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A Switched MPPT Approach for PV Solar Farm as STATCOM (PV-STATCOM) for Increasing Grid Power Transmission Limits during Night and Day

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ABSTRACT

This paper proposes a switchedphotovoltaic (PV) approach to enhance the extracted maximum power from a PVarray during partial shading conditions where utilizing PV solar farm inverter as STATCOM, termed PV-STATCOM, for improving stable power transfer limits of the interconnected transmission system. The proposed system issimple and cost effective. However, it may provide lower powerenhancement compared to other existing solutions, which makesit more suitable for domestic applications.The entire inverter rating of PV solar farm which remains dormant in the nighttime is utilized with voltage and damping controls to enhance stable power transmission limits. During daytime, the inverter capacity left after real power production is used to accomplish the above objective.

Transient stability studies are conducted on a realistic single machine infinite bus power system having a midpoint located PV-STATCOM using MATLAB/Simulink simulation software. The PV-STATCOM improves the stable transmission limits substantially in the night and also in the day even while generating large amounts of real power. Power transfer increases are also demonstrated in the same power system for i) two solar farms operating as PV-STATCOMs and ii) a solar farm as PV-STATCOM and an inverter based wind farm with similar STATCOM controls. This novel utilization of PV solar farm asset can thus improve power transmission limits which would have otherwise required expensive additional equipment such as, series/shunt capacitors, or separate Flexible AC Transmission System (FACTS) Controllers.

INTRODUCTION

The extensive use of fossil fuels has led to the global problem of greenhouse emissions. Moreover, the supply of fossil fuels are depleted in the future they will be more expensive. Therefore, the solar energy it produces less pollution, and decreasing the cost of solar arrays, while the cost of fossil fuel energy, kilakamavutundi from growing. In particular, the distribution of solar energy power generation systems using a small capacity can be used more widely in the near future residential applications [1], [2].

It is, AC power to DC power generated by a solar cell array and utility grid, converts the AC power feeds and solar power generation systems connected to the grid is important because the energy conversion interface. C to the power of an inverter to convert the DC power to the power conversion interface [2] - [4]. The output

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voltage of a solar cell array, is less so, disi DC power converter to increase the output voltage of the solar power generation system with a small capacity is used, so it will match the inverter DC bus voltage. The power conversion efficiency of the solar cell's energy conversion through the array of interface energy production is important to insure that there is no waste.

Active devices and passive devices, power loss in inverter production.Conduction losses and switching losses of active power losses due to both devices [5]. Conduction loss results from the use of active devices, and each switching voltage and switching frequency of the switching loss is proportional to the current changes. A filter inductor, so an inverter is used to convert the balance of the process is proportional to the amount of change the balance of power loss.

There are the traditional multi-level inverter topology is clamped diode [6] - [10], the flying-capacitor [11] - [13], and the cascade H-bridge, [14] - [18] types. Diode-clamped and flying capacitor multilevel inverters and capacitors in the development, use several voltage levels. But this is difficult to control the voltage on the capacitors. Two diode-clamped and flying capacitor voltage technology topologies difficult to create a uniform, so that the electric circuit of a multi-level inverter is complicated by an increase in the level of voltage that is necessary. For the seven-level single-phase inverter, 12 power electronic switches, two diode-clamped and flying-capacitor topologies required. Uneven voltage technology output voltage [17] H-bridge cascade multilevel inverter is used to allow for more levels, so the cascade H-bridge multilevel inverter is suitable for applications with increased voltage levels. Multiple contact DC The bus voltage is used in the H-bridge inverters, single phase electronic switches and eight seven-level inverter connected in cascade to produce power.

PHOTO VOLTAIC SYSTEM

A photovoltaic system and solar power system, solar PV system, PV system, or a solar array in general, will be used by the solar photovoltaic energy system is designed to supply power. It is a solar inverter from DC to AC power to absorb and convert sunlight directly intoelectricity, including solar panels, as well as the mounting, cabling and other electrical equipment to set up a working system, equipped with an array of many parts. It is expected to decline in the prices of the storage device, or an integrated battery solution is to improve the overall performance of the system include the use of a solar tracking system.

