

THE NEW THICK-FILM HYBRID CONVERTERS FOR HALOGEN AND FLUORESCENT LAMPS

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Abstract

Economical consumption of energy, longer life of lamps, higher lighting comfort and new aesthetic of illumination is subject of numerous research and development works. The halogen lamps are an example of positive solution some of above mentioned problems. The electronic transformers are more frequent used for their supply. In comparison with conventional transformers they have less weight, less volume and 60% less power losses. Their advantages are particular visible, when the hybrid technique is applied.

The paper presents the results of engineering research and development works carried out in Private Institute of Electronic Engineering, in R. & D. Center for Hybrid Microelectronics and Resistors and in Technical School of Communications in Krakow, in the field of the design and exploitation tests of hybrid converters 220V AC /12V DC (electronic transformers) and electronic ballasts destined for the supply of halogen lamps 20W to 150W and fluorescent lamps respectively. To perform the converters, thick film technology and surface mount technology were used. For the protection of converter electronic circuit the thick film temperature sensor and transistors were applied. Moreover the paper presents the base application circuits of elaborated converters, their technical parameters and exploitation results. The development perspectives of such domain of hybrid circuits are also discussed.

Introduction

The halogen lamps are modern source of light. Thanks their excellent lighting parameters they are wider and wider applied in electric – light fittings of common use. Up-to-date technologies enable the manufacture of halogen lamps with light distribution angles from 8° to 60° with following advantages:

- stable value of luminance during whole exploitation period,
- stable temperature of colour,
- two times longer life time in comparison to standard incandescent bulbs,
- eliminating from the useful light not needed part of UV spectrum (i.e. UVB, UVC),
- reduction up to 66% of the heat stream in light bunch,

- small dimension.

In light-fittings existing on the market, the halogen bulbs with power rating 20W to 150W are built in. In most cases the supply voltage is low [6 – 24V] and from this reasons the lamps can't be supply directly from the 220 VAC main. The supply source of such bulbs can be accumulators or transformers.

Mains Transformers for Halogen lamps

In general the mains transformers used for supplying of low voltage halogen lamps are mostly manufactured as a toroidal transformers. The core of such toroidal transformer is winded up from iron-plate with thickness of 0.3 mm. In comparison to traditional transformers toroidal transformers characterize higher efficiency (89 – 92%). The magnetic losses in toroidal core are significant reduced. Also the numbers of windings, the dimensions and weight are less than in conventional transformers. For instance: At output power of 50W the diameter of toroidal core should be 60 mm and height 50 mm. But the considerable decreasing of dimensions and weight of transformers can be obtained by applying so-called “electronic transformers”. Tab. 1 presents typical parameters of electronic transformers.

Tab. 1. Typical parameters of electronic transformers.

| Output power [W] | Dimensions [mm] | | | Weight [g] |
|------------------|-----------------|----------|-----------|------------|
| | length: l | width: w | height: h | |
| 20 – 55 | 60 | 40 | 28 | 120 |
| 60 – 105 | 86 | 40 | 28 | 200 |

The Electronic Transformers (converters)

As we can see from the Tab. 3 the electronic transformer has in comparison to conventional transformer 80% less weight and 40% less volume. The losses of power are 60% less and consequently the heat emission is seriously limited having an effect on the decreasing of its temperature. The other advantages of electronic transformers can be listed:

- the possibility of continuously control of light intensity (dimming),
- electronic protection against load short circuit and over heating.

The electronic transformer includes few main blocks:

- mains filter,
- rectifier in bridge configuration,
- half bridge converter,

- output transformer,
- control set of output voltage.

The role of mains filter is to suppress the r.f. interferences flowing from the power network to a converter and from the converter to the mains.

An alternating voltage 220/50Hz rectified in Graetz Bridge supplies half-bridge converter working in two transistors circuit with the frequency, 25 – 125 kHz. Thanks this high frequency the miniaturization of components used, especially transformers, is possible. The control set enables adjustment of output voltage influenced on light intensity of halogen lamp. In some cases the output voltage from converter can be rectified and such AC/DC converter is applied for supplying of halogen lamps laying further then 1.5 m from the converter. This solution influences on decreasing of r.f. interferences. Schematic diagram of converter designed by authors and manufactured in various versions is presented on Fig. 1.

