Indian Streams Research Journal
Vol.2,Issue.IV/May; 12pp.1-4 Helen Priscilla A.S. ISSN:-2230-7850

Research Papers

SIMULATION AND ANALYSIS OF PWM-CONTROLLED QUASI-RESONANT CONVERTER FOR DRIVES

Ms. Ashly Mary Tom,
Assistant Professor
Jeppiaar Engineering College,
Chennai – 600 119

Helen Priscilla A.S.,
P.G Scholar,
Jeppiaar Engineering College,
Chennai – 600 119

ABSTRACT

This paper presents the development of a new resonant capacitor assisted pulse width modulation-controlled quasi resonant converter with an auxiliary circuit which does the load regulation by controlling the ripple of the resonant voltage. This resonant converter is simulated through MATLAB/SIMULINK. This newly developed quasi resonant DC-DC converter can regulate its DC output under a principle of constant frequency soft switching commutation by a controllable PWM duty cycle control scheme. The ripple of the resonant voltage across the primary resonant capacitor is controlled with a bidirectional auxiliary circuit, while the main switches are operated at a fixed duty ratio and fixed switching frequency. The operating performances of the newly proposed PWM-controlled quasi resonant converter are represented based on simulation results from an applications point of view. .

The practical effectiveness of the proposed PWM-controlled quasi resonant converter has been proved on the basis of simulation results.

Index Terms—Liquid Crystal Display (LCD), pulsewidth modulation, quasi-resonant converter.

I INTRODUCTION

Quasi-resonant conversion technology has been extensively used in power supplies in the consumer arena, with flyback and buck converters improving power supply efficiency. The principle of quasi-resonant conversion is to reduce the turn on losses of the power switch in a topology. For quasi-resonant switching, the device does not have a fixed switching frequency. Instead, the controller waits for one of the troughs in the drain voltage and then switches on. Older quasi-resonant devices designed for the colour television market always switched on the first trough. This was a good solution for colour televisions where the load is always high. However, for loads with a wide dynamic range, this presents a problem. The time between device turn off and the first trough is fixed by the resonant frequency. The time between device turn on and turn off is set by the controller. For lighter loads, the time is smaller as less energy in required in the inductor, resulting in a shorter on time, and also a shorter output diode conduction time. So for lighter loads the frequency increases, resulting in much higher switching losses. The highly efficient pulse width modulation (PWM) control technique in this resonant topology looks very promising. The adverse effects of the associated nonzero current turn-off switching can be reduced by using non-dissipative snubbers. The resulting, PWM-controlled quasi-resonant convertor topology combines the advantages of both resonant power conversion and pulse width modulation techniques.
This quasi-resonant convertor topology has high power conversion efficiency due to the favourable

Please cite this Article as : Helen Priscilla A.S. and Ms. Ashly Mary Tom , SIMULATION AND ANALYSIS OF PWM-CONTROLLED QUASI-RESONANT CONVERTER FOR DRIVES : Indian Streams Research Journal (MAY ; 2012)

switching conditions for the transistors and output rectifier diodes. In addition, this topology can employ output transformer parasitics in the resonant tank which makes it attractive for high voltage switched mode power supply applications. Unfortunately, a very broad range of operating frequency is required to control the output power, and therefore the highly efficient pulse width modulation (PWM) control technique in this resonant topology looks very promising. The adverse effects of the associated nonzero current turn-off switching can be reduced by using non-dissipative snubbers. The resulting, PWM-controlled quasiresonant convertor topology combines the advantages of both resonant power conversion and pulse width modulation techniques.

II. BLOCK DIAGRAM OF PROPOSED CONVERTER

The block diagram of proposed PWM-controlled quasi-resonant converter is shown in the Fig.2.1.

