ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, *Vol 9(S1), DOI: 10.17485/ijst/2016/v9iS1/99614, December 2016* ISSN (Online) : 0974-5645

Dual Active Converter using Low Voltage PV Source for Domestic Applications

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Abstract

In this paper, an analysis of series connected Forward Flyback converter is carried out. SFFB (series connected Forward Flyback converter) is a type of forward and fly back converter which shares the transformer for increasing its utilization factor. The SFFB converter has a series-connected output for high boosting voltage transfer gain. However, few predefined topologies are available for the power conversion based on voltage boost that has poor efficiency due to the lack of isolation. In the arranged SFFB (arrangement associated Forward Flyback converter) has a change for security, framework relentlessness, galvanic separation and high transformation proficiency. A few promising application like request detachment, the SFFB is the one, which suits the necessity of such applications. The PIC (Peripheral Interface Controller) controller is utilized to give activating heartbeat to the converter switch, in this way streamlining its operation and gives better productivity by method for controlling the yield. The operating standard and design rule of the planned converter is developed and the performance is analyzed in a simulation. This converter has four operation modes when the turn ratio of the second and the third windings of the transformer is set to be a certain value. In addition, it achieves high-energy efficiency from low load to high load condition by reducing the required power level for DC/DC converter by one-third of conventional DC/DC converter.

Keywords: Demand Isolation, Galvanic Isolation, Integrated Converter, Peripheral Interface Controller, Series-Connected Forward Flyback Converter (SFFB)

1. Introduction

The various techniques are modelled for integrating photovoltaic system and the grid in different papers. Solar energy has more potential to supply electricity with minimum effect on the environment. The integration of non-conventional Energy Sources with the grid is becoming more popular over traditional stand-alone systems. The arrangements are broadly created four unique frameworks in matrix associated sun powered power applications. They are incorporated inverter framework, string inverter framework, multi-string inverter framework, and module-coordinated inverter framework. The imminent conveyed era is basically in light of the photovoltaic module coordinated converter framework. With the expectation of conveying energy to the lattice, the voltage from the PV module is changed over to high DC Voltage.

The Serial combined flyback-forward converter[1] was utilized as a solitary stage single-stage power figure corrector for secluded power supply and its execution was examined in view of force element and element reaction of the yield voltage. The steady state analysis of the forward-flyback converter with current doubler rectifier was developed and analyzed[2] for a 40-60v input voltage range. The high efficiency and high step up dc-dc converter for low voltage renewable energy systems were developed and verified[3] with the complementary pulse width modulation

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controller. The static characteristic for the four operating mode of the novel DC-DC (where both forward and Fly back actions are mixed) converter was analyzed[4] by means of extended space averaging method. A topology was proposed for the PV DC/DC converter[5] by means of reducing inductor filter size and rating. A topology for PV module integrated converter was proposed[6] for the power range below 500 Watts. The converter for dual outputs power supply[7] was designed by using FFB converter and its operation was verified on a basic application. A comparative study of different DC/DC step up topologies for renewable energy sources which deliver the output voltage around 12 to 70V was performed[8,9]. The improved MPPT control method for a dual module PV system was developed based on the multiplicative operation of the converter[10]. A grid connected power inverter for low power PV system with three different topologies: a voltage amplifier, a current shaping, and an unfolding stage was developed[11–13].

The conventional forward–fly back converters are narrowed to power factor correction circuit applications. The DC-DC converter settled the building issues of expansive voltage improvement issue, for example, producing expense and low dependability. The inconveniences of customary forward–fly back converters are Low effectiveness, huge volume, high cost, and high channel esteem. This paper proposes a high stride up topology utilizing a Series-associated Forward-Flyback (SFFB) converter, which has an arrangement-associated yield for high boosting voltage-exchange pick up. By stacking the yields of them, amazingly high voltage pick up can be gotten with little volume and high productivity even with a galvanic separation. The optional is a structure where the forward converter and the fly back converter are isolated by transformer winding. The yields are serially associated for the yield voltage help.

2. System Overview

In Three Winding Transformer, the primary and secondary windings in a transformer, there may be a third winding known as tertiary winding, which has the low-voltage rating whereas the primary has the highest voltage rating. The kVA ratings in three-phase transformers are unequal. The switch is used to energize and de-energize the primary winding of the three winding transformer in various modes of operation. Turning on the switch is done by providing firing pulse of a fixed frequency which in turn is generated by a pulse generator. The input DC Supply to the proposed SFFB is provided with the help of step down transformer, rectifier and a filter. The transformer steps down the 230V AC supply to a suitable low voltage level. The rectified output is filtered and given to the circuit. The input voltage is set to be around 30V DC. The block diagram of the proposed system is shown in Figure 1.

