Volume 2, Issue 7, July 2012 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Design and Implementation of DC/DC based Zero Voltage Switching QRC Luo-Converter

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Abstract:* This paper deals with the design of a smart novel control technique for bidirectional power electronic energy management systems for EV/PHEV energy storage systems. More specifically, the digital control technique is proposed for the popular 4Q switched-capacitor (SC) DC/DC converter as well as the Luo DC/DC converter. The main advantage of using SCCs for EV/PHEV energy management is the absence of transformers and inductors, which makes the complete integration of switching converters possible. In addition, switches are controlled by capacitors, which are charged and discharged through different paths, and transfer their stored energy to either the high voltage (HV) battery side, or the low voltage (LV) ultra-capacitor side. Furthermore, an SCC enables good regulation capability, low electromagnetic interference (EMI), lower source current ripple, ease of control, and continuous input current waveform, in both buck and boost modes of operation, which are critical aspects when dealing with sensitive current applications, such as an EV battery or UC system. For the boost mode, the voltage lift technique presents an excellent method to practically implement the proposed control strategy. Hence, by using a suitable combination of the SCC and voltage lift technique, a new converter with high voltage gain, high power density, high efficiency, low EMI, ease of control, and small size can be easily constructed.

***Keywords:* electromagnetic interference, switched-capacitor**

1. Introduction

A novel switched inductor Four-Quadrant DC/DC Luo-converter in power electronics energy management system for hybrid electric and plug-in hybrid electric vehicles (PHEV) is designed using a bidirectional switched capacitor (SC) DC/DC Luo converter. The controller uses the voltage-lift technique and presents a low output ripple, high power density, high efficiency, high voltage gain, and simple structure. A detailed efficiency modeling and analysis is also presented to support the claims. Switched Inductor Four-Quadrant DC/DC Converter will developing in motor based converter circuit. Simulation results will be done using Matlab Simulink.

A battery/ultra-capacitor arrangement is an excellent as well as practical solution. A switched capacitor converter (SCC), using a combination of switches and capacitors, offers a good solution for EV/HEV bidirectional energy management. Switches are controlled by capacitors, which are charged and discharged through different paths, and transfer their stored energy to either the high voltage (HV) battery side, or the low voltage (LV) ultra- capacitor side.

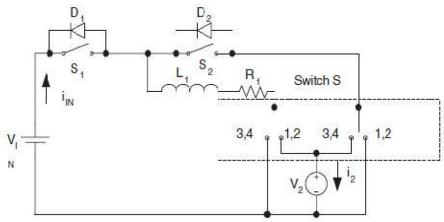
This is basically a DC/DC converter This basic model was found by Fang Lin Lou´ Which converts constant DC voltage into variable DC Voltage The output voltage can be greater or lesser than the input voltage This is the modified and enhanced version of basic Lou converter.

2. Circuit Description

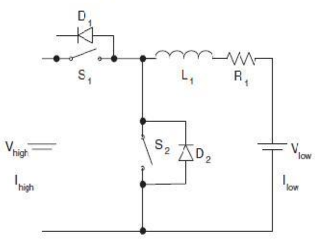
Figure 1 Presents two circuits 1 and 2 in (a) and (b) that can be converted each other by auxiliary switch (not show in the figure). It combines a buck, boost and buck-boost converter together with two resonant L-C circuits. Circuit 1 operates Quadrants I and II; Circuit 2 operates Quadrants III and IV. Since this converter is carefully designed, only one resonant inductor Lr i s required.

Each mode has two states: "on" and "off". If the switching signal repeating frequency is f, the repeating period is T = 1/f. Therefore, the switchin g -on period is kT, and the switching- off period is (1-k) T. For a ZVS-

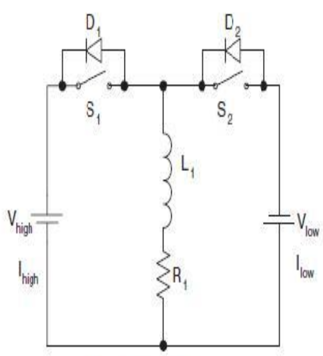
QRC there are four intervals in a whole period T. The switching-on period covers the first two intervals (t3 + t4), and the switching-off period covers



(a) Circuit diagram

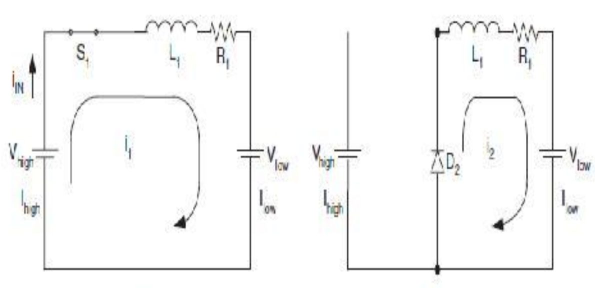


(b) Quadrant I and II operation circuit



(c) Quadrant III and IV operation circuit

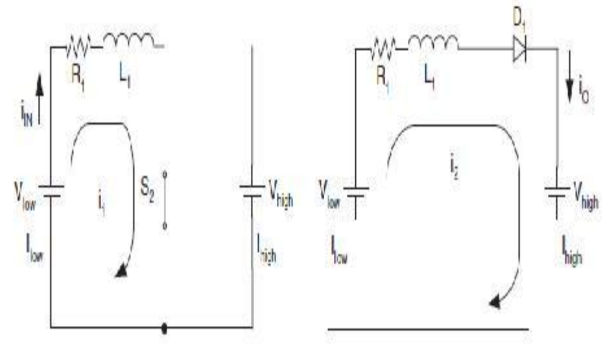
3. Mode A (Quadrant I Operation)