Strictly speaking, the ensemble of solar panels into a solar array, look to the visible part of the PV system, and all the other hardware, often the balance of system (BOS) on does not have to be summarized.

PV systems for small, roof-top mounted or hundreds of megawatts of utility-scale power stations in the several tens of kilowatts, capacity building and integrated systems range from a few. These days, most PV systems alone or off-grid systems accounted for only a small part of the market, however, can be connected to the electricity grid.

OVERVIEW

A photovoltaic system converts it into usable electricity, the sun's radiation. It comprises a solar array and balance of system components. PV systems can be made in various configurations:

- Optionally using a battery storage connected to the grid
- Off-grid without battery (array-directed)
- Battery storage hell grid, optionally converting AC to

In addition to these basic configurations can be categorized by different aspects, such as PV systems, building integrated versus rack-mount systems, residential versus utility systems, centralized distribution systems, roof-top versus ground-mounted systems, tracking vs. vs. fixed-tilt systems, new construction vs. installed systems . Other differences versus the European and US manufacturers from

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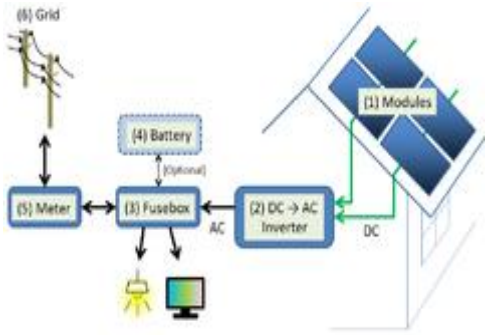
Chinese microinverters vs. central inverter modules, polysilicon versus thin-film technology, systems and systems of systems may have.

2 Grid-connection



A typical residential PV system forms

Main article: grid-connected photovoltaic power system

A grid connected system to a large independent grid (typically the public electricity grid) and feeds power directly to the grid. Income before or after the measurement point in a residential or commercial building can share the power.

The difference is credited to the customer's energy consumption, independent power production (feed in tariff) or energy (net metering) is the difference between the measured good. Grid connected systems (up to 10s of MWp) solar power stations in the residential (2-10kWp) vary in size. This decentralized form of power generation. Feeding electricity into the grid in a separate, simultaneous to the grid tie inverter is required by the transformation of into the AC to DC. [15] installations kilowatts in size, DC side of the system to limit the risks of ohmic voltage (1000V common except US residential 600V) is as high.

2.3 Scale of system

Residential roof-top, commercial roof-top and ground-mounted utility-scale systems, photovoltaic systems are generally categorized into three different market segments. Megawats from a few hundred kilowatts up to their abilities. MW-scale commercial systems to reach and low-slope or flat roofs are usually installed in a typical residential system, mounted on the roof has a slope of around 10 kilowatts. Allthough roof-top mounted systems, they accounted for the largest share in the market for the benefit of small and large-scale installations that demonstrate increased than what the price. Of the planet, "the Sunbelt" in the area, however, the trend of a growing trend towards large utility-scale power plants.[7]:43[17]

Roof-top system

A 5.3 kW residential rooftop system near Boston, United States.

2.4 Performance

Over the years, the solar source of income for most of the uncertainties related to the evaluation and performance of the system. The best of cases, the uncertainties of the general 4% year-to-year climate variability, 5% of the solar resource assessment (in a horizontal plane), for the assessment of radiation in the plane of the range of 3%, 3% of the power rating for the modules, 2% due to dirt and soiling, snow losses due to 1.5%, and 5% for other sources of error losses.

In response to identifying and managing risks is the key to revenue and O & M efficiency. Range performance monitoring range owner, builder, and the purchase of energy produced as part of the deal may be of use. [Citation needed] Recently, a method using open authentication using readily available weather data and "Synthetic days" to create the Solar Outdoors Test Field with high degrees of accuracy, it is possible to predict the performance of photovoltaic systems.

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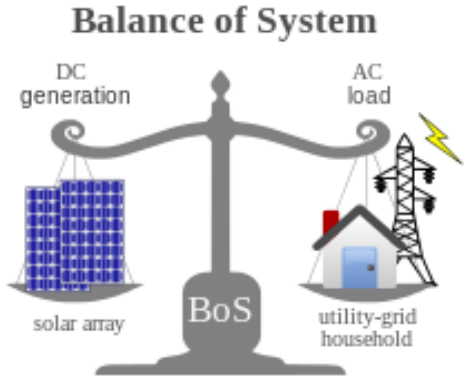
2.5 Components



A PV balance of system components (BOS) on the side of using the power of AC household appliances and utility grid (right side) with the solar array (left side) to balance the energy sub-system.

Residential, commercial or industrial energy supply systems for the photovoltaic solar array and balance of system components to many frequently (BOS) to sumarized.Some of the BOS components, using the power of the word to the solar array, the load balancing of the fact that the production of energy is derived from the sub-system. BOS components, power conditioning equipment and mounting, generally, DC-AC power converters, the inverters, a power storage device, a solar array, electric wiring and connections that support one or more structures, known as the racking system, and other components are mounted.

Diagram of the possible components of a photovoltaic system.

2.6 Solar array

A photovoltaic array in the Negev Desert, Israel

More information: Photo Voltaics, solar module and solar cell weather.The from the module cover, a soft and flexible encapsulant, a weathering and fire-resistant material made of tempered glass, a rear backsheet consisting of a traditional solar cells, wired in series to protect them, usually wrapped in a solar module and a alumnium frame around the outer edge. Electrically connected to the auxiliary building, solar systems, often called solar panel modules in a string, to build the Mount. A solar array consists of one or several of such panels. [26]

A photovoltaic array (or a solar array) linked to the collection of solar panels. [27] A module that produces hardly sufficient to meet the requirements of energy in a home or a business, so that the modules are linked together to form an array.

2.6.1 Insolation and energy

Direct solar radiation, made up of diffuse, and reflected radiation. A PV cell, the cell is absorbed by the absorption of incident solar irradiance, as opposed to take the item from the fiction. [30] on a cloudless day at high noon on the equator, the sun is a plane that is perpendicular to the rays of the sun's energy, about 1 kW / m², [31] is on the surface of the earth. As such, PV arrays to track the sun through each day can greatly enhance energy collection. However, add to the price tracking devices, and maintenance is needed, therefore, fixed tilt mounts and solar PV arrays at mid-range (in the north to the south in the northern hemisphere or the southern approximately) face more

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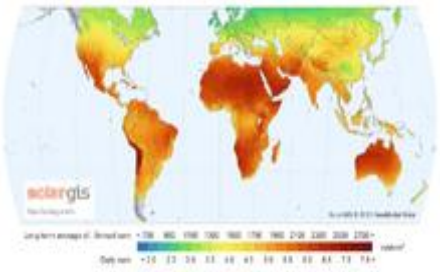
and more common. Tilt angle, from horizontal, season change, [32] but fixed, as a stand alone system in a normal year for peak electricity demand, which is part of the output should be set at the correct setting. The tilt angle of the module tilt angle for maximum power output in the annual range is essentially identical.



Global solar potential

A photovoltaic system for a particular environment, the solar flux optimization soiling problems, complicate, and ice losses to be taken into effect. In addition, recent work has shown that the spectral effects play a role in the selection of the photovoltaic material. For example, the spectral albedo of the photovoltaic system, [34] and around the surface of the solar cell, depending on the type of material that plays a significant role in production. [35]

2.6.2 Module

Module output and life are also degraded by increased temperature. Allowing ambient air to flow over, and if possible behind, PV modules reduces this problem. Effective module lives are typically 25 years or more.[38] The payback period for an investment in a PV solar installation varies greatly and is typically less useful than a calculation of return on investment.[39] While it is typically calculated to be between 10 and 20 years, the financial payback period can be far shorter with incentives.[40]

2.6.3. Efficiency

An individual solar cell (typically ca. 0.5V), many cells are wired to the low voltage (see: photovoltaic power systems of copper) in the series as a "laminate" in the making. Therefore, making a photovoltaic module or solar panel laminate protective weather proof enclosure assembled. Then the modules can be strung together into a photovoltaic array.

In 2012, up to 17% efficiency of solar panels available to consumers, [41] 27% of the commercially available panels are going to be most of the time. A group from the Fraunhofer Institute for Solar Energy Systems, which is much more feasible to reach 50% of the capacity of scientists' hopes of 44.7%, as capacity, that can reach the cell that has been recorded in the.[42][43][44][45]

2.6.4 Shading and dirt

Generation photovoltaic cell is very sensitive to shading. The shading effects are well known. [46] [47] [48] in a cell, module, or array, of even a small part of the dim, when the rest of the sunlight, the product significantly, due to the internal 'short circuit' (p-n junction on the shaded part of the course by reversing the electrons) comes back. Shaded cells in the series string of current drawn from the cell that produces the current is greater than the current (and thus power) limits the development of the string. Is available from the rest of the cells in a string of sufficient voltage, the current will be forced through the cell by breaking down the shaded side of the junction. The breakdown voltage normal cells is between 10 and 30 volts. The power produced by the panel, instead of adding heat to alter the shaded cell, absorbs energy. Shaded cell reverse voltage is higher than the forward voltage of the cell, so that a bright, dim cell in a string of many other cells, power output is a panel that can absorb impact. For example, instead of a shaded cell, a certain current level, added 0.5 volts, thereby absorbing the energy of the 16 other cells, is reduced to 8 volts. [49]

2.6.5 Cabling

Main articles: Solar cable and electrical wiring

The use of external UV radiation and solar cables specifically designed for very high resistance against temperature fluctuations and are generally unaffected by the weather. Standards of the group number "of solar photovoltaic (PV) power supply systems" in

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section 712, as the International Electrotechnical Commission IEC 60364 by the PV systems, electrical wiring, the use of the British Standard BS 7671, including the provisions relating to microgeneration and photovoltaic systems, and the US UL4703 standard, subject 4703 "of photovoltaic wire in".

2.7 Mounting systems

A 23-year old, ground mounted PV system on a North Frisian Island, Germany

Main article: Photovoltaic mounting system

The ground-mounted or pole-mounted modules, mounted on the roof of some type of mounting system, which is classified, assembled into arrays on. Ground mounted solar parks and large rack, and rack mount modules. Buildings, pitched roofs, devised many different racks. Flat roofs, racks, bins and used for building integrated solutions. [Citation needed] The solar panel racks mounted on stationary or moving columns, see the trackers. A light fixture that mounts to the side of the pole or anything else that has an antenna mounted at the top of a pole and the conditions are suitable.

If the pole is mounted on top of the weeds of a ground-mounted array of shadows and what livestock, exposed wiring and electrical code requirements with respect to participation may be satisfied with the raises.

2.8 Solar trackers

A 1998 model of a passive solar tracker, viewed from underneath.

Main article: Solar Tracker

Pagulutondi a solar panel, a solar tracking system throughout the day. Depending on the type of tracking system, the panel either the sun or the clouds in the sky, the bright part is aimed directly at the area. Trackers great performance early in the morning and afternoon, for a dual axis tracker, a single axis tracker and about 30% or more increase the amount of power generated by a system of 20-25%, depending on the latitude and expand. [53] [54] trackers to direct sunlight is not going to be a big part of the effective areas. Diffuse light (ie below the cloud or fog), the tracking of little or no value. Highly concentrated photovoltaic systems are very sensitive to the angle of sunlight, because the energy of the tracking systems can produce more useful than a short time with them every day.

