독립전압 제어를 위한 다중출력 공진형 컨버터의 적용

다니엘, 박종후
숭실대학교

Implementation of a multi-output resonant converter topology for an independent voltage control

Daniel Isaac, Joung-Hu Park
Soongsil University

ABSTRACT

A multiple output dc-dc resonant converter topology for an independent voltage control technique is proposed, using a narrow frequency selection band-pass filters. The multi- output converter is supplied by a single source inverter with the superposed sinusoidal signals reserved for each output. A series-series parallel resonant topology is utilized to implement the narrow frequency selection channels for minimum interference. Finally the experimental setup for four output dc-dc converter is verified with the narrow channel frequencies of 26 kHz, 32 kHz, 38 kHz and 46 kHz.

1. Introduction

In recent days, due to the advancements in electrical manufacturing technology, more than one power electronic devices can be integrated into a single system. However, the voltage/current levels of every single converter output required to be different based on their application. Therefore, an independent voltage regulation even under severe load transients is invariably required.

This paper proposes a new multiple-output resonant converter system which regulates all the output voltages independently with a single inverter circuit. The superposed sinusoidal PWM is generated through a comparison between a superposition of multiple frequency sinusoidal reference waveforms and a triangular carrier waveform. Each sinusoidal reference waveform is assigned for one output voltage stage. The output voltage can be regulated by controlling the magnitude of the corresponding sinusoidal reference voltage. The similar concept has been already proposed in few articles in past [1-2]. However, a simple series resonance circuit is employed in the circuit whose Q factor severely varies along with the load variations. Therefore, at light load conditions, interference between the output stages increases and the controllability of the corresponding output voltage becomes difficult. Because of the reason, the number of output stages that can be connected to the single inverter also limited. However, the proposed topology is considered to be an ideal for n number of output stages along with the ability to control each output voltages independently even under heavy load transients.

II. Operating Principle

The operating principle of the proposed converter can be realized with the circuit diagram shown in fig. 1. A simple series resonance circuit operates as the band pass filter with the center frequency of ω_1, ω_2, ω_3… assigned for each converter output. In addition, each output resistance has a parallel resonance capacitors connected to resonant with the magnetizing inductance L_m. Therefore, the Q factor of the each series resonance circuit remains almost constant even at light load conditions. The resonant elements for series and parallel resonant branches can be driven as,

$$\omega_1 = \frac{1}{\sqrt{L_{S1}C_{S1}}} \quad (1)$$

$$\omega_1 = \frac{1}{\sqrt{L_m C_{P1}}} \quad (2)$$

From the design, the output voltage of the each output stages can be controlled by varying the corresponding control reference voltage V_c at the constant frequency.

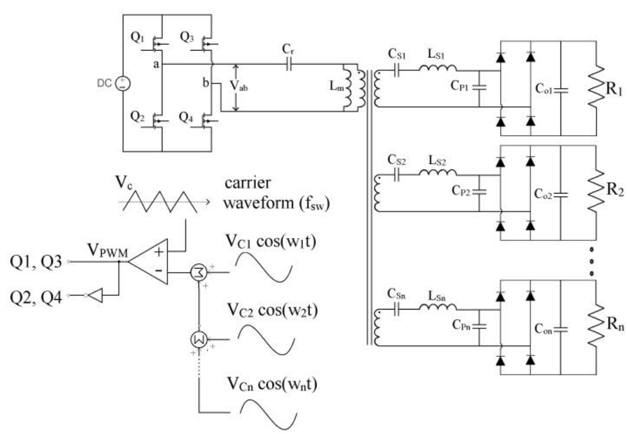


Fig. 1 proposed multiple-output resonant converter

III. Experimental Verification

To verify the controllability of the proposed converter, a hardware prototype for a 4 output, 50W system is built.

The small signal voltage transfer gain is obtained from HP 4194 network analyzer and the result is shown in Fig. 2. It can be seen that resonant frequency of the each frequency selection resonant channels are fixed even under different load conditions. The voltage gain of the resonant converter changes when the load resistances of the converter are changed. However, the converter still operates at the fixed resonant frequency with minimum interference between the neighborhood channels.

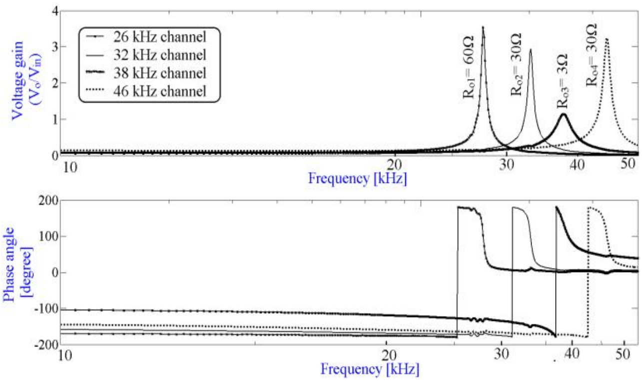
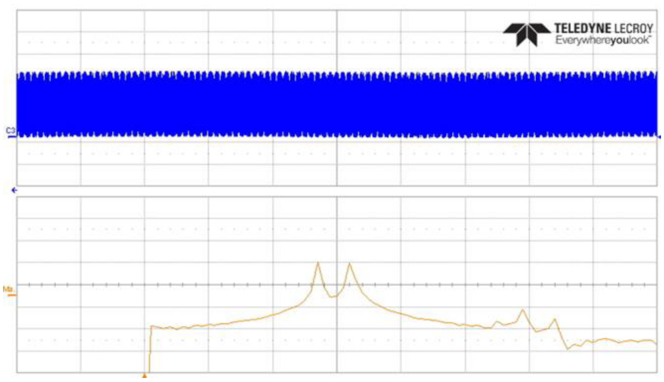


