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Proportional Resonant Controlled Dual Active Bridge DC to AC Converter System with Enhanced Response

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ABSTRACT

This paper deals with comparison of responses of PI and Proportional Resonant controlled DC to AC Converter systems. The objective of this work is to regulate the output of Dual Active Bridge DC to DC converter (DABDAC). The input DC is converted into high frequency AC using half bridge inverter. It is stepped up by using step up transformer and then it is rectified. The DC is converted into Low frequency AC using a Half bridge inverter. The open loop DABDAC system, closed loop PI based DABDAC system an Proportional Resonant Controller (PRC)based DABDAC system are designed, modeled and simulated using MATLAB Simulink. The results of PR controlled system are compared with those of PI controlled system. The results indicate that the proposed PRC-DABDAC has better time domain response than PI controlled DABDAC system. The proposed DABDAC system has advantages like high gain and steady state error in output voltage.

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1. INTRODUCTION

High frequency, high power density integrated point of load and bus converters is presented by Reusch[1]. Analysis and optimization of switched-capacitor DC to DC converters is suggested by Seeman[2]. Analysis methods are developed that fully determine a switched-capacitor (SC) DC-DC converter's steady-state performance through evaluation of its output impedance. This analysis method has been verified through simulation and experimentation. These advancements at that point allow examination among a few exchanged capacitor topologies, and correlations of SC converters with ordinary attractive based DC-DC converter circuits, with regards to different application settings. Switched-capacitor DC to DC converters for low-power on-chip applications is given by Maksimovi[3].

Resonant switched capacitor converter with high efficiency is presented Shoyama [4]. High power density, high efficiency system two-stage power architecture for laptop computers is suggested by Ying[5].The high-efficiency and high-frequency first stage based on switching capacitor technology and second stage design is presented in this paper respectively. Two different designs are illustrated and verified by experiments. Transient analysis of the novel voltage divider is given by Lee[6]. Merged two-stage power converter architecture with soft charging switched-capacitor energy transfer is presented by Pilawa-Podgurski[7] The proposed design is particularly well-suited for an integrated CMOS process, as it makes use of the available on-die device characteristics.

Buck converter with merged active charge controlled capacitive attenuation is suggested by Redic[8]. Digitally controlled multiphase buck-converter with merged capacitive attenuator given by Jain[9]. A low volume power management module for portable applications based on a multi-output switched-capacitor circuit is presented by Ahsanuzzaman[10]. A three-phase soft-switched high-power-density DC/DC converter for high power applications is suggested by Doncker. Three DC/DC converter topologies suitable for high-power-density high-power applications are presented. All three circuits operate in a soft-switched manner, making possible a reduction in device switching losses and an increase in switching frequency.

The three-stage double scaffold converter proposed is appeared to have the most great attributes. n complexity to existing single-stage AC-interface DC/DC converters, bring down kill top streams in the power gadgets and lower RMS current evaluations for both the info and yield channel capacitors are gotten. This is in addition to smaller filter element values due to the higher-frequency content of the input and output waveforms. [11].

Performance characterization of a high-power dual active bridge Dc-to Dc converter is given by Kheraluwala[12].Active clamp LLC resonant converter for point-of-load applications is presented by Maksimovi[13]. This document proposes new architectures for switched-mode DC/DC power conversion. The proposed models empower sensational increments in changing recurrence to be acknowledged while safeguarding highlights basic by and by, including control of the yield over a wide load range and high light-stack effectiveness. This is achieved in part by how the energy conversion and regulation functions are partitioned. New architectures for radio-frequency DC/DC power conversion is suggested by Wahby[14] The design and experimental evaluation of prototype systems with cells operating at 100 MHz are also described. It is anticipated that the proposed approaches will allow substantial improvements in the size of switching power converters to be achieved and, in some cases, to permit their integrated fabrication.

