IMPROVED VOLTAGE GAIN BY THE IMPLEMENTATION OF SOFT-SWITCHING TECHNIQUE IN FORWARD-FLYBACK CONVERTER

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Abstract - ***This paper presents a high step-up topology employing a ZVS soft-switching technique in forward-flyback DC-DC converter to improve the voltage-gain. With the implementation of the ZVS soft-switching technique in a DC-DC converter the voltage spikes are suppressed, which reduces the switch voltage stress as well as improves the voltage gain of the converter. MATLAB software is used to verify the result of the test system and a comparison is made between the hard-switching and soft-switching technique in a forward-flyback converter. From the result it is evident that with the implementation of soft-switching technique in a forward-flyback converter the voltage gain is improved.***

Key Words: *DC-DC converters, forward-flyback converter, ZVS soft-switching, voltage gain*

1. INTRODUCTION

Today photovoltaic (PV) power systems are becoming more and more popular, with the increase of energy demand and the concern of environmental pollution around the world. Four different system configurations are widely developed in grid-connected PV applications; the centralized inverter system, the string inverter system, the multi string inverter system and the module-integrated inverter system. Generally three types of inverter systems except the centralized inverter system can be employed as small-scale distributed generation systems, such as residential power applications. The most important constraint of the PV DG system is to obtain high voltage gain [1]. To obtain a high voltage gain from PV DG system there are some existing topologies such as high voltage-boost power converters, soft-switching converters where a coupled inductor is applied or a switched-capacitor is used. But they have poor reliability due to the absence of isolation. On the other hand, isolation type converter has an advantage of the safety and system reliability, and also the high power conversion efficiency [2]-[4].

The isolation converter needs magnetic-coupled transformer. However, using a magnetic coupled transformer requires a reset circuit that has disadvantages in performance and cost, resulting in the difficulty of circuit design. This reset also gives loading effect by its impedance, which increases the voltage stresses of the switching devices and the turn ratio of the main transformer. Conventional research has suggested some solutions for high-power high-boost with isolation type advantage [5]-[7].

All the conventional researches suggest that Series connected Forward–Flyback (SFFB) DC-DC switching converter can be used to obtain a high voltage gain. This forward-flyback converter solves the isolation type disadvantages and delivers the required energy to the load when the switch is either turned on or off. Thus it provides more power to the load than any other single-ended schemes [8]-[12]. Even though the SFFB converter provides high voltage gain, because of the hard-switching technique used, the converter suffers from high voltage stress which produces voltage spikes and degrades the voltage gain.

In this paper a Zero Voltage Switching technique has been implemented in a forward-flyback converter in order to eliminate this problem and to suppress the voltage spikes. This ZVS technique implementation reduces the switch voltage stress and improves the voltage gain. The performance of the test system is analyzed using MATLAB software.

2. SFFB CONVERTER

The structure of the conventional SFFB converter circuit diagram is shown in Fig1.In this circuit the outputs of the two converters are connected in series. It consists of magnetizing inductance, high frequency transformer, diodes and filtering inductance, capacitance. It delivers energy to the load when the main switch turns on and off.

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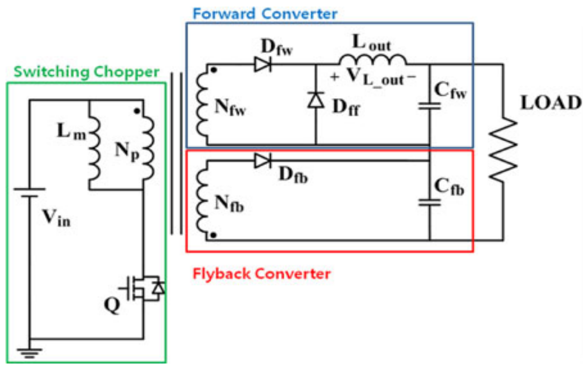

Fig -1: Conventional SFFB Converter

Switching waveform of the conventional converter is shown in fig 2.This switching waveform says that the gate voltage to the switch is applied before the switch drain to source voltage becomes zero.Hence the switch suffers high voltage stress and it reduces the voltage gain. MATLAB result of the conventional circuit is shown in fig 3 and fig 4. Fig 3 shows the output voltage of the conventional circuit and fig 4 shows the output current waveform. Fig 3 shows that with the input voltage of 40V an output voltage of 295V can be reached using conventional converter.The output voltage raises from zero to 295V in steps.At 295V transformer core saturates and hence after that the output voltage cannot be raised even with the increase in the input voltage. Fig 4 shows the output current waveform of the conventional circuit.With the conventionalconverter an output current of 0.0659 is obtained.

