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Interleaved Flyback Inverter for High Power Applications

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ABSTRACT: Conventional converters used like buck, boost have certain disadvantages hence we go for the improved flyback topology for high power application ,especially with a PV source. A grid-tied, isolated, and central-type inverter based on the flyback converter topology is introduced. The interleaved structure is an effective solution to increase the power level, which can minimize the current ripple, can reduce the passive component size. The flyback converter is recognized as the lowest cost converter among the isolated topologies since it uses the least number of components. This paper deals with simulation and analysis, design, of an isolated grid-connected inverter for high power applications. The system uses an interleaved flyback converter followed by a single phase inverter. Flyback topology works in discontinuous current (DCM) mode of operation .The aim of this paper is to monitor and operate flyback converter at high power with good performance which is difficult to implement. The interleaved inverter system gives an added benefit of reduced size of passive filtering element and reduces the overall cost. A simulation model of the proposed inverter system is developed and the design is verified for good performance based on the simulation results.

KEYWORDS*:* Flyback converter, interleaved converters,DCM.

I.INTRODUCTION

There are many converters available in the market. The flyback converter is recognized as the lowest cost converter among the isolated topologies since it uses the least number of components. One of the major application of high power flyback converter is in the area of renewable resources especially in solar systems. The solar energy is considered as one of the most renewable and freely available source of energy and it plays a greater role in the energy market of the world in the near future . Therefore, the research and development in the solar technology field is in the rise . However, the high cost of the technology still limits its usage globally. The low cost is greatly important for commercialization especially in small electric power systems including the residential applications. Therefore high power flyback converter is introduced. The simple structure of the flyback topology and easy power flow control with high power quality at the grid interface are the key motivations. The flyback converter is recognized as the lowest cost converter among the isolated topologies since it uses the least number of components. This advantage comes from the ability of the flyback topology combining the energy storage inductor with the transformer.

Furthermore, the interleaving of these high-power flyback stages (cells) facilitates developing a central-type PV inverter. The added benefit of interleaving is that the frequency of the ripple components (undesired harmonics) at the waveforms are increased in proportion to the number of interleaved cells. This feature facilitates easy filtering of the ripple components or using smaller sized filtering elements. The ability to reduce the size of passive elements is beneficial for reducing the cost and obtaining a compact converter. If it is implemented effectively with good performance, the developed inverter system can be a low-cost alternative to the commercial isolated grid-connected PV inverters in the market.

The selection of operation mode is another important factor. The mode of operation for the converter is discontinuous current mode (DCM) which has several advantages summarized as follows:

1) Provides very fast dynamic response.
2) No reverse recovery problem.
3) No turn on losses.

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4) Small size of the transformer.
5) Easy control.

It has several disadvantages as well. In this mode of operation, the current waveforms have higher form factor (high RMS to mean ratio) compared to continuous current mode (CCM). This normally leads to more power losses. So, as a solution, every current carrying path including the switching devices should have low resistivity. Another drawback of DCM operation is the current pulses with large peaks and high amount of discontinuity in the waveforms. Device paralleling is a way to handle the high peak currents. Nevertheless, these disadvantages can be considerably reduced by interleaving of several cells. As a first benefit, the current in each cell will have much less peak butNthe same amount of discontinuity. However, the discontinuity will be significantly reduced as soon as the cells connect at the common point. All this benefits come from the ability of phase shifted
several cells spreading the power flow evenly over the switching cycle with minimum discontinuity at the source and grid side. In brief, the effective interleaving has the potential to solve or greatly reduce the adverse effects of the DCM operation.

The remaining sections of this paper are organized as follows. Section II describes the analysis of flyback converter.. Section III describes flyback converter topology. Sections IV gives the overall simulation and result analysis. Finally, section V provides the conclusion.

II.FLYBACK CONVERTER

The flyback converter is used in both AC/DC and DC/DC conversion with galvanic isolation between the input and any outputs. More precisely, the flyback converter is a buck-boost converter with the inductor split to form a transformer, so that the voltage ratios are multiplied with an additional advantage of isolation. The two configurations of a flyback converter in operation: In the on-state, the energy is transferred from the input voltage source to the transformer (the output capacitor supplies energy to the output load). In the off-state, the energy is transferred from the transformer to the output load (and theoutput capacitor).