(a) Switch-on (b) Switch-off

Mode A operation is shown in Figure 2a (switch on) and b (switch off). During switch-on state, switch S1 is closed. In this case the source voltage V1 supplies the load V2 and inductor L, inductor current iL increases. During switch-off state, diode D2 is on. In this case current iL flows through the load V2 via the free-wheeling diode D2, and it decreases

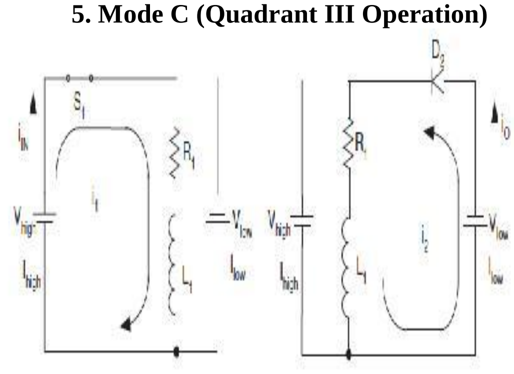
4. Mode B (Quadrant II Operation)



(a) Switch-on (b) Switch-off

Mode B operation is shown in Figure 3 a (switch on) and b (switch off). During switch-on state, switch S2 is closed. In this case the load voltage V2 supplies the inductor L, inductor current iL increases. During switch-off state, diode D1 is on, current iL flows through the source V1 and load V2 via the diode D1, and it decreases.

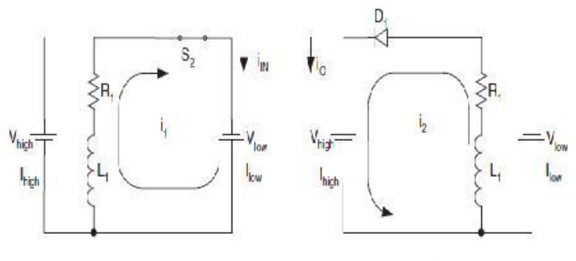
5. Mode C (Quadrant III Operation)



(a) Switch-on (b) Switch-off

Mode C operation is shown in Figure 4 a (switch on) and b (switch off). During switch-on state, switch S1 is closed. The source voltage V1 supplies the inductor L, inductor current iL increases. During switch-off state, diode D2 is on. Current iL flows through the load V2 via the free-wheeling diode D2, increases. During switch-off state, diode D1 is on. Current iL flows through the source V1 via the diode D1, and it decreases. A novel switched inductor Four-Quadrant DC/DC Luo-Converter in power electronics energy management system for hybrid electric and plug-in hybrid electric vehicles (PHEV) is designed using a bidirectional switched capacitor (SC) DC/DC Luo converter. Four-Quadrant DC/DC circuit based Inductor output through motor.

6. Mode D (Quadrant IV Operation)



(a) Switch-on (b) Switch-off

Mode D operation is shown in Figure 5 a (switch on) and b (switch off). During switch-on state, switch S2 is closed. The load voltage V2 supplies the inductor L, inductor current iL the classical converters whose PD is usually less than 5 W/in3. Since the switching frequency is low (f < 55 Hz) and the switches work at the mono- resonance frequency, the components of the high order harmonics are small. Using Fast Fourier Transform (FFT) analysis, we obtain the total harmonic distortion (THD) is very low. Therefore, the switch status is shown in Table.

7. Experimental Results

A testing rig with a battery of ±28 VDC as a load and a source of 42 VDC as the power supply was tested. The testing conditions are: V1 = 42 V and V2 = ±28 V, L = 30 µH, Lr = 4 µH, Cr1 =Cr2= 1 µF; the volume is 40 in3. The experimental results are shown in Table 2. The average power transfer efficiency is higher than 96%, and total average power density (PD) is 3 and it decreases17.6W/i

Q.NO	State	S1	D1	S2	D2	S3	Source	Load
I (Mode A) FM	ON	ON				ON 1/2	V1+	V2+
	OFF				ON	ON 1/2	I1+	I2+
II (Mode B) FR	ON			ON		ON 1/2	V1+	V2+
	OFF		ON			ON 1/2	I1-	I2-
III (Mode C) RM	ON	ON				ON 3/4	V1+	V2-
	OFF				ON	ON 3/4	I1+	I2-
IV (Mode D)	ON			ON		ON 3/4	V1+	V2-

8. Conclusion

A new type of soft-switching DC/DC converter – Design and Implementation of four- quadrant DC/DC ZVS Quasi-Resonant Luo- Converter has been developed.It implements the zero-voltage-switching technique, and largely reduces the power losses. Consequently high- power transfer efficiency is obtained. Since the switching frequency is low (f <55 kHz) and this converter works at the mono-resonance frequency, the components of the high order harmonics are small. After FFT analysis the THD issmall. Comparing with the International standards, the EMI is weak, and the EMS and EMC are reasonable. The experimental testing results confirmed the advantages of this converter and verified the theoretical analysis.

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