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Closed Loop Control of the Two Switch Serial Input Interleaved Forward Converter Fed DC Drive

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Abstract:
This paper deals with closed loop control of the two switch Interleaved Forward Converter with motor load. When any sudden change occurs at the input of the open loop two switch interleaved forward converter, the output is disturbed for a long time. In order to avoid this, a closed looped control is introduced. By using closed loop control, the steady state error in speed is reduced. The DC input is converted into high frequency AC using the Forward Converter. The AC is rectified using a Half-wave rectifier. The output voltage is regulated using the closed loop system. The simulation results are compared with the theoretical results.

Key words: *Interleaved Forward Converter, DC-DC Converter, Matlab, Microcontroller*

1. Introduction

Many industrial applications require DC power. A DC to DC converter is an Electronic Converter which converts a source of Direct Current (DC) from one voltage level to another. DC to DC converters (with isolation) convert one DC voltage level to another, by storing the input energy temporarily and then releasing that energy to the output at a different voltage level. The energy can be stored in magnetic field storage components (inductors, transformers) or electric field storage components (capacitors). This conversion method is more efficient than linear voltage regulation which dissipates unwanted power as heat. The efficiency is increased by the use of power FETs, which operates at high frequency and more efficient than power bipolar transistors. DC to DC converters are important in portable electronic devices such as cellular phones and computer which are supplied with power from batteries.

Galvanic isolation is the principle of isolating functional sections of the electrical system by preventing the moving 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, e.g. capacitance, inductance electromagnetic waves, optical, acoustic or mechanical means. Such a principle is used in these DC to DC converters (with isolation). Two types of converter with galvanic isolation are 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. Applications of this forward converters are Power supply for DC motor, Battery charging, Battery operated Electric vehicle, Telecom applications etc.

The input DC supply for a forward converter is often derived after rectifying (and little filtering) the AC voltage. The forward converter, when compared with the flyback circuit is generally more energy efficient and is used for high power output applications (in the range of 100 watts to 200 watts). Whereas, the flyback converter used for low power application below is 100 watts. The forward converter is simple and retains many features of the buck converter. With a proper choice of the transformer turns ratio, the forward Converter can attain wide step down voltage which is useful for offline applications. Moreover, this forward converter is quite easy to control. These advantages make the forward converter for low to medium isolated offline power applications.

Series-input interleaved forward converter with a shared switching leg for wide Input Voltage Range Application is given by Xu (2013). Analysis and design of forward converter with energy regenerative snubber is given by K. Smedley (2010). A novel ZVS resonant reset dual switch forward DC-DC converter is given by Y. Gu (2007). Reducing common-mode noise in two-switch forward converter is given by P. Kong (2011). High efficiency active clamp forward converter for sustaining power module of plasma display panel is given by T.S. Kim (2008). Zero-voltage switching post regulation scheme for multi output forward converter with synchronous switches is given by J.K. Kim (2011). RCD reset dual switch forward DC/DC converter is given by Y.Gu (2004). Two switch active-clamp forward converter with one clamp diode and delayed turnoff gate signal is given by K. B. Park (2011). A new interleaved series input parallel output (ISIPO) forward converter with inherent demagnetizing features is given by T. Jin (2008). Analysis, design and experimentation of a double forward converter with soft switching characteristics for all switches is given by S. de Souza Oliveira (2011).

The above literature does not deal with closed loop control of two switch interleaved forward converter with motor load. Two switch interleaved forward converter is proposed for the control of DC motor. This paper deals with modeling and simulation of closed loop controlled two switch interleaved forward converter with motor load.

2. Forward Converter

The block diagram of a forward converter system is shown in Figure 1. This converter converts unregulated DC power to regulated DC power. It contains a high frequency transformer which is also called isolation transformer. This transformer 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.

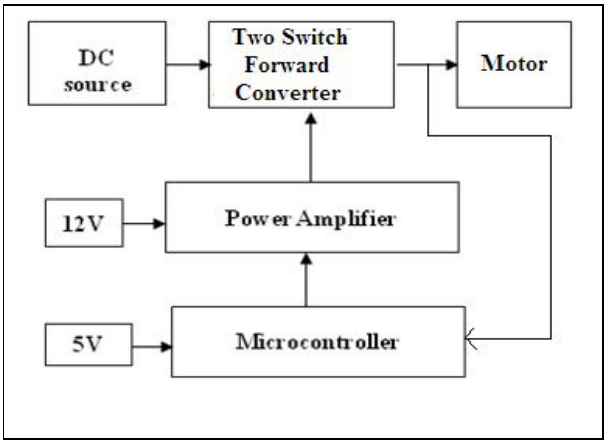

Figure 1: Block Diagram of Forward Converter system

3. Simulation Results

The simulink model for two switch DC-DC converter is shown in Figure 2. The scopes are connected to measure output voltage and output current. A step change in input voltage is applied to the open loop system.

