A HIGHLY EFFICIENT BRIDGE INVERTER WITH DOUBLED OUTPUT VOLTAGE

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Abstract

A common problem in equipping cars, buses, and other vehicles is the incompatibility of household appliances (coffee makers, converters, radio-receiving sets, audio amplifiers, etc.) that are powered by a constant current with a nominal voltage of 12 or 24 V, which differs from the vehicle's onboard voltage. This problem can be solved by using inverters that provide a twofold decrease or a twofold increase in the output voltage with minimal losses [1]. In this paper, a circuit of this highly efficient inverter is proposed.

1. Introduction

The impetus for designing the proposed inverter was the task of developing a powerful and still cost-effective adapter for powering the equipment with an input supply voltage of +/–24 V, while the vehicle in which this equipment was used had an onboard voltage of +/–12 V. Preliminary prototyping with circuits containing a double-wound transformer and circuits with high-frequency boost did not give the desired results because of high heat losses. The primary winding of the transformer connected to the diagonal of a power bridge composed of four field-effect transistors was initially designed for an AC voltage of 12 V, while all the field-effect transistors were excited by means of two standard drivers.

2. Experimental

The solution of the problem, as shown in Fig. 1, consisted in the replacement of one primary winding designed for a voltage of 12 V by two series-connected center-tapped windings, while the secondary winding of the power transformer was eliminated; in other respects, the circuit remained unchanged. The terminals to which a source voltage of +/–12 V was applied were replaced by the center tap of the primary winding and the sources of the lower power switches, rather than by the drains and sources of the power transistors, as was the case with the secondary circuit. The synchronous operation of the power switches located diagonally in the bridge made it possible to construct a push–pull inverter from two windings of the power transformer and two lower power switches of the bridge; in this case, the two upper power switches of the power bridge act as a synchronous rectifier, in which the drain voltage is two times higher than the input voltage. Taking into account the low ohmic resistance of the field effect transistors (0.002 Ω for IRF2804), the heat losses were extremely small. Figure 1 shows the circuit of this inverter.

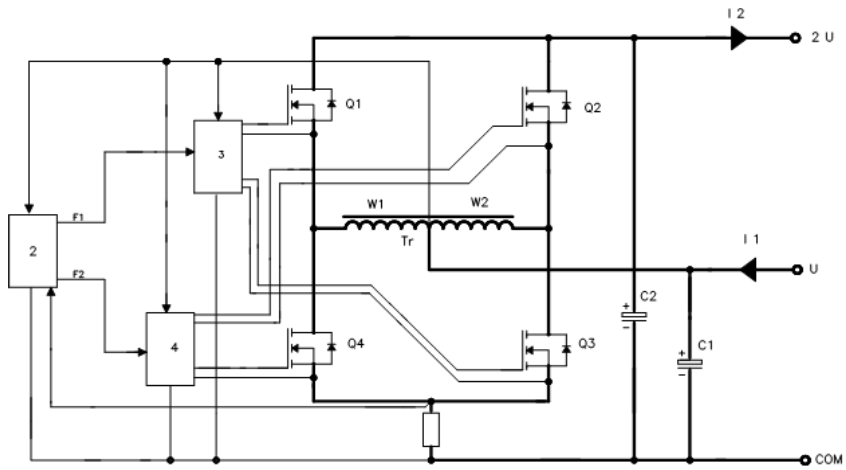

Fig. 1. Circuit of a highly efficient inverter with doubled output voltage.

Here, *2* is a pulse generator based on the KA3525 microcircuit (F = 400 Hz); *3* is a driver based on the IR2011 microcircuit; *4* is a driver based on the IR2011 microcircuit; *C*1 is an input capacitor 3 × 22000 µF/16V; *C*2 is an output capacitor 2 × 10000 µF/35V; *Q*1, *Q*2, *Q*3, and *Q*4 are field-effect transistors of the bridge IR2804 (*Z* = 0.002 E); *Tr* is a power transformer; *W*1 and *W*2 are the windings of the power transformer *S* = 20 mm²; COM is a common bus; *U* is the input voltage bus of 12 V; and 2*U* is the output voltage bus of 24 V.

3. Results and Discussion

To determine the parameters and efficiency of the inverter, respective measurements were conducted. The results are as follows:

- voltage across terminal «*U*» is 12.77 V;
- voltage across terminal «2*U*» is 24.01 V;
- «*I*1» current is 61.2 A;
- «*I*2» current is 34.5 A.

The calculated efficiency is as follows:

$$\mu 1 = (12.77 \text{ V} \times 61.2 \text{ A})/(24.01 \text{ V} \times 34.5 \text{ A}) = 0.943 \ (94.3\%).$$

At a laboratory temperature of +21°C, measurements of the temperatures of the different parts of the inverter gave the following results: the temperature of the field-effect transistor heat sink (60 × 40 × 2 mm) is 43.6°C, the temperature of the power transformer core is 39.2°C, and the temperature of the power winding is 54.6°C. The ideas embedded in this design were described in the application for an invention [2].

Figure 2 shows the physical form of the inverter. It is mounted in a rectangular metal casing, without using forced ventilation methods.

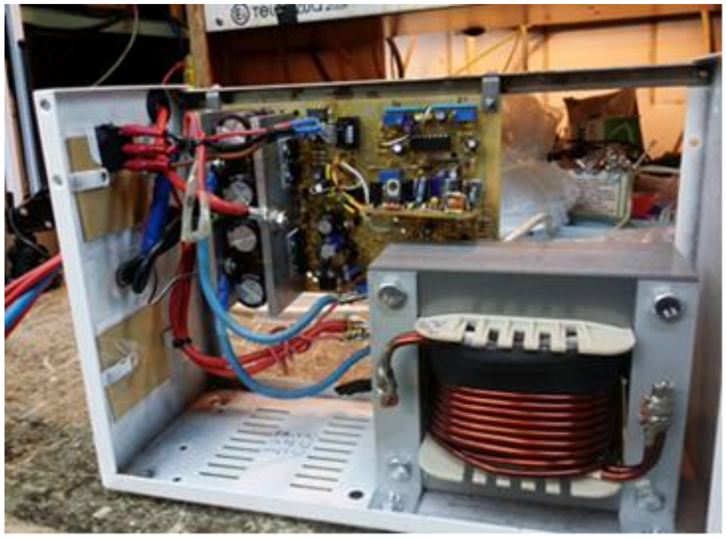

Fig. 2. Physical form of the inverter.

4. Conclusions

The results obtained during the tests suggest a high efficiency of the inverter. The operating temperature of the transformer and power elements makes it possible to predict the high reliability of the inverter over time.

References

[1] M.A. Shustov, Prakticheskaya skhemotekhnika. Preobrazovateli napryazheniya, Altex, Moscow, book 3, 2002.

http://publ.lib.ru/ARCHIVES/P/"Prakticheskaya_shemotehnika"/_"Prakticheskaya_shemotehnika".html

[2] Iu. Sainsus, A. Conev, Iu. Russev, and A. Sidorenko, MD Short-Term Patent no. 1797 (2018).