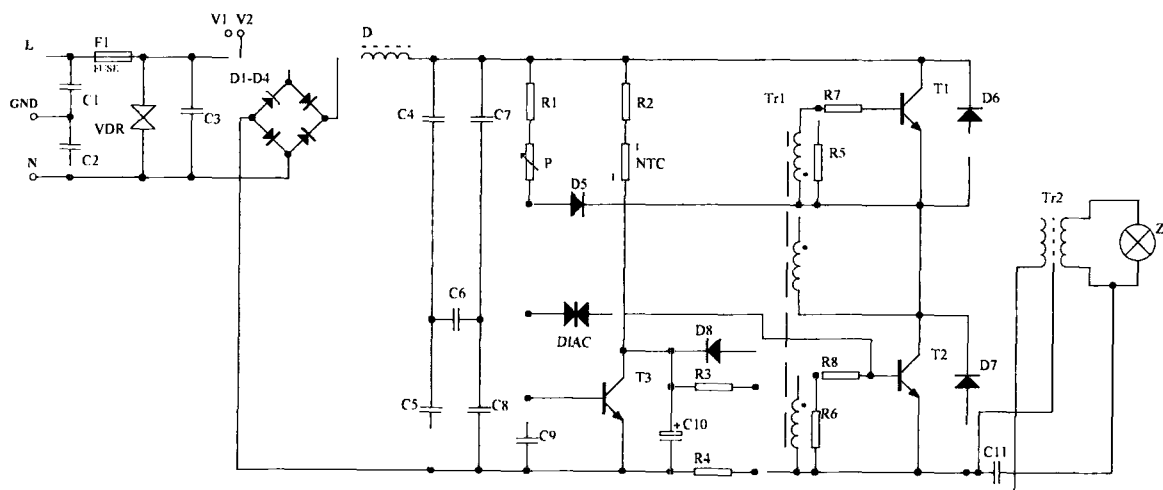


Fig. 1 Schematic diagram of hybrid electronic converter for supplying halogen (Z_1) lamps 20 – 150 W. (Registered design)

On the mains input the converter is protected against overvoltages and spikes by means of VDR. The time delayed cut-out secures the circuit against long term overload. The mains filter consists of capacitors $C_1 - C_6$ and ferrite choke D_1 . The converter circuit form transistors T_1 and T_2 , capacitors C_7 and C_8 . Output transformer is connected to the halogen lamps.

The half-bridge converter is excited by pulse transformer TR_1 and starter set realized on diac and two – terminal network R_1 , C_9 . Potentiometer P changes the frequency and pulse-width modulation of converters and enables the continuously regulation of light intensity. To avoid the effects of excessive current loads, the quick electronic safety fuse was applied. The fuse realized on transistors T_3 is controlled by voltage drop on resistor R_4 (thick film resistor), which is proportional to the current J flowing also across the transistor T_1 , T_2 . When the voltage drop exceeds the value 1.4V transistor T_3 is activated, shorts capacitor C_9 and breaks the converter's action up to time, when the fault will be corrected. The recovery time is defined by time constant $\tau \approx R_3 * C_{10}$ and averages few seconds.

Additional protection against overheating of circuit is realized on thick film NTC resistor. When the heatsink temperature crosses the value of 70°C, the NTC sensor causes the activation of transistors T_3 and switches off the convector and waits the temperature decreases to a safe value. In the experimental exploitation of converter various types of transistors (T_1, T_2) were used. Standard bipolar transistors, as well as manufactured with the H2BIP (with surge diode inside and active decreasing of charge accumulation) technology transistors, MOS and IGBT transistors were applied.

The reduction of r.f. interferences was also possible by earthing of heatsinks and introduction of additional shield between the n_1 and n_2 windings and grounding them through capacitor C_{11} .

High reliability level required for electronic converters was achieved by applying of thick film technology and surface mounting technology (SMT).

Application of ceramic substrate for printing thick-film and assembling of active and passive components enables temperature compensation and stabilization of the electronic circuit. The various versions of converters versus output power were manufactured. Test for variants: 35W, 35 ÷ 55W, 55 ÷ 105W and 150W were carried out and compared with classic transformers supplying halogen lamps. The results achieved, presents chart on Fig. 2.

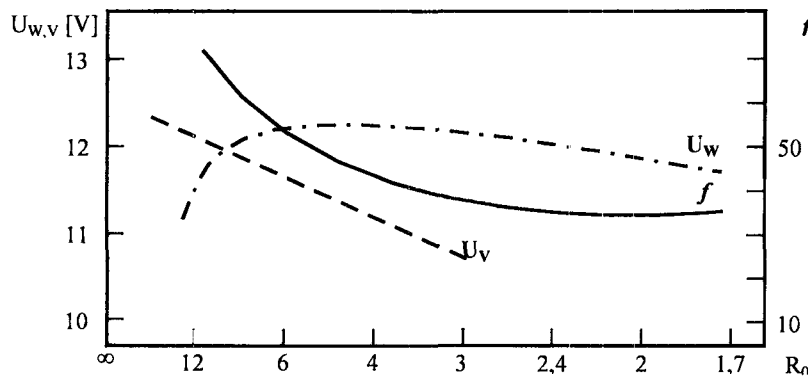


Fig. 2. Output characteristics vs load resistance R_0

U_w – output voltage of hybrid converters; U_v – output voltage of classic transformers; f – frequency of converter

The long – term exploitation tests (15.000 hours) of converters showed that changes of output power don't exceed 5% and were caused mostly by altering of transistors and less by altering of ferrite cores. Another observation was made, that electronic converter is more flexible on load variation then classic transformer. This fact permits connect to converter a few lamps with various electrical power.

Electronic Ballasts for Fluorescent Lamps

One of the method of increase working reliability and life of fluorescent lamps is application full electronic stabilised - ignition circuit supply from mains replaced classical inductive ballast and starter.