3.1. Open Loop Controlled Two Switch Forward Converter With Motor Load

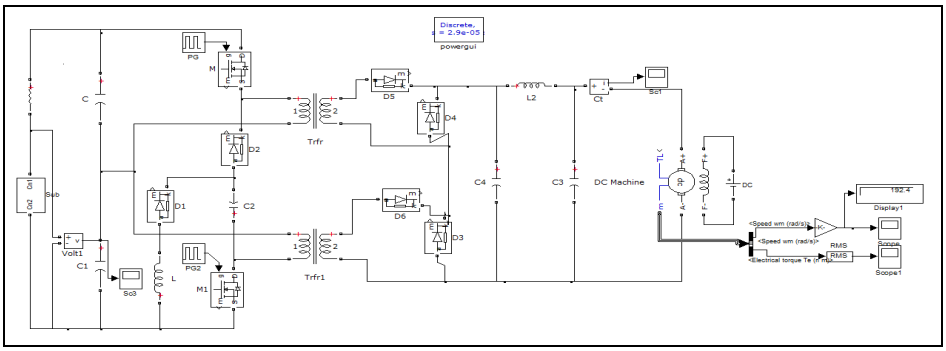

Figure 2: Open loop controlled two switch forward converter with motor load

DC input voltage is shown in Figure 3 and it is 300volts. When a step change is applied, the input voltage increases to 324V.

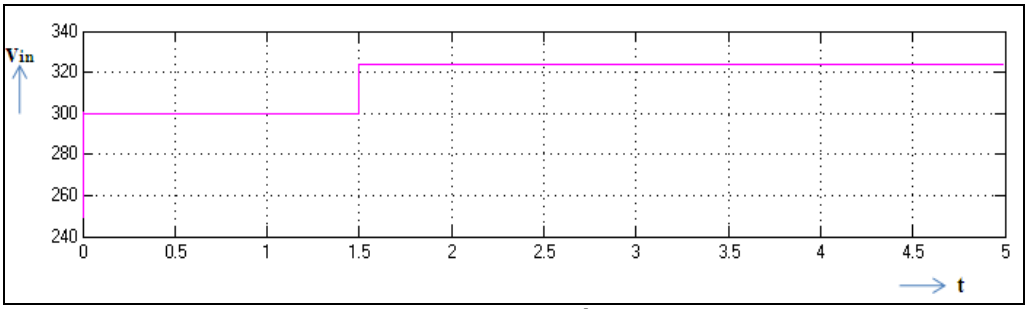

Figure 3: Input voltage

The speed and torque are shown in Figure 4 and figure 5 respectively. The step rise in torque is due to the step rise in the input voltage.

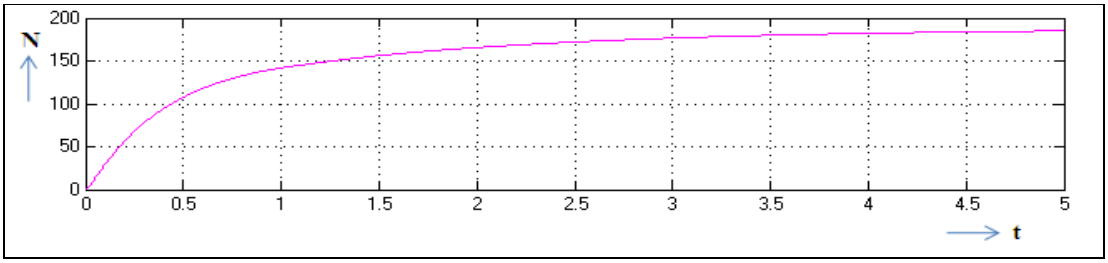

Figure 4: Motor speed

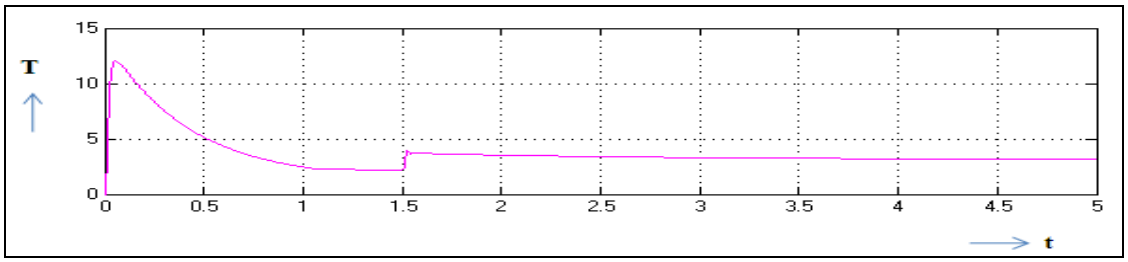

Figure 5: Torque

3.2. Two Switch Forward Converter System With Closed Loop Control

The two switch serial input interleaved forward converter with closed loop is shown in Figure 6. The PI controller is used to reduce the error in the output. The output voltage is measured and it is compared with the reference voltage. The error is processed by a PI controller. The output of the PI controller is the input to the comparator. The diodes in the rectifier are replaced by MOSFETs so that the output voltage can be controlled. The output voltage is regulated by contolling the pulse width applied to the MOSFETs.

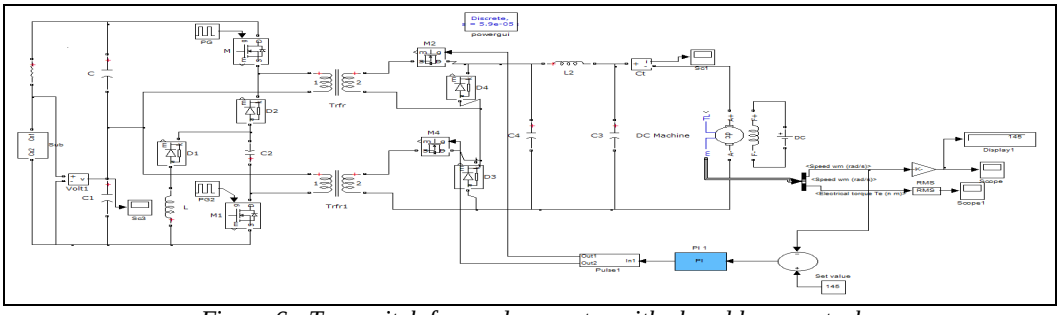

Figure 6: Two switch forward converter with closed loop control

DC input voltage is shown in Figure 7 and its value is 324volts.

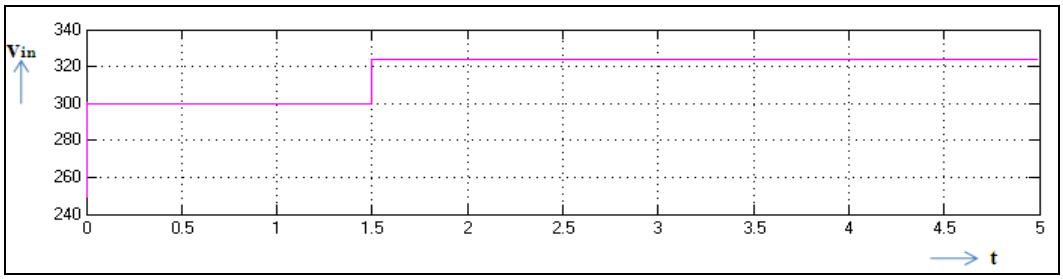

Figure 7: Input voltage

The speed and torque are shown in Figure 8 and figure 9 respectively. It can be seen that the torque reaches steady state value due to the action of closed loop system.

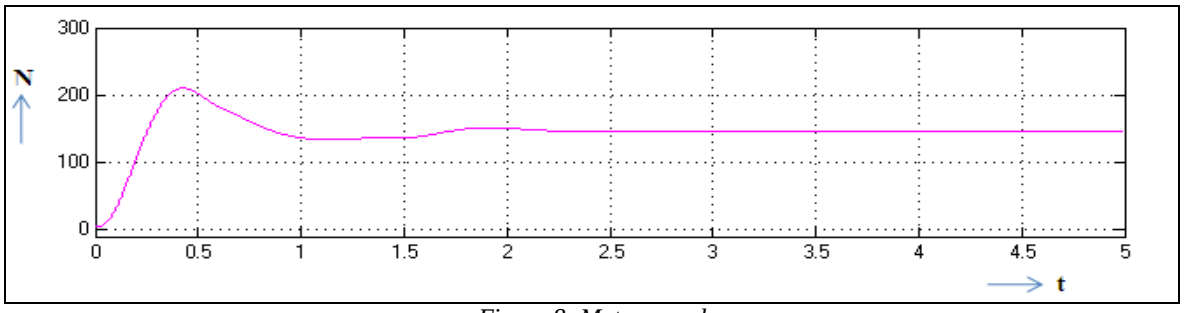

Figure 8: Motor speed

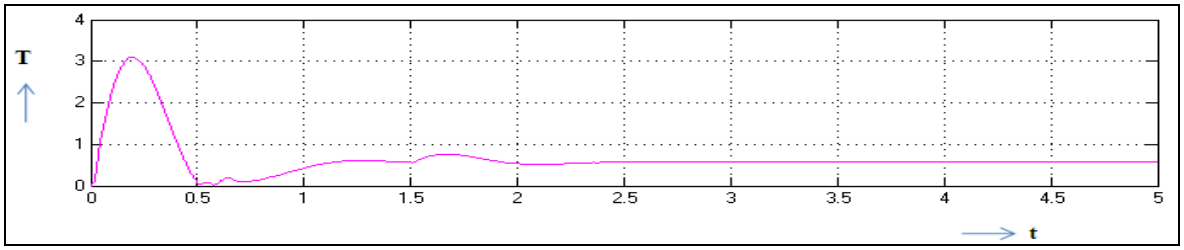

Figure 9: torque

4. Conclusion

Open loop and closed loop controlled two switch serial input interleaved forward converter fed DC drive systems are modeled and simulated using MATLAB Simulink and the results are presented. The speed of two switch converter system with PI controller is regulated. The steady state error is reduced by using closed loop system. The simulation results are in line with the predictions. The scope of this work is the modeling and simulation of closed loop controlled two switch ILFC with motor load. The hardware will be implemented in future. The disadvantages of this circuit are the requirement of four switches and four drivers.

5. References

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