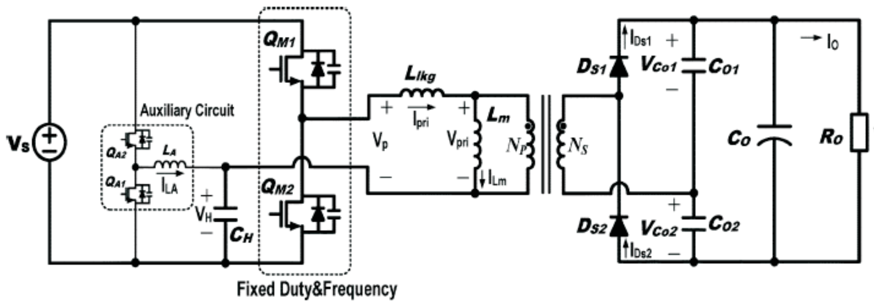


Fig.2.1 Block diagram of proposed PWM-controlled Quasi Resonant Converter

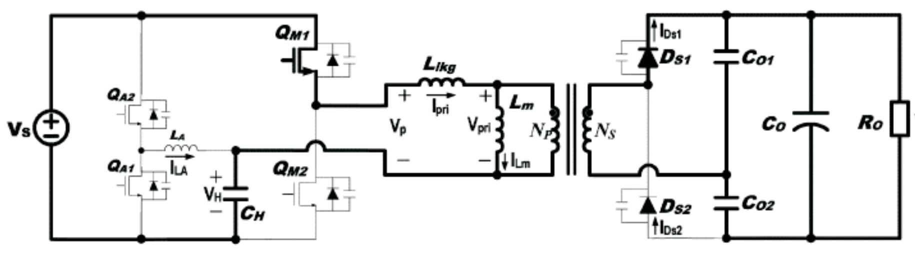
This PWM-controlled quasi-resonant converter is similar to the half-bridge LLC resonant converter except for the auxiliary circuit which is needed to control the output voltage. In this converter, the output voltage can be regulated by controlling the voltage across the primary resonant capacitor while two main switches are operating at a fixed duty ratio and fixed switching frequency. Therefore, the waveforms of both primary and secondary currents can be expected to be optimized from the view-points of conduction loss and current stress. In this PWM-controlled quasi-resonant converter, the bidirectional auxiliary circuit is operating in order to change the resonant voltage ripple using the PWM method while two power switches and are operating with a constant duty ratio and constant switching frequency. Since the load regulation can be achieved by the auxiliary circuit, the magnetizing inductance of the PWM-controlled quasi-resonant converter is larger than that of the half-bridge LLC resonant converter. Thereby, the circulating energy of the PWM-controlled quasi-resonant converter is considerably reduced under light load conditions.

III. OPERATIONAL PRINCIPLES

The operation of PWM-controlled quasi resonant converter can be explained with the key waveforms of this converter. The operation of the PWM-controlled quasi resonant converter can be divided into ten modes. One switching cycle of the proposed circuit is divided into two half cycles, t0-t5 and t5-t10. Since the operational principles of two half cycles are symmetric, only the first half cycle is taken into consideration. A half cycle can be divided into five modes mode1 – mode5.

Mode 1 [t0, t1]:

After the ZVS turned on of QM1 is achieved and the commutation between DS1 and DS2 is completed, Mode 1 begins.



The primary current Ipri, which rises with resonance between the leakage inductor and overall resonant capacitor, is given by

$$I_{pri}(t) = \frac{1}{nZ_O}\left[\frac{V_S}{n} - \frac{V_H(t_0)}{n} - V_{Co1}(t_0)\right] \times \sin\omega_r(t - t_1) + I_{Lm}(t).$$

Together the magnetizing current, ILM, also rises with the resonance between the magnetizing inductor LM, and secondary resonant capacitors C01//C02. On the other hand, since the resonant frequency, fm, determined by LM and C01//C02., is much slower than the switching frequency ILM, can be linearly approximated as follows:

