A NOVEL NINE-SWITCH CONVERTER FOR SOLAR ENERGY GENERATION SYSTEMS

D.Pugazhenthi, P.Sathishbabu and R.M.SasiRaja

Abstract - Renewable energy sources plays an important role in electricity generation. Various renewable energy sources like wind, solar, geothermal, ocean thermal, and biomass can be used for generation of electricity and for meeting our daily energy needs. Converter which converts DC power into either AC power or DC power is very essential part in solar power generation system. With rapid development in power semiconductor devices, the usage of power electronic systems has expanded to new and wide application range that include residential, commercial, aerospace and many others. These developments also allow introducing a new topology in power conversion system, here solar energy generation system. Solar energy generation systems usually include energy storages, local dc/ac loads or/and grid-tied dc-ac inversion stages. All these entities have their own converters since the solar energy is DC but domestic loads are dealing with AC. Even though this approach made the system flexible and easy design for the converter, this will not give the solution for some practical issues like increased switch count and poor utilization of solar panel. But all these issues must be taken in to account since solar energy generation is bulky and cost effective. This project mainly concentrates on these issues and provides better solution. This also allows various combinations of solar sources, energy storages and local loads to be compactly assembled for either grid-tied or standalone usage, and through proper control, the overall systems can still deliver the same levels of performances as their traditional correspondences.

Keywords: renewable energy, voltage source inverter, current source inverter, rectifier inverter topology.

I.INTRODUCTION

Every day, the sun radiates (sends out) an enormous amount of energy-called **solar energy**. It radiates more energy in one second than the world has used since time began. This energy comes from within the sun itself. Like most stars, the sun is a big gas ball made up mostly of hydrogen and helium gas. The sun makes energy in its inner core in a process called **nuclear fusion**. It takes the sun's energy just a little over eight minutes to travel the 93 million miles to Earth. Solar energy travels at a speed of 186,000 miles per second, the speed of light. Only a small part of the **radiant energy** that the sun emits into space ever reaches the Earth, but that is more than enough to supply all our energy needs. Every day enough solar energy reaches the Earth to supply our nation's energy needs for a year! Solar energy is considered a **renewable energy** source. Today, people use solar energy to heat buildings and water and to generate electricity.

D.Pugazhenthi is a PG scholar, Regional Centre of Anna University, Madurai, P.Sathishbabu is working as Assistant professor/Department of EEE, University College of Engineering, Ramanathapuram and R.M.SasiRaja is working as Assistant professor/Department of EEE, Regional Centre of Anna University, Madurai, E-mail id:pugalganthi@gmail.com

II.SOLAR ENERGY SYATEM

Filling the individual blocks with some simple representative circuits where twelve semiconductor devices are used in total (eleven controllable switches and one diode, which can be replaced by a controllable switch if the input source can absorb the backward flow of energy).

Quite obviously, no integration is introduced, and the overall system appears to be realized by connecting individual well-known circuit entities at a single common dc-link. Being fully decoupled by the dc-link capacitor, each circuit entity can be modulated as per when it is operating individually without interfering with the other entities. Surely, that is an advantage, but because of the intermittent nature of the solar source and battery charging process, having multiple individual converters might not appear to be a cost effective and compact solution, since most entities are not operated continuously. Therefore, some amount of circuit integration might be preferred to cut down on the number of semiconductor devices needed, while yet still attaining comparable performance as per the fully decoupled system. Like all reduced component count circuits, some tradeoffs like higher voltage stresses and control limitations can never be avoided, but can surely be minimized. Approaches to realize the minimization, together with operating principles of the proposed integrated single- and three-phase systems, are discussed in the following sections.

III.BOOST CONVERTERS (DC-DC)

A boost converter (dc-dc) is shown in Fig.3.1(a). Only a switch is shown, for which a device belonging to transistor family is generally used. Also, a diode is used in series with the load. The load is of the same type as given earlier. The inductance of the load is small. An inductance, L is assumed in series with the input supply. The position of the switch and diode in this circuit may be noted, as compared to their position in the buck converter(Fig.3.1(a)).

