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Review of Flyback based Micro-Inverter for Photovoltaic Applications

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Abstract: **Grid-connected photovoltaic (PV) micro-inverters deliver the solar energy from a single PV panel to AC/DC utility. Compared with conventional centralized inverters, micro-inverters have several advantages, such as higher maximum power tracking efficiency, easier installation and longer life-time. In this paper, a grid-connected micro-inverter based on interleaved fly back converters is reviewed by various researchers. A dc/dc flyback converter is mainly used for low-power applications. However, for higher-power applications, interleaved flyback structure provides better advantages.**

***Index Terms*–** **Flyback, Ratio, Micro-inverter, Voltage, Gain.**

I. INTRODUCTION

In photovoltaic (PV) micro-inverter systems, a flyback inverter is an attractive topology because of the advantages of fewer components, simplicity, and galvanic isolation between the PV modules and the ac bus. A dc/dc flyback converter is mainly used for low-power applications. However, for higher-power applications, interleaved flyback structure provides better advantages: the ability to process more power with lower-current ripple [1]. By using the interleaved technique in the flyback inverter, the conduction loss of each switch can be reduced due to decreased current flowing in each stage. At the residential level, Photovoltaics (PV) usually output a low dc voltage. The interleaved flyback dc/dc converter is suitable for a residential level solar micro-inverter, since it easily boosts a low voltage to a high voltage providing galvanic isolation and high power density. The interleaved flyback topology is a proper choice for photovoltaic application. However, the voltage spikes across the power switch at turn-off instant become a problem in flyback type converters. To overcome this issue, many passive and active clamp circuits have been proposed in different literatures [5].

The active clamp circuit techniques have their own advantages, but generally they cause the complexity of the control circuit. Each active clamp is digitally controlled. Using an active clamp in the interleaved flyback converter increases the complexity of the control and the number of gate drivers.

To significantly reduce the voltage spikes across each switch turning-off, the RCD clamp circuit (RCD1 to RCD4 in Fig. 1) is selected for a proposed interleaved flyback converter. Compared to the active clamp circuits considered in papers [7], the RCD clamp alleviates the complexity and offers better overall cost solution, since it does not require both the gate driver and extra switching device. This snubber circuit offers a better solution in interleaved flyback converter when considering trade-offs between the cost and the simplicity of the control.

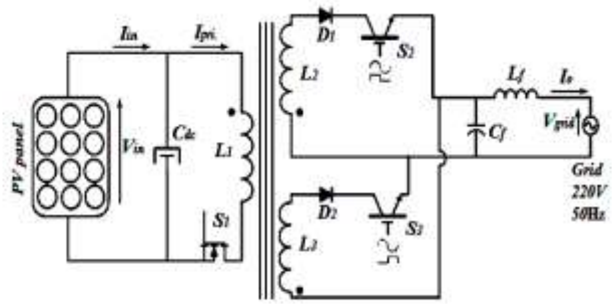

Figure 1: Flyback Microinverter

Photovoltaics (PV) is the conversion of light into electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon studied in physics, photochemistry, and electrochemistry.

Solar PV has specific advantages as an energy source: once installed, its operation generates no pollution and no greenhouse gas emissions, it shows simple scalability in respect of power needs and silicon has large availability in the Earth's crust.

Photovoltaic systems have long been used in specialized applications as stand-alone installations and grid-connected PV systems have been in use since the 1990s. Photovoltaic modules were first mass-produced in 2000, when German environmentalists and the Eurosolar organization got government funding for a ten thousand roof program.[4] Advances in technology and increased manufacturing scale have in any case reduced the cost,[5] increased the reliability, and increased the efficiency of photovoltaic installations.

Net metering and financial incentives, such as preferential feed-in tariffs for solar-generated electricity; have supported solar PV installations in many countries. More than 100 countries now use solar PV.

To maximize the power utilization of PV system, proper power conditioning units are required. To synchronize the PV system to the grid, a proper DC-AC inverter is required, which should be capable of bidirectional power flows to charge and discharge the battery as per the load requirements. When a PV system is connected to the utility grid, it might deliver excess PV output with respect to the load and battery capacity to the grid or use the grid as a backup system, in the case of insufficient PV generation.

II. LITERATURE SURVEY

F. Zhang et al.,[1]Presents For photovoltaic applications, the flyback microinverter with pseudo-dc-link is popular as a simple topology but brings large transformer turns ratio and thus large leakage inductance, which would deteriorate the converter efficiency. To solve this issue, based on the nonisolated pseudo-dc-link structure, this paper proposed a hybrid boost-flyback/flyback (BF/F) microinverter. This new topology is operated at the BF mode for the most segment of a half grid cycle and the F mode for the rest. During the BF mode, high voltage gain with low voltage stress is easily available in minimized transformer turns ratio

F. Ronilaya et al.,[2] discusses the input-series output-parallel (ISOP) flyback-type micro-inverter which is implemented for AC photovoltaic module to achieved higher voltage input and output current rating. The main features of this micro inverter include a stable current injection, lower level harmonic distortion, potentially lightweight and lower cost. Additionally, as the inverter is mounted in a single PV module, the inverter may harvest maximum power when partial shading occurs. However, since the two flyback-inverters are connected in series/parallel, there should be a proper control strategy for each inverter to obtain optimum performance. The strategy to control the inverters is based on a power-sharing loop using the droop method. Several experiments and simulations are carried out to examine the design and the results show the effectiveness of the proposed control strategy.

