Novel Multiple Output Converter using Quasi Load

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Abstract

In this paper, a novel multiple output converter using quasi load is proposed. Conventional multiple output converters using multi-winding transformer has poor output voltage regulations. To solve this problem, there are many proposals like post regulation method, weighted control method, and etc. However, the post regulation method regulates output voltage tightly but its conduction loss and cost are increased. And the weighted control can achieve high efficiency and low cost but its regulation is not enough. To solve these problems, this paper proposes a novel multiple output converter using quasi load. The proposed method uses a quasi load which acts like an active dummy load for tight regulation but there is rarely increase of loss and cost. The proposed method is verified by hardware test by two output(24V and 15V) flyback type converter.

1. Introduction

Generally, most electrical equipments operate with several different voltage levels. For this use, multiple output converters have been widely considered because of merits of cost and size.

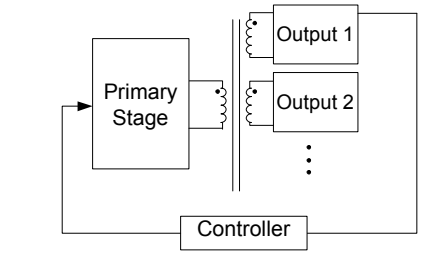
There are three typical types of conventional multiple output converters [1]-[4]. One is only cross regulation(OCR) type and the other one is cross regulation with post regulator(PR) type. And the last one is cross regulation with weighted control type. These three types are constructed with a multi-winding transformer so that their output voltages are related to the transformer turn ratio.

The OCR type controls the output voltage of the main output stage and the other secondary output voltages are just determined by cross regulation which greatly related to the transformer turn ratio. This scheme is very simple and cheap so is widely used for cost-important-applications. However, secondary output voltages could be out of regulation range in specific load conditions because there is no pass to sense these voltages.

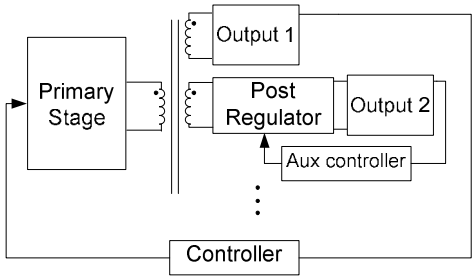
The post regulation scheme adds switches on the secondary output stages to chop the current to each output load. By these switching, each secondary output voltage is tightly regulated. On the other hand, power losses increase due to its additional switches which critically increase conduction loss at heavy load condition. And also the cost is increased because the post regulator control scheme is not simple and the additional switch's performance should be high enough to minimize the loss.

As an effort to regulate all output voltages without loss increasing, a weighted control was suggested. In this method, the controller adds up all output voltage and regulates them. However, this method does not increase degree of freedom of control, each output voltage regulation is worse than main output voltage of OCR method.

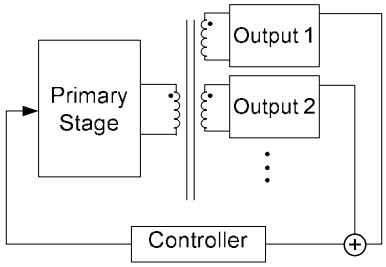
However, today's issue is focused on the efficiency related to the environmental problems and the government policies[5]. Therefore the multiple output converters should find solutions to reduce their losses to increase the efficiency with tight regulation. As a solution, a novel multiple output converter with quasi load is proposed. The quasi load is acting like an active dummy load at secondary output stage but this load almost does not make loss. For a quasi load, buck, boost, flyback, or any types of dc-dc converter can be used. The quasi load handles very small part of the whole power and these converters are very widely used so the cost is not critically increased.



(a) Only Cross Regulation Type



(b) With Post Regulation Type



(c) Weighted control type

Figure. 1 Conventional Multiple Output Converters

The proposed method is experimentally verified on a 100W two-output dc-dc converter and its efficiency is compared with the conventional PR method.

2. Operation Principle of the Proposed Method

2.1 Conventional Multiple Output Converters

Figure. 1 shows three typical types of the conventional multiple output converters and Fig.1 (a) is structure of the OCR type and (b) is of the PR type and (c) is of the weighted control type. The output stages of the OCR type converter are linked by a single transformer. This scheme does not require more switches while auxiliary output stages are added, so it has merits on size and cost. But, except for the main output stage, the dynamic performances

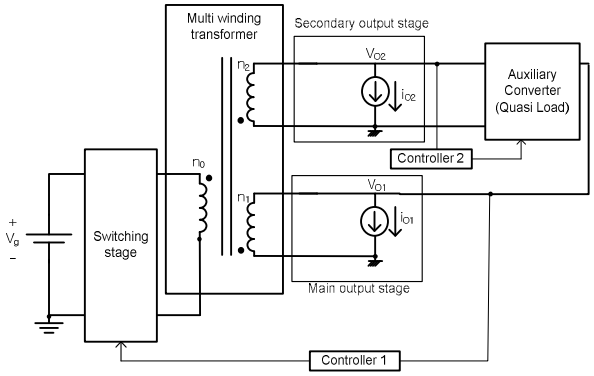


Figure 2. Structure of the proposed method

of the overall converter are very poor and what is worse, the voltages can't be regulated at light load condition. Because there is no path to sense the secondary output voltages. These secondary output voltages are just determined by transformer turn ratio.

