ISSN 2250-3153

Simulation of closed loop control of DC to DC convertor

Jaimy Rachel Skaria, D. Godwin Immanuel

Dept. of Electrical and Electronics Engineering, Sathyabama University
Dept. of Electrical and Electronics Engineering, Sahtyabama University

Abstract- A Closed loop Boost dc-dc converter with novel capabilities of fuzzy logic controller is proposed, which mainly meant for constant power loads. The fuzzy logic controller controls the system to achieve constant output as per the requirement of the load. Due to the variation of input voltage and load current, a two stage ZVT boost converter with series resonant convertor is used to give supply to the load. The selected converter has the advantage of No duty cycle loss, wide zero voltage switching (ZVS) range, No ringing problem of the rectifier. The closed loop system is developed in such a way that, it provides necessary corrections for any slight variation in system output. The advantage of fuzzy logic improved the system efficiency in terms of accuracy compared to other conventional controllers. The system suits for electrolyzer.

Index Terms- Boost converter, Closed loop control, series resonant convertor, fuzzy logic controller

I. Introduction

Constant power drivers are very essential for industrial application. Advanced techniques in power electronics are available in industries for constant power applications [1]. The proposed system comes under such category which does power conditioning to improve efficiency[4]. The dc-dc converter mainly designed as a power conditioning unit, where a ZVT boost converter is used at initial stage and a series resonant converter unit at the latter stage.[7] The dc-dc converter connected to the system makes an open loop, which solely does not satisfy the load demand.[1] Considering variations in output parameter, a closed loop system is proposed to the power conditioning unit with a fuzzy logic controller. The output variables must be monitored continuously to avoid system malfunction.[5] Hence closed loop is preferred, since it eliminates erroneous conditions to a very good extend. The converter unit provides power as per the load demands.[1]

II. POWER CONDITIONING UNIT

A two stage approach is used to develop the converter unit. At first stage, ZVT boost converter provides supply to the series resonant converter unit for specified input voltage. The input voltage is boosted up to make input voltage to the series resonant converter. It provides ZVS for all primary switches.[6] The series resonant converter is operated for almost fixed input voltage. The series resonant converter works with lagging power factor and no duty cycle losses, ringing problem of rectifier is not present .A wide range of ZVS is possible. This scheme has good load efficiency [1]. To increase their efficiency and to further increase the switching frequency wile reducing the size cost and EMI frequency resonant topology that achieves ZVS while operating at constant frequency operation simplifies EMC and magnetic component design

The resonant frequency fr of the converter is mainly determined by the inductance Lr and the capacitance Cr of the series capacitor. Turn-on switching losses of the power switches are reduced under zero-voltage switching condition as the [3] The gating signals are generated with respect to the change in output occurred. The signal is 30º phase shifted to achieve three level output. The duty cycle will be taken as per the change in output voltage.[8] The reference voltage is directly proportional to the duty cycle, which itself is proportional to the output voltage.

III. CIRCUIT DESCRIPTION AND OPERATIONs

Fig. 1 shows a closed loop system for a dc-dc converter. The circuit consists of a boost converter and a high frequency (HF) resonant converter. High frequency switching is implemented using MOSFET switches[2]. This is the high frequency link. A HF transformer provides voltage transformation and isolation between the DC source and the load. At the output side, a full bridge rectifier is connected to load. For analytical study, a resistive load is selected. The closed loop is controlled for constant output

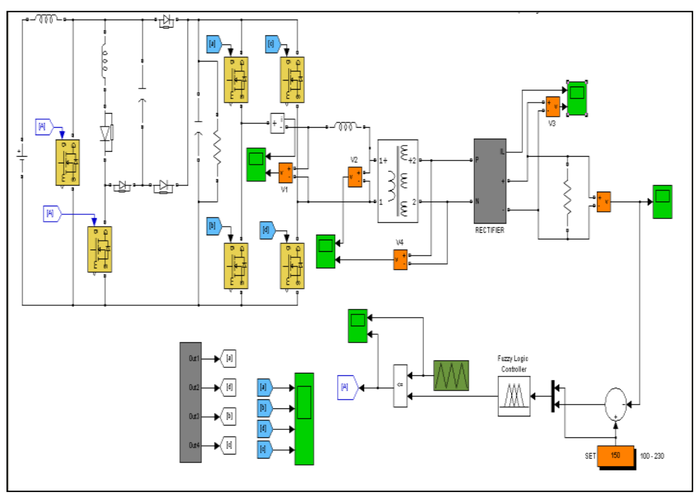

Fig.1 Closed loop control of Dc-Dc converter with fuzzy logic controller

The circuit operation is as follows, the input voltage is boosted up through ZVT boost converter and the boost converter output is given to the series resonant circuit (SRC) .The switching frequency of MOSFET switch is 10Khz.The SRC will do the power conditioning process through its filter components. This power will be fed to the load through rectifier circuit. The fuzzy logic controller is designed in such a way, which maintains the output constantly according to the set voltage

