International Journal of Current Trends in Engineering & Technology
ISSN: 2395-3152
Volume: 02, Issue: 05 (SEPTEMBER-OCTOBER, 2016)

Realization of Three Phase Two Stage Grid System By Using LLC Resonant Converter

Bhooshan Dileep Darkonde, Prof. Prabodh kumar Khampariya
Sri Satya Sai Institute of Science and Technology, Sehore, India

Abstract— Module integrated converters (MICs) in single phase have witnessed Current market achievement due to unique features inclusive of improved energy harvest, progressed efficiency of the system, decrease set up costs, plug-and play operation, and better flexibility and modularity. A niche marketplace has been grown by means of the MIC zone to mainstream, mainly in the America. Assuming in addition enlargement of the MIC market, this paper affords the micro inverter idea included in large size photovoltaic (PV) installations including megawatts (MW) magnificence solar farms where a three-phase ac connection is employed. The first stage particularly considered for an excessive efficiency full bridge LLC resonant DC-DC converter which interfaces to the PV panel and produces a DC link voltage. A middle point's iteration algorithm developed specifically for LLC resonant topologies is used to track the maximum power point by the PV panel. The second stage is constituted of a three-phase dc–ac inverter circuit which employs a simple soft-switching scheme without including auxiliary components.

Keywords- Center points iteration (CPI), maximum power point tracking (MPPT), module integrated converter (MIC), three phase two stage converter.

I. INTRODUCTION

With ever degenerate natural resources and growing needs for electricity, the need to be searching for out possible alter local sources of renewable strength isn't always just vital pressing. Because of the reality that solar energy offers superb merits together with environmentally impartial , unlimited availability and low cost able to competing with conventional sources with generation advances and mass production in the coming few years. Over of 25% increase on an average during the last 10 years has been visible by using the photovoltaic (PV) enterprise aside from the PV panel itself [1], the inverter is the most important device in a PV system both for off-grid or grid-connection applications due to the fact the assets of the inverter uses for converts dc supply to ac supply and ac supply is converted in dc deliver is referred as rectifier, this is referred as converter. The simple concept of the converter is that to get the required supply. Now-a-days, the PV device architectures can be categorized into three basic classes with admire to the styles of grid-tied inverter: i) central inverter, ii) string or multi string inverter, iii) module integrated converter (MIC) (additionally referred to as micro inverter) [2] [3]. Although the central inverter can be operated at high performance with most effective one dc/ac power conversion stage, this system has some drawbacks: Each PV module might not function at its maximum energy point which results in less energy utilized. Extra losses are take-placed by string diodes and junction box; and Single factor of failure and Mismatch of each string or PV panel impacts the PV array efficiency greatly. The string inverter is a modified model of the central inverter. It partly overcomes the issues arising in central inverters; however, it nevertheless suffers some of the drawbacks of the central inverter. The MIC typically utilized in dispensed PV systems is a small grid-tie inverter of 150–400 W that converts the output of a single PV panel to ac. The MIC ac outputs are connected in parallel and routed to a not unusual ac coupling point. No series or parallel dc connections are made leaving all dc wiring at an especially low voltage stage of a single panel module. The MIC may be in addition included into PV modules to realize a real plug-and-play solar ac PV era system. Hence, ac PV modules with included MIC have substantial advantages over traditional PV systems when you consider that allow maximum peak power tracking on each solar panel to maximize energy making use of, and offer disbursed and redundant device architecture. Further, MIC and ac PV structures substantially simplify system design, take away safety risks, and reduce set up expenses .With those advantages; the trend for future PV system has been became by the ac module for improvement. Although MIC and ac PV modules have witnessed latest marketplace success, MIC nevertheless has many technical demanding situations final such as excessive efficiency, high reliability at module level, low-cost and high-level control issues. For the latter two cases, bidirectional power flow is needed among ac grid and the power decoupling capacitor requiring MIC with bidirectional energy flow capability. For applications with power levels below several kilowatts, generally the single-phase connections are used.

II. LITERATURE SURVEY

Architecture of Two-Stage Three-Phase Grid-Tie Inverter System In order, so one can provide galvanic isolation, diverse isolated converters for high step up

