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To Study, Analysis and Comparison of Different Converters for Solar Energy Sources - A Review

Shyam Gupta
Shri Guru Sandipani Institute of Technology & Science, Ujjain, India

Abstract - At present, power electronics advancements on solar energy sources are mainly lying on converters and inverters (i.e.) moderators. The power electronic modules play a vital role in handling generation, transmission, distribution and consumer end appliances. Due to the lack of familiarity on the power electronic modules the researchers experience the complexity in choosing appropriate power electronic modules for standalone solar energy sources like Photovoltaic panels, wind turbines etc. The improper selection of power modules leads to deteriorating the efficiency of the system and detriment of the equipments too. There is a discussion on the usefulness of hybridization of solar energy resources by taking into account of optimum utilization and compensation of the investment done on the sources. So, choosing a suitable power module for the hybrid system further increases the complexity in choosing the appropriate power electronic modules. This proposed paper will emphasis on different power electronic converters that have been presented in the literature which are suitable for stand-alone and an array of solar energy sources. In addition, it presents about different kinds of power converter topologies along with the technical requirements, control structures and boundaries. This paper also gives an insight on the evaluation of the existing converter topologies by considering the various parameters. Through which a suitable characterization of promising converter topology can be opted for either stand alone or hybrid solar energy resources.

Keywords: *Solar Energy Sources; Hybridization; Power Electronic Converter; Photovoltaic Panels, Wind Turbine*

I. INTRODUCTION

In current years, the traits on new and extra easy approaches to supply strength turns the researchers to attention at the solar strength reassets. Since, the strength produced via way of means of the solar strength reassets are now no longer steady at all of the times, a huge variety of strength manage strategies have to be worried to offer a dependable strength to the consumers [1]. As the manage moves are on electric parameters, strength digital converters/inverter/modulators are very much appropriate/essential for controlling the solar strength that's derived from solar reassets [32]. Further, there are big quantity of studies works were done at the strength digital modulators,which ends special forms of converters are to be had for use [33]. Selection of a appropriate converter amongst them via way of means of thinking about all of the conditions and standards will cause confusion. This paper will give an explanation for the special forms of converter topologies appropriate for solar strength reassets; it'll assist the users/researchers in characterizing the converter easily. Stand-by myself solar strength providing to the burden have its personal limitation, because of its restricted present day wearing capability and the strength produced will now no longer be stays equal in any respect times, so mixture of or extra solar strength reassets will clear up the problem of non-stop strength deliver to the burden. So this paper describes the converts completely for 2 or extra solar strength (sun and wind) reassets linked parallel. In order to put into effect stand by myself or combined solar strength reassets that's to be interconnected with electric grid, the DC-DC and DC-AC converter topologies have to be applied within side the system.

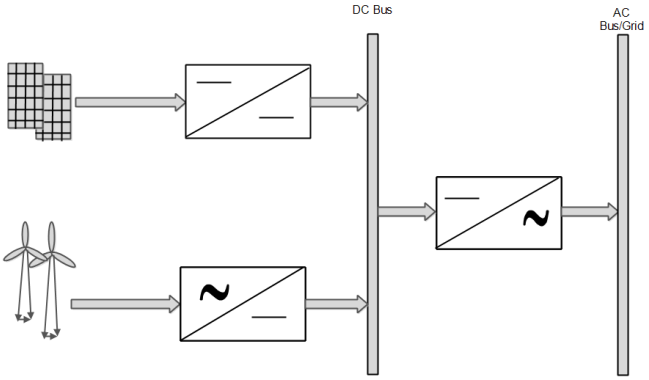

Fig.1. General Power Conversion method for combined Solar energy systems connected to DC and AC grid

II. DC-DC CONVERTER TOPOLOGY

Generally, Solar panel output is in the form of DC, when these SPV panels are connected as stand-alone, first the DC output must be regulated with required DC bus voltage. For this regulation, a suitable DC/DC converter to be placed. Different kinds of DC/DC converters are available in use; the following are the details of various converters,

A. DC-DC Converter - 1

For lower range PV systems, output from the panel itself required to raise the voltage to the required value, so that you can obtain the voltage regulation a DC/DC Boost Converter ought to be in place. But a conventional increase converter isn't appropriate to obtain the voltage extra than three instances of the enter voltage because of its balance and performance concern [1]. But practically, growing best 3 instances of the enter voltage will now no longer remedy the cause whilst the weight current is growing steadily. So, to keep away from the over load situation and isolate the weight from the sources instantly, the converter ought to have the functionality to deliver the voltage in a huge variety (ideally extra than three instances deliver functionality). In current research papers, a singular DC-DC converter topology which approach to obtain 10 instances of the enter voltage has been referred to below [1].