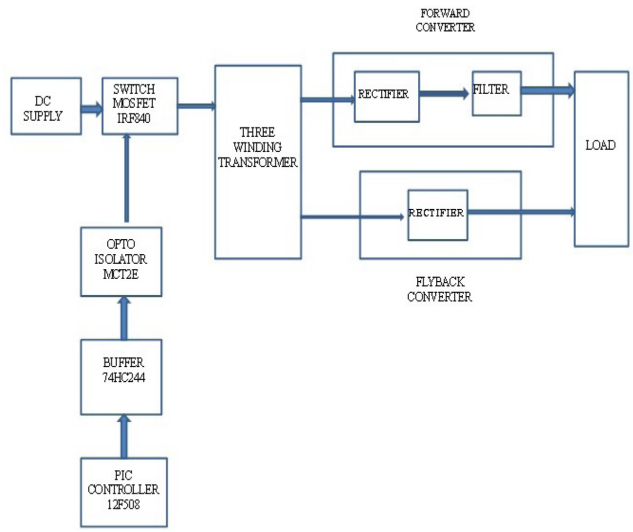

Figure 1. Block diagram of the proposed system.

Inductor in the forward converter, a freewheeling diode is provided to provide a discharge path. Output of both forward and flyback converter is connected in series. Rectifier circuit comprises of the diode which is used to the convert the AC output from the transformer into DC. Both the Forward and Fly Back converter uses a separate diode for the rectification purpose. The Peripheral Interface Circuit Microcontroller is used to generate the firing pulse to control the switch. The controller has been programmed to generate pulse of fixed frequency by programming it suitably. Then the pulse is modified as per the requirement with the help of Opto Coupler and Buffer. A buffer amplifier is one that provides electrical impedance transformation from one circuit to another. Two main types of buffer exist: the voltage buffer and the current buffer. Current buffer is used in our circuit for boosting up the current of the firing pulse to a suitable value. Buffer IC 74HC244 is used in our circuit. In an electronic device designed to transfer electrical signal by utilizing light waves to provide coupling with electrical isolation between its input and output. It acts as an interface between the analog and digital part of the circuit. The main purpose is to prevent high voltage circuit from low voltage circuit. The Figures 2 and 3 shows the conventional SFFB and proposed SFFB respectively.

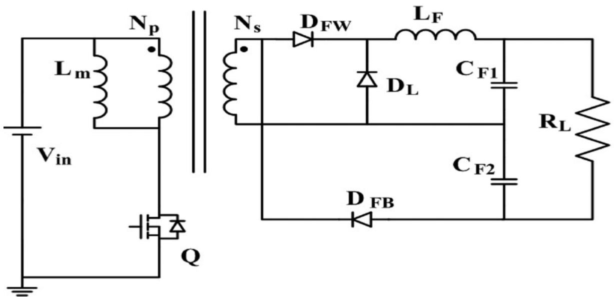

Figure 2. Conventional series connected Forward Flyback converter (SFFB).

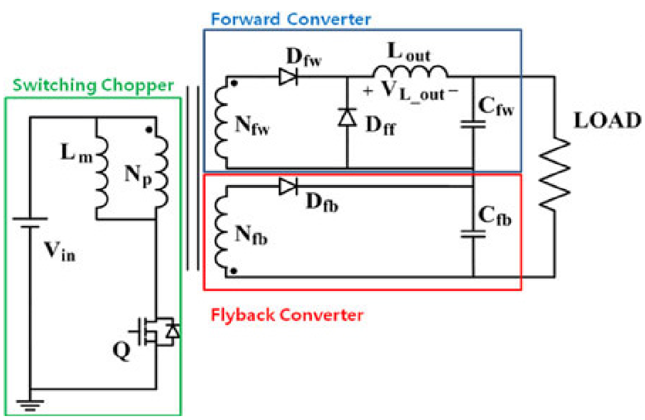

Figure 3. Proposed series connected Forward Flyback converter (SFFB).

3. Circuit Configuration and its Operation

The pulse generated by the microcontroller is given to the MOSFET through buffer and opto isolator circuit. The energization of the primary transformer is controlled by the switch. A magnetizing inductance is connected in parallel across the primary of the transformer. It provides a time varying voltage across the primary for the working of the transformer. The given input energy is transferred to the secondary side of the transformer due to transformer action. Depending upon the load sharing ratio of the transformer, depending upon the load sharing ratio of the transformer is shared between the forward and flyback converter. Both forward and flyback converter use diode to rectify the AC obtained from the transformer into DC.