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applications have been widespread. In general, the topologies with galvanic isolation appropriate for this utility may be categorized into two groups: single-switch topologies and multi switch topologies. Recently, the LLC resonant topology has become appealing due to its perfect traits including high performance and natural zero voltage switching (ZVS)/zero current switching (ZCS) commutation. Therefore, a full-bridge LLC resonant converter is hired within the first stage to achieve excessive performance efficiency and track the maximum power point of every PV panel. For the 3-phase dc/ac converter in the second stage, a spread of active soft-switching topologies have been proposed in remaining three decades of long time. Most of them can be divided into three groups: auxiliary resonant commutated pole (ARCP) group, resonant dc-link inverter (RDCLI) group, and resonant ac-link converter (RACLC), The ARCP may be implemented widely for the voltage-source type single-phase or three-phase inverters but it requires a big variety of auxiliary components. As compared to the ARCP, the RDCLI has the benefits of fewer auxiliary switches and a less complicated circuit. Several soft-switching topologies in have been proposed to attain the minimal quantity of extra additives. However, the using signals of the auxiliary switches are very sensitive to the noise from the principle circuit. Since the RACLC can attain voltage boosting and electrical isolation at the equal time, its miles extraordinarily preferred for renewable energy power era. Unfortunately, the control circuit for the RACLC is complicated and bidirectional switches are required. In reality, auxiliary components are unavoidable for all of the smooth switching topologies cited earlier. The proposed smooth-switching technique shown in Fig.1 simplifies the inverter topology and decreases the cost since it does no longer require any auxiliary components. The body capacitors of the main MOSFETs and the output inductor L1 are combined to form a resonant circuit. The inductor current is deliberated bidirectional inside a switching cycle to generate ZVS conditions in the course commutation. In the meantime the common inductor current is controlled to produce a sinusoidal current in L1. The proposed smooth-switching technique is appropriate for MIC applications wherein the switching losses are generally dominant. Based on the above, Fig. 1 indicates the proposed excessive-efficiency MIC architecture with both-stage zero-voltage switching together with of a full-bridge LLC resonant dc–dc step up converter and three phase 4-wire soft-switching dc–ac converter. The elements working modes inside the three-phase four wire dc/ac converter might be provided within the following sections.

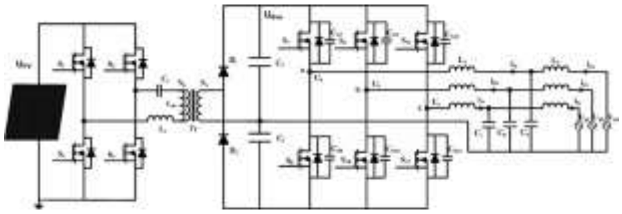

Figure 1 Two-stage three-phase four-wire grid-tie inverter system.

2.1 Full Bridge LLC Resonant Converter

Secondary batteries are broadly used in the utility of residential, industrial, and commercial power storage systems to keep electricity and deliver the load for various types of electronic equipment [1]–[7]. If the dc supply it at once related to secondary battery, the output voltage of the dc source is fixed to the voltage of the secondary battery; therefore, the system can't constantly perform at each greatest working point. Consequently, it is essential to install a dc–dc interface among the dc supply and the secondary battery to make the energy storage system always operates on the most effective running point of view. This dc–dc interface is also called the battery charger. The traditional battery charger, which extracts power from an ac-line supply, requires a thyristor ac/dc converter rectifier with an equal series resistance to control the power flow to charge the battery system. This kind of charging circuit necessarily draws a high-ripple charging current. Hence, as the priority approximately the best quality of a charger grows, a charging circuit for reducing the ripple and lengthening the battery lifestyle becomes more critical in designing the battery storage systems. Numerous charging circuits have been proposed to overcome the disadvantages of the traditional battery charger. In contrast to linear regulators, switching regulators use active power switches to function in either the saturation region or the cutoff region. Due to the fact both location will result in low switching voltage or low switching current, it's miles viable to convert a dc voltage to a distinctive level with more efficiency, in addition to with low cost, enormously small size, and light weight between the two columns. The life and ability of the secondary batteries depend on several elements e.g., charge mode, maintenance, temperature and age. Among these factors, the charge mode has a brilliant impact on battery lifestyle and potential. To reduce the electricity losses, it is crucial not to waste energy within the conversion system. The series resonant converter is inherently short circuit and protected by the impedance resonant tank. But, the drawback of the series resonant converter is that the charging voltage

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cannot be regulated at any load and mild-load conditions. The drawback of the parallel converter is that the current in the resonant components is fantastically unbiased of the load. The conduction losses are fixed, and the efficiency of the converter is extraordinarily poor for light loads. On the other hand, the series–parallel converter combines the benefits of the series and parallel converters. The output is controllable for no load or mild load, and the mild load efficiency is exceptionally excessive. For that reason, a series–parallel dc–dc converter is mounted between the ac input source and the storage batteries to govern the operating points of the dc supply. Operation Mode of the Proposed ZVS Three Phase Four-Wire Dc/Ac Converter Due to the fact many articles about LLC resonant converters have been published over the last decade of years, this paper does not discuss it in high quality detail. The operating modes of the proposed ZVS three-phase four-wire dc/ac converter are offered in this phase. The three phases of the dc/ac second stage are symmetrical across the neutral point; therefore, the analysis can be performed on a single phase as shown in Figure. Interval 1 [t0 – t1]: Prior to t0, S7 is off and S8 is remains turned ON. Assume that the current direction through L1, as shown in Fig. 3, is already from right to left at t0.