C. Chen et al.,[3] According to the characteristics of the staggered flyback photovoltaic grid-connected inverter topology, a new control strategy is proposed. The inverter is in the interleaved flyback critical continuous mode, the single flyback critical continuous mode and the single inverse. The alternating intermittent mode of operation alternates between work.

The control strategy is suitable for each power level of the inverter, and can also improve the efficiency of the inverter at each power level and the quality of the grid-connected current. The principle of the new control strategy is analyzed, and the relation expression between reference signal and grid-connected current in the new control strategy is derived. The feasibility of the control strategy is verified by PSIM simulation software.

F. Zhang et al.,[4] Based on the combination of boost-flyback and flyback converter, a dual-mode mirco-inverter with pseudo-dc-link was proposed in this paper. This new topology operates at boost-flyback (BF) or flyback (F) mode alternatively dependent on a pair of double-line frequency complementary switches. During the BF mode, high voltage gain with low voltage stress on the power devices is obtained owing to the serial output of the boost and flyback sub-converter. Furthermore, this mode also provides a passive snubber to recycle the energy stored in the leakage inductor of transformer and clamp the turn-off voltage spike of main switch.

N. Singh et al.,[5] Solar energy is one of the most used and readily available renewable energy sources among the other energy sources. The power generated by PV systems is dependent on solar irradiance and temperature parameters. Although, PV system under uniform environment has only one maxima point on P-V curve which is simple to estimate correctly by conventional MPPT techniques, it is not as simple as under non-uniform condition such as partial shading and mismatch effects. To overcome the drawbacks of the conventional MPPTs under non uniform condition, researchers has been investigated new soft computing MPPTs, PV array configurations, system architectures and topologies.

E. KABALCI et al.,[6] The reserve of fossil sources such as coal, natural gas, and crude oil are rapidly decreasing with increasing demand of electricity in the world. On the other hand, fossil fuels cause air pollution, global warming and similar environmental problems. Therefore, recent studies have become widespread about renewable energy sources (RESs) such as biomass, hydropower, geothermal, wind and solar which are the most popular in the worldwide. Among other RESs, solar energy is assumed as the best alternative to fossil sources. The photovoltaic (PV) systems generate electricity by using solar energy. In this study, a micro inverter is designed by using flyback converter on dc-dc side and neutral point clamped (NPC) inverter for dc-ac conversion. The power capacity of designed micro inverter is rated at 345 W where the input voltage is 62 V while output voltage is converted to 220 Vrms at 50 Hz frequency.

Two different controllers are used against changing irradiation conditions in this work. The flyback converter is controlled by a maximum power point tracking (MPPT) while a proportional integral (PI) controller controls the NPC inverter. The designed micro inverter presents 0.57% total harmonic distortion (THD) ratio of voltage and current in FFT spectrum.

R. de Oliveira Lima et al.,[7] The micro-inverters for photovoltaic panels are capable of transforming the continuous energy the photovoltaic panels in alternate with a nominal voltage value equal to that of the supply. This technology is being increasingly improved and one of the points to be explored is the Maximum power point tracking of the photovoltaic panels. Therefore, this paper proposes a hybrid tracking algorithm with variable step size based on the conventional methods of Perturb and Observe and Incremental Conductance. The proposed method is compared with conventional methods and with some methods presented in the literature. In the presented results, the accuracy of the proposed algorithm of tracking with flyback micro-inverter reached a peak of 99.16% while the highest efficiency of the comparative methods was 98.95% obtained with the conventional method of Incremental Conductance.

N. Falconar et al.,[8] presents a sensorless peak current mode (PCM) control technique for a flyback photovoltaic (PV) micro-inverter. The micro-inverter is used to extract energy from rooftop solar tiles and deliver it to the utility grid. Current sensors are usually required in the micro-inverter circuitry in order to perform maximum power point tracking (MPPT), as well as in the current loop to shape the output current to a sinusoidal waveform synchronous with the utility grid. The proposed method in this paper is able to estimate the current mathematically, thus, eliminating the need for current sensors on the converter. This provides a practical and cost-effective solution for solar tile applications. Simulation and experimental results show the feasibility of the proposed technique and demonstrate its superior performance.