$$I_{Lm}(t) = I_{Lm}(t_1) + \frac{nV_{Co1}(t)}{L_m}(t - t_1)$$

Where,

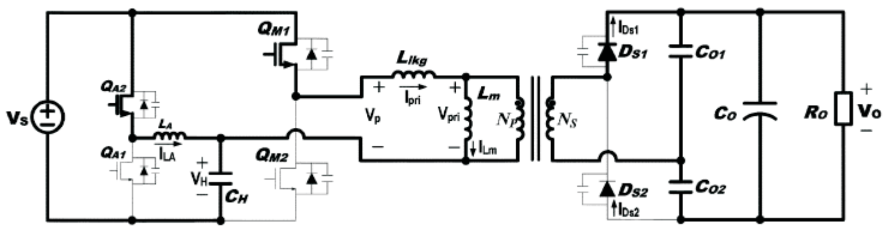
$$\omega_r = 1/\sqrt{L_r C_r},\ Z_O = \sqrt{L_r/C_r},$$

$$L_r = L_{lkg}/n^2,\ n = N_p/N_s$$

$$C_r = (n^2 C_H \times C_{o1}//C_{o2})/(n^2 C_H + C_{o1}//C_{o2})$$

The current of the rectifier diode DS1, IDS1, flows through C01 and the equivalent load resistor, while the secondary resonant capacitor C01 and C02 is charged and discharged, respectively.

Mode 2 [t1, t2]:

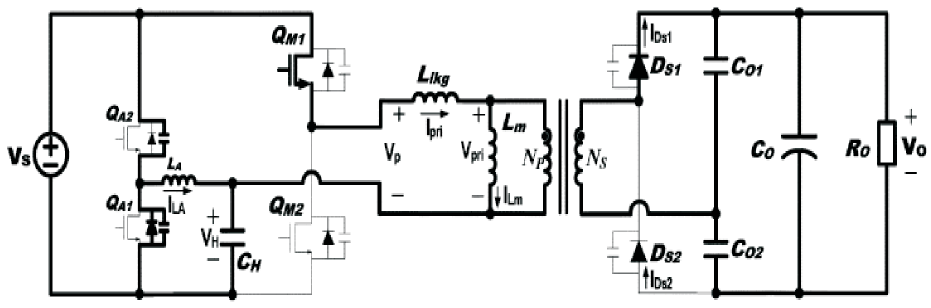


When QA2 is turned on, mode 2 begins. During this mode, the primary resonant capacitor, CH, is additionally charged from the input source, VS, through the auxiliary inductor LA operating in discontinuous conduction mode (DCM). It is assumed that LA is large enough to approximate ILA which is increased and decreased linearly. The slope of ILA can be obtained as follows:

$$\frac{dI_{LA}(t)}{dt} = \frac{V_S - V_H(t)}{L_A}.$$

The operation of primary and secondary side of the transformer is similar to Mode 1.

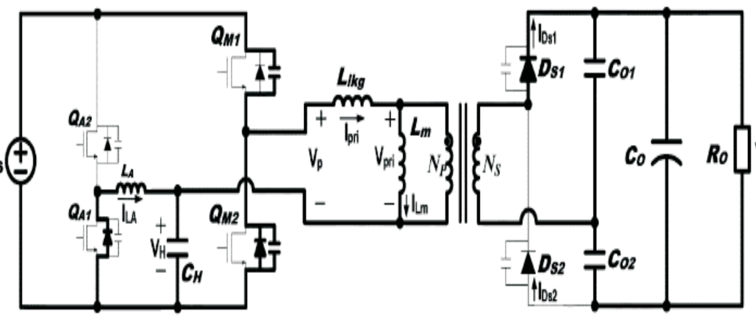
Mode 3 [t2, t3]:



After QA2 is turned off, ILA starts to increase and decrease the phase-node voltage of QA2 and QA1 respectively. When the voltage across QA1 becomes 0V, ILA begins to flow through the internal diode of QA1.

