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STAND –ALONE PV POWER GENERATION WITH FLEXIBLE SYSTEM ARCHITECTURE OF ENERGY STORAGE DEVICE

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ABSTRACT:
A independent photovoltaic (PV) structure with imperativeness accumulating requires a mind boggling control configuration to consider the distinctive working modes. When in doubt, a supervisory controller is critical to manage the difference in the control plan according to the associated mode. This paper shows a versatile outline of a PV control forming structure with essentialness amassing. The proposed shaping unit contains a help converter (BC), a lone stage inverter, and a bidirectional dc/dc converter related with the PV side of the BC. The BC coordinates the dc-join transport voltage. The bidirectional dc/dc converter endures battery bank charge/discharge control and PV most prominent power point following (MPPT). Such outline guarantees non change in controller setup when the limit isolates. Thusly, the officially required supervisory controller is murdered. A system control method in perspective of sliding-mode control (SMC) ensures a strong yield voltage heading, for instance, fast component response, minimal constant state bumble, and low total consonant twisting (THD) under walk changes and nonlinear weights. The controller structure, the dynamic direct, and the setup techniques are introduced. Finally, the authenticity of the proposed module with control framework is affirmed through gear tests a 500-W demonstrate demonstrating ground with a solitary TMS320F28335 DSP module.

Keywords: Photovoltaic (PV), MPPT, Sliding-Mode Control (SMC), THD.

I.INTRODUCTION

A photovoltaic framework, additionally sun based PV control framework, or PV framework, is a power framework intended to supply usable sun oriented power by methods for photograph voltaics. It comprises of a course of action of a few parts, including sun powered boards to ingest and change over daylight into power, a sunlight based inverter to change the electric current from DC to AC, and in addition mounting, cabling and other electrical accomplices to set up a working framework. It might likewise utilize a sunlight based following framework to enhance the framework's general execution and incorporate a coordinated battery arrangement, as costs for capacity gadgets are relied upon to decrease. Entirely, a sun based exhibit just incorporates the outfit of sun oriented boards, the unmistakable piece of the PV framework, and does exclude the various equipment, frequently condensed as adjust of framework (BOS). Also, PV frameworks change over light straightforwardly into power and shouldn't be mistaken for different advances, for

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example, concentrated sunlight based power or sun oriented warm, utilized for warming and cooling. PV frameworks extend from little, housetop mounted or constructing coordinated frameworks with limits from a couple to a few several kilowatts, to vast utility-scale control stations of many megawatts. These days, most PV frameworks are lattice associated, while off-matrix or remain solitary frameworks represent a little segment of the market. Working noiselessly and with no moving parts or natural outflows, PV frameworks have created from being specialty showcase applications into a develop innovation utilized for standard power age. A housetop framework recovers the contributed vitality for its assembling and establishment inside 0.7 to 2 years and delivers around 95 percent of net clean sustainable power source more than 30-year service lifetime.

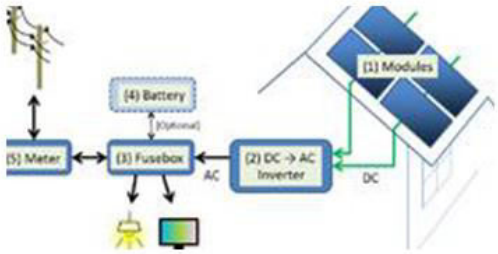

Fig1. Schematics of a typical residential PV system.