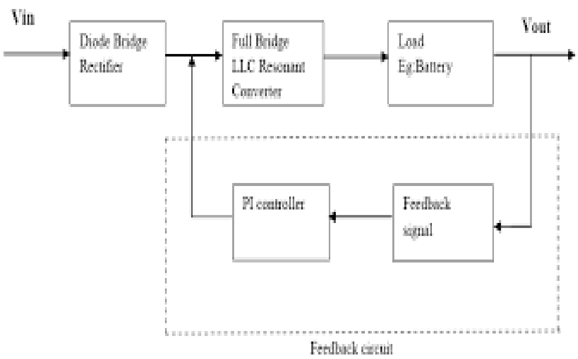

Figure 2 Block Diagram of Full Bridge LLC Resonant Converter for Battery Charging Application.

Then S8 is turned OFF and the voltage across the parasitic capacitor CS8 of low side MOSFET S8 starts increasing due to the inductor current. As CS8 charges the voltage across S7 decreases. This interval ends once the voltage across S7 reaches zero. Interval 2 [t1 – t2]: The body diode of S7 will be conducting at t1 and S7 can be become ON with ZVS. The current flow decays linearly from right to left due to the fact that U bus/2 minus the voltage throughout L1. This mode ends while the inductor current decays to zero. Interval 3 [t2 – t3]: S7 is conducting and the current direction via L1 is now changed from left to right and growing linearly. This is the power delivery interval. Interval 4 [t3 – t4]: At t3, S7 is turned OFF and its parasitic capacitor CS7 is charged by the inductor current while CS8 is discharging. As soon as the voltage across CS8 drops to zero, the parasitic body diode of MOSFET S8 conducts for the reason that current direction via L1 does not change. Interval 5 [t4 – t5]: Continuing from the previous interval 4, the body diode of S8 keeps conducting which creates a ZVS circumstance while when S8 is become ON. The length of this interval is commonly pretty brief and ends as soon as S8 is become ON. Interval 6 [t5 – t6]: S8 is turned ON underneath ZVS situation at t5. The current via S8 is gradually decreasing because of the fact that U bus/2 plus the output voltage appears across the inductor L1. All through this interval the energy stored in the inductor is transferred to the load and the current that was flowing inside the body diode of S8 now flows through the MOSFET on resistance as a consequence decreasing conduction losses. Interval 7 [t6 – t0]: The current through S8 maintains to flow and the current direction will change as soon as the current decays to zero at t6. As soon as the current through S8 changes path from top to bottom. ZVS condition is created for S7 .When the current through S8 reaches the negative threshold current, the cycle repeats. Interval 1: [*t*0 – *t*1], interval 2: [*t*1 – *t*2], interval 3: [*t*2 – *t*3], interval4: [*t*3 – *t*4], interval 5: [*t*4 – *t*5], interval 6: [*t*5 – *t*6], and interval 7: [*t*6 – *t*0].

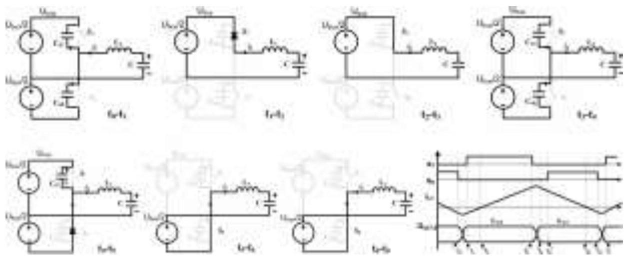

Figure 3 Theoretic waveforms and operating intervals of a single-phase dc/ac converter.

2.2 Interleaved Three Phase LLC Resonant Converter

LLC Resonant converters exhibit large voltage ripple on output filter capacitor because of the rectified sine-wave current injected through the transformer secondary windings. In order to reduce the capacitor size and/or the steady-state output voltage ripple, the interleaved approach may be profitably applied. The advantage of increasingly parallel modules on the overall rectified current ripple, that is the peak-to-peak ac current injected into the output filter capacitor. The consequences acquired from MATLAB Simulink Simulations with 400 V input voltage 24 V output voltage and specific output currents. The huge reduction of total current ripple within the 3 modules solution may be liked in comparison to 1and two modules opposite numbers, suggesting the opportunity. To substantially reduce the output filter capacitor size. The use of parallel connected LLC Resonant Converters to supply the equal load and proportion the identical output filter capacitor affords barriers limitations and disadvantages because of resonant devices mismatch. The modules are operated at the same switching frequency controlled by the voltage regulation loop, even as resonant component mismatch causes the three phases to show off distinctive voltage conversion ratios. Accordingly, the load current is no longer equally supplied by the modules and one of the phases may totally reduce its output power to zero illustrates the results of some measurements at the prototype for extraordinary working situations. With the intention to emphasize the mismatch, the third module resonant capacitor has been multiplied by 12 % by including A 2.7 Nf capacitor in parallel to the nominal one (22 Nf). It can be observed from the data in the left-half of the table, that the third module delivers zero output current,