The circuit diagram of the proposed system is shown in Figure 4.

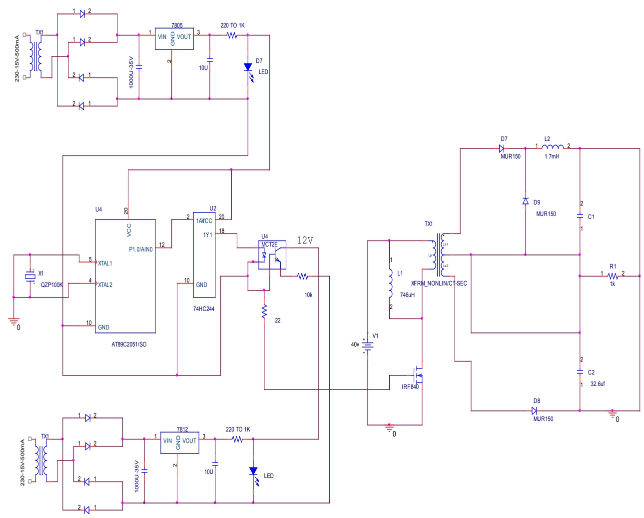

Figure 4. Circuit diagram.

Forward converter has a LC filter to remove the ripples from the output. The output capacitances are serially connected for high boost up of the voltage obtained. With a input of around 12V, the converter steps it up to a value of around 240V. Depending upon the load sharing ratio of the transformer, energy is shared between the forward and flyback converter. Both forward and flyback converter use diode to rectify the AC obtained from the transformer into DC. The given input energy is transferred to the secondary side of the transformer due to transformer action. Depending upon the load-sharing ratio of the transformer, depending upon the load sharing ratio of the transformer is shared between the forward and flyback converter. The proposed SFFB operates in four different modes based on the states of various devices in the circuit. Each operating mode of proposed SFFB is explained.

Mode 1**:** Current streams to the Lm and the essential twisting Np as an aftereffect of turning ON switch Q. The essential current is exchanged to the auxiliary new curl of the forward converter by means of the attractive linkage. At that point, the AC power is amended into dc in which the heap requires through a forward diode D_{fw} and a low-pass channel Lout and C_{fw}. Since a fly back diode D_{fb} is turn around one-sided, the yield capacitor gives the heap current amid this mode. Figure 5 shows the Mode 1 Operation.

Mode 2: At the point when turn Q is killed, a forward diode D_{fw} is switch one-sided and the vitality put away in

Lout is exchanged to the heap by the freewheeling current by means of D_{ff}, and in the meantime, the vitality attractively put away at Lm is additionally provided to stack through D_{fb} of the flyback converter. Along these lines, all the freewheeling current in attractive gadgets diminishes directly. Figure 6 shows the Mode 2 Operation.

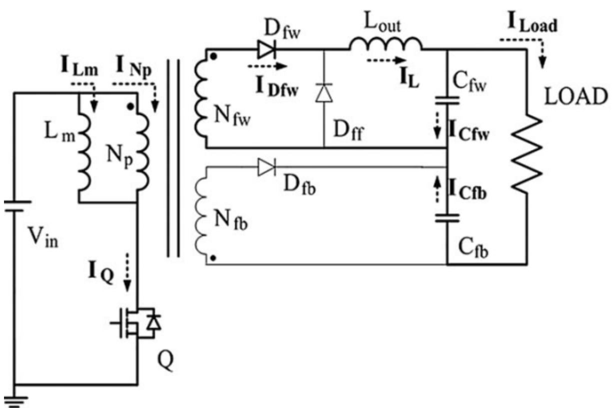

Figure 5. Mode 1 operation.

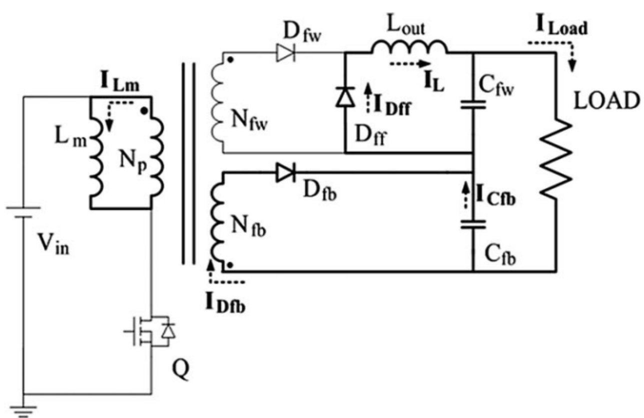

Figure 6. Mode 2 operation.