A design methodology for switched-capacitor dc-dc converters is given by Seeman[15].Simple accurate expressions for planar spiral inductances is presented by Mohan[16]. Printed circuit board integrated toroidal radio frequency inductors is suggested by Kamby[17]. Understanding output voltage limitations of DC to DC buck Converters is given by Tucker [18]. Modeling and optimization of bidirectional dual active bridge DC to DC converter topologies is presented by Krismer[19]. Point-of-load (POL) power supplies contribute significantly to the overall volume, weight, and cost of many electronic devices. This is mainly due to the fairly large inductor of the buck converter commonly used in these applications, which causes it to have a relatively low power density. The proposed converter, referred to as a transformerless dual active half-bridge (DAHB), uses an ac-link to transfer power, instead of the more conventional dc-link. Not only does the transformerless DAHB offer a significant reduction in the volume of the bulky inductor, but it also allows soft switching and 50% duty cycle operation of all active devices. A transformer less dual active bridge dc-dc converter for point-of-load power supplies is suggested by Amin[20].

Block diagram of existing system is shown in Figure 1. Low voltage DC is applied to DABDDC. The output of DABDDC is applied to Single Phase Half Bridge Inverter (SPHBI). The block diagram of proposed DABDAC is shown in Figure 2.The load voltage is sensed and it is compared with the reference voltage. The error is applied to PR controller. The output of PR is used to update the width of the pulses.

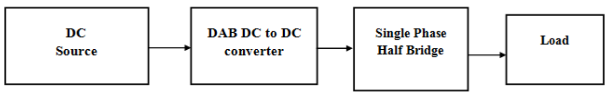

Figure 1. Block Diagram of Existing System

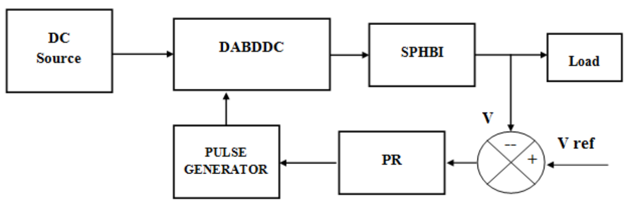

Figure 2. Bloc Diagram of Proposed DABDAC system

The above literature does not deal with comparison of PI & PRC based DHB inverter system. This work proposes PRC controller for the closed loop system to improve the dynamic response. This paper presents strategy for the comparison of responses with PI and PR controlled DABDAC systems.

2. INTRODUCTION PROPORTIONAL RESONANT CONTROLLER

Basically an ideal Proportional resonant controller gain value is infinity ideally but practically we put some real values for our system. Normally we use PR control to reduce steady state error up to zero. Therefore it is an efficient controller to use in the systems involving sinusoidal signals. Here in our system as we use a system involved sinusoidal signals or AC power so the PR controller work very efficiently in such systems to track the desired input reference signal. Supporting multiple topology (multi-topology) configurations, our devices provide customers with the flexibility to cover a broad range of power supply designs used in DC-DC and AC-DC power conversion circuits for a wide range of end equipment.

2.1. Importance of research

The above literature does not deal with PR controlled DABDAC system. This work proposes PRC for DABDAC system. This paper is organized as follows: Section II describes the details of proposed system. Section III analyzes the results of DABDAC system. Section IV provides experimental results to verify the theoretical analysis the conclusion is given in Section V.

3. SIMULATION RESULTS

Closed loop DABDAC with PI controller is shown in Figure 3.1. Load voltage is compared with the reference voltage. The error is applied to a PI controller. The output of PI is applied to the comparator. The output of comparator generates two pulses to drive the MOSFETs of voltage doubler circuit. The input voltage is shown in Figure 3.2. Its value is 30 V and it increases to 35 V.