Fuzzy logic controller developed is as shown in Fig,2.The references block are set for -350V to 350V range with seventeen membership functions, in which one membership function is within the range of 50V.The error block contains three membership function for comparison

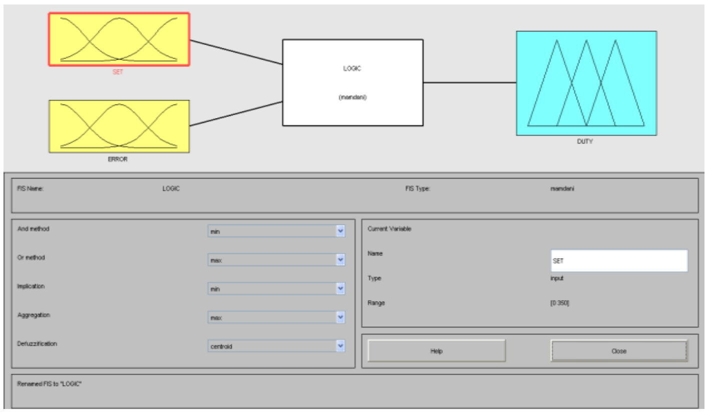

Fig.2 Fuzzy Logic Controller

IV. A. SIMULATION RESULTS

The simulation of closed loop system is done using MATLAB and the results are presented .The driving pulses for MOSFETs is given in the Fig.3 .The gating pulses are given to the interleaved multicell configuration of SRC MOSFETs. The output of Dc-Dc convertor is shown in Fig. 4

For the input voltage of 40V, the output voltage is 150V provided the closed loop is set for 150V.The reference voltage can be set within a range of 100 to 350V.The controller is programmed to maintain the output within the above mentioned limit.

The output waveform of series resonant converter is given in Fig.5.Its typical operation waveforms for fixed frequency operation using phase shifted gating signals are in Fig.3

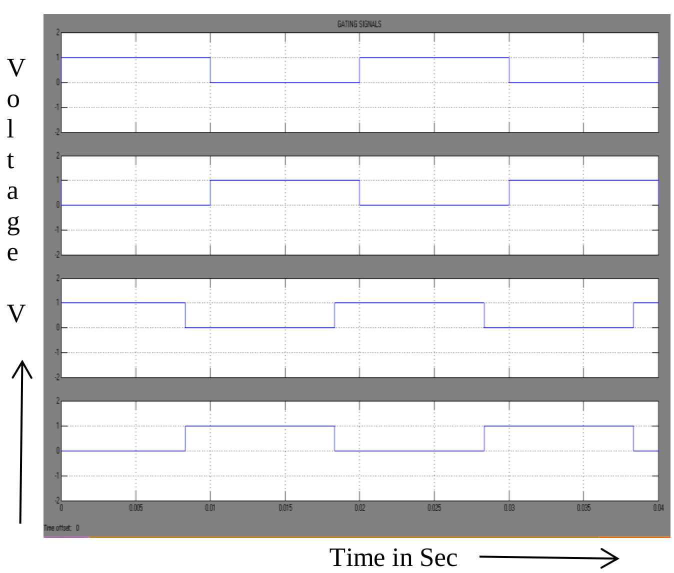

Fig.3 Gating signal for MOSFETS

Plot for output current and output voltages is shown in Fig.4.The time response is improved compared to open loop. Hence the system can be chosen for industrial application