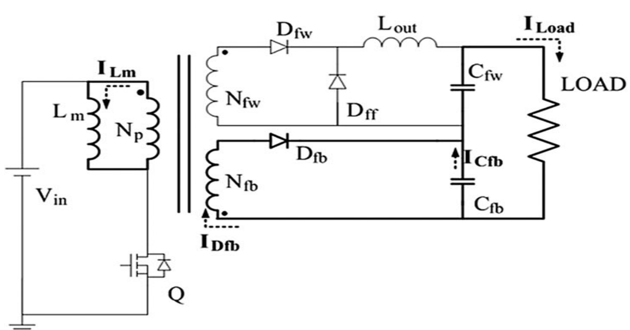

Figure 7. Mode 3 operation.

Mode 3: The forward converter begins to work in DCM when all the vitality in Lout is released, and after that a freewheeling diode Dff is turn around one-sided. The vitality just put away in Lm is provided to stack through the flyback converter. Figure 7 shows the Mode 3 Operation.

Mode 4: The transformer of the forward–fly back converter is demagnetized totally amid this period and the yield voltage is kept up by the release of the yield capacitors C_{fw} and C_{fb}. All the rectifier diodes are switch one-sided. Figure 8 shows the Mode 4 Operation.

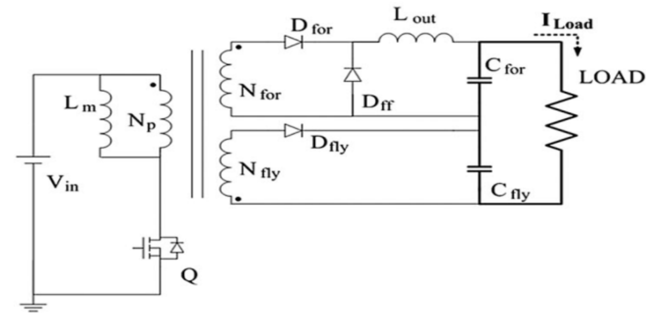

Figure 8. Mode 4 operation.

4. Simulation Results

The Figure 9 shows the circuit diagram of the closed loop operation of series connected forward flyback converter done using matlab Simulink software.

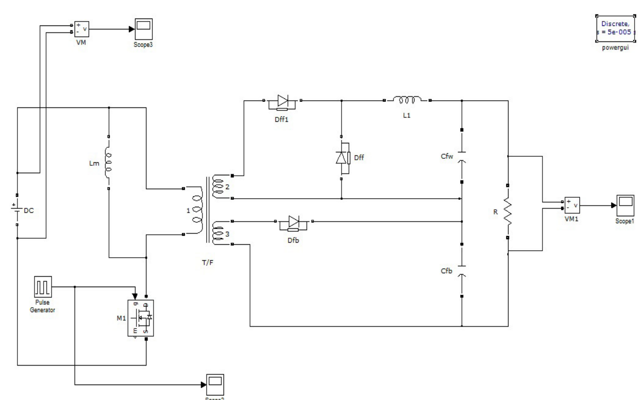

Figure 9. Simulation circuit.

The input supply is given to the magnetizing inductance and the primary winding of the transformer by turning ON the switch. As the voltage is DC, it has to be changed into a time varying quantity in order to give it to the transformer. The magnetizing inductance converts the constant DC voltage into time varying voltage across the primary of the transformer.

Due to transformer action, the power is transferred from the primary to the secondary and tertiary winding based on the load sharing ratio. Diodes rectify the AC output from the transformer into DC output. The forward converter has a combination of L and C which act as a filter, hence a freewheeling diode to provide a discharge path for the charge stored in the inductor. Both Forward and Flyback converter has an output capacitance connected across it to store the output power. Both the capacitors are connected in series for high step-up gain, hence the input specifications for waveforms are Sampling time is 50 e-6, DC input voltage is 30V, firing pulse is 1V, Switching frequency is 2KHz, the magnetizing and output inductance are 100mH and 0.1mH respectively. The Forward and flyback capacitances are 600 μF and 600 μF respectively. The voltage for the primary, secondary and tertiary winding of the transformer are 8V, 72V, and 40V respectively. The number of turns in the primary, secondary and tertiary winding of the transformer are 20, 150, and 60 respectively. These values and specifications of the various circuit components used in the simulation of the proposed SFFB Converter circuit. The input voltage and the firing pulse waveform is shown in Figures 10 and 11 respectively.