This circuit is the electronic ballast.

Electronic ballasts are circuits of electronic converters working in range of frequency up to 1000 times higher than frequency of supply voltage (50 Hz). High frequency enables radically change dimensions of elements such as: capacitors, chokes and transformers. Usually are used inductive elements, made with ferrite core, which guarantee to obtain small losses for eddy currents. Finally obtains considerable decreasing of weight and dimensions of electronic ballasts, in comparison with classical inductive ballast, and considerable saving of materials: copper and steel. Schematics diagrams of electronic ballast and modules controlling designed by authors and manufactured in various version is presented on Fig. 3 ÷ Fig. 5.

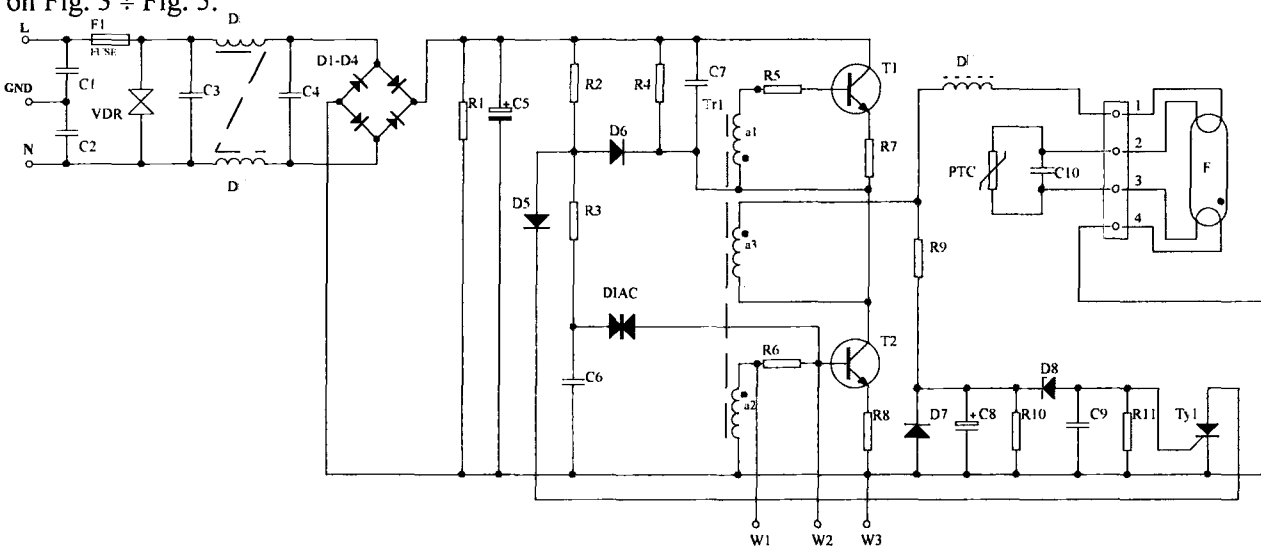


Fig. 3. Hybrid electronic ballast for supply fluorescent lamps (F). (Registered design)

Elaborated circuit has all necessary protections for overvoltage, thermal and current overload.

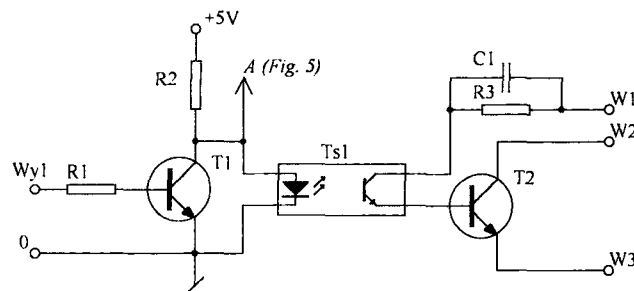


Fig. 4. Schematic diagram of module controlling single electronic ballast. (Registered design)

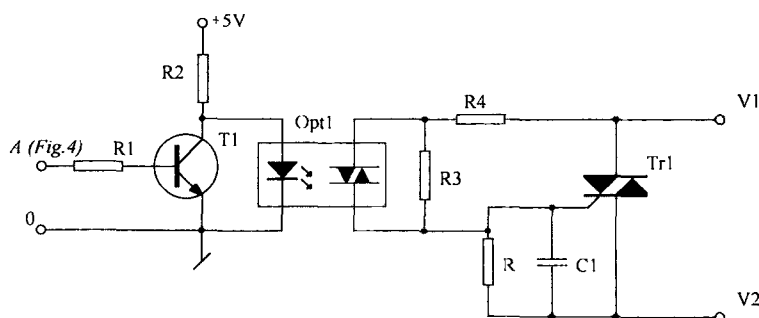


Fig. 5. Schematic diagram of module controlling single electronic converter for halogen lamps.
(Registered design)

As shown on above mentioned examples, in electronic ballast and controlling modules, specialised integrated circuits are in common use. Control circuits are often designed in hybrid technology. Particularly very interesting is pro-ecological technology of thick-film, which enables considerable miniaