Single-Phase Inverter Based on Class E dc/dc Converter for Automotive application

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Abstract: In this paper, we present the circuit topology and control scheme of single-phase dc/ac inverter based on class E dc/dc converter for automotive application. The proposed inverter consists of class E series resonant inverter and class E low *dv/dt* PWM synchronous rectifier with bi-directional switch.

1. Introduction

To use the electrical concumer products or electronic equipments in car which use 12Vdc batteries as the power source, the dc/ac inverter is needed to invert the direct current to alternative current at the desired frequency. Most of battery powered dc/ac inverter use 2-stage conversion technique shown in fig.1.

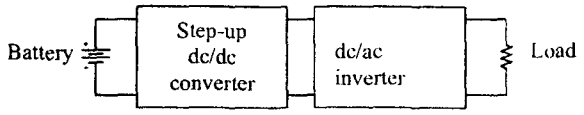

Figure 1. Two-stage conversion dc/ac inverter

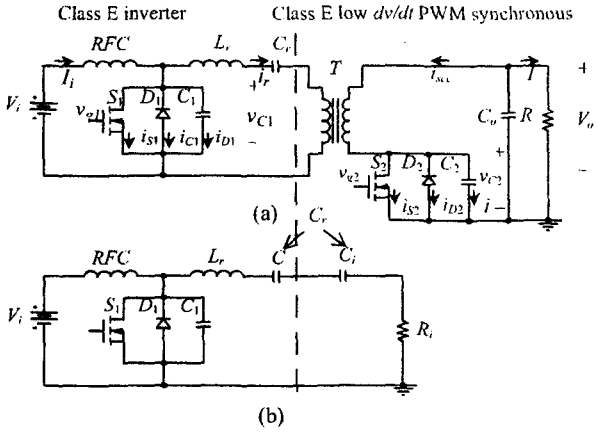

Figure 2.(a) Class E isolated dc/dc converter using low *dv/dt* PWM synchronous rectifier. **(b)** equivalent circuit.

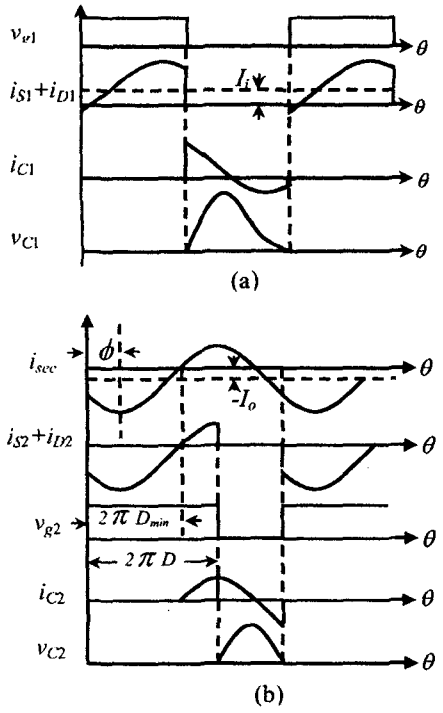

Figure 3. Typical operating waveforms of converter (a) class E inverter, (b) class E low *dv/dt* PWM synchronous rectifier.

The step-up dc/dc converter is used for step the battery voltage (12V or 24V) up to high dc voltage [1], which higher than the output peak voltage, and the bridge inverter is used for invert the high dc voltage to the desired ac voltage and frequency [2]. Generally, push-pull, forward or flyback dc/dc converters operated in kHz range are used in voltage step-up stage but theirs component sizes are large since low operating frequency and power conversion efficiency. By using the soft switching technique, the converter can operates at the very high switching frequency with high conversion efficiency and the circuit size can be decreased. Class E inverter [3]-[4], can operates in MHz range with very high conversion efficiency and low switching noise.