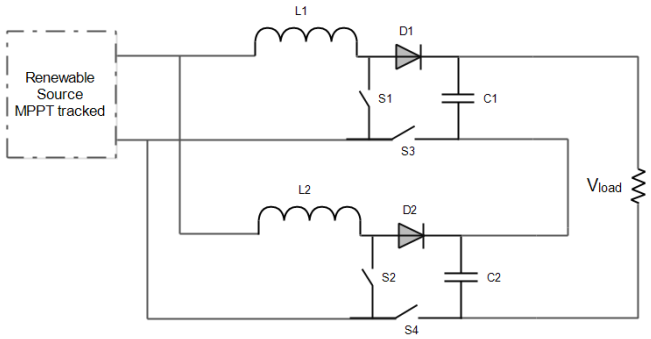

Fig.2. DC-DC Converter -1

The basic operation of the circuit is logic operation of the two parallel connected converter system with its switches. The following sequence/switching table makes us to understand the operation clearly,

Table 1: Switching Sequence

S1, S4 = 0	S2, S3 = 0	No Output
S1, S4 = 0	S2, S3 = 1	Boosted output with high Gain
S1, S4 = 1	S2, S3 = 0	Boosted output with high Gain
S1, S4 = 1	S2, S3 = 1	Boosted output with maximum Gain

From this, we can declare that, this converter is very much suitable for the applications where a high gain is required to feed the load [1]. This converter may be well suits for standalone solar energy source applications.

B. DC-DC Converter - 2

In general, conventional boost converter to be implemented with high step up voltage gain with a

large duty ratio [3]. However, the conversion efficiency and step up voltage gain is limited due to the constraints of losses of power switches and diodes, capacitors, inductors and reverse recovery problems of diodes and other semiconductor switches. So, a step-up converter with reasonable duty ratio to achieve high efficiency and high voltage gain is very much important for standalone solar energy sources. The isolated converters such as forward, fly back, full bridge, half bridge and push-pull can be used to step up the input voltage by adjusting the transformer turns ratio [3]. These converters, will suffer from high voltage stress across the switch and high power dissipation because of leakage inductance of the transformer. The above mentioned issues can be resolved by using snubber circuits, but the efficiency will deteriorate. In order to recycle the energy dissipated in the transformers windings, active clamp techniques can be imposed [4]. Due to the mentioned changes/additional circuitry the cost will shoot up. With the intention of eliminating the technical issues mentioned above, a new converter topology has been declared below [3]. This converter has the following features,

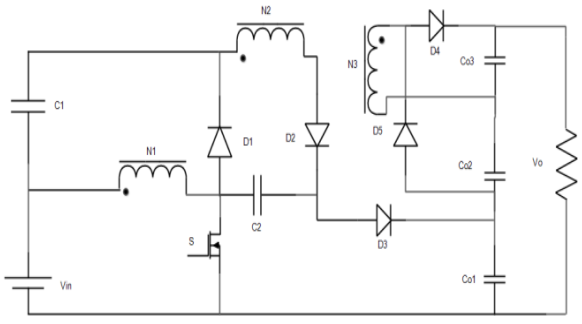

Fig.3. DC-DC Converter-2

- This circuit is exclusive for standalone solar Energy source.
- High step up voltage gain can be achieved.
- Energy stored in the leakage inductor will be recycled, so that the efficiency may increase.
- Only one switch is used in this circuitry and the electrical stress across the switch can be easily eliminated using suitable clamp techniques.
- Complexity in designing suitable capacitor values (C1, C2, Co1, Co2, Co3).

C. DC-DC Converter - 3

Using power digital converters with excessive advantage for solar electricity sources are inevitable. A coupled inductor improve converter can offer excessive voltage advantage with out severe obligation cycle operations [2] [24]. But, because of the presence of inductor the strain throughout the transfer will growth [7]. However, massive voltage spikes throughout the transfer for the duration of flip off is because of its transformer leakage inductance should be overcome with a appropriate spike suppressing method/circuits. Otherwise, the existence time of the transfer will pass down and the transfer reaction for the duration of activate and flip off may work wrong. On the opposite hand, the use of appropriate clamp strategies for suppressing the voltage spikes throughout the transfer ends in growth the cost. Also, any overlap in switching can direct to failure of the complete circuitry, thereby decreasing the reliability of the circuit too. The beneath referred to DC/DC Converter topology designed to attain excessive voltage advantage with minimized voltage strain throughout the strength transfer by incorporating coupled inductor and switched capacitor.