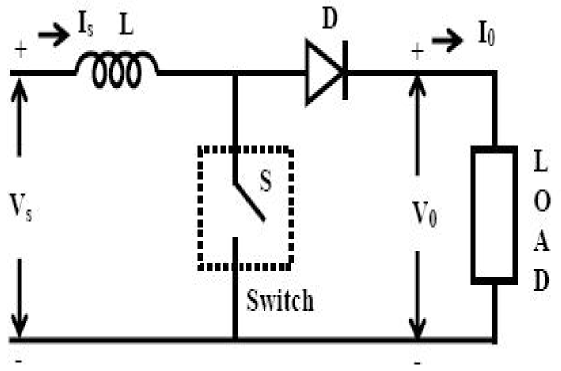

Fig 3.1(a) Boost converter (DC-DC)

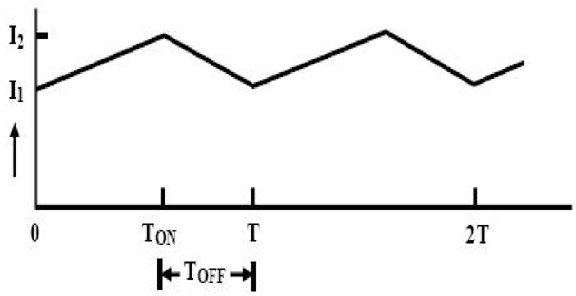

Fig 3.1(b) Waveforms of source current (i_S)

Firstly, the switch, S (i.e., the device) is put ON (or turned ON) during the period, $T_{ON} \geq t \geq 0$, the ON period being $T_{ON.}$ The output voltage is zero (v_o= 0), if no battery (back emf) is connected in series with the load, and also as stated earlier, the load inductance is small. The current from the source (i_S) flows in the inductance L. The value of current increases linearly with time in this interval, with(di / dt) being positive.

The switch, S is put OFF during the period, $T \geq t \geq T_{ON}$, the OFF period being $T_{OFF}= T- T_{ON}$ is the time period. As the current through L decreases, with its direction being in the same direction as shown (same as in the earlier case), the induced emf reverses, the left hand side of L being -ve. So, the induced emf (taken as -ve in the equation given later) is added with the supply voltage, being of the same polarity, thus, keeping the current (i_S=i_O) in the same direction.

IV. NINE SWITCH CONFIGURATION

Three-phase ac/dc/ac and ac/ac converters with variable frequency (VF) and variable voltage operation have found wide applications in the industry. The most popular configuration uses voltage source inverter (VSI) with a diode rectifier as the front end for adjustable speed drives (ASDs), uninterruptible power supplies (UPS), and other industrial applications. This configuration features low cost and reliable operation due to the use of a diode rectifier, but it generates highly distorted input line currents and does not have regenerative or dynamic braking capability. These problems can be mitigated by using a back-to-back two-level voltage source converter (B2B 2L-VSC) where a pulse width modulation (PWM) voltage source rectifier is used to replace the diode rectifier. There are 12 switches have used for ac/dc/ac conversion, where as only nine switches have used. The idea is to combine the switches SX'(X=A, B & C) and SY'(Y=U, V & W). Switches SX' & SY' can be replaced by the switch SXY. In Nine switch topology Upper three & Middle three switches act as a Rectifier and Middle three & Lower three switches act as an Inverter. So the Middle three switches are shared by both upper and lower three switches. The PWM pulses should be generated in such a way that Upper half will give DC, and Lower half will give AC simultaneously. This configuration is the key for this project which makes a Nine switch converter for Solar power generation. But this converter converts DC/AC for grid connection or AC load, and DC/DC for charging Battery connected with the system simultaneously.

