

Power Factor Enhancement in Bridgeless LUO Converter Fed Switched Reluctance Motor Using Fuzzy Controller

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ABSTRACT: This paper presents about the Power Factor Correction based Bridgeless LUO converter fed Switched Reluctance Motor drive by using Fuzzy Controller. The proposed topology aims at designing and modelling of a Bridgeless LUO converter for driving a Switched Reluctance Motor in a simple and effective manner. The proposed control scheme has the concept of DC link voltage control relative to the desired speed of the Switched Reluctance Motor. Bridgeless LUO converters are the combination of two dc to dc converters with less semiconductor switches. The C-Dump converter is used for the Switched Reluctance Motor which results in power factor correction and phase de-fluxing component with reduced device count. The current regulation is achieved by this converter and it is suitable for low voltage applications. The result of fuzzy logic controller to a SRM drive gives the better performance and high robustness.

KEYWORDS: Bridgeless LUO converter, Switched Reluctance Motor, Fuzzy Logic Controller, Power Factor Correction, C- Dump Converter

I. INTRODUCTION

The Switched Reluctance Motor is a type of electric motor that runs by reluctance torque. Switched Reluctance Motor is electro-magnetic and electro-dynamic equipment which convert electrical energy into mechanical energy. It provides high reliability, at constant power it provides high speed range, manufacturing cost is low, good dynamic response, ruggedness and fault tolerance. The switched reluctance motor drives are finding application in high volume appliances and industrial applications which can take good advantage of their characteristics with high starting torque.

Switched Reluctance Motors (SRM) have qualities such as easy structure with non-winding assembly in rotor side and low cost with no permanent magnet in the construction, and the switched reluctance motor operate by high temperatures or with temperature variations [1]. The switched reluctance motor is an electric machine which converts the reluctance torque into mechanical output. In switched reluctance motor the stator and rotor enclosed by a structure of salient-pole. The high output torque is obtained due to salient poles. The torque is obtained by the arrangement inclination of poles [1].

LUO converters are one of the simplest forms of DC to DC converters which operates on voltage lift technique [2]. Employing voltage lift technique has opened a way in designing high voltage gain converters. It allows voltage to be increased stage by stage, in arithmetic progression [2].

The growing awareness of industries towards SR drive is for the better performance as compared to inverter/converter fed ac and dc motors [3]. This paper investigates the application of fuzzy logic controller for dynamic analysis of SRM drive.

II. SYSTEM MODEL

The proposed Bridgeless LUO converter fed Switched Reluctance Motor drive is designed and its performance is simulated in MATLAB/Simulink software. The Fuzzy Logic Controller is implemented for improving the performance. With the help of Fuzzy logic controller, the performance indices like supply voltage and current, DC link voltage, motor speed, inductor current, capacitor voltages, PFC switches voltage and current are analysed for decisive the performance of proposed Bridgeless LUO converter fed SRM drive. The simulation diagram of the proposed Bridgeless LUO converter is as shown in Fig. 1