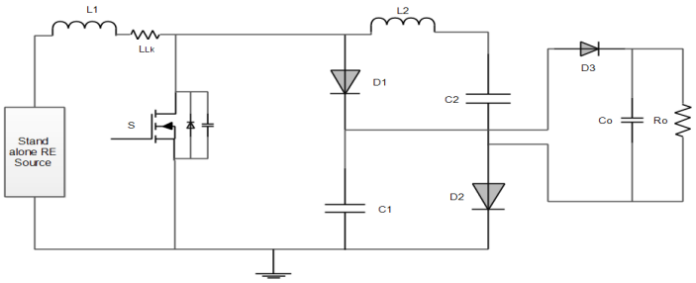

Fig.4. DC-DC Converter - 3

The capacitors C1, C2 are charged by L2 and the same will be discharged in series which increase the output voltage gain. A passive clamp circuit connected across the switch 'S' will minimize the turn-off spike. Preferably, the clamp circuit is used for enabling Zero Current Switching (ZCS) which guides for smooth/stress free switching [11] [21].

D. DC-DC Converter - 4

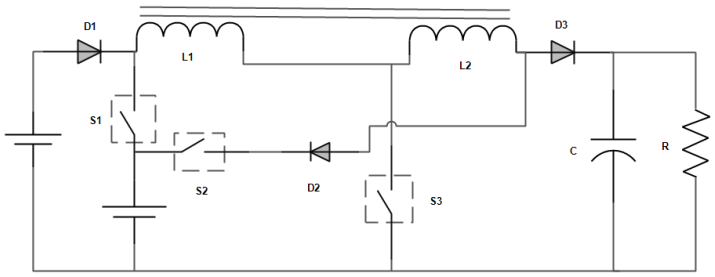

Fig. 5 DC-DC Converter - 4

In PV based generating structures, all of the strength converters gift in the structures are used to extract most strength from sun panels further to offer dependable strength to the load. Different topologies facilitate unmarried degree conversion to grid has its very own demerits. But in the case of degree conversion machine has DC-AC and DC-DC converters, due to the fact the intermittent nature of PV source, batteries are advised to be linked for preserving the non-stop and dependable strength to the grid [8]. In general, photovoltaic machine output is substantially low. In order to synchronize this PV machine with electric grid, the output have to be improved step by step to the specified fee with the circumstance of preserving the voltage constant. So, the raise converter have to be located in among PV machine and DC

grid [9]. The traditional raise converter has to function at most obligation ratios to gain excessive gain, which results in lessen the reliability of the converter, in order that the additives of the converter may fit failure. The above noted converter circuit able to managing 3 specific styles of solar power reassets at a time. From this converter, most strength may be extracted from all of the reassets linked, via which voltage law on the output may be achieved.This is possible through L1 and L2 and by controlling the switches S1, S2 and S3 with different switching frequencies. When L1 alone connects with the sources, the energy will be stored in L2 and anyone of the two sources connected to load by making the suitable switch in ON condition both inductors comes in series and transfers power to load, thereby providing high voltage gain [8].

III. MULTI-INPUT SOLAR ENERGY SOURCE CONVERTERS

Providing electrical power to the DC/AC grid through stand-alone solar energy sources are not reliable due their intermittent nature. Connecting different version of solar energy sources such as solar, wind, hydro-energy in parallel may address the reliability issues [25]. So that continuous power supply will be provided to the grid either by connecting all the sources or by connecting any one source which delivers maximum output [10] [18]. From this, a converter which immediately connected with the solar energy sources for moderating variable DC to fixed/constant DC must have the provision for connecting different solar energy sources [20].

A. Essential of Multi Input Converters (MIC)

The main reason for using the power electronics converters in solar energy sources are to capitalize the solar energy to the maximum and delivering to the load. Common forms of solar energy sources can be connected parallel which leads to complement each other in the sense that they can be utilized simultaneously to maintain continuous power delivery to the load. However, the different numbers of energy sources can be connected with individual converters and their outputs can be synchronized with a common DC bus. But when the sources are added subsequently, again the converter circuitry to be implemented separately to the DC bus [14]. It directs us to invest more and more and relatively the cost towards on this will be increasing heavily. The Multiple-Input converter (MIC) capable of handling different sources connected at a time and can delivers the constant DC voltage to bus. The basic Multiple-input converter derived from buck converter by including more DC voltage sources connected in the form of parallel. The bottle neck is, the different sources connected with MIC may not have the same amplitude, so they all must not be connected parallel rather be connected in parallel through a series connected switch [9]. The multiple input forward converters can be derived from isolated multi-input buck converter with the transformer isolation [16]. All the DC input voltages together with series connected active switches have their own individual primary windings, but they share secondary windings. The other way of optimizing the different sources through time-multiplexing scheme, that is the switch can be engaged with the individual source at a time and the current delivers to the load.