V.RENEWABLE ENERGY AND RESOURCE BUFFERING

Definitions for 'renewable energy' vary depending on the context and scope of the energy system under investigation but this is generally understood as energy derived from natural, repetitive processes that can be harnessed for human benefit without consuming exhaustible resources. The source for most of this energy is from the sun, harnessed directly through solar heating or electricity generation, or indirectly through wind, waves, running water, and the ecosystem. Additional sources of renewable energy include tidal energy derived from gravitational pull and geothermal energy from heat generated within the earth. Renewable energy sources can be highly transient and exhibit strong short-term and seasonal variations in their energy outputs. Their variability poses problems for applications that require a continuous supply of energy. In addition, renewable resources typically have a low energy density, often large collection areas are required to generate modest power outputs. Various agencies like the Department of Energy, the International Energy Agency, the UN International World Energy Assessment etc. the have generated estimates for the contribution that renewable energy sources provide to the total world energy usage. The estimates vary slightly, but in general, the largest contribution is from combustible renewables and renewable waste streams at approximately 10%, followed by hydro at approximately 2.2%, while all the other renewable forms combined contribute only 0.5% of the total world energy demand [5]. These percentages have remained fairly constant over the past 20 years; however, the total world energy usage has nearly doubled during that time to 11,435 Mega tons of oil equivalent (479 Exajoules) in 2005. While it is encouraging to see that the installed capacity of renewables has kept pace with the general increase in world energy demand, renewables still provide only a small fraction of our overall energy needs. Scenarios for energy consumption put forth by the various energy agencies all point to substantial growth in the total world energy consumption. A primary driver for the increase is due to the projected population growth coupled with increase in energy usage per capita as developing countries strive to improve their standard of living.

VI.METHODOLOGY

As mentioned earlier, the development of power electronic devices lead us to introduce new topologies for power conversion. This project also concentrates on the converter that can replace Back to Back converter with minimum number of switches but can do the same operation. The following figure shows the block diagram of the Nine switch converter that can be used for solar power application. The following figure shows the block diagram of the Nine switch converter that can be used for solar power application.

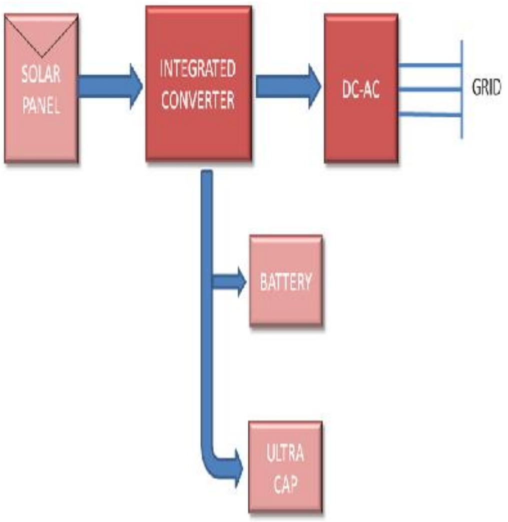

Fig 6.1 Block diagram of SPGS with Integrated Converter

The Integrated Converter which shown in the above block diagram can replace all individual converters in the system. This can be capable of doing the same operation that the individual converter can do. This will be explained in the following section.

VII.CIRCUIT DIAGRAM AND EXPLANATION

Figure 7.1 shows the proposed compact three-phase solar generation systems, derived by merging functionalities of some switches found in Figure4. 1(b). Based on the labeling convention adopted in Figure4.1(b) and 2, the gating signals to the middle "merged" switches SXY (X = A, B or C, and Y = a, b or c) in Fig.4.2 can be written as the XOR-ing of signals for SA and Sa', with the signals to the remaining upper and lower switches kept unchanged. The resulting system then uses only nine switches, instead of twelve, with the upper three and middle three switches forming the dc-ac inverter, and the same middle three and lower three switches forming three dc-dc converters with a common ground for processing energy flowing from the indicated solar module, battery and ultra-capacitor.

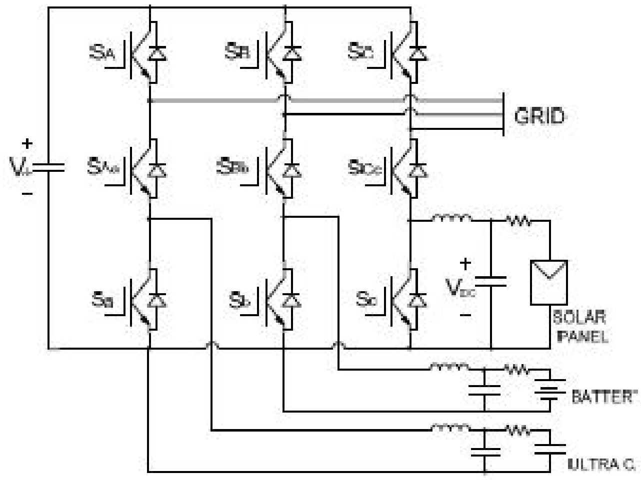

Fig 6.2 Circuit diagram of SPGS with Integrated Converter

The switching constrain for this proposed topology is slightly complicated as the middle switches have been shared by both top and bottom switches. In the nine-switch topology, the converter input and output voltages can be independently controlled although the middle switch in each leg is shared by the inverter and chopper. The proposed converter has only three valid switching states per phase as illustrated in Table 7.1.