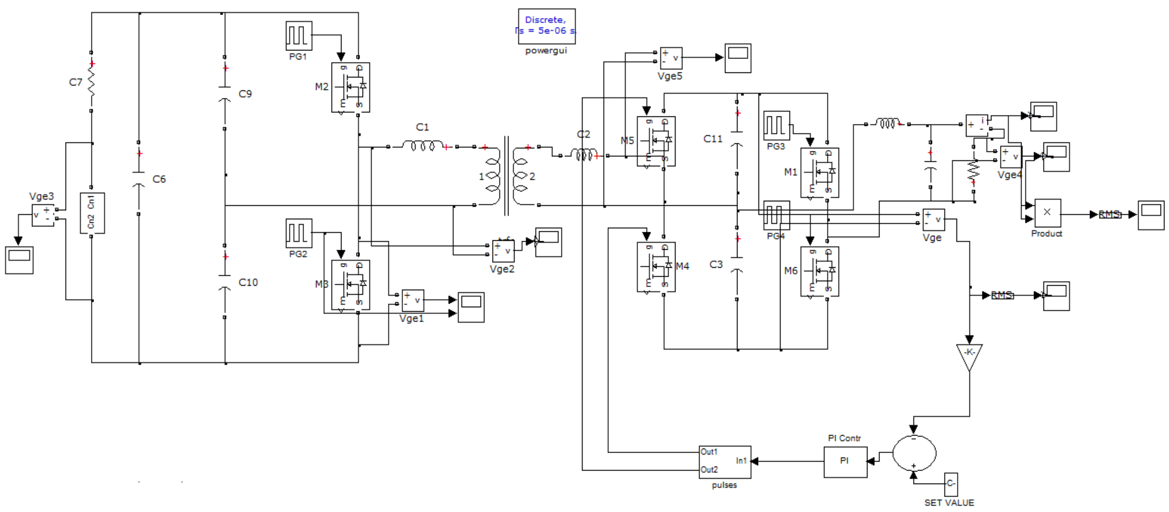

Figure 3.1 Closed loop DABDAC system with PI controller

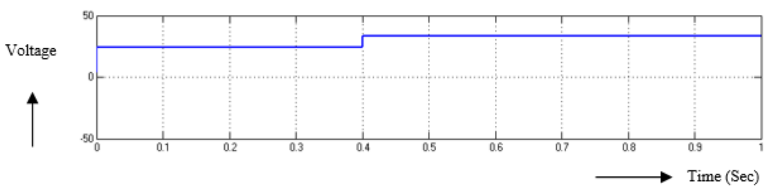

Figure 3.2 Input voltage

The output voltage is shown in Figure 3.3 and its peak value is 350 V. The output voltage of inverter is shown in Figure 3.4 and its peak value is 400 V. The output power is shown in Figure 3.5 and its value is 100 W. The current through load is shown in Figure 3.6 and its peak value is 0.7 A.

