Interleaved high power improved two-stage flyback inverter for photovoltaic applications

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Abstract: The interleaved flyback converter is used to increase the power level and decrease the current ripple, Harmonics, passive component size, and total cost. The topology of flyback is used for lower output power in micro inverters. The flyback converter in this paper is designed for high output power. The grid is developed based on the interleaved topology of flyback converter, which is connected to central type photovoltaic inverter. The principles of the converter operation are discussed in detail. In MATLAB software the designed converter is simulated. Dual-stage flyback converter interleaving is being investigated for flyback inverter design rated at 01KW. The conversion system is run in DCM, providing a quick, easy to monitor dynamic response and no losses due to switchover action. As 90.16 percent, 3.9 percent and 0.998, the proposed efficiency of flyback inverter, total harmonic distortion, and the power factor were calculated.

Keywords: Flyback converter, DCM mode, Maximum power point tracking (MPPT), Flyback interleaved converter

1. INTRODUCTION

Photovoltaic (PV) is most significant source of renewable and low-cost energy in the generating system. Cost reduction of the power generation is one of the important aspects of industries, residential applications, etc. [1]. The low-cost fly-back converter is commonly used in the PV since the flyback transformer is paired directly with the inductor, because due to insulation the voltage ratio is multiplied. [2]. One of the key elements of the flyback converter is a transformer but it produces heavy flux leakage. It also has a lower efficiency of transmission of power. Therefore, the flyback concept does not exist for really efficient applications. To overcome this problem, Flyback converters are linked in order to be suitable for applications with high power. Furthermore, the frequency of swelling components can be expanded by the number of cells allowing for simple separation. The usage of the overall power point tracking (MPPT) for the PV network can be done very effectively for solar energy [3]. In addition, the DCM, which is used for flyback conversion systems, has many advantages such as instant dynamic reaction, lack of turn-on losses, compact transformer scale, easy to manage and low cost. However, Continuous Current Mode (CCM) behavior compared to, it has a high form factor which further leads to big amounts of power losses. [5] The device’s parallel arrangement by interleaving converters at a common point gives a better solution to this problem as it decreases the current’s peak value with high discontinuity.

Three transformers are used in the existing system. But the system has certain drawbacks like it increases the size and cost of circuits due to usage of more elements which further increases the circuit size as well as weight [6]. For industrial applications, it is important to reduce the size and cost of the
converter. Therefore, circuit size and complexity are reduced in the proposed system by simply removing the switch as well as transformer. The existing system’s capability may be enhanced by increasing transformer turns.[7-8]

This paper’s key objective is:
- Using the interleaving flyback inverter to develop photovoltaic (PV) inverter technology to achieve high power;
- The easiest configuration and essential flow management power for flyback inverters.

2. CIRCUIT CONFIGURATION AND SYSTEM DESCRIPTION

The systems consist of the main five blocks as shown in figure 1 i.e. PV module, DC/DC converter, DC/AC converter, Filter circuit and Control system with MPPT. The photovoltaic (PV) source formed by the combined combination of parallel and series connections of PV cells, which converts solar energy into electrical energy and give to DC/DC converter integrating with decoupling capacitor this can further increase the voltage level.

The DC power output from converter supplied to full-bridge inverter network that transforms the converter’s DC Output to an AC output by using the MOSFET conversion technique PWM. The low-pass filter decreases the harmonic efficiency of the output current of the inverter. Photovoltaic power and voltage input were regulated in the first case. Secondly, technological supervision was carried out to transform direct current (DC) into alternating (AC) power for grid controller injection. Bridge inverter with intertwined glide converters.

The current & voltage of PV source depends on solar radiations available through-out the day. The maximum power point monitoring algorithm (MPPT) is used to obtain the full power to the photovoltaic array using interlaced voltage converters, full PV performance is derived from just one point of operation, named maximum power point. P&O algorithm are being used for MPPT due to in simplicity, unsettle duty ratio and adjust to the DC link power among with the photovoltaic array. The P&O algorithm flow chart is shown in figure 2.

The duty ratio of flyback converter changes by changing power. It can be reduced by small amount of change in power and can be increased by making power to be positive and voltage to be negative. With MPPT and pulses from the converter the duty ratio can be determined.
Start Perturb & Observe Algorithm

Measure
PV Voltage (VPV)
PV Current (IPV)

Ppv (n) = Vpv(n) - Vpv(n-1)

Δ Vpv = Vpv(n) - Vpv(n-1)
Δ Ppv = Ppv(n) - Ppv(n-1)

Ppv > 0

Vpv > 0

D = D - ΔD
D = D + ΔD
D = D + ΔD
D = D - ΔD

Return

Figure 2. Flow chart of P & O Algorithm.

For obtaining maximum power from PV module in the P&O algorithm adjustment with DC power is required in the PV module. The power of PV panel is measured from PV panel output voltage and current. To obtain the change in voltage and power the difference between previous value and current of iterations are considered as shown in figure 2.

3. FLYBACK CONVERTER CIRCUIT AND ITS ANALYSIS

Figure 3 shows an arrangement of flyback converter circuit wherein topology mainly consists of switches connected in series with the flyback transformer. In an inductor (Lm) is contained the electric energy supply by the PV panel. It is divided into two loops and connected in parallel to form a flyback transformer. It boosts the voltage level by multiplying turns ratio and gives galvanic isolation between PV array module and grid. The mode relies on the degree of the inductance magnetization. In this system MOS- FETs are used for switching purposes. The input supply from the PV module is given to primary side flyback transformer to flow the current through transformer when the switch is closed. So, the energy is stored in the transformer. In secondary winding negative voltage is induced and diode acts as reverse biased, during this operation output capacitor supplies power to the load.