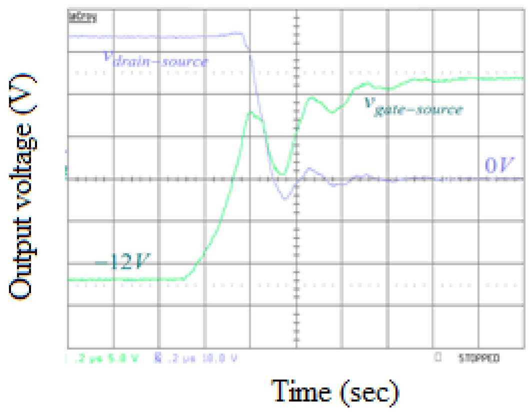

Fig -2: Switching waveform of conventional converter

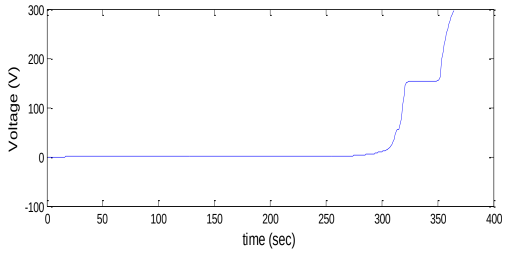

Fig -3: Simulated output voltage waveform of conventional converter

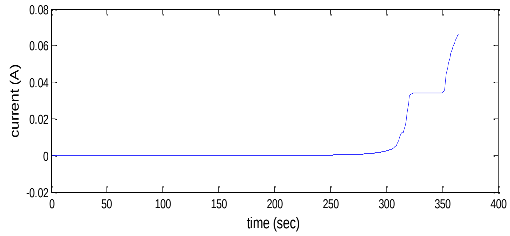

Fig -4: Simulated output current waveform of conventional converter

3. ZVS SOFT SWITCHED FORWARD-FLYBACK CONVERTER

The structure of the soft-switched forward-flyback converter is shown in fig 5.It consists of switch, magnetizing inductance, high frequency transformer, diodes, soft-switching capacitance and filtering inductance, capacitance. The capacitance connected across the mosfet does the soft-switching action. By turning on and off the switch, the energy is transferred to the load without interruption. High frequency transformer provides the isolation between the input and output circuit as well as steps up the voltage.

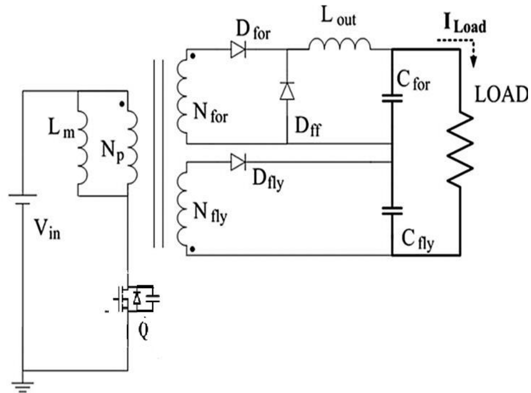

Fig -5: Equivalent circuit of soft-switched Forward-flyback Converter

In a soft-switching technique switching transitions occur under favorable conditions. This refers that the switch is turned on and off when the switch drain to source voltage or current is zero. In this paper Zero Voltage Switching (ZVS) has been implemented. In a ZVS technique the device is turned on when the drain to source voltage across it becomes zero.

Zero voltage switching circuit is shown in fig 6. Zero Voltage Switch consists of a switch in series with a diode. The resonant capacitor is connected in parallel with it and the resonant inductor is connected in series .A voltage source which is connected in parallel injects the energy into this system.

The switching waveform of the proposed converter is shown in fig 7.This waveform shows that the gate voltage/signal to

the gate of the switch is applied after the drain to source voltage across it becomes zero. Hence the switch stress becomes low which directly improves the voltage gain of the converter.
The parameter specifications of the test system is shown in the table 1 and the simulation result for the mentioned specifications of the proposed converter is shown in fig 8, 9, and fig 10.

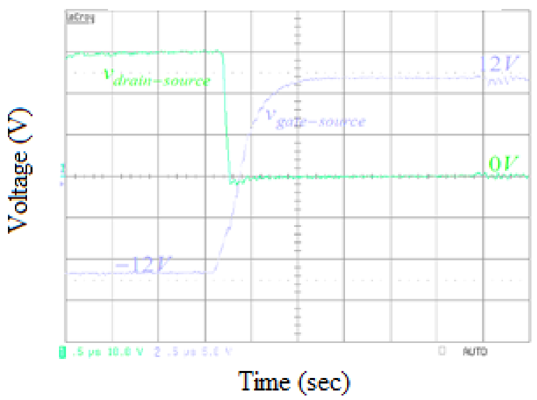

Fig -7: Switching waveform of proposed converter

Table -1: Parameters specifications of the test system

Input voltage	20-40v
Switch-MOSFET	R_{on}-0.1, R_d-0.01, R_s-1e^5
Multi winding transformer	40/480,60V 100VA,50Hz
Magnetizing inductance	10H
Forward's output inductance	2.185mH
Forward's output capacitance	15.55µF
Flyback output capacitance	32.6µF
Resistive load	80W