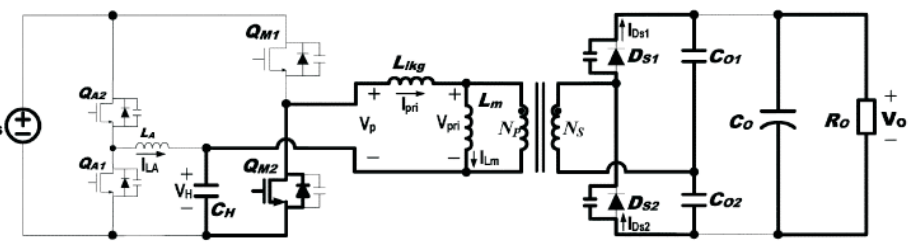
Since the voltage across the CH, VH is applied to LA oppositely, ILA is decreased. During this interval, CH is still charged and both of the transformer sides operate similarly to mode 1.

Mode 4 [t3, t4]:



When QM1 is turned off, mode 4 begins. Since Ipri starts to increase and decrease the phase-node voltage of QM1 and QM2, respectively, the voltage across the primary side of the transformer, VP is decreased to -VS. Since the rectifier diode DS1 is still conducting, the voltage across LM, Vpri is maintained to be nVC01. Thus, the negative voltage which is the same as the difference between VP and Vpri is applied to the leakage inductor, Llkg. Thereby Ipri is decreased rapidly. Mode 4 is finished when Ipri is equal to ILM.

Mode 5 [t4, t5]:



At t4, When Ipri is smaller than ILM, the current of the secondary side of the transformer flows oppositely through the junction capacitors, DS1and DS2. Since the voltage across each diode is increased and decreased respectively, the commutation between DS1and DS2 is started. During this mode, the ZVS turned on of QM2 can be achieved. After DS2 is fully conducting, mode 5 is finished.

V. RESULTS AND DISCUSSION:

The simulation of PWM-controlled quasi resonant converter with resistive load and motor load is done with MATLAB. The MATLAB Simulink model of the PWM-controlled quasi resonant converter with R load is shown in Fig. 5.1.

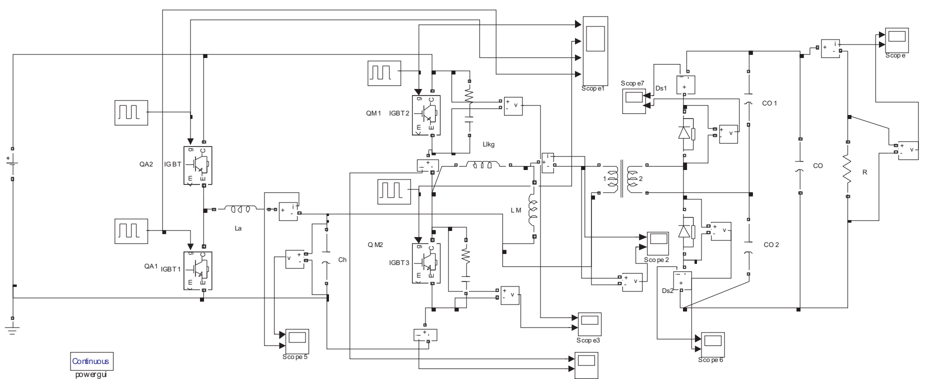


Fig. 5.1 MATLAB Simulink model of the PWM-controlled QRC with R load

Please cite this Article as : Helen Priscilla A.S. and Ms. Ashly Mary Tom , SIMULATION AND ANALYSIS OF PWM-CONTROLLED QUASI-RESONANT CONVERTER FOR DRIVES : Indian Streams Research Journal (MAY ; 2012)

The current and voltage of the primary side of the transformer is shown in the Fig. 6.