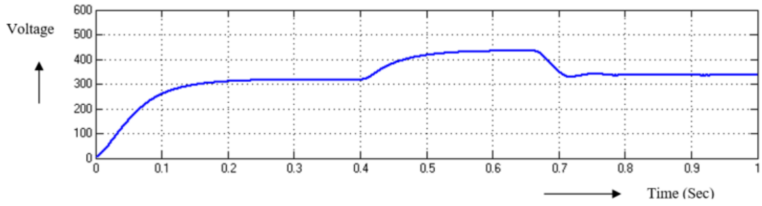

Figure 3.3 Output voltage of rectifier

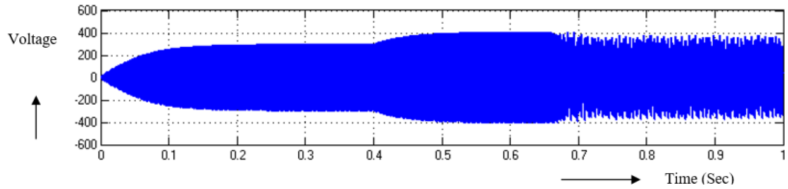

Figure 3.4 Output voltage of inverter

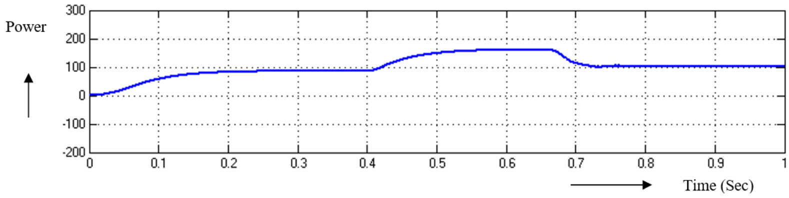

Figure 3.5 Output power from Inverter

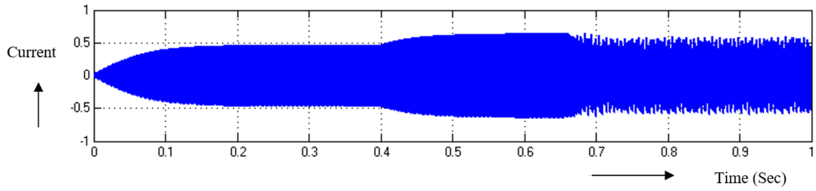

Figure 3.6 Current through Load

Closed loop DABDAC system with PR controller is shown in Figure 4.1. The PI controller in the previous section is replaced by PR controller. The input voltage is shown in Figure 4.2 and its value is 30 V. The Output voltage of rectifier is shown in Figure 4.3 and its value is 325 V.

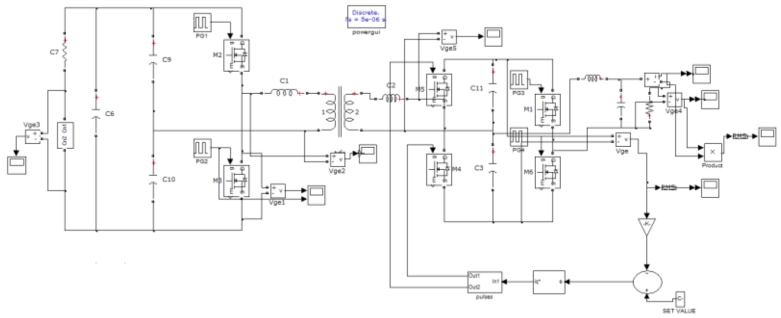

Figure 4.1 Closed loop DABDAC system with PR controller

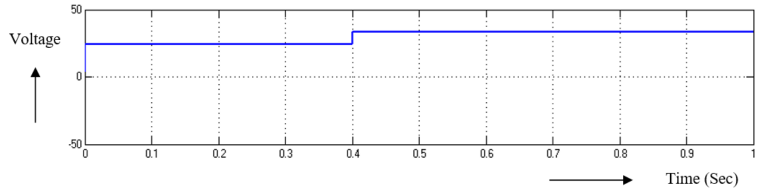

Figure 4.2 Input voltage

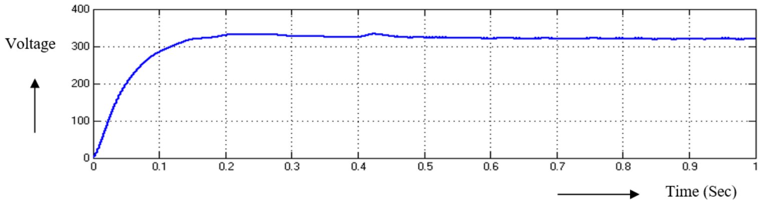

Figure 4.3 Output voltage of rectifier

The output voltage of inverter is shown in Figure 4.4 and its peak value is 250 V. The Output current of inverter is shown in Figure 4.5 and its peak value is 0.7 A. The Output power of DABDAC is shown in Figure 4.6 and its value is 80 W.