2.9 Solar inverters

Inverter for grid connected PV

Main articles: solar inverter, solar micro inverter power inverter

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2.9.1 Maximum power point tracking

Maximum power point tracking (MPPT) photovoltaic grid-connected inverters, a technique used to get the maximum power from the array. To do so, the digital option at any time of the MPPT system power output of the solar array and the maximum power point of the changing patterns in the covers to find the right resistance.[65]

2.9.2 Anti-islanding

When the anti-islanding no longer exists as soon as the connection to the load, preventing it from AC power inverter shuts down the production process as a defense. In this example, happens in the case of a blackout. If the security of the supply of DC power supply line of a solar array at the time of the power outage continues, do not use the power lines in a "sea" of energy around the "island" has become. Islanding utility workers who may not realize the power of an AC circuit is still dangerous, and automatic re-connection of devices to prevent it.[66]

2.9.3 Charge controller

Main article: Charge controller

PV systems solutions with integrated battery from overcharging and to prevent damage to the constant need to adjust the different voltage and current, such as a solar array, a charge controller is required. [67] The basic charge controllers, PWM or pulse-width modulation of the PV panels in the array and turn off, or the power of the pulses may be necessary out of the meter. MPPT charge controllers and battery charging algorithms are more sophisticated logic into it. Other than the purpose of charging the battery charge controllers can also redirect the energy. PV power shut off when not needed, rather than just a free, one can choose to heat air or water once the battery is full.

EXTENSION TOPIC

E photovoltaic (PV) PV-fed applications, partial shading resources, particularly energy is an important criterion in XTRACTING. Tracking (MPPT) techniques, with no shading, maximum power point tracking PV array, typically using a conventional peak power into the power-voltage characteristic typical of the [1]. During the partial shading, feature multiple peaks (global and local maximum) [1], [2]. In the second case, the conventional MPPT algorithms may fail to track

The maximum power point (MPP), in Munich, will be trapped on the highest point of the first [3]. MPPT [4] In order to avoid - [6] should be used to extract the maximum power of international. Traditionally, the open circuit voltage and short circuit current from the MPP MPPT PV scanning features of the respective mark on the world. [4], the fastest MPP MPPT algorithm to recognize introduced to the world in a short time.

In general, traditional PV systems, the hardware configuration of existing inverters and inverters, string inverters, the module integrated inverters (converters distributed MPPT) to be classified, and most recently, differential power processing (DPP) based PV systems [7], [8]. The central inverter, as shown in Fig. 1 (a), provides installation, high reliability and simplicity. Central Inverter range (at the time of shading due to the mismatch losses) may be less than the sum of the maximum power available for each module of the PV array to extract the peak of the property. String inverters, as shown in Fig. 1 (b), a PV array with multiple inverters for the use of multiple strings.String inverters, reducing the risks of an imbalance in the case of shading on all the strings, a string-level MPPT with being independent of each other as well.Distributed MPPT converters, as shown in Fig. 1 (c) for the multiple modules in a PV array using multiple converters. As a result of extracting the maximum power converters for distributed independently of each other being perfect all the modules of a module-level MPPT with the offer. However, it should be used to process the full power converters module. On the other hand, DPP, as shown in Fig. 1 (d), was recently able to extract the maximum energy efficiency, which is partially accurate with