(V_A= Upper and V_b = Lower Terminal Voltages)

SA	*SAa*	*Sa*	V_A	V_a
ON	*ON*	*OFF*	V_{dc}	V_{dc}
ON	*OFF*	*ON*	V_{dc}	*0*
OFF	*ON*	*ON*	*0*	*0*

Table7.1 Switching States And Output Voltages Per Phase.

VIII. SIMULATION AND RESULTS

The control scheme shown in Figure 3.1(a) and Figure 3.1(b) has been simulated. The Fig.7.2(a) shows the Matlab Simulink model of the control scheme. And the result is shown in Fig.7.2(b).

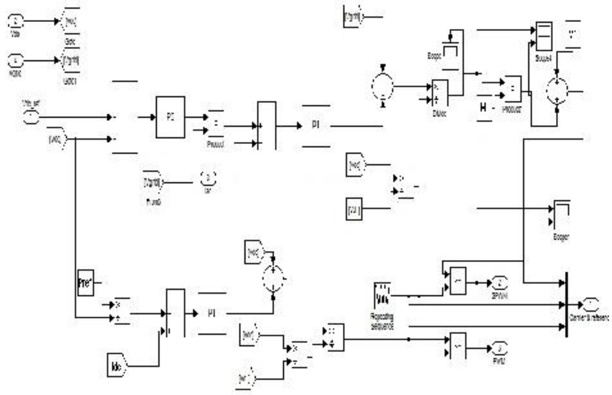

Fig 8.1(a) Simulink model of Control scheme1

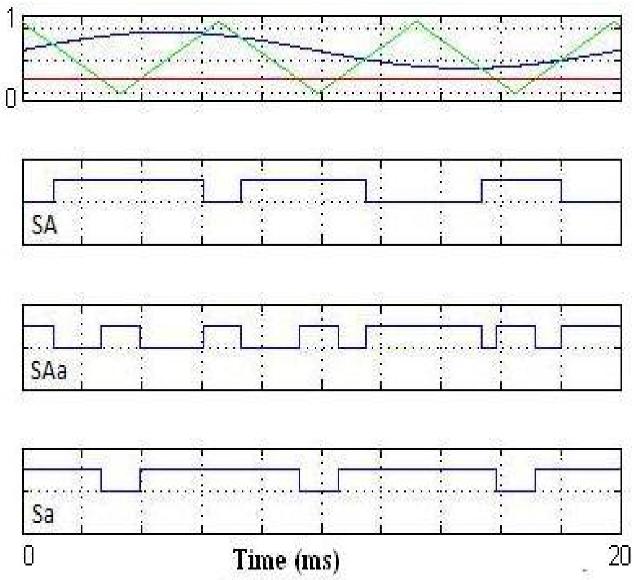

Fig 8.1(b) Simulation Result of Control scheme

The Integrated systems drawn in Figure 8.2 was simulated in Matlab / Simulink environment using those parameters listed in Table 8.1.

Parameters	Value
Grid RMS line voltage	226V
Switching frequency	10 kHz
DC-link voltage	440V
DC-link capacitance	2200 µF
Carrier sub-bands	*h1* = 0.8, *h2* = 0.2

Table 8.1 Parameters used for Simulation

The correspondingly captured results for the proposed system is shown in Figure 8.2. As intended, the three-phase sinusoidal references with triplen offset added are centrally placed within the upper sub-band of *h1* = 0.8, while the linear references are placed within the lower sub-band of *h2* = 0.2.