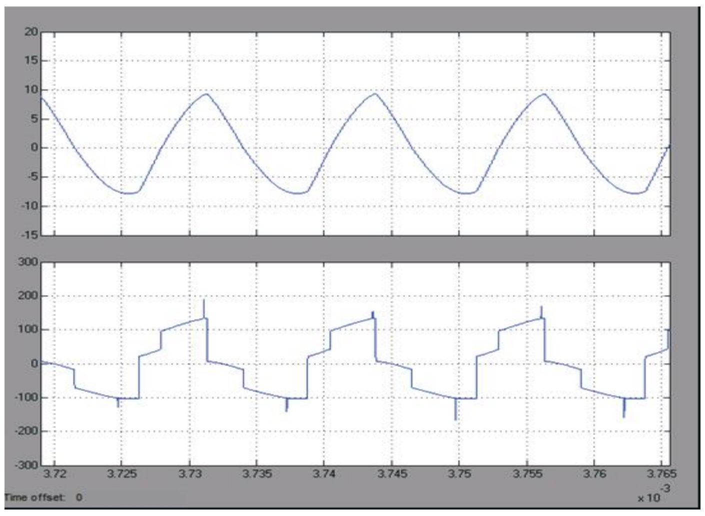


Fig. 5.2 Simulation output of Current and voltage of the primary side

The resonant voltage and current flowing in the auxiliary is shown in the Fig. 5.3.

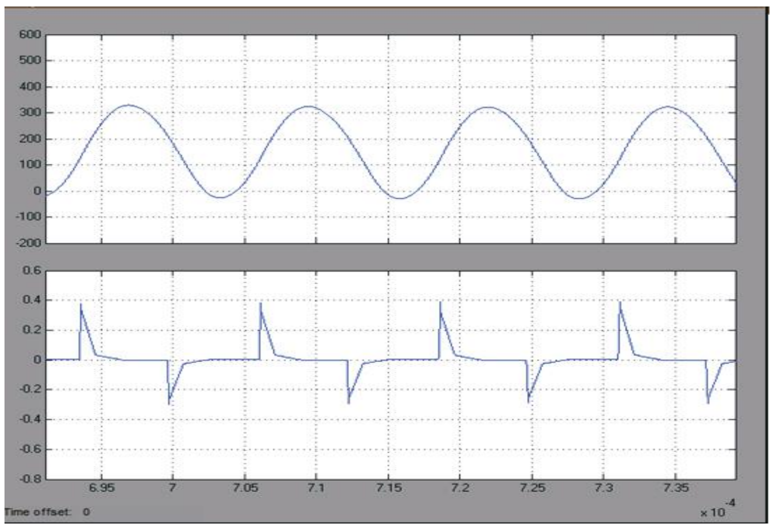


Fig. 5.3 Simulation output of Resonant voltage and current flowing in the auxiliary circuit.

The output current and voltage of the PWM-controlled quasi resonant converter is shown in the Fig.5.4.

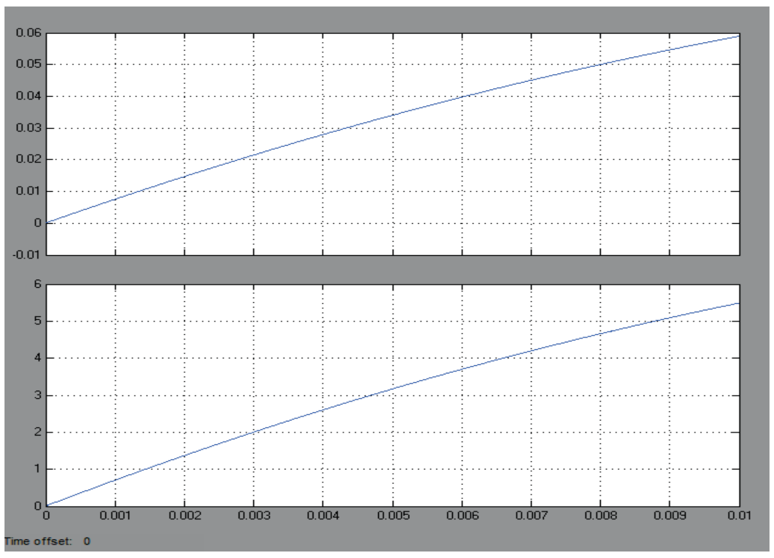


Fig. 5.4 Simulation output of current and voltage of the PWM-controlled quasi resonant converter

The MATLAB Simulink model of the PWM-controlled quasi resonant converter with motor load is shown in Fig. 5.5.