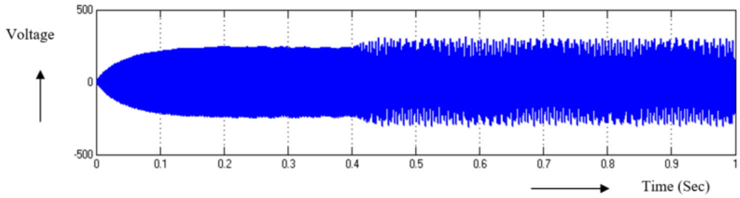

Figure 4.4 Output voltage of inverter

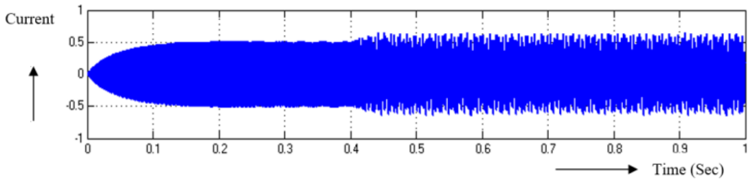

Figure 4.5 Output current of inverter

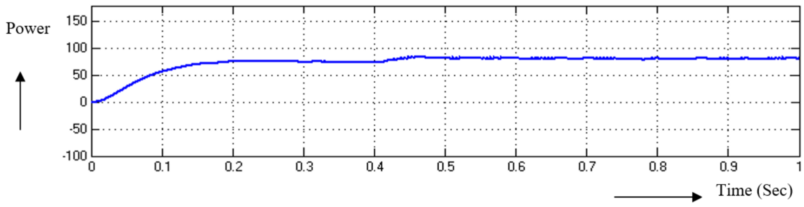

Figure 4.6 Output power

Table 1. Comparison of Time Domain Parameters with PI & PR controllers for DABDAC system

Type of Controller	t_r	t_s	t_p	E_{ss}
PI	0.44	0.71	0.53	3.3
PR	0.42	0.45	0.41	1.2

4. CONCLUSION

Closed loop controlled DAB type DC to AC converter system is designed, modeled and simulated with PI and PR controllers. The results indicate that PR control is superior to the PI controlled system since the settling time and steady state error are reduced. The settling time is as low as 0.45 sec and steady state error is reduced to 1.2 V using PRC. The rise time is as low as 0.42 sec. The peak time is as reduced to 0.41 sec this converter has advantages like low switching loss, high step up ratio and high power density. The disadvantages of the proposed system are higher switch count and high frequency operation

The scope of the present work is to compare PI and PR controlled systems. The comparison of responses with Neural and Fuzzy control systems will be focused in future.

ABBREVIATIONS

PI – Proportional integral
PR- Proportional Resonant
HB – Half bridge
DAB - Dual Active Bridge
ZVS – Zero Voltage Switching
MOSFET – Metal Oxide Semiconductor Field Effect Transistor
DABDAC- Dual Active Bridge DC to AC Converter

REFERENCES

[1] D. Reusch, "High frequency, high power density integrated point of load and bus converters," Ph.D. dissertation, Virginia Tech, 2012.

[2] (2015, May 3). Non-isolated - point of load (POL) [Online]. Available: http://power.murata.com/en/products/dc-dc-converters/single-outputnon- isolated.html

[3] M. D. Seeman and S. R. Sanders, "Analysis and optimization of switched-capacitor dc-dc converters," *IEEE Trans. Power Electron*., vol. 23, no. 2, pp. 841-851, Mar. 2008.

[4] D. Maksimovi and S. Dhar, "*Switched-capacitor dc-dc converters for low-power on-chip applications*," in Proc. IEEE Power Electronics Specialists Conf., 1999, pp. 54-59, Aug. 1999.

[5] M. Shoyama, T. Naka, and T. Ninomiya, "*Resonant switched capacitor converter with high efficiency*," in Proc. IEEE Power Electronics Specialists Conf., 2004, pp. 3780-3786, Jun. 2004.