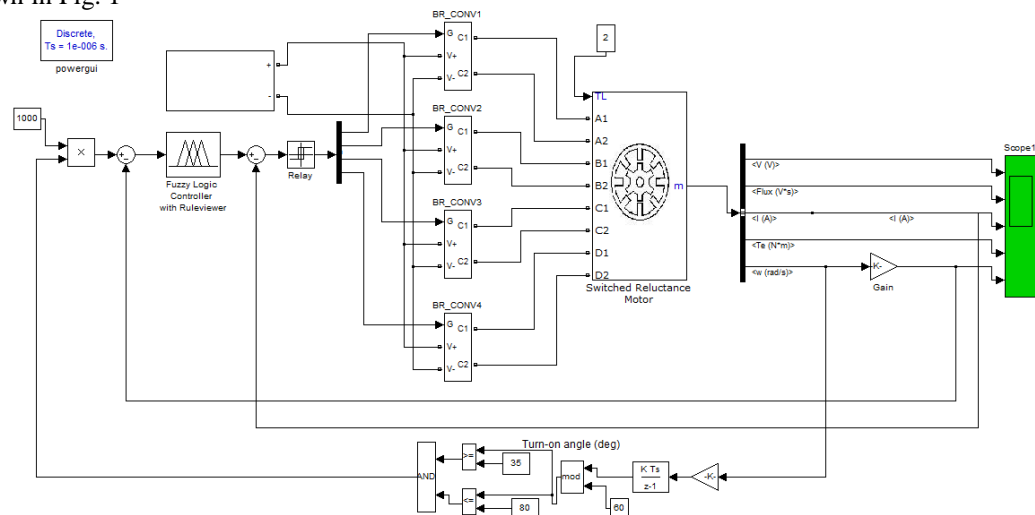


Fig 1: Simulation diagram of SRM with FLC

III. PROPOSED LUO CONVERTER FED SWITCHED RELUCTANCE MOTOR DRIVE

The Fig.2 shows the proposed block diagram of Bridgeless – LUO converter fed SRM drive. A single phase supply followed by filter and a Bridgeless – LUO converter is used for feed a C-dump converter driving a SRM drive. The LUO converter is used to progress the output quality of the supply. It means in the LUO converter output it contain the low level harmonics, small distortion and less ripple. The Bridgeless-LUO converter is operated in a discontinuous inductor current mode [4]. The speed of the SRM drive is controlled by varying the DC link voltage of C-dump converter using a single voltage sensor. By controlling the LUO converter output, SRM motor output performance is improved. The LUO converter operation and SRM Drive operation is controlled by using Fuzzy Logic Controller (FLC).

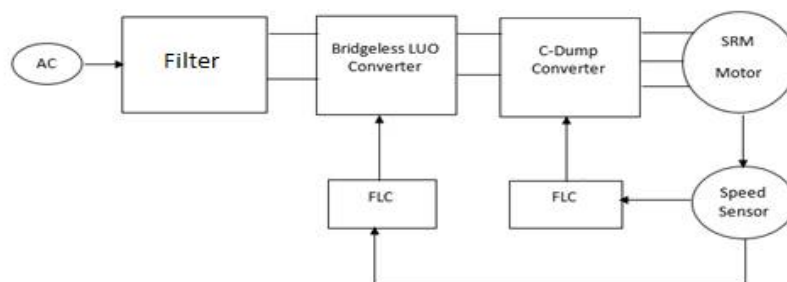


Fig. 2 LUO Converter Based SRM Drive

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IV. OPERATING PRINCIPLE OF BL-LUO CONVERTER

A LUO converter is mostly used due to its innate advantages of voltage lifting technique. Due to the intrinsic advantages of the LUO converter, a bridgeless arrangement of the LUO converter is explored in this paper for feeding a SRM as a low cost solution for low power applications [5-9].

Operation of Bridgeless LUO Converters

The Fig.3 shows the proposed block diagram of Bridgeless – LUO converter fed SRM drive. The projected scheme is designed and its performance is simulated for achieving an enhanced power quality at AC mains for a broad range of speed control and supply voltage variations.

The operation of proposed Bridgeless LUO converter is classified as two parts which consists of the operation during the positive and negative half cycles of supply voltage.

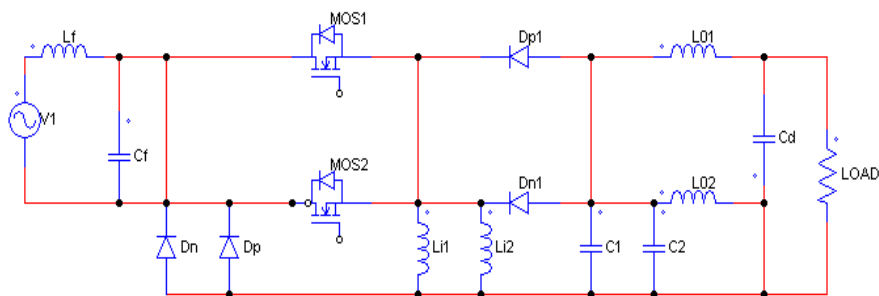


Fig. 3 Bridgeless LUO Converter

The Fig. 4 shows the principle of operation of Bridgeless LUO converter during a complete switching period.