Due to the exponential development of photovoltaics, costs for PV frameworks have quickly declined as of late. Be that as it may, they fluctuate by showcase and the span of the framework. In 2014, costs for private 5-kilowatt frameworks in the United States were around $3.29 per watt, while in the exceptionally infiltrated German market, costs for housetop frameworks of up to 100 kW declined to €1.24 per watt. These days, sun oriented PV modules represent not as much as half of the framework's general cost, leaving the rest to the rest of the BOS-parts and to delicate costs, which incorporate client obtaining, allowing, assessment and interconnection, establishment work and financing costs. Starting at 2015, the quickly developing worldwide PV showcase is quickly drawing nearer the 200 GW check – around 40 times the introduced limit of 2006. Photovoltaic frameworks right now contribute around 1 percent to overall power age. Top installers of PV frameworks as far as limit are at present China, Japan and the United States, while half of the world's ability is introduced in Europe, with Germany and Italy providing 7% to 8% of their separate household power utilization with sun based PV. The International Energy Agency anticipates that sunlight based power will turn into the world's biggest wellspring of power by 2050, with sun oriented photograph voltaics and concentrated sun based warm contributing 16% and 11% to the worldwide request, separately. A matrix associated framework is associated with a bigger autonomous network (commonly people in general power lattice) and sustains vitality straightforwardly into the network. This vitality might be shared by a private or business working earlier or after the income estimation point. The distinction being whether the credited vitality creation is figured autonomously of the client's vitality utilization (nourish in tax) or just on the distinction of vitality (net metering). Network associated frameworks change in estimate from private (2– 10 kWp) to sun

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oriented power stations (up to 10s of MWp). This is a type of decentralized power age. The sustaining of power into the framework requires the change of DC into AC by an exceptional, synchronizing network tie inverter. In kilowatt-sized establishments the DC side framework voltage is as high as allowed (ordinarily 1000V aside from US private 600 V) to restrict ohmic misfortunes. Most modules (60 or 72 crystalline silicon cells) create 160 W to 300 W at 36 volts. It is here and there fundamental or alluring to associate the modules mostly in parallel instead of all in arrangement. One set of modules connected in series is known as a 'string'.

II. PROPOSED PV-STORAGE SYSTEM ARCHITECTURE

A. Batteries

In the modern era, electrical vitality is ordinarily changed over from mechanical vitality, sun oriented vitality, and synthetic vitality and so forth. A battery is a gadget that believers concoction vitality to electrical vitality. The main battery was produced by Alessandro Volta in the time of 1800. In the year 1836, John Frederic Daniell, a British scientific expert built up the Daniell cell as an enhanced rendition of the voltaic cell. From that time until today, the battery has been the most well known wellspring of power in numerous day by day life applications. In our every day life, we for the most part utilize two sorts of battery , one of them is which can be utilized once before it gets completely released. Another sort of battery is rechargeable which implies it can be utilized various circumstances by energizing it remotely. The previous is called essential battery and the later is called auxiliary battery. Batteries can be found in various sizes. A battery might be as little as a shirt catch or might be so huge in estimate that an entire room will be required to introduce a battery bank. With this variety of sizes, the battery is utilized anyplace from little wrist watches to an extensive ship. We regularly observe this image in many outlines of electrical and hardware arrange. This is the most famously utilized image for battery . The greater lines speak to positive terminal of the cells and littler lines speak to negative terminal of the cells associated in the battery . We are regularly confounded about the terms battery cell and battery . We for the most part allude a battery as a solitary electro-synthetic cell. In any case, actually, battery does not imply that. Battery implies various electro-synthetic cells associated together to meet a certainvoltage and current level. In spite of the fact that there might be a solitary cell battery , actually, battery and cell are different.

B. History of Battery

In the year of 1936 during the middle of summer, an ancient tomb was discovered during construction of a new railway line near Bagdad city in Iraq. The relics found in that tomb were about 2000 years old. Among these relics, there were some clay jars or vessels which were sealed at the top with pitch. An iron rod, surrounded by a cylindrical tube made of wrapped copper sheet was projected out from this sealed top. When these pots were filled with an acidic liquid, they produced a potential difference of around 2 volts between the iron and

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copper. These clay jars are suspected to be 2000 year old battery cells.

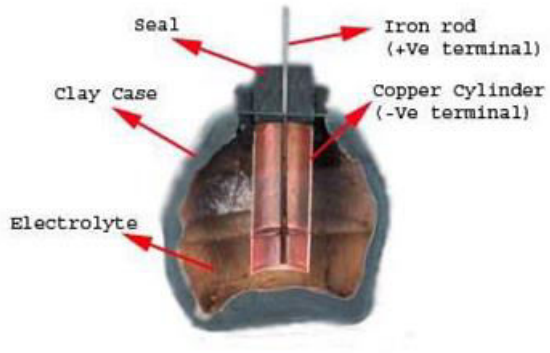

Fig2.

In 1786, Luigi Galvani, an Italian anatomist and physiologist was amazed to see that when he touched a dead frog's leg with two unique metals, the muscles of the legs contracted. He couldn't comprehend the real motivation behind why, else he would have been known as the main creator of the battery cell. He figured the response may be because of a property of the tissues. From that point forward, Alessandro Volta understood that same wonder could be made by utilizing cardboard absorbed salt water rather than frog's leg. He sandwiched a copper circle and a zinc plate with a bit of cardboard absorbed salt water in the middle of them and found a potential distinction between the copper and zinc. After that in 1800, he built up the primary Voltaic Pile (battery) developed of exchanging copper and zinc circles with bits of cardboard absorbed saline solution between them. This framework could deliver quantifiable current. Alessandro Volta's voltaic heap was viewed as the primary "wet battery cell". Along these lines, the historical backdrop of battery started. The fundamental issue with the Voltaic heap was that, it couldn't convey current for quite a while. This issue was comprehended by a British creator John F. Daniell in 1836. He created a more created rendition of the battery cell which is known as the Daniell cell. Here in this cell, one zinc rod is immersed in zinc sulfate in one container and one copper rod is immersed in copper (II) sulfate in another container. The solutions of these two containers are bridged by a U shaped salt bridge. A Daniell cell could produce 1.1 volt and this type of battery lasted much longer than the Voltaic pile.

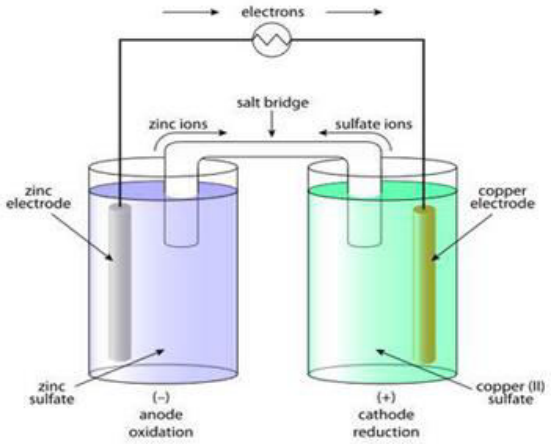

Fig3.

In 1839, the fuel cell was designed by Sir William Robert Grove, a discoverer and man of science. He mixed hydrogen and oxygen within an electrolyte solution, and created electricity and water. The fuel cell did not deliver enough electricity, but it is helpful. Bunsen (1842) and Grove (1839) created enhancements to battery that used liquid electrodes to supply electricity. In the year of 1859, Gaston Plante; first developed the lead acid battery cell. This was the first form of rechargeable secondary battery. The lead acid battery is still in use for many

industrial purposes. It is still the most popular to be used as car battery. In 1866, the battery was again developed by a French engineer, Georges Leclanche. It was a carbon-zinc wet cell battery known as the Leclanche cell. Crushed manganese dioxide mixed with a bit of carbon forms the positive electrode and a zinc rod is used as the negative electrode. Ammonium chloride solution is used as a liquid electrolyte. After some years, Georges Leclanche himself improved his own design by replacing liquid ammonium chloride solution with ammonium chloride. This was the invention of the first dry cell. In 1901, Thomas Alva Edison discovered the alkaline accumulator. Thomas Edison's basic cell had iron as the anode material (-) and nickel oxide as the cathode material(+). This is just one portion of an endless **history of** battery.

C. Working Principle of Battery

To understand the essential standard of battery appropriately, to begin with, we ought to have some fundamental idea of electrolytes and electrons proclivity. As a matter of fact, when two unique metals or metallic mixes are drenched in an electrolyte, there will be a potential contrast delivered between these metals or metallic mixes. It is discovered that, when some particular mixes are added to water, they get broke down and create negative and positive particles. This kind of compound is called an electrolyte. The well known cases of electrolytes are a wide range of salts, acids, and bases and so forth. The vitality discharged amid tolerating an electron by a nonpartisan iota is known as electron partiality. As the nuclear structure for various materials are unique, the electron liking of various materials will vary. In the event that two various types of metals or metallic mixes are inundated in a similar electrolyte arrangement, one of them will pick up electrons and the other will discharge electrons. Which metal (or metallic compound) will pick up electrons and which will lose them relies on the electron affinities of these metals or metallic mixes. The metal with low electron liking will pick up electrons from the negative particles of the electrolyte arrangement. Then again, the metal with high electron partiality will discharge electrons and these electrons turn out into the electrolyte arrangement and are added to the positive particles of the arrangement. Along these lines, one of these metals or mixes picks up electrons and another loses electrons. Therefore, there will be a distinction in electron fixation between these two metals. This distinction of electron focus makes an electrical potential contrast create between the metals. This electrical potential contrast or emf can be used as a wellspring of voltage in any hardware or electrical circuit. This is a general and essential guideline of battery . All batteries cells are construct just in light of this fundamental standard. We should examine one by one. As we said before, Alessandro Volta built up the main battery cell, and this cell is famously known as the straightforward voltaic cell. This sort of straightforward cell can be made effectively. Take one compartment and fill it with weakened sulfuric corrosive as the electrolyte. Presently inundate zinc and one copper bar in the arrangement and associate

them remotely by an electric load. Presently your straightforward voltaic cell is finished. Current will begin coursing through the outside load. Zinc in weakened sulfuric corrosive surrenders electrons as underneath: These Zn + particles go into the electrolyte, and their fixation is high close to the zinc terminal. Because of the above oxidation response, the zinc terminal is left adversely charged and thus goes about as cathode. The weakened sulfuric corrosive and water disassociate into hydronium particles as given underneath: Because of the high grouping of Zn + particles close to the cathode, the H3O+ particles are repulsed towards the copper terminal and get released by expelling electrons from the copper molecules. The accompanying response happens at the anode: Because of the decrease response occurring at copper electrode, copper is left positively charged and hence it acts as the anode.

Daniell Battery Cell:

The Daniell cell consists of a copper vessel containing copper sulfate solution. The copper vessel itself acts as the positive electrode. A porous pot containing diluted sulfuric acid is placed in the copper vessel. An amalgamated zinc pole plunging inside the sulfuric corrosive goes about as the negative terminal. At the point when the circuit is finished, weakened sulfuric corrosive in the permeable pot responds with zinc in order to free hydrogen gas. The response happens as underneath: The arrangement of ZnSO4 in the permeable pot does not influence the working of the cell, until the point that gems of ZnSO4 are kept. The hydrogen gas goes through the permeable pot and responds with the CuSO4 arrangement as underneath: Copper so shaped gets kept on the copper vessel. The proposed SPVS is appeared in Fig. 2 and comprises of a PV board, batteries, two converters, and a solitary stage dc/air conditioning inverter. The lift converter (BC) is utilized to keep up the dc interface voltage, while the charging or releasing method of the bidirectional dc/dc converter is connected to track the MPPT of the PV cluster when the accessible PV control is lacking to meet the heap. In this way, the two dc/dc converters in the framework should be composed by an upper level controller. One of the key highlights of the proposed remain solitary framework is that the capacity subsystem is associated with the PV module specifically. This setup gives an adaptable smooth operation to the framework, since the part of the principle PV control stream and that of the capacity subsystem are unmistakably isolated from each other. The framework could work with and without battery both, with no real mode change in the nearby controllers, which is ideal from mechanical perspective. The proposed framework engineering does the switch between the distinctive methods of operation smooth and basic without the requirement for supervisory controller. Besides, this course of action gives greater adaptability in picking the battery's ostensible voltage with a sensible advance up proportion. It likewise stores the abundance PV vitality in the battery to adjust the framework and supplies the prompt pinnacle control request. One of the principle worries in the past design is the

battery voltage, which needs stacking up of different packs to improve the voltage extend. As a matter of fact, the stacking up requires an adjusting circuit, a supposed charge balancer, which influences the framework to structure more muddled, bringing about an unwanted arrangement as far as the size and cost aggressiveness. Additionally, some wellbeing issues are watched, whereby the high-voltage dc lines can make lethal harm the human body since the battery is alive notwithstanding amid the principle control framework kill; the voltage range should along these lines meet the electrical security standard and directions of the IEEE and the IEC. In this manner, the proposed conspire is more attractive for the PV-stockpiling blend framework. In the past segment, it has just been seen that the battery voltage in the customary plans ought to be more noteworthy than 100 V on account of a principal trademark that the bidirectional converter (BDC) should release the battery vitality to 400 V dc connect. The necessity evacuates every one of the benefits of the low-voltage battery and the adaptability from the traditional structures. Five adaptable operation modes are workable for the proposed plot. These modes rely upon the power delivering and vitality putting away conditions, as takes after. Mode I—PV-stockpiling associated (PMPP < Pload): The PV isn't sufficient to take care of load demand, so the battery bank is released to take care of the heap demand. The BDC releases the put away vitality to the contribution of PV PCS, and the BC improves PV voltage up to the 400 V dc interface. Mode II—PV-associated (PMPP < Pload): If the battery turns out to be completely released, or when the battery bank is expelled, the framework enters the non-MPPT mode or under voltage lockout and close down. Mode III—PV-stockpiling associated (PMPP > Pload): The collected power surpasses the heap and the battery is accused of the abundance control, until the point when the battery is completely charged. Electric power can spill out of the PV source to the heap and in addition charge the battery. Mode IV—PV-associated (PMPP > Pload): If the battery is completely charged, the battery bank ought to be disengaged from the PV control molding framework. The MPPT must be impaired (non-MPPT), and the PV voltage reference is set at consistent to hold the CPV voltage, giving the heap control following. Mode V—Battery-associated (evening time): When PV sources don't deliver adequate power for the heap, for instance, during the evening or on a shady day, the PV modules are detached from the power molding framework. Pload is given just by the battery through falling the BC, BDC, and full-connect inverter. Such a fell operation makes it conceivable to venture up the voltage from 24 Vdc, given by the battery bank, up to 400 Vdc to encourage the dc/air conditioning inverter and the heap. The PV-voltage circle reference of the control circle of the BDC switches simply to a constant value instead of the perturbed step of MPPT. The summary of operation modes is shown in Table I. Fig. 3 shows the flexible system configuration to realize each mode. In order to ensure the previous multistage power conditioning system such as SPVS

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operations with a stable response and a negligible steady-state error, some complex controllers were proposed previously. Among the proposed controllers, a linear controller based on proportional-integral-derivative (PID) was widely used and discussed. However, since these controllers require precise linear mathematical models, the PID family of controllers does not perform satisfactorily under parameter variation, nonlinearity, load disturbance, etc. Thus, in the previous literature, various control laws were proposed to handle the issue. One of the state-of-the-art technologies for the trou ble shooting is to use a nonlinear controller in order to improve the power quality under arbitrary loads.

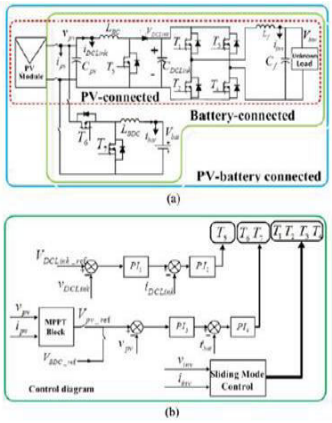

Fig.4. Block diagram of the overall system configuration of the SPVS. (a) Power stage. (b) Control strategy.

In this paper, a novel strategy that combines a multi loop proportional-integral (PI) controller and an SMC law is presented. The multi loop PI is used to control the operation of the dc/dc converters, whereas the SMC law is utilized for the output regulation of the dc/ac inverter due to its robustness and good performance with any type of unknown arbitrary load. In this paper, a simple algorithm of SMC that is easy to implement using digital signal processor (DSP) is applied. In this paper, all the power converters used for the SPVS as shown in Fig. 3(a) operate at 20 kHz switching frequency. The overall control strategies of the SPVS are shown in Fig. 3(b). This system has a number of advantages. First, the flexibility for various types of operating modes, with and without energy storage, is strongly guaranteed without the control configuration change. Second, the system can be applied even with a single 24 V commercial battery without any extra connection. The key feature of the configuration is that the control part [see Fig. 2(b)] does not change, even though the power stage varies according to the operating modes. The feature guarantees large flexibility and compatibility to the system.