Figure 3. Flyback converter [4].
When MOSFETs turns off automatically, switch opens the primary side of PV module is disconnected. The secondary voltage becomes positive of the fact that the diode acts as a forward biased. It further allows current to flow in the transformer, capacitor and load/grid. This method removes the costly inductor filter. In addition to this, weight of converter get reduces.

Figure 4. Flyback frequency regulation input, magnetizing current (Im) and primary voltage (Vp) flyback transformer.

Figure 4. The transformer power, primary voltage, and magnetic current are shown and reflect the activity of the DCM.

3.1. Flyback switch at ON position

Once the MOSFET switch is switched on, the primary current begins with the original value of zero. The PV source power output and the flyback parameter relation can be written as follows,

\[ P_{PV} = V_{PV}I_{PV} = \frac{\eta_{cell}V_{PV}^{2}D_{peak}^{2}}{4L_{m}f_{s}} \]  

(1)

3.2. Flyback switch at OFF position

When MOSFET turn-off the average power can be calculated as,

\[ P_{PV} = V_{PV}I_{PV} = \frac{\eta_{cell}V_{PV}^{2}D_{peak}^{2}}{4L_{m}f_{s}} = \frac{\bar{V}_{grid}I_{grid}}{2} = P_{grid} \]  

(2)

Where,

- \( PPV \) = Power of photovoltaic panel,
- \( VP \) = Voltage of photovoltaic panel,
- \( IPV \) = Current of photovoltaic panel,
- \( Lm \) = Magnetizing inductance,
- \( \eta_{cell} \) = Numbers of the interleaved cells,
- \( f_{s} \) = Switching frequency,
- \( D_{peak} \) = Peak duty ratio.

4. OPERATION OF PROPOSED SYSTEM

The flyback converter technique used to galvanic input insulation and multiple outputs for DC / DC and AC transition. That is like an inducer separating buck boost converter to provide the right shape of the transformer to increase the voltage.
Figure 5. PV I inverter device circuit diagram interlocked with two topology flyback converter cells.

Figure 5 Shows the circuit configuration of the converter where the PV source is the source of input to the converter where the A two-stage flyback converter with a condenser disconnector (C) should be fitted with a photovoltaic present. It is used to remove photovoltaic current from harmonic contents. It gives system equilibrium. The primary side of the MOSFET is used as switch. When MOSFET switches (S1 and S2) turn on, the PV source current is gone through the flyback transformer’s magnetizing inductance and main winding. The main purpose of the inductor (Lm) is to store power from the magnetic field. Due to reverse biased diode, power cannot flow during the turn-on period of the switches during the secondary side of the transformer.

At turn-off time of switches, the put away attractive field vitality in charging inductor (Lm) is additionally conveyed as present to the load/grid. It functions as a power supply regulated by voltage. The converter is controlled in DCM mode and enables the AC current to be produced in a fast and steady state. For each switching period the converter with open circle control creates triangular current pulses. In the flyback converter input and output current is shown in figure 6 and 7 respectively. For service of a device, the low grid frequency is used, hence the errors of switches on and off are negligible. The drive losses are considered due to heavy ON state resistance of switches.

Figure 6. Flyback converter performance present period.
5. RESULT AND DISCUSSION

The simulation has been performed for getting current ratings and power required. Figure 5 displays the platform for simulation studies.

5.1. Model of Proposed System

The system shown in figure 8 is simulated to check the converter’s efficiency.

![Flyback converter power output over a grid after the complete bridge inverter.](image)

**Table 1. Specifications of flyback inverter design.**

| Design Parameters                                      | Specifications                                      |
|---------------------------------------------------------|-----------------------------------------------------|
| **PV Module**                                           | **BP365**                                           |
| **Maximum Power**                                       | 65 W                                                |
| **Present open as well as Short Circuit Voltage by Panel** | 21.7 V & 3.99 A                                      |
| **Group arrangement of PV panel**                       | 5 panels are connected in one string and same 6 strings are in Parallel |
| **Voltage and present per panel and panel group configuration Maximum power point** | 17.6 V, 3.69 A, 88V, 22.16 A                        |
| **The panel group’s overall effective performance of MPPT energy collection** | DC capacity 1950 W                                 |
| **Grid Characteristics**                                | Single Phase, 220V, 143-264V, 50Hz, RMS 45.5-54.5Hz |
| **Switching Frequency**                                 | 40 kHz                                              |
5.2 Model of Proposed System

![Figure 9. Duty limit values provided with the MPPT P&O algorithm.](image)

For the different three sun levels, peak value of duty ratio generated by using MPPT P&O algorithm which is shown in the top trace, the output power of PV module and power delivered to grid is shown in bottom trace of Figure 9. To achieve the tracking performance of 99.30%, the time required is less than 0.1 s.

![Figure 10. Grid voltage and current waveforms.](image)

Figure 10 shows the grid voltage and current with THD which found high quality power transfer to the grid. Top trace indicates the peak to peak ripple at 7.5 voltage and under that ripple condition the grid current THD is 3.9 percent. The simulation results hold good argument with the expected results.

6. CONCLUSION

Two stage interleaved fly back inverter is designed to increase the efficiency of converter. The numerical simulation is also performed which is having efficiency of 90.16 percent. Average harmonic distortion is 3.9 percent, with a power factor of 0.998. compared to other inverters, this is quite favorable. Ultimately, the perfect option for all photovoltaic applications was an advanced interleaved high power two-stage fly-back inverter.
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