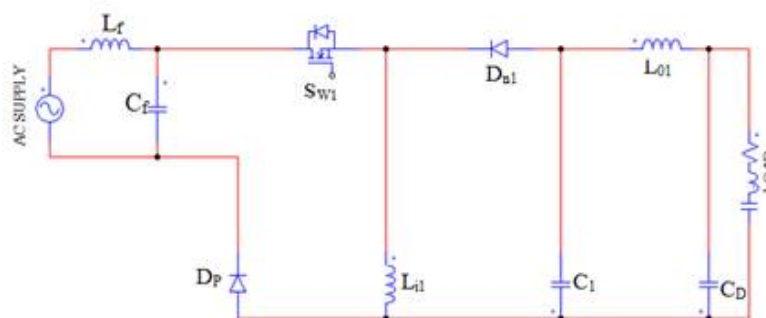


Fig. 4 BL-LUO Converter Mode I operation

As shown in Fig. 4, When SW_1 is turned-ON, the inductor at the input side (L_{i1}) stores energy with respect to the current flows through it and the corresponding value of inductor (L_{i1}). The energy stored in the C_1 capacitor is transferred to the (C_D) i.e DC link capacitor and the output side inductance. Therefore, the voltage across capacitor (V_{C1}) reduces, at that time the current in output side inductance and the DC link voltage (V_{dc}) are increased.

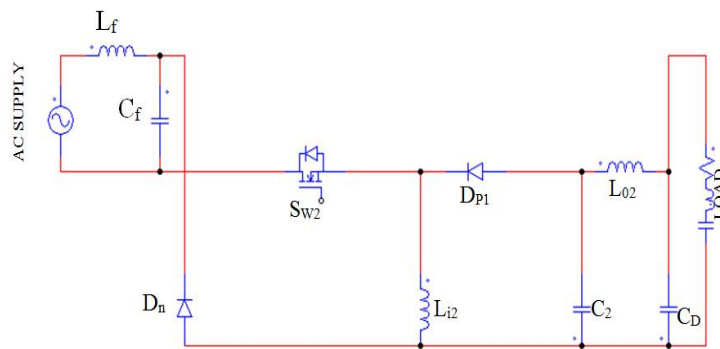


Fig. 5 BL-LUO Converter Mode II operation

As shown in Fig. 5, When SW₁ is turned-OFF, the inductor at the input side (L_{i2}) transfers energy to the capacitor C₁ by the D_{P1} diode. Therefore the current i_{L_{i2}} reduces till it reaches zero, whereas the capacitor voltage V_{C1} increases. The Dc link capacitor has the sufficient energy for the load, therefore (V_{dc}) the DC link voltage reduced in this mode.

V. C-DUMP CONVERTER FOR SRM DRIVE

Among the SRM converters, C-dump converter circuit is mostly used for better demagnetization during commutation of the phases [10-11]. Figure 6 shows the C-dump converter. It is derived from the C- Dump converter [11] circuit by eliminating the inductor of the Cuk converter. In this converter, the energy from the phase winding is dumped into a capacitor C before it reaches the aligned position. In capacitor the energy will be stored and in next phase it will be used. The capacitor voltage to be maintained at twice the supply voltage ($2V_{dc}$). While the C-dump converter is capable of giving a better performance, dump capacitor size, capacitor voltage rating and the switching devices, the control requirements and the energy dump inductor shows that, the converter is expensive and complicated. This proposed modified C-dump converter to overcome these limitations and makes the converter as cost effective and energy efficient [12].