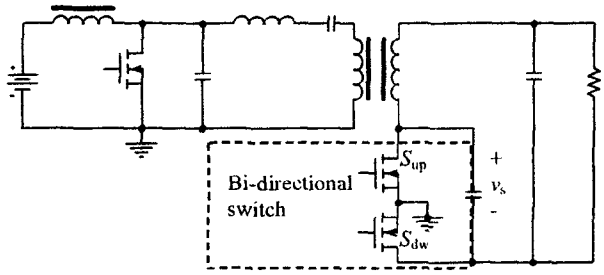

Figure 4. Proposed single phase dc/ac inverter

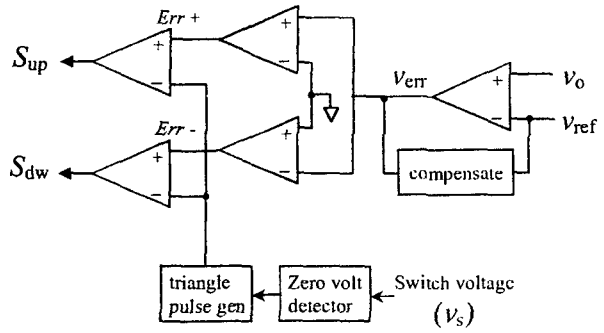

Figure 5. Control block diagram

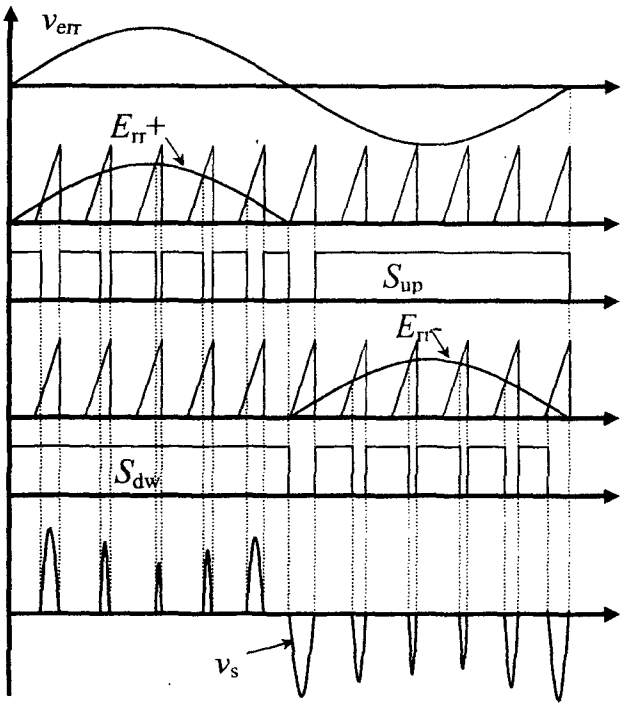

Figure 6. Control signal timing diagram

In this paper, we present the dc/ac single-phase inverter based on the class E isolated dc/dc converter using low *dv/dt* PWM synchronous rectifier.

2. Circuit Description

Figure 2 show Class E isolated dc/dc converter using low *dv/dt* PWM synchronous rectifier which is a application of class E inverter with the class E low *dv/dt* PWM synchronous rectifier. Zero voltage switching of all switches in the converter can be maintained from full load to open load. The typical operating waveforms are shown in figure 3. By vary the duty cycle (D) of driving signal (v_{g2}) of the rectifier switch (S_2), the dc output voltage can be controlled from zero to the desired value. Moreover, if we replace the rectifier switch (S_2) into the opposite side and apply the varying driving duty cycle, the negative output voltage can be obtained.

3. Circuit Operation

The proposed inverter is shown in figure 4 and control block diagram is shown in figure 5. The bi-directional switch is replaced into the rectifier switch in conventional class E isolated dc/dc converter using low *dv/dt* PWM synchronous rectifier. The dc input voltage is switched to very high frequency ac by class E inverter to drive the step up transformer. The high frequency current at the output of transformer will be rectified to low frequency ac 50Hz by control the pulse width of driving signal of both rectifier switches. The duty cycle of the upper rectifier switch (S_{up}) and lower rectifier switch (S_{dw}) are varied by PWM signal to control the output voltage or compensate the error signal (v_{err}) while positive (*Err* +) and negative (*Err* -) cycle respectively.

4. Conclusion

The main advantages of the proposed inverter are following

1. Operate in MHz range and need the small heat sink, therefore small circuit size.
2. Zero voltage switching (ZVS) and single state conversion, therefore high power conversion efficiency.
3. Soft and low *dv/dt* switching, therefore low switching noise and EMI problems.
4. All switch elements connected directly to ground level, therefore need no floating drive circuit.

5. Acknowlegement

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