[6] J. Sun, M. Xu, Y. Ying, and F. C. Lee, "*High power density, high efficiency system two-stage power architecture for laptop computers*," in Proc. IEEE Power Electronics Specialists Conf., 2006, pp. 1-7, Jun. 2006.

[7] J. Sun, M. Xu, and F. C. Lee, "*Transient analysis of the novel voltage divider*," in Proc. IEEE Applied Power Electronics Conf., 2007, pp. 550-556, Feb. 2007.

[8] R. C. N. Pilawa-Podgurski, D. M. Giuliano, and D. J. Perreault, "*Merged two-stage power converter architecture with soft charging switched-capacitor energy transfer*," in Proc. IEEE Power Electronics Specialists Conf., 2008, pp. 4008-4015, Jun. 2008.

[9] A. Radi and A. Prodi, "Buck converter with merged active charge controlled capacitive attenuation," *IEEE Trans. Power Electron*., vol. 27, no. 3, pp. 1049-1054, Mar. 2012.

[10] B. Mahdavikhah, P. Jain, and A. Prodi, "*Digitally controlled multiphase buck-converter with merged capacitive attenuator*," in Proc. IEEE Applied Power Electronics Conf., 2012, pp. 1083-1087, Feb. 2012.

[11] S. M. Ahsanuzzaman, J. Blackman, T. McRae, and A. Prodi., "*A lowvolume power management module for portable applications based on a multi-output switched-capacitor circuit*," in Proc. IEEE Applied Power Electronics Conf., 2013, pp. 1473-1479, Mar. 2013.

[12] R. W. A. A. De Doncker, D. M. Divan, and M. H. Kheraluwala, "A three-phase soft-switched high-power-density dc/dc converter for highpower applications," *IEEE Trans. Ind. Appl*., vol. 27, no. 1, pp. 63-73, Jan. 1991.

[13] M. H. Kheraluwala, R.W. Gascoigne, D. M. Divan, and E.D. Baumann, "Performance characterization of a high-power dual active bridge dc-todc converter," *IEEE Trans. Ind. Appl*., vol. 28, no. 6, pp. 1294-1301, Nov. 1992.

[14] H. Nguyen, D. Maksimovi, and R. Zane, "*Active clamp LLC resonant converter for point-of-load applications*," in Proc. IEEE Applied Power Electronics Conf., 2013, pp. 1406-1412, Mar. 2013.

[15] J. M. Rivas, R.S. Wahby, J. S. Shafran, and D. J. Perreault, "*New architectures for radio-frequency dc/dc power conversion*," in Proc. IEEE Power Electronics Specialists Conf., 2004, pp. 4074-4084, Jun. 2004.

[16] M. D. Seeman, "A design methodology for switched-capacitor dc-dc converters," Ph.D. dissertation, University of California at Berkeley, 2009.

[17] S. S. Mohan, M. del Mar Hershenson, S. P. Boyd, and T. H. Lee, "Simple accurate expressions for planar spiral inductances," *IEEE J. Solid-State Circuits*, vol. 34, no. 10, pp. 1419-1424, Oct. 1999.

[18] P. Kamby, A. Knott, and M. A. E. Andersen, "*Printed circuit board integrated toroidal radio frequency inductors*," in Proc. IEEE Industrial Electronics Society Conf., 2012, pp. 680-684, Oct. 2012.

[19] J. Tucker, "Understanding output voltage limitations of dc/dc buck converters", *Analog Applications Journal*, Texas Instruments, pp. 11-14, 2008.

[20] R. W. Erickson and D. Maksimovi, Fundamentals of Power Electronics. New York, NY: *Springer Sience + Business Media Inc*., 2001.

[21] F. Krismer, "Modeling and optimization of bidirectional dual active bridge dc-dc converter topologies," Ph.D. dissertation, ETH Zurich, 2010.
[22] A. Amin, "A transformer less dual active bridge dc-dc converter for point-of-load power supplies," M.A.Sc. thesis, University of Toronto, 2015. 140