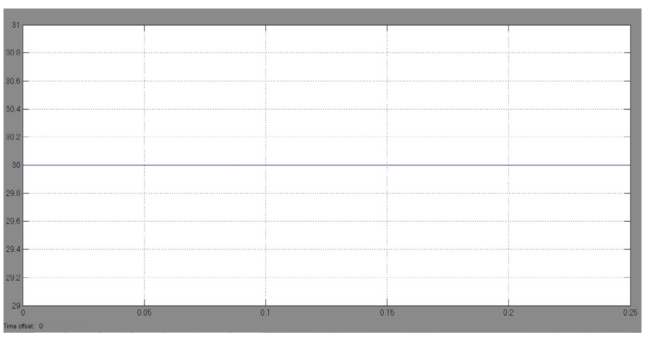

Figure 10. Input voltage.

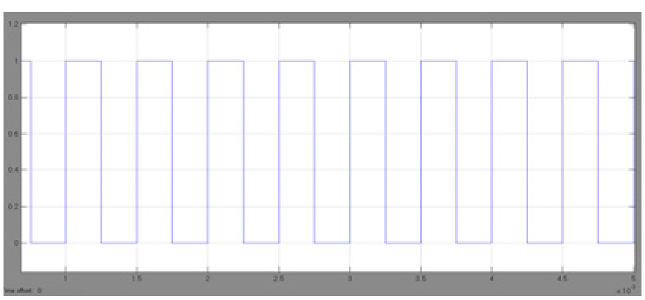

Figure 11. Firing pulse, 50% duty cycle.

From the output waveform shown in Figure 12 we can infer that the value of output voltage is stepped up substantially by the proposed series connected forward-flyback converter. By varying the duty cycle ratio, the value of output voltage can be varied. Here the duty cycle ratio value (α) is taken as 0.5. This makes the MOSFET switch to conduct for particular interval of each input cycle. The magnetizing inductance provides time varying input to the transformer. The output filter is employed in the forward converter helps in removing the ripple components present in the output waveform, thus making the waveform similar to DC wave with low Total Harmonic Distortion (THD) value. In this project the input supply is stepped up from 12V to 230V. The transformer steps up the voltage and the rectifier circuits convert them to DC.

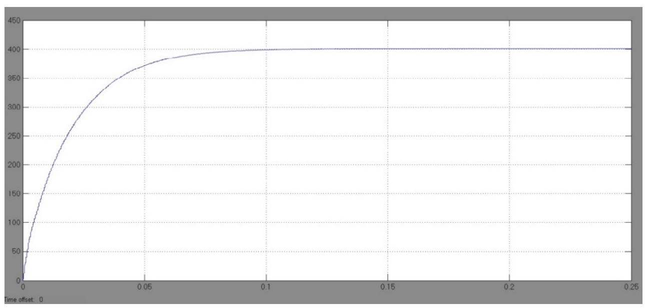

Figure 12. Output waveform.

The magnetizing inductance provides time varying input to the transformer. The output filter is employed in the forward converter helps in removing the ripple components present in the output waveform, thus making the waveform similar to DC wave with low Total Harmonic Distortion (THD) value. In this project, the input supply is stepped up from 12V to 230V. The transformer steps up the voltage and the rectifier circuits convert them to DC.

5. Conclusion

A high step-up DC to DC converter was designed and realized in this study. The High Step-Up DC to DC converter was designed with the help of MATLAB R2010a design software. The simulations were made in order to see the performance of the converter under a wide range of circuit parameters. Simulink which is a part of the MATLAB standard library is used for the simulation purpose. Circuit components are taken from the Sim power systems. The circuit is designed and simulated to get output ant the obtained output is examined. From the data obtained from the simulation of the proposed SFFB

(Series Connected Forward Flyback Converter) circuit, a hardware prototype of the circuit is designed. The output of the hardware prototype and the simulation circuit is compared and analysed. It is Simple to control and provides smooth, silent, efficient operation. It requires less number of components and cost effective. For future works the duty cycle of the proposed series connected forward-flyback converter can be varied depending upon the variation in the output voltage or current. By doing the ripple and distortions in the output can be reduced and the stability can be improved. Furthermore, by using a better switch than the MOSFET, the switching losses can be reduced.

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