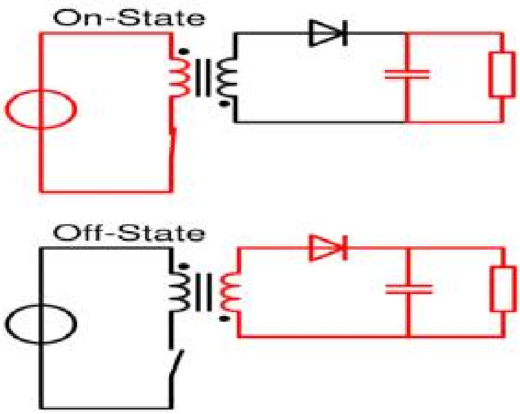

FIG 1. Flyback transformer

III.INTERLEAVED FLYBACK CONVERTER

Interleaving is a method of paralleling converters. Normally in other type of isolated topologies, the energy storing inductor and transformer are separate elements since the inductor is responsible for energy storage and transformer for energy transfer over galvanic isolation .Thus the combination of these, eliminate the bulky and costly energy storing Inductor and thus lead to reduction in cost and size of converter. Fig. 2 shows the circuirt diagram of interleaved flyback converter.

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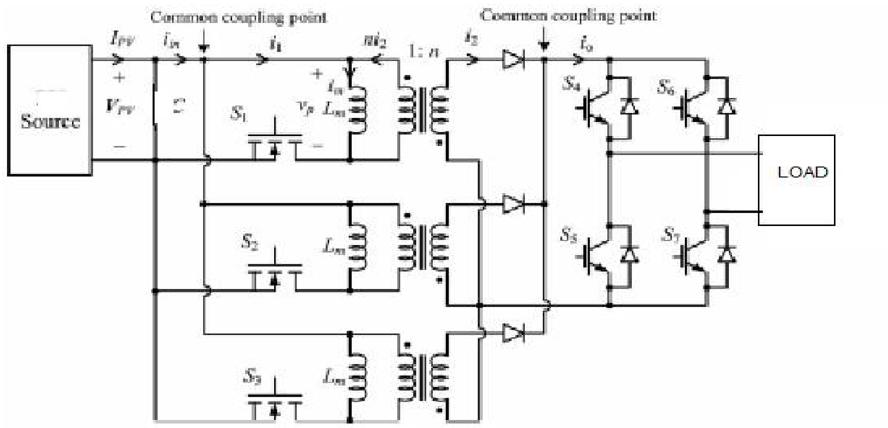

Fig.2.Interleaved flyback converter

As shown in Fig. 2, the source is applied to a three cell interleaved flyback converter through a decoupling capacitor. Each flyback converter uses a metal–oxide–semiconductor field-effect transistor (MOSFET) for switching at the primary side, a flyback transformer, and a diode at the secondary side. The topology also has to employ a full-bridge inverter and a low-pass filter for proper interface to the grid. When the flyback switches ($S1$,$S2$,$S3$) are turned ON, a current flows from the common point (the PV source) into the magnetizing inductance of the flyback transformers, and energy is stored in the form of magnetic field. During the on time of the switches, no current flows to the output due to the position of the secondary side diodes; therefore, energy to the grid is supplied by the capacitor Cf and the inductor Lf .When the flyback switches are turned OFF, the energy stored in the magnetizing inductances is transferred into the grid in the form of current. So, the flyback inverter acts like a voltage-controlled current source.

A high power flyback converter design needs large air gap in transformer which reduces the magnetizing inductance. As a result, large leakage flux with poor coupling and low energy transfer efficiency occurs. Due to this reason, the flyback converters are generally not designed for high power applications. Through interleaving of flyback stages, it can be used for high power applications. The success of the proposed inverter system is very much related to the success in the design and the practical realization of the flyback transformers. As aforementioned, the flyback transformers have to store large amount of energy and then transfer it to the output through magnetic coupling at every switching cycle. Therefore, during the design process, the strategies that first create the most effective energy storage mechanism and second the most optimum and efficient energy transfer path must be employed.