III. SIMULATION DESIGN AND RESULT

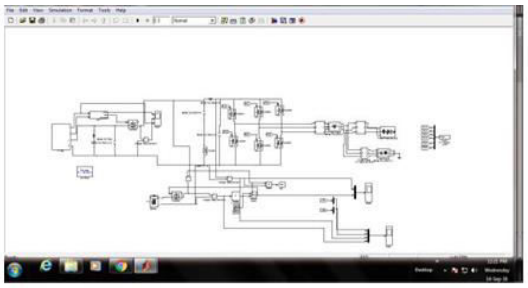

Fig5. Simulation model of the proposed pv and energy system topology.

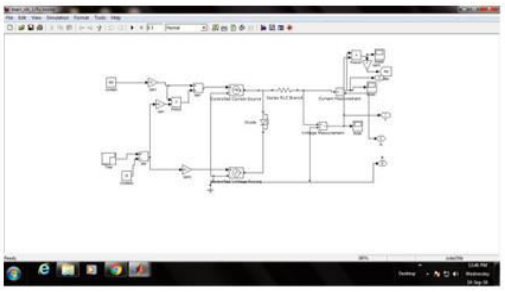

Fig6. Mathematical Modeling of PV System.

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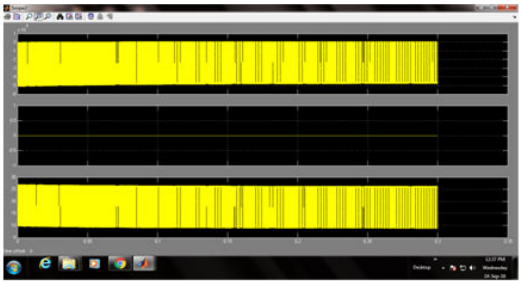


Fig7. PV System output current(Individual And MPPT) and voltages.

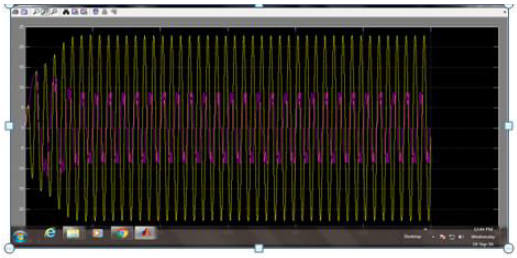
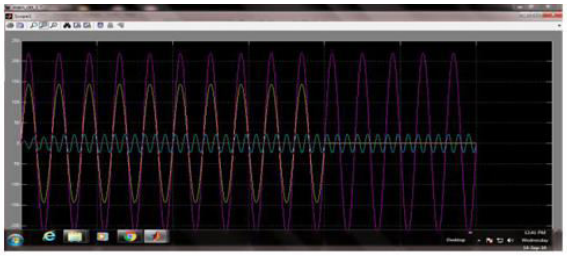


Fig8. Voltage of DC Capacitor and Currents in the Energy Storage System.



IV.CONCLUSION

In this paper, the dynamic-response analysis and the controller-design procedure of the flexible SPVS, including the lead-acid batteries as the energy storage devices, are studied. Both dc/dc converters are successfully controlled in a variable operation condition, and the control strategy achieves fast and accurate control of the inverter output voltage, even with nonlinear loads and step-load changes. From the proposed control architecture of the PV-storage system, multiple operating modes such as PV-only, storage only, and PV-storage coupled are allowed without any instantaneous control configuration changes. The experimental tests are verified by utilizing a 36-V battery bank; actually, the SPVS can also operate well when associated with a 24 V commercial single battery. The proposed topology, along with its control strategy, is very practical because of the flexibility of the configuration, and the controlling strategy of the bidirectional dc/dc converter and dc/ac inverter is simple and strong. As a result, it is compatible with a conventional PV or battery systems without any control configuration modification. This topology is highly promising for a commercial product of PV conversion systems

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