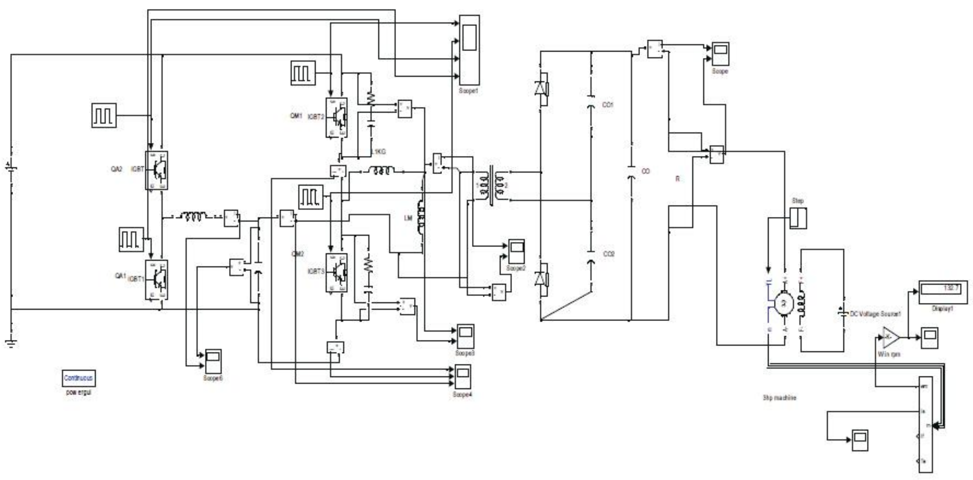


Fig. 5.5 MATLAB Simulink model of the PWM-controlled QRC with motor load

The output current and voltage of the PWM-controlled quasi resonant converter with motor load is shown in the Fig. 5.6.

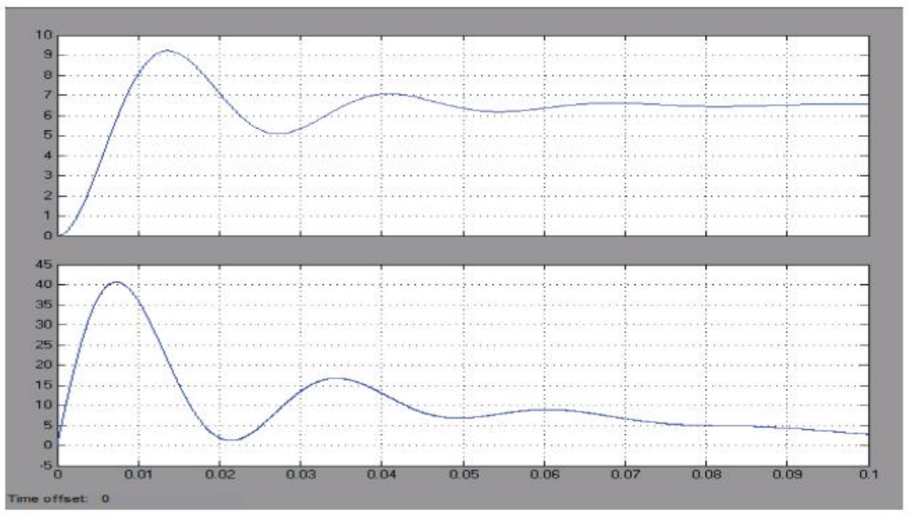


Fig. 5.6 Simulation output of speed of the dc motor load

The armature current of the dc motor which is connected as a load to the PWM-controlled quasi resonant converter is shown in the Fig. 5.7