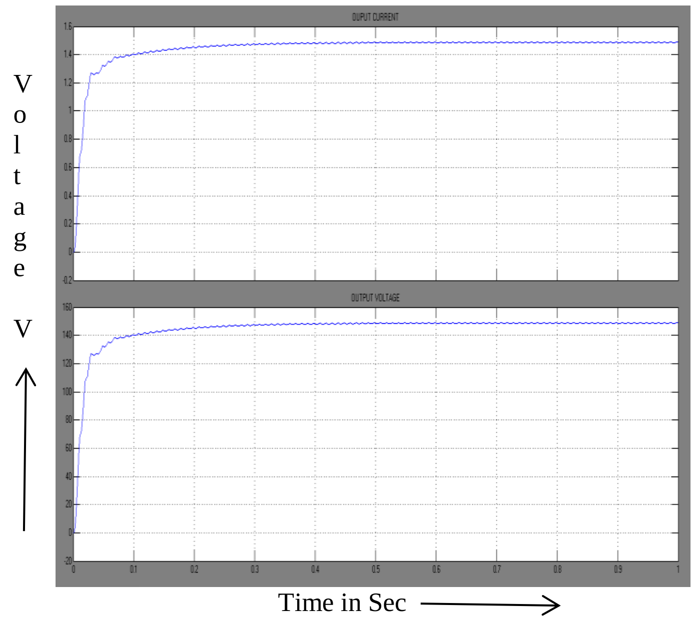

Fig.4 Output voltage of power conditioning module

The fuzzy logic controller provides an improvement by reducing peak overshoot and the settling time. The controller is programmed to maintain the output within the above mentioned limit. The output voltage is checked with the set voltage and the error signal is sent to the fuzzy logic controller unit. The controller does necessary action looking at the commands provided.

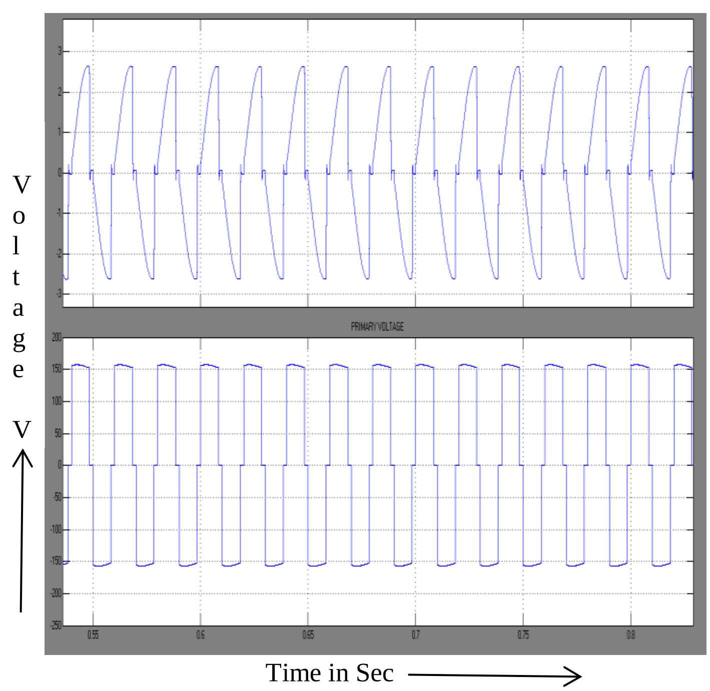

Fig.5 Output voltage of series resonant converter

The output waveform of series resonant converter is given in Fig 5. The Output of SRC is a three level output, that can be studied from the plot given above. The three level output is due to 30° phase shift of the gating signals during operation. An Isolation transformer is used in order to provide isolation between the converter and the load side. The transformer turns ratio is 1:1.The plot for isolation transformer is given in Fig 6

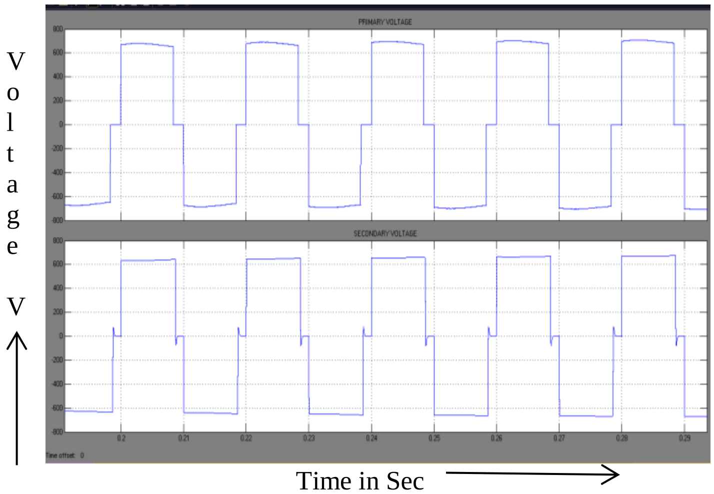

Fig.6 Output voltage of Isolation transformer

The soft switching technique is usually implemented using MOSFET or IGBT. Here we implemented zero voltage switching (ZVT) .Force the voltage across the switching device to drop to zero before turning it ON is Zero-Voltage Switching (ZVS)