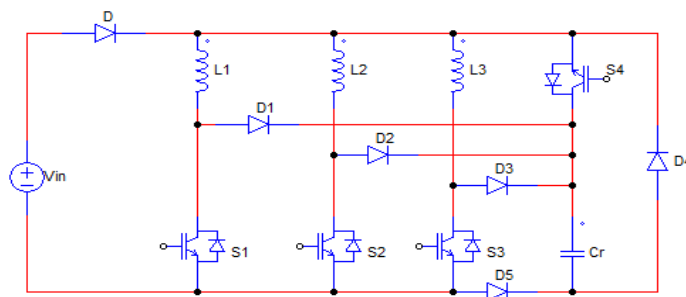


Fig. 6 C-Dump Converter

Fig. 6 shows the energy competent C- Dump converter topology, derived from the conventional C- Dump converter [12]. The converter can function efficiently during the modes of chopping and commutation for each cycle. During the conduction mode the switches S_1 and S_4 is ON for magnetizing the Phase L_1 . When current passed through the phase L_1 it attains a command value, then the converter is switched into the chopping mode by turning S_1 OFF. At that time the blocking diode becomes forward biased and the source begins to provide for energy to the phase. The current will be maintained at the instruct level by switching S_1 between the ON and OFF states. The phase current freewheels throughout diode D_1 and S_4 when the switch S_1 is " OFF" . The current commutates from S_1 and S_4 "off"

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and charges the dump capacitor. The commutation mode is initiated by turning both S_1 and S_4 OFF. The diode D_5 stops the demagnetizing current, which flows throughout the source. While L_1 phase is being demagnetized, L_2 phase can be magnetized by turn on S_2 . During this period, the current through L_2 phase is maintained at the instruct value by dumping any added energy keen on the capacitor. These can be continued for the next phase also.

VI. SIMULATION RESULTS

Without LUO Converter Fed SRM Drive

The Fig. 7 represents the outputs for Flux and Current without LUO converter.

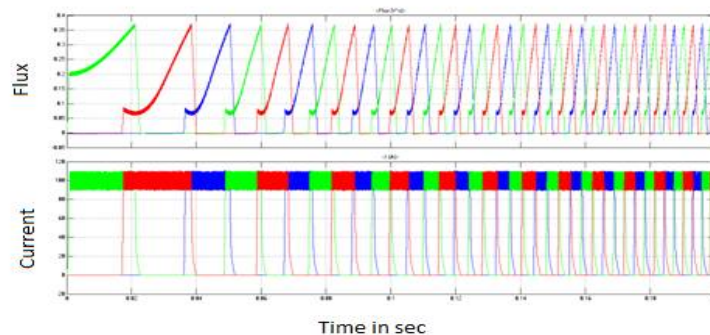


Fig. 7 Output of Flux and Current without LUO Converter

The performance of SRM drive is simulated for various supply voltages to demonstrate its behaviour for practical conditions. The result shows that the range of the torque is reducible in nature and also the speed range is also low.

The Fig. 8 represents the outputs for Torque and Speed without LUO Converter.

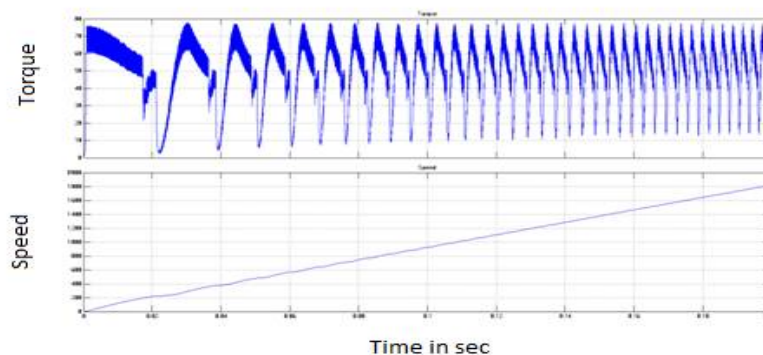


Fig. 8 Output of Torque and Speed without LUO Converter

The ripple produced in the flux of the motor is high and the range of current present in the motor is low. Without LUO converter circuit the motor takes before 0.2 seconds to reach the steady state condition.

