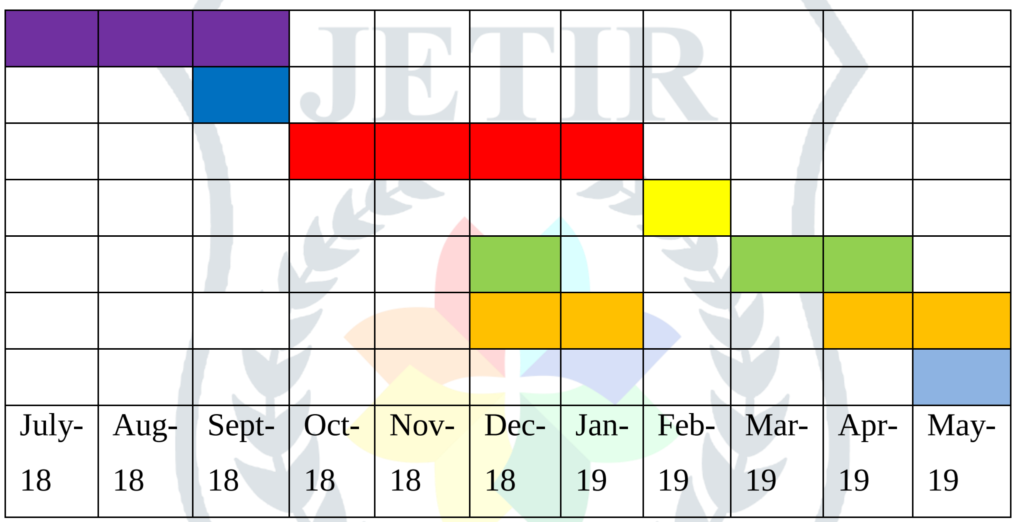
These individual system help to get expected power, where as Dc to dc boost converter and inverter have own different control methodology, PWM inverter control method [5]. Voltage source inverter control method regulates phase angle of the grid mainly through receiving voltage signals from DC side of inverter which is called the outer loop to control the grid voltage, while it regulates the voltage reference from the AC side load voltage to control the inverter output current which is called the inner loop [6]. However, the process of the inner loop will not affect the results of the outer loop. Power-type PWM inverter bridge circuit formed by the two groups, which uses two reverse diodes synchronized transformation. Required power can be obtained by changing the modulation rate of PWM inverter. Therefore, whether the grid-connected PV generation inverter control system is able to achieve the maximum power point tracking (MPPT) and to ensure high power quality of the photovoltaic cells or not are the key issues in electric power system [7].

6. WORK TO BE DONE

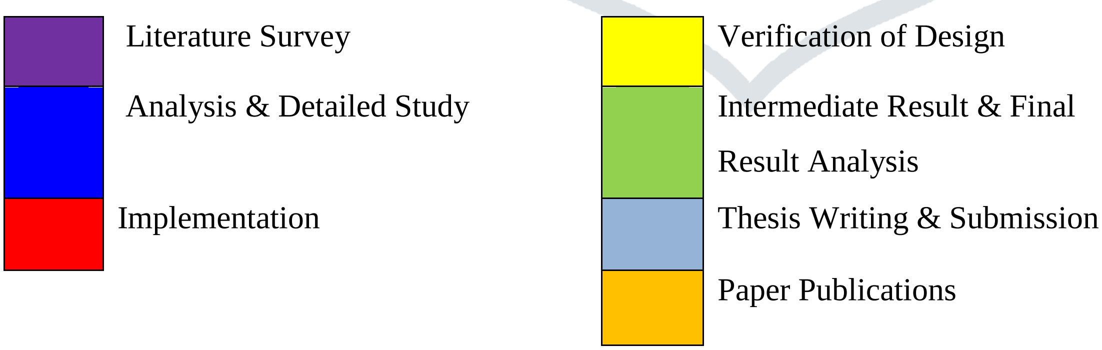
1. To reduces THD profile.
2. To Improve Power Stability.
3. To improve power efficiency.
4. To reduce power loss

7. PLAN OF RESEARCH

Research Planning



Duration in Months



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