IV.SIMULATION AND RESULTS

Electrical power systems are combinations of electrical circuits and electromechanical devices like motors and generators. Engineers working in this discipline are constantly improving the performance of the systems. Requirements for drastically increased efficiency have forced power system designers to use power electronic devices and sophisticated control system concepts that tax traditional analysis tools and techniques. Further complicating the analyst's role is the fact that the system is often so nonlinear that the only way to understand it is through simulation .Land-based power generation from hydroelectric, steam, or other devices is not the only use of power systems. A common attribute of these systems is their use of power electronics and control systems to achieve their performance Sim Power Systems is a modern design tool that allows scientists and engineers to rapidly and easily build models that simulate power systems. Sim Power Systems uses the Simulink environment,allowing you to build a model using simple click and drag procedures. Not only can you draw the circuit topology rapidly, but your analysis of the circuit can include its interactions with mechanical, thermal, control, and other disciplines. This is possible because all the electrical parts of the simulation interact with the extensive Simulink modeling library. Since Simulink uses MATLAB® as its computational engine, designers can also use MATLAB toolboxes and Simulink block sets. Sim Power Systems and SimMechanics share a special Physical.

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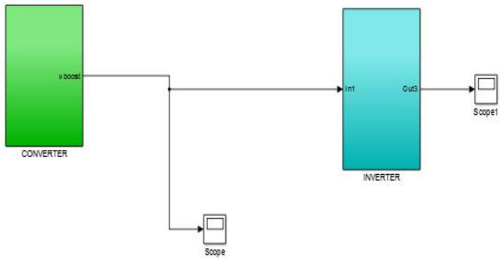