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LUO Converter Fed SRM Drive:

The Fig. 9 represents the outputs for Flux and Current with LUO Converter

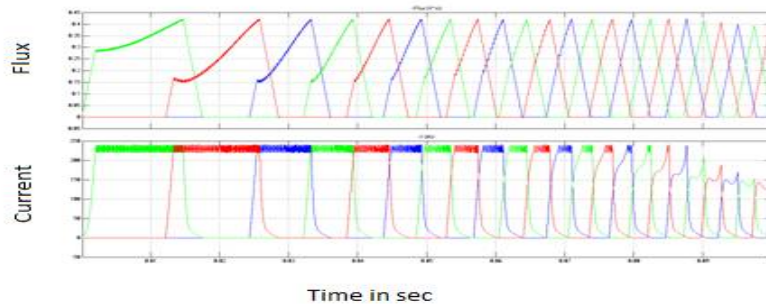


Fig. 9 With LUO Converter Outputs for Flux and Current

The result shows that, the range of the torque is increasable in nature and the range of the speed is also high. The ripple produced in the flux of the motor is low and the range of current produced in the motor is increased.

The Fig. 10 represents the outputs for Torque and Speed with LUO Converter.

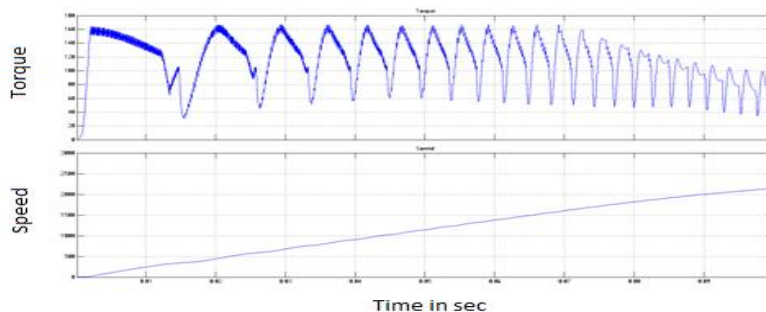


Fig. 10 With LUO Converter Outputs for Torque and Speed

With LUO converter circuit the motor takes 0.10 seconds to reach the steady state condition when compared to the without LUO converter operation. By this result the acceleration torque is high.

From the Simulation results the output torque ripple is reduced when compared to the without LUO converter circuit.

Table. 1 Comparative Study of Set Speed and Settling Time

| S.No | Speed (RPM) | PI (Settling Time) | Fuzzy Controller (Settling Time) |
|------|-------------|--------------------|----------------------------------|
| 1 | 1500 | 0.18 | 0.05 |
| 2 | 2000 | 0.26 | 0.10 |
| 3 | 2500 | 0.28 | 0.12 |
| 4 | 3000 | 0.32 | 0.14 |

The Table 1 shows the different set speed and settling time in PI controller and fuzzy logic speed controller. From the tabulation results it shows, the settling time of fuzzy logic controller as low compared to PI controller.

VII. CONCLUSION

A Power Factor Correction bridgeless LUO converter fed SRM drive has proposed for broad range of speed and supply voltages. By using the concept of variable DC link voltage with single voltage sensor the speed control of

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SRM is achieved. By the LUO converter fed SRM drive the efficiency of the drive gets improved compared to the without LUO converter operation. In LUO converter fed Switched Reluctance Motor drive the normal PWM pulse generator is used and in future it will be implemented for the neural network and Genetic algorithm for improving the efficiency of the SRM drive. The implementation of LUO converter the speed will be increased and the torque ripple gets reduced.

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