D. Voglitsis et al.,[9] Over recent years, the output power of micro-inverters [module-incorporated inverter (MIC)] is progressively pushed to higher levels, following the current photovoltaic (PV) modules market trends. The interleaved Flyback inverter-under discontinuous conduction mode of operation (DCM)-is an appealing solution for PV applications which are based on MIC technology. This topology provides increased power level for distributed PV generation exploitation with simple control configuration, high efficiency, and reduced filter size.

In this paper, the harmonic injection capability is incorporated into the interleaved Flyback inverter for the implementation of an active anti-islanding scheme.

H. A. Sher et al.,[10] A single-stage flyback PV inverter with maximum power point tracking (MPPT) high-speed capability is presented in this paper. The proposed stand-alone photovoltaic energy system (SAPES) incorporates the use of hybrid MPPT to ensure peak energy harvesting under all weather conditions. The proposed hybrid MPPT method combines the conventional short current pulse (SCP) MPPT method and the perturb and observe (P&O) methods. Measurement of the offline parameter [short-circuit current of PV module (Is,)] for SCP is made on the basis of the difference between the offline parameter and the instantaneous current of PV module (Ipv).

F. Karbakhsh et al.,[10] Flyback inverter is known as a low cost solution for photovoltaic (PV) ac module application. This study presents a two-switch flyback inverter followed by a low frequency unfolding bridge for fractional horse power water pumping systems. This topology mitigates the problem of high-voltage transients at switch turn off which commonly exists in single switch flyback inverters. Moreover, the proposed control strategy achieves an integration of a novel sensorless maximum power point tracking (MPPT) algorithm as well as a constant v / f control for the efficient utilisation of both the PV panel and the motor.

III. Benefits And Challenges

In Renewable energy systems have been popular in recent years due to their promise of unlimited energy and due to environmental concerns about other, less clean, forms of energy. Solar energy systems are especially attractive and considerable research has been done on such systems. An important part of any solar energy system are the DC-AC converters (inverters) that convert DC power into AC power that can be fed to the grid. There are three basic types of inverter architectures, each with their merits and demerits. These architectures are central inverters, string inverters and micro-inverters. The focus of this paper has been on micro-inverters.

Micro-inverters are small DC-AC converters that are attached to each solar photovoltaic (PV) panel of a solar energy system. The main advantage of using micro-inverters is that they make the solar energy system less prone to the effects of shading. They are typical low power converters (100 W- 200W) that are based on low power DC-DC converter topologies. Many micro-inverters are based on the DC-DC flyback converter as this converter is the simplest DC-DC converter with transformer isolation.

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A transformer is needed to step up the voltage that is obtained from the PV panels so that it can match the level needed to be fed to the grid.

Microinverters can offer substantial benefits to homeowners contemplating switching to solar, more so than traditional string inverters. Here's a look at the advantages of microinverters:

The most significant advantage of microinverters is that they are designed to determine each system's optimal voltage and generate maximum peak power voltage or Vpp. Known as Maximum Power Point Tracking (MPPT), this feature allows the microinverter to track real-time solar intensity and cell temperature as it varies throughout the day.

Some key factors that should be considered when researching microinverter solar panel installations include higher upfront costs and possible failure rates. With microinverters, there are many more system components in comparison to string or central inverters. For instance, a 5kW solar system with 250W panels consists of 20 inverters, meaning the inverters are theoretically twenty times more likely to have the same failure rate than with a single-point-of-failure string inverter. That said, if a single microinverter fails, the only solar panel affected is the one it's attached to as opposed to a complete system failure when a string inverter goes down. Also, since there are more components in a microinverter solar panel system, the initial trade-off of out of pocket costs will be slightly more expensive.

1. *Higher Initial Cost:* The main disadvantage of a Micro Inverter is been its higher initial cost. But it's cost can be justified in cases where there are technical challenges in installing a solar array (series of solar panels) or shading issues that could cause the entire system underperform.
2. *Extra Monitoring Device:* As each inverter is independently located below a solar panel, a communication bus and a common monitoring system is required as there is on board display system like in string inverters.
3. *Higher Cost of Replacing:* As a inverter is below the solar panel, it might be very difficult to replace the micro inverter due to existing site conditions and might require more than 1 technician on site to replace.

Microinverters have become common where array sizes are small and maximizing performance from every panel is a concern. Microinverters have been most successful in the residential market, where limited space for panels constrains array size, and shading from nearby trees or other objects is often an issue.

IV. Conclusion

Energy is the most important source in today's world, the more the better. Renewable energy sources is beginning to boom and we need to make best out of it. This paper revied about PV based microinverter system, which is the third most used energy source. Many methods are available to prevent the energy loss age and to increase the efficiency. The design guide lines of PV grid connected system along with a flyback converter and an inverter is proposed in future. Another feature is cost reduction for material from a new architecture of distributed dc-dc flyback converter feeding an inverter with a dc rejection controller. Then, the analysis and design guide lines will be verified through MATLAb/ SIMULINK software. We hereby conclude that save energy and use it efficiently because today's wastage is tomorrow's shortage.

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