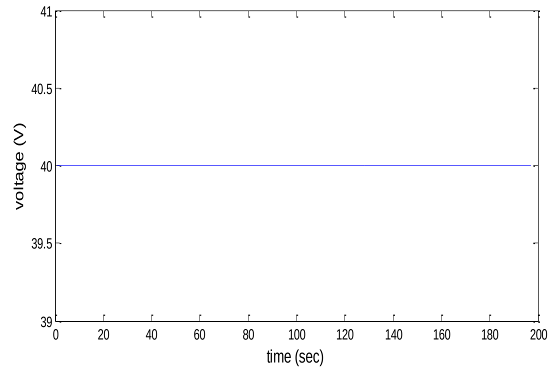

Fig -8: Simulated input voltage waveform of proposed converter Switching

Fig 8 shows the simulated waveform of input voltage. This shows that DC voltage of 40V is applied as an input to the converter. This 40V is applied to the converter via switch. The switch converts the DC voltage into High frequency square wave and it is fed to the primary of the high frequency transformer.
Fig 9 shows the simulated output voltage waveform.From fig 9 it is evident that using soft-switched forward-flyback converter for the same parameters value and an input voltage of 40V, 326V of output voltage is obtained. Because of the implementation of soft-switching scheme in a converter output voltage is increased. The voltage raises from zero and reaches about 50,100V at steps and finally settles at a constant value of 326V since the transformer core saturates.

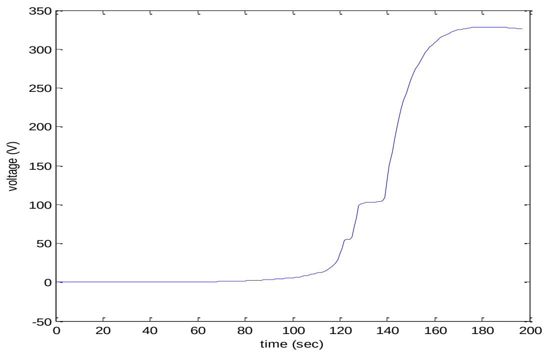

Fig -9: Simulated output voltage waveform of proposed converter.

Fig 9 shows the output current waveform of soft switched forward-flyback converter. The proposed converter provides an output current of 0.0723A.This total output current is same for both the forward and flyback converter since it is connected in series at the output side.

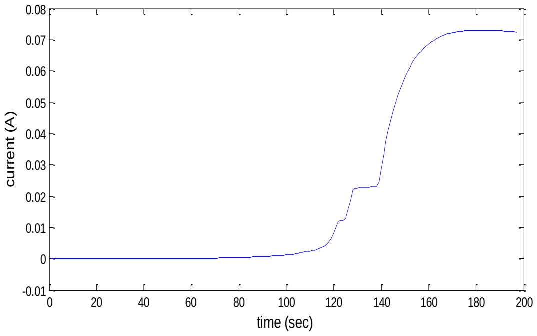

Fig -10: Simulated output current waveform of proposed converter.

Table -2: Comparison of conventional and proposed converter

S. No	VALUES	WITHOUT SOFT-SWITCHING	WITH SOFT-SWITCHING
1	OUTPUT VOLTAGE	295 V	326 V
2	OUTPUT CURRENT	0.0659 A	0.0723 A
3	VOLTAGE GAIN	7.4	8.2

Table 2 shows the comparison result of conventional and proposed converter. As comparing the simulation output of a conventional converter and a proposed converter the output voltage gain of the proposed converter is increased. With the implementation of soft-switching technique, the output voltage of the converter is increased from 295V to 326V and the current from 6.5mA to 7.2mA.The voltage gain of the converter is increased to 8.2 from 7.4.

3. CONCLUSIONS

A high step up topology employing a soft-switching technique in forward-flyback converter has been implemented in this paper. With the implementation of this converter a high voltage gain is obtained compared with other conventional converters. The single-ended forward–flyback operation contributes to high-density power delivery of the transformer with a isolation and the series-connected output is quite beneficial to the enhancement of the output voltage. The high-voltage, low-current output has a filter inductor under DCM operation that contributes to better performances by eliminating reverse recovery of the rectifying diodes.

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