To stay away from the constraints of the time multiplexing, Multiple-Input Converter standards were introduced. In which, the energy may be efficaciously transferred to the weight via way of means of connecting with the correct reassets both via way of means of connecting individually/simultaneously [9]. There are different forms of topologies included for the MIC strategies to attain the specified output voltage withinside the load side. The designing of MIC has described a scientific techniques thru which a required MIC may be extracted from the not unusualplace simple non-isolated converters consists of buck, boost, buck-boost, cuk, zeta and SEPIC converters. Synthesizing of the MIC are accompanied with the idea of Pulsating Voltage Source Cell (PVSC), Pulsating Current Source Cell(PCSC) and they may be all derived from Pulsating Source Cell(PSC) that are all consistent with the six simple converters[9].

B. DC-DC Converter - 5

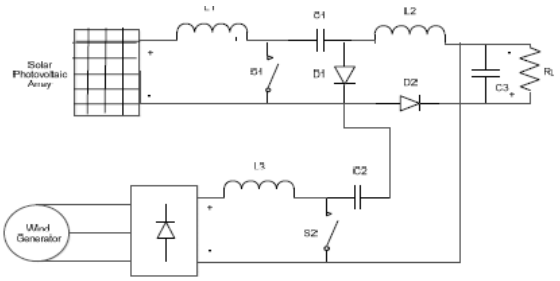

Fig. 6. DC-DC Converter - 5

One of the Multi-input and single output multiport converter topology has been mentioned in the above diagram which includes Cuk and SEPIC converter topologies. The load is supplied using both of input sources simultaneously and separately [8]. The main advantages of this topology includes, both sources are capable of adopting MPPT techniques, absence of input filter and can operate both in boost and Cuk converter. Other than the above mentioned, importantly the output voltage polarity is reverse to the polarity of the input sources [10].

When the output voltage is delivered from the solar panels, the Diode D2 is always turned ON and the respective switch S1 and D1 will be in action, so that time the converter action can be termed as Cuk converter and the voltage gain is mentioned as,

$$\frac{V_0}{V_{pv}} = \frac{d_1}{1-d_1}$$

$$V_0 = \frac{1}{1-d_2}\left[\frac{d1}{1-d_1}\,V_{pv} + \frac{d2}{1-d_2}\,V_w\right]$$

C. DC-DC Converter - 6

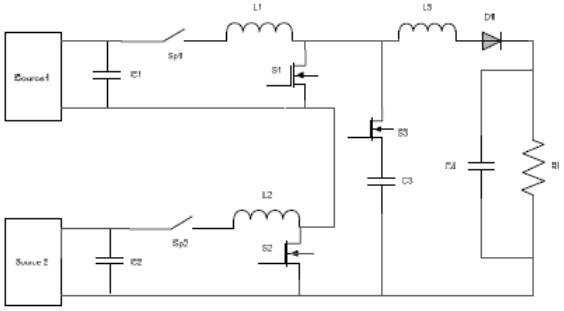

Fig. 7. DC-DC Converter - 6

This topology consists of two different solar energy sources which are going to deliver different output voltages [11]. By varying the Ton and Toff of the switches connected in this topology varies/modifies/regulates the output voltage and it delivers to the load RL. In the First mode of operation, the Source-1 delivers the load by switching on Sp1, S2 and switching off by Sp2. By considering the source-1 as the voltage source, the voltage gain can be written as,

$$Vo = \frac{2V1}{1-d1}\left[1+\sqrt{1+\frac{8La}{RoT\left(1-d1\right)^2}}\right]$$

CONCLUSION

This paper describes the different kinds of DC-DC Converters both stand-alone and MIC - single output and their modes of operation, features, advantages and disadvantages. In addition, the necessity/importance of Multi-input converters are also mentioned, from which we can understand that all the issues raised in the standalone sources can be eliminated using MIC. And it is highlighted the feature of MIC in managing the load either by connecting the source separately or simultaneously. Overall, this paper helps in suitable characterization of DC-DC Converters which are all used in solar energy sources.

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