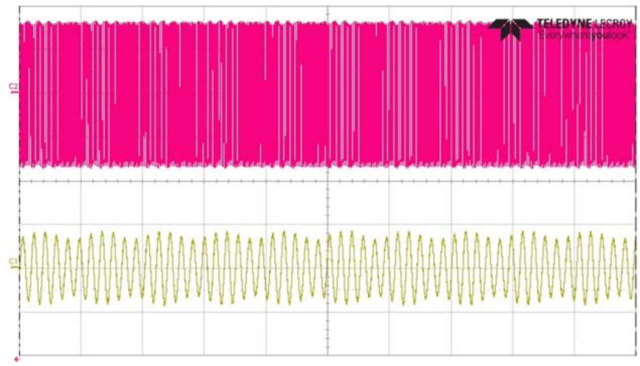
Fig. 2 small signal voltage transfer gain measured from network analyzer



Ma: *12.6dB/div*, C3: *10V/div* Time base: *2ms/div, 10 kHz/div*

Fig. 3 FFT result of V_{PWM} signal

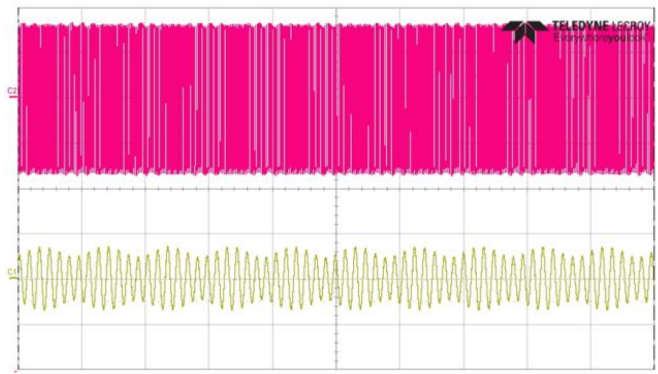
The key waveforms obtained through hardware implementation are shown in fig. 3 to fig. 5. Fig. 3 shows FFT result of V_{PWM} signal with two sinusoidal reference voltages 26 kHz and 32 kHz super imposed. It can be seen that the FFT result contains both 26 kHz component and 32 kHz component in the frequency spectrum. Fig. 4 and fig. 5 shows measured ac output voltages at the first two output stages. It can be seen that the output voltage waveform is still controllable although the signal is influenced by neighborhood channel frequency components. The hardware is built with 4 narrow frequency resonant channels for independent voltage control and the first two output waveforms are shown in fig. 4 and fig. 5.



C1: *20V/div*, freq: *26 kHz* C2: *10V/div*, freq: *220 kHz*

Time base: *200us/div*

Fig. 4 Key voltage waveforms of the output 1



C1: *10V/div*, freq: *32 kHz,* C2: *10V/div*, freq: *220 kHz*

Time base: *200us/div*

Fig. 5 Key voltage waveforms of the output 2

Table 1 key parameters of the hardware

L_{S1}, L_{S2}, L_{S3}, L_{S4}	250uH
C_{S1}, C_{S2}, C_{S3}, C_{S4}	150nF, 100nF, 70n, 47nF
C_{P1}, C_{P2}, C_{P3}, C_{P4}	1.33uF, 883nF, 626nF, 427nF
Lm	28uH
n	1:1
MOSFET	IRFP4568
Vin, Vo1, Vo2, Vo3, Vo4	48V, 18V, 5V, 5V, 12V

IV. Conclusion

A four output multiple resonant converter for independent voltage control with narrow frequency selection channel is built and the new series-series resonant topology is validated with load transients. Load regulation and interference between the neighborhood channels are tested at different load resistances. It is also verified that all the outputs can be controlled independently by varying the carrier and sinusoidal reference waveforms.

References

[1] Kyusik Choi, Joung-Hu Park, and Bo-Hyung Cho, "A Novel Multiple-Output Converter using Band Pass Filters," *IEEE Telecommunications Energy Conference*, pp. 1-4, October 2009.

[2] Joung-Hu Park, Kyusik Choi, Bo-Hyung Cho, "The Single PWM Multioutput Converter with an Arbitrary Number of Output Regulation", *in Proc. KIEE 2009*, pp. 121-124, April 2009.