SIMULATION AND IMPLEMENTATION OF THE THREE SWITCH SERIAL INPUT INTERLEAVED FORWARD CONVERTER

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ABSTRACT

Forward converter used for producing isolated and controlled DC voltage from the unregulated dc input supply. This paper deals with simulation and implementation of three switch Interleaved Forward Converter for telecommunication application. The simulation results of three switch forward converter with LC filter and experimental results obtained from the hardware prototype confirm the theoretical analysis and the performance of the proposed converter. The experimental results are compared with those of the simulation.

Keywords: Interleaved Forward Converter, DC-DC Converter, Matlab, and Microcontroller.

1. INTRODUCTION

Many industrial applications require DC power and there is a great need for the stepping down of the voltage of DC in many an electronic gadget such as mobile phones, laptops, etc. This kind of conversion of the voltage of the same type of current is achieved by what is called DC to DC converter which is an Electronic Converter that converts DC voltage from one level to another. DC to DC converters (with isolation) effectuate the conversion, by storing the input energy temporarily and then releasing it to the output at a different voltage level. DC to DC converters are indispensable in portable electronic devices such as cellular phones and computers which get their power from their batteries.

DC to DC converters (with isolation) use what is called Galvanic isolation. It is the principle of isolating functional sections of electrical system by preventing the flow of charge carrying particles from one section to another, i.e., there is electric current flowing directly from one section to the next. Energy and/or information can still be exchanged between the sections by other means such as capacitance, inductance, electromagnetic waves, optical, acoustic or mechanical means. Converters with galvanic isolation are of two types, namely Flyback converter and Forward converter. Forward converter is a popular switched mode power supply (SMPS) circuit that is used for producing isolated and controlled DC voltage from the unregulated DC input supply. Forward converters find applications in Power supply for DC motor, Battery charging, Battery operated Electric vehicle, Telecom industry etc.

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New Interleaved Series Input Parallel Output (ISIPO) Forward Converter with Inherent Demagnetizing Features is given by Taotao (2008). As the literature cited above does not give instances of studies comparing simulation and experimental results of three switch interleaved forward converter, this work chooses to compare the experimental results with those of simulation. The implementation of three switch forward converter using PIC controller is also not available in the reports of recent research. Hence this work proposes embedded controller for the control of TSFC system.

2. FORWARD CONVERTER

The block diagram of Three switch Forward converter system is shown in Fig1. This converter converts unregulated DC power to regulated DC power. It comprises high frequency transformer which is also called isolation transformer. This provides isolation between the load and the main circuit. As the frequency increases, the size of the transformer decreases. This is because the flux decreases with the increase in the frequency of the transformer.

2.1 DC LOAD

The output power is regulated DC power which can be used in applications like speed control of the motor, battery charging, telecommunication, computers, cellular phones, electrical drives, and other applications which need DC power.

2.2 THREE SWITCH FORWARD CONVERTER

The three switch forward converter as three switches T1, T2 and T3 which turns on, transferring energy through the transformer primary into the secondary. On the secondary, the forward rectifying diode conducts, transferring the energy into the output filter and load.

2.3 MICRO CONTROLLER

Micro controller is used to generate triggering pulses for the MOSFETs. The triggering pulses are of same width and have equal intervals of time. It is also used to control the output of the Forward converter by varying the pulse width applied to the MOSFET. Microcontrollers have more advantages like fast response, low cost, small size, and improved reliability etc., compared with the analog circuits.

3. SIMULATION RESULTS

The simulink model for three switch DC-DC converter is shown in Fig 2. The scopes are connected to measure output voltage, output current and output power. The output power is obtained by multiplying the output voltage and
the output current. The energies in the transformer secondaries are added and stored in the LC filter and then it is released to the load.

Fig 2 Circuit diagram of three switch forward converter

DC input voltage is shown in Fig 3 and its value is 300Volts.

Fig 3 Input voltage

The switching pulses for M₁, M₂ and M₃ of three switch forward converter system are shown in Fig 4.

Fig 4 Switching pulses for M₁, M₂ & M₃
The voltage across primary and secondary of the transformer 1 are shown in Fig 5.

![Fig 5 Primary and secondary voltages of the Transformer1](image)

The voltage across the primary and secondary of the Transformer 2 are shown in Fig 6.

![Fig 6 Primary and secondary voltages of the Transformer2](image)

The DC output voltage is shown in Fig 7. The output voltage is 48.35V

![Fig 7 Output voltage](image)

The output current and output power are shown in Figs 8 and 9 respectively. The output current is 9.7A and the output power is 469 Watts.
4. HARDWARE PARAMETERS

Hardware parameters of two switch forward converter with resistive load are shown in the table1. A step-down 230/15V transformer is used to give input supply to the power circuit. The 15V AC input is rectified into 15V pulsating DC with the help of full bridge rectifier circuit.

An output voltage of 12V obtained from the output pin of 7812 is fed as the supply to the pulse amplifier. An output voltage of 5V obtained from the output pin of 7805 is fed as the supply to the pic controller. Pic controller generates gate pulses for mosfet. These generated pulses are amplified by pulse amplifier and fed to mosfets. The load used in this two switch forward converter is 330ohm. The hardware is fabricated and tested. The experimental results are also described.
The hardware setup of three switch forward converter with R load is shown in Fig 11. The hardware consists of control circuit and power circuit. DC input voltage is shown in Fig 12. Switching pulse1 and output of driver1 are shown in Figs 13 & 14 respectively. The Drain to source voltage and switching pulse 2 is shown in Fig 15. Transformer primary and secondary voltages are shown in Figs 16 & 17 respectively. DC output voltage is shown in Fig 18.

### Table 1 Hardware Parameters of Three switch Forward Converter

| Parameter       | Value      |
|-----------------|------------|
| Vin             | 48V        |
| L               | 1µH        |
| C1,C2           | 47µF       |
| C3              | 104µF      |
| C4,C5           | 1000µF     |
| RL              | 330Ω       |
| MOSFET(IRF840)  | 500V/8A    |
| DIOED           | 230V/1A    |
| V0              | 12V        |

4. HARDWARE INVESTIGATIONS

The hardware setup of three switch forward converter with R load is shown in Fig 11. The hardware consists of control circuit and power circuit. DC input voltage is shown in Fig 12. Switching pulse1 and output of driver1 are shown in Figs 13 & 14 respectively. The Drain to source voltage and switching pulse 2 is shown in Fig 15. Transformer primary and secondary voltages are shown in Figs 16 & 17 respectively. DC output voltage is shown in Fig 18.
Fig 11 Hardware setup

Fig 12 Input Voltage (48V)

Fig 13 Switching pulse for M1 (5V)
Fig 14 Output of Driver1 (12V)

Fig 15 Drain to Source Voltage and switching pulse for M2 (5V)

Fig 16 Voltage across the Primary of the Transformer
CONCLUSION

The three switch serial input interleaved forward converters were modeled and simulated using MATLAB Simulink. The simulation results were found to be inline with the predictions. The hardware was fabricated and tested. The experimental results obtained from the hardware prototype were found to support the theoretical analysis and the performance of the proposed converter. They are almost similar to the simulation results.

The scope of this study includes the modeling, the simulation and the implementation of closed loop controlled three switch ILFC system.

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