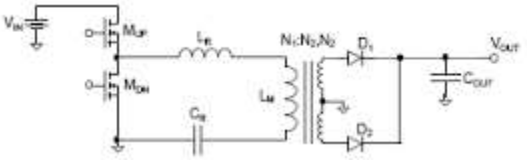

Figure 4 Scheme of a single module LLC resonant converter.

to a simple parallel interleaved connection.

Table 1 Three-Phase Unbalanced Dips Due To Different Fault Types And Transformer Connections

	Location of dip		
Fault Type	I	II	III
Three-Phase	A	A	A
Three Phase to ground	A	A	A
Two Phase to ground	E	F	G
Two Phase	C	D	C
Single Phase to ground	B	C	D

In presence of resonant component mismatch this condition is confirmed by the inspection of the primary-side currents (400 V Input Voltage, 8 A output current conditions): The primary-side current of the third module is certainly interested only by the magnetizing current. In order to overcome such issue, that is unavoidable in mass production, a three-phase topology is proposed, where the transformers primary windings are star connected. This modification permits, by way of the voltage modulation of star connection point, to substantially lessen the mean current unbalance caused by issue mismatch. From data shown in the right-half of, the intrinsic balancing capability of this topology is talked about compared to the simple parallel connection. Moreover, affirm the amazing balancing capability of the star connection topology compared.

III. CAPACITANCE CALCULATION OF DC-LINK CAPACITOR & INPUT CAPACITOR

The dc/dc stage and dc/ac stage are decoupled due to the movement of the dc-link capacitor, simplifying the controller design for both stages. Due to of the three-phase dc/ac converter in the second stage, the value of the dc-link capacitor can be smaller for a given MIC power rating. Therefore, the reliability of entire system could be drastically advanced if the electrolytic capacitors are replaced by using film capacitors. Although the capacitance value

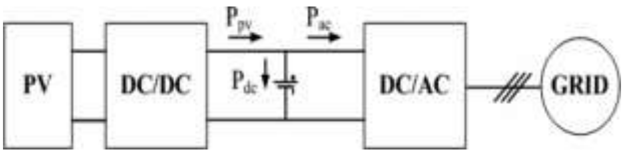

Figure 5 Simplified block diagram of two-stage MIC

3.1 Advantages of Full Bridge LLC

Using Proposed Converter (Full Bridge LLC), we will expect Better Controllability than Half Bridge for extensive voltage range. By adopting soft switching topologies, either voltage or current is zero at some stage in switching transition, which largely reduce the switching loss and additionally increase the reliability for the battery charger. It eliminates both low- and high-frequency current ripple on the battery, without using bulky filter capacitor, for this reason maximizing battery life without penalizing the volume of the charger. By means of use of closed loop control operation gives extra accuracy and stability beneath the presence of nonlinearities. Resonant converter topologies can be used to increase circuit switching speeds, progressed power factor and reduced switching losses.

IV. RESULT ANALYSIS

The LLC has the advantage of zero voltage switching, which leads to a better efficiency in comparison to standard increase converters. Because of its operation at excessive frequencies, the use of smaller and cost effective magnetic additives is viable. Moreover, DC-link capacitor for the inverter may be selected smaller thanks to the excessive switching frequency and rapid dynamic reaction of the converter. The inverter controller includes of the outer loop to keep the DC bus voltage constant, and the inner loop to synchronize the output voltage of the inverter with the grid voltage and also maintain the output current in phase with voltage. The simulation results showed the effectiveness of the system to offer and make sure appropriate strength and unity power factor to the grid, in addition to DC-link voltage stability. The capability of the DC-DC converter to extract maximum power from the solar arrays below fast converting irradiance has also proven. Which will assemble a PV grid connected system, some of parameters have to be thinking of and to be optimized which will acquire maximum electricity generation. The maximum power point tracking algorithm when applied an accurate PV model has the potential to growth the efficiency of the system. In addition to that a controller has for use with a purpose to obtain the synchronization to the grid and to perform the power management among the system and the electrical grid. PV grids related with its control are carried out with MATLAB SIMULINK for simulation. To improve the dynamic and steady state performance of the PV system concurrently. Through simulation, it's far observed that the system completes the maximum power point tracking efficaciously. Moreover, this study shows that the proposed control scheme offers an easy manner to have a look at the Performance for utility interface applications. It is easy to put in force and able to producing quality sinusoidal current and voltage waveforms.

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