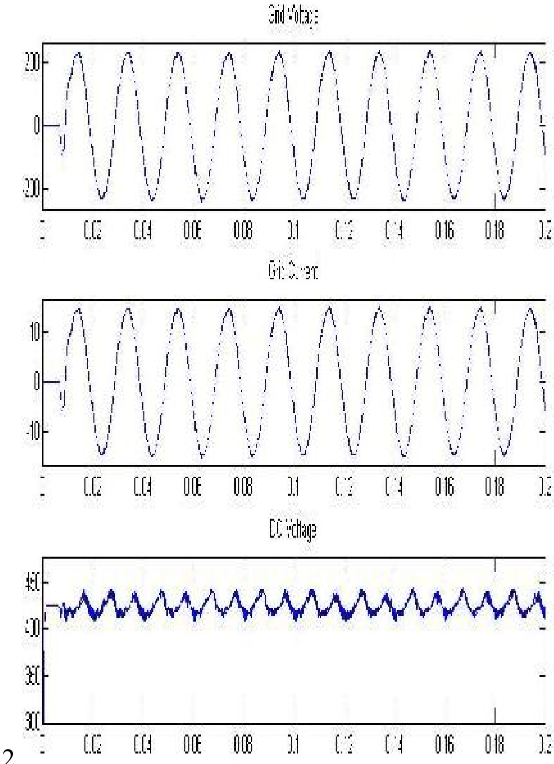

Fig 8.2 Simulink Result of Proposed System for the single phase

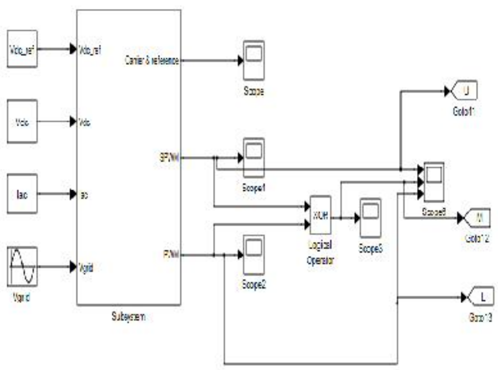

Fig 8.3 Simulink model of Control scheme2

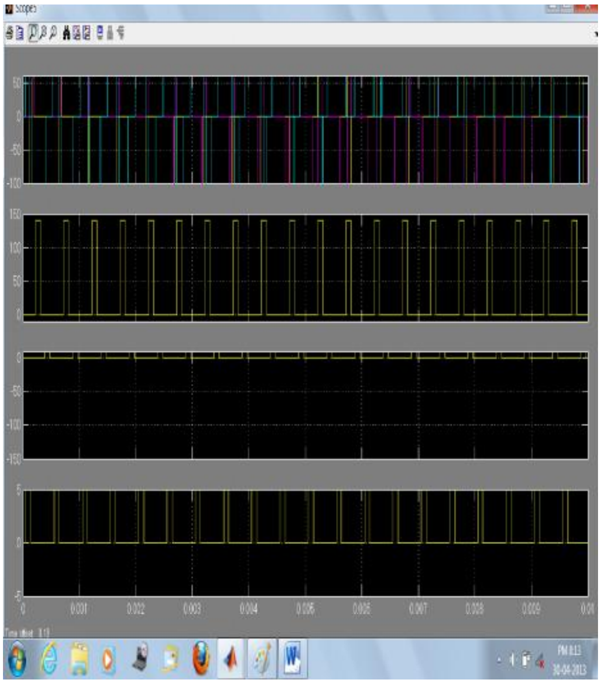

Fig 8.4 Simulink Result of Proposed System for the three phase

IX.CONCLUSION AND FUTURE WORK

Our paper work mainly concentrated on the low power design and the simulation of the same. Through proper design, the proposed solar systems are shown to output equally good terminal waveform quality, while yet gaining advantages like reduced switch count and compactness. Surely, some tradeoffs cannot be avoided, but can be minimized through proper modulation planning, and therefore does not constitute a major problem. Even though a high amount of effort is needed to design, this integrated converter offers many advantages over other topologies like reduced size and weight with increased efficiency. With all considerations, it can be safely concluded that this designed nine switch topology offers a satisfying solution. For verifying the theoretical validity, simulation testing have been performed, whose results clearly show the favorable responses of the proposed solar generation systems.

In future this work may be implemented in hardware and may extended for higher power rating with higher performance. The power factor correction and harmonic analysis may also be carried out for this system to increase the performance.

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