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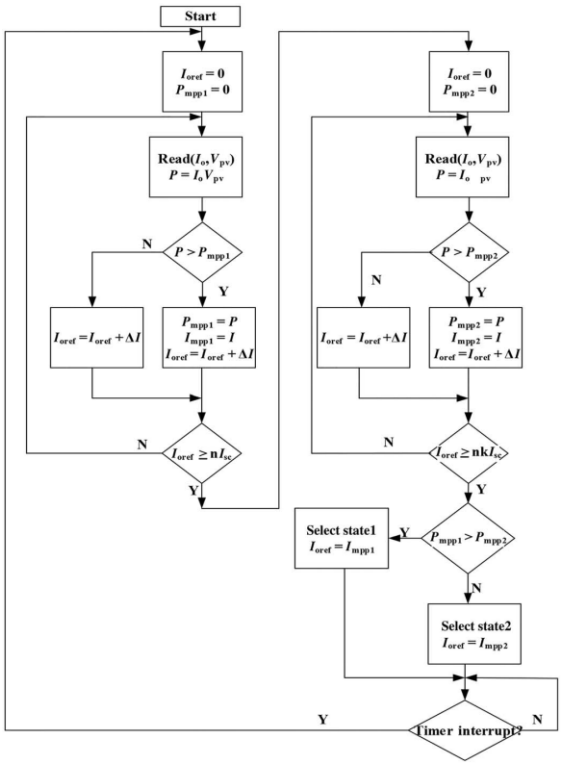
converters rate proposed [8]. Recently, using a shunt-series compensation, the maximum energy extraction from a partially shaded PV array has been presented [9]; However, another approach is to expand it to a relatively large number of switches has been presented in the literature uses the Collect the maximum energy from the PV array at the time of partial shading, namely, dynamic PV array reconfiguration process [10] - [17], which is available at the PV modules can power reconnection.

The main drawback of this approach is to control the switching matrix, [10] the need to build a large number of switches.



A. State1

All of the controlled switches are closed as shown in Fig activate State1. 2 (c), refers to the PV array's traditional connection. In this state, the highest in the The number of possible output current of strings (ie, nIsc) multiplied by the short-circuit current if the output voltage modules, the entire string (ie, Voc) is the voltage of the circuit. The two values must be able to withstand the output converters.

B State2

All of the switches are controlled as shown in Fig State2 activated when opened. 2 (d). In this state, the highest output voltage high output current (short circuit current double module is multiplied by the number of strings, however, the open circuit voltage of the string (ie, 0.5Voc) half, ie 2nIsc). Using the converter output with a high current rating (state1 compared) to avoid, MPPT will limit Fig. A case study of PV-based system for the switch using the power tool 4. Illustration (state1: switches are closed; state2: switches open). (A) was the construction of PV. (B) Power-voltage characteristic in the two states.

Fig. 5.used for the assessment of different shading patterns. (A) no shading condition. (B) - (e) the various partial-shading conditions. The current forecast for the current rating of the output of the converter output of semiconductor devices (for example, state1 high current ie, 1.25nIsc 125%). This can usually be nkIsc where 1 <k <kmax, and kmax<2. state1 state2 possible output voltage is equal to half of the output voltage is possible. Therefore, in the case of resistive load or battery, the output of the buck and boost converter should be able to be successful, regardless of the value of the input voltage to provide power to the load. In this work, SEPIC converter continuous input current and the prospect of similar polarities of the output and input voltage from the PV array will be used to ensure that the current drawing. Three-phase AC load or applications to connect to the grid, DC To DC SEPIC / Boost Converter in three phases over the next two / three-level voltage source inverter can be used (two-phase conversion). Alternatively, a single-stage semi-Z source inverter, changing and increasing capabilities, which can be used.

C is one of choosing the States

During shading, state2 state1 extracted energy is extracted energy is much higher than on the basis of the value of k. In order to check which of the two states of high energy yield, MPPT algorithm, the first state1 activated, then it will search for the MPP