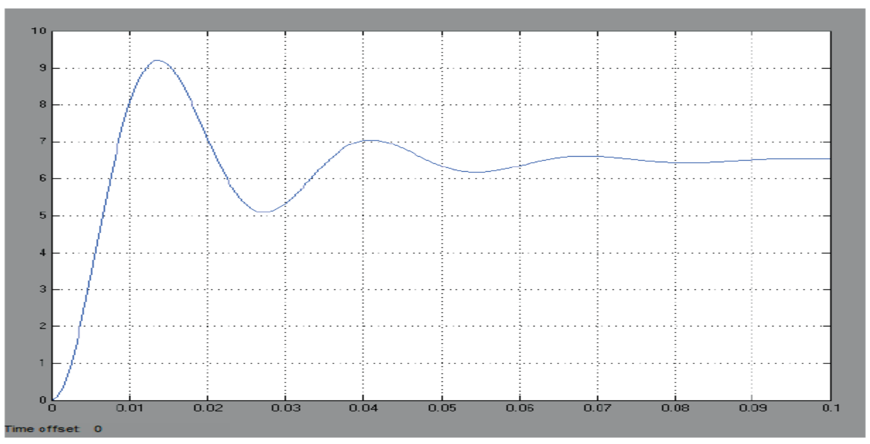


Fig. 5.13 Simulation output of armature current of the dc motor load

VI. CONCLUSION

The MATLAB simulation was done for PWM-controlled quasi resonant converter with resistive load and motor load. Since the load regulation of the proposed converter can be achieved by an auxiliary circuit, the waveforms of the current can be optimized from the view-points of the conduction loss especially under the light load conditions. Besides, dc offsets of the magnetizing current and magnetic flux can be completely blocked. Switching stresses get reduced since voltage and current waveforms have lesser slope. Power density is increased since the volume is reduced. The measured efficiency within the 10% ~ 40% load range is higher. Thus the PWM-controlled quasi resonant converter demonstrates its suitability as power module owing to its simple control circuits, low conduction loss and high efficiency.

REFERENCES

[1]Y. Hu, Z. Lu, L. Hang, Z. Qian, and G. Huang, "Three-level LLC series resonant DC–DC converter," IEEE Trans. Power Electron., vol. 20, no.4, pp. 781–789, Jul. 2005.

[2]A. Eid, K.-J. Choi, H.-W. Lee, and M. Nakaoka, "A novel edge-resonant soft switching PWM controlled high frequency inverter with minimum circuit components," Proc. Int. Power Electronics and Drives System Conf., vol. 1, pp. 101–106, Jan. 16–18, 2006.

[3]K. Fathy, K. Morimoto, T. Doi, T. Doi, H. Ogiwara, and M. Nakaoka, "A divided voltage half-bridge high frequency soft-switching PWM DC-DC converter with high and low side DC rail active edge resonant snubbers," in Proc. 5th Int. Power Electronics and Motion Control Conf. (IPEMC), Aug. 2006, vol. 2, pp. 1–5.

[4]K. Yao, M. Xu, Y. Ren, J. Zhou, Y. Qiu, and F. C. Lee, "Quasi-resonant converters for high-frequency voltage regulator applications," in Proc.19th Annu. Applied Power Electronics Conf. and Expo. (APEC), 2004, vol. 2, pp. 891–897.

[5]Y. Ren, M. Xu, Y. Meng, and F. C. Lee, "Novel PWM-controlled resonant converter," in Proc. 18th Annu. Applied Power Electronics Conf. and Exposition, Feb. 9–13, 2003, vol. 1, pp. 420–425.

[6]B.T. Lin, G. Lin, S.S. Oiu, " A new group of quasi resonant converters ", South Ohina University proc, Vol 23, No 8, PP 131 – 137, 1995.

[7]H. Tanimatsu, H. Sadakata, T. Iwai, H.Omori, Y.Miura, E.Hiraki, H.W.Lee, and M. Nakaoka, " Quasi-Resonant Inductive Snubbers-Assisted Series Load Resonant Tank Soft Switching PWM SEPP High-Frequency Multi Resonant Inverter with Auxiliary Switched Capacitor", Proceeding of International Conference on Power Electronics ICPE, pp II-299, Busan, Korea, October, 2004

[8]Hang-Seok Choi; Bo Hyung Cho; " Novel zero- current switching (ZCS) PWM switch cell minimizing additional conduction loss", IEEE Transactions on Industrial Electronics, Vol. 49, No. 1, pp:165–172, Feb. 2002

[9]Bo-Tao lon and Yim Shu Lee, 1997," Novel actively-clamped zero current switching Quasi resonant converters", IEEE International Symposium on circuits and systems, Hongkong.