To prevent this situation and to increase the dynamic performance, the PR type converter was suggested. Its structure is similar to the OCR type converter, but it has an additional part, a post regulator. The post regulator regulates each output voltage tightly, so the dynamic performance is increased. However, it causes decreased efficiency and increased cost.

To increase regulation performance without post regulator, a weighted control method was suggested. This method adds up all sensed output voltages and controls them, therefore regulations of all sensed stages are enhanced than freely leaved. Nevertheless, this method in not widely used because its regulations are fairly bad.

This dilemma is solved by the proposed method which will be introduced in next paragraph.

2.2 Operation Principle of the Proposed Method

Figure. 2 shows the structure of the proposed quasi load method with a multiple output converter. The main concept of the quasi load method is based on the conventional active dummy load(ADL) at the secondary output stage. ADL operates when secondary output voltage is higher than aim which occurs at the secondary output load goes through light load condition so that secondary output stage operates in discontinuous conduction mode(DCM). This means that V_{O2} is now in inverse proportion to the I_{O2} rather than independent from I_{O2}. To prevent this result, the ADL increases I_{O2} so that V_{O2} would not exceed regulation range. However, the increased current is wholly nothing but loss.

The proposed method, quasi load regenerates dummy load current to main output stage by an auxiliary converter. This auxiliary converter deals only dummy load which is need to

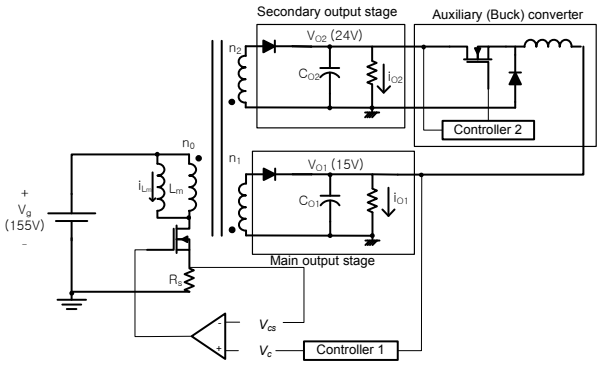


Figure 3. Structure of the hardware prototype

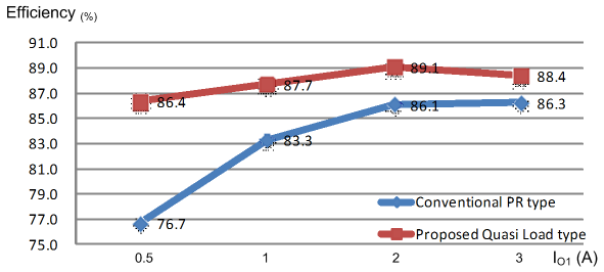


Figure. 4 Efficiency test result (I_{O2}=0.5A)

prevent voltage increasing at light load condition. For this converter, buck or boost converter which is very simple, cheap and high efficient can be used. As a result, the system efficiency is increased without critical cost increasing and even the secondary output voltage is tightly regulated because the auxiliary converter controls the V_{O2}.

3. Experimental Result

To verify the efficiency increase of the proposed method, a hardware prototype for a two-output(24V and 15V) flyback type converter is built and experimented. Fig. 3 shows that structure of the hardware prototype. The main output voltage is only sensed and controlled by main controller. The secondary output voltage is determined by the cross regulation and the auxiliary buck type converter. This buck converter controls the own input voltage, V_{O2} rather the output voltage, V_{O1}, therefore V_{O2} is well regulated in light I_{O2} condition.

A conventional secondary side post regulation type converter is employed to compare with the proposed method. The hardware prototype efficiency comparison results are shown in Fig. 4. The efficiencies with the quasi load method are higher than the conventional method about 2~10% when secondary output load is small.

4. Conclusion

This paper introduced an improved multiple output converter. The proposed method regulates all output voltage without loss and cost increasing. The hardware prototype test result shows that the efficiency of the system with the proposed quasi load method is increased 2~10% compared to the conventional PR method.

Reference

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