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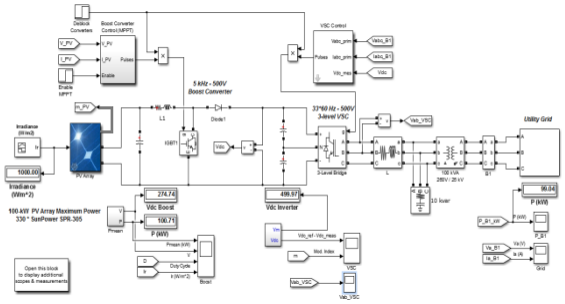
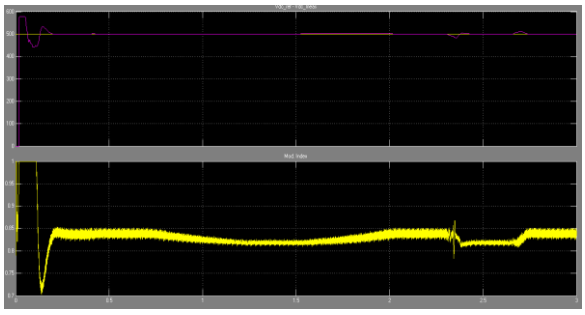
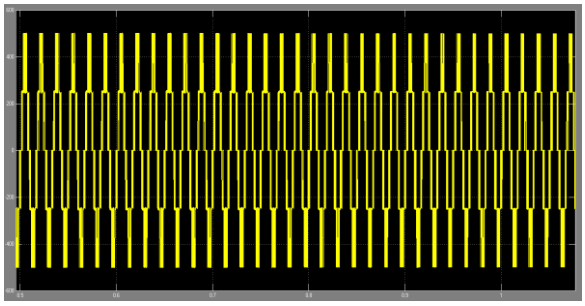
(Pmpp1) and saves it. After that, the state of the global MPP (Pmpp2) state2 and stimulates the search for and save as well. Save the world on the basis of MPPs, MPPT, which gives a higher energy state to decide to switch to the system. MPPT routine to reduce the power loss due to the changing situation in the shading of the state update the system using the timer interrupt, the flag should be repeated every predetermined period. MPPT in a flowchart shown in Fig. 3, Ioref output current forecast of PV, PV output current Io, Vpv PV output voltage, P is the maximum power at PV output power Pmpp1 state1, Pmpp2 state2, ΔI is the maximum power at the current increment, n state1 number of parallel strings, ISC PV the module is short-circuit current, and to kmax of k 1 is a constant.



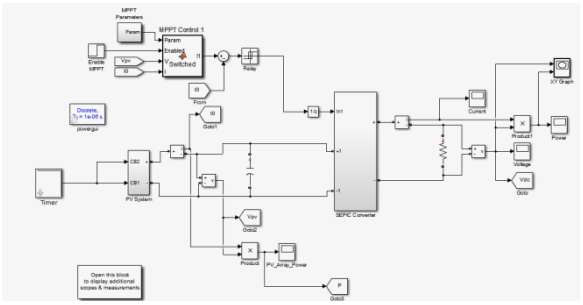
Base Paper Simulation Circuit



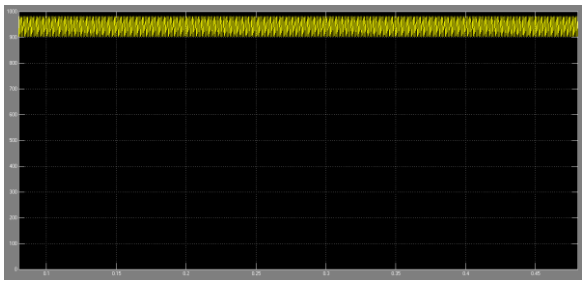
DC Link Voltage b) Modulation Index



Inverter Voltage



Extension Simulation Circuit



Output DC Voltage

CONCLUSION

Solar farms are idle during nights. A novel patent-pending control paradigm of PV solar farms is presented whereby they can be operated in nighttime as a STATCOM with full inverter capacity and during daytime with inverter capacity remaining after real power generation, for providing significant improvements in the power transfer limits of transmission systems. This new control of PV solar system as STATCOM is termed PV-STATCOM. A switched MPPT technique is proposed in this paper for PV system to extract maximum power under partial shadings. It is observed that the proposed technique provided efficient operation.

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