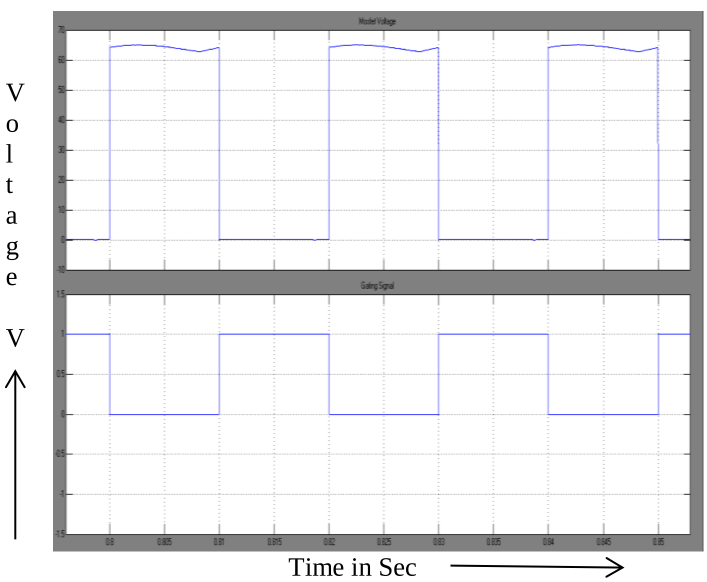

Fig.7 Zero Voltage Switching Waveform

The waveform associated with soft switching is given in Fig.7. Switching transition of MOSFETs occur at zero voltage level of gating signal [3].

V. CONCLUSION

A Closed loop Boost dc-dc converter is simulated using Simulink MATLAB and the plots are presented in this paper. From the graphical plots , we can conclude that the system is able to maintain output constantly. Due to the presence of fuzzy logic controller, rise time and settling time of the output voltage is very less and error is only ± 2 %.Hence the accuracy rate is good .

REFERENCES

[1] A.K.S. Bhat, "Analysis & design of a fixed-frequencyLCL-type series resonant converter",IEEE Trans on Aerospace and Electronic systems, vol.31, no1, January 1995, pp 125-137

[2] A.K.S. Bhat, "Analysis & design of LCL-type resonant converter", IEEE Trans on industrial electronics, vol. 41, no1, Feb 1994, pp.118-124

[3] A.K.S. Bhat, "Analysis and design of a fixed-frequency LCL-type series resonant converter with capacitive output filter", IEEE Proceedings: Circuits, Devices and systems, vol.144, no2, April 1997, pp.97-103.

[4] A.K.S. Bhat, "Fixed frequency PWM series –parallel resonant converter", IEEE Industry Applications society annual meeting, vol.1, October 1989, pp.1115-1121.

[5] Deepak S. Gautam, Student Member, IEEE, and Ashoka K. S. Bhat, Fellow, IEEE ,"A Comparison of Soft-Switched DC-to-DC Converters for Electrolyzer Application", IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 28, NO. 1, JANUARY 2013

[6] F.S.Tsai, J.Sabate & F.C Lee, "Constant-frequency, zero voltage-switched, frequency clamped-mode parallel resonant converter", IEEE International Energy conference, 1989, paper#16.4, pp1-7.

[7] J.A.Sabate & F.C.Lee,"Off-line application of the fixed-frequency clamped-mode series resonant converter", IEEE Trans on Power electronics, vol. 1, no1, January 1991, pp 39-47

[8] R.L. Steigerwald, "A comparison of half-Bridge Resonant converter topologies", IEEE Trans on Power electronics, vol. 3, no 2, April 1988, pp.174-182.

[9] R.L. Steigerwald, "High-frequency Resonant transistor DC-DC Converters", IEEE Trans on industrial electronics, vol.31, no2, May 1984, pp.181-191.

[10] V. Sivachidambaranathan, Sathyabama University, Chennai,,s.s dash,S.R.MUniversity" Simulation of Half Bridge Series Resonant PFC DC to DC Converter", ,2010

AUTHORS

Jaimy Rachel Skaria completed M.E in Power Electronics from Sathyabama University in the year 2014 and obtained her B.E degree in EEE from St. Joseph Engineering college, Mangalore under vishweshwariah technological university in the year 2010. Her research areas are in Converters, Industrial drives etc.(email: jaimyskaria23@gmail.com)

Godwin Immanuel Dharamraj is working as a faculty in the Department of Electrical and Electronics Engineering, Sathyabama University, Chennai. . His research areas are in power Systems, Converters, industrial drives etc.
(e-mail: dgodwinimmauel@gmail.com).