FIG.3 OVERALL SIMULATION

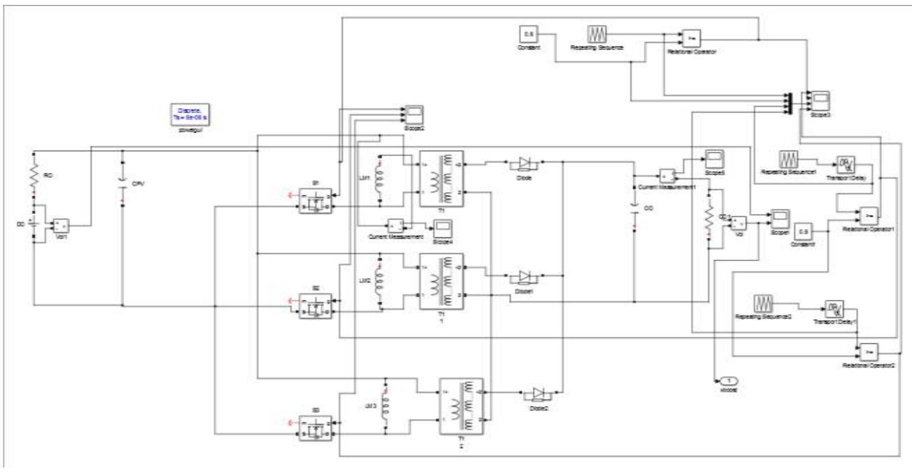

FIG 4.CONVERTER SECTION

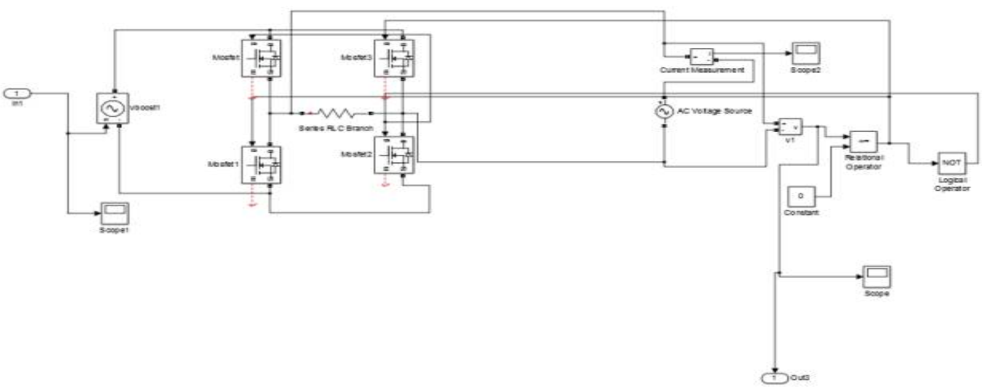

FIG 5.INVERTER SECTION

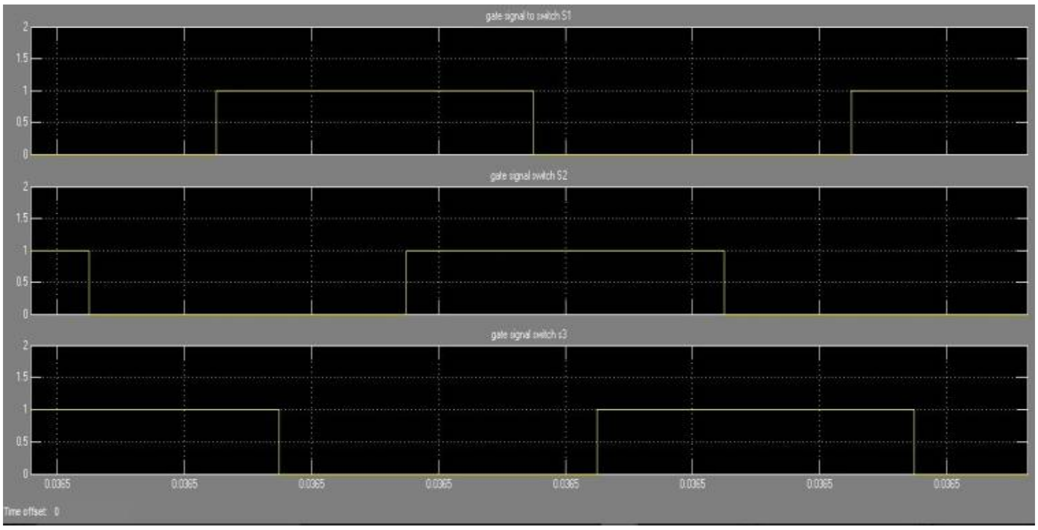

FIG 6.SWITCHING PULSES FOR S1,S2,S3

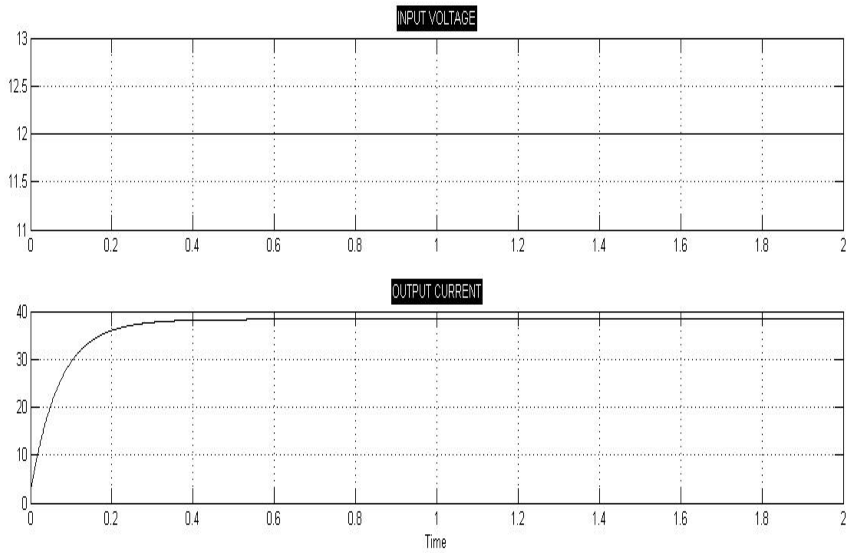

FIG 7. INPUT AND OUTPUT VOLTAGE WAVEFORMS

V.CONCLUSION

The interleaved flyback converter topology was implemented effectively with DCM mode of operation Flyback inverter is an attractive solution for photovoltaic ac module application..The flyback inverter should have high efficiency to satisfy users demand.In this topology, DCM is more preferred compared to BCM and CCM, because of its higherpower level, higher efficiency, and wider switching frequency bandwidth. The flyback topology is selected because of its simple structure and easy power flow control with high power quality outputs at the grid interface. The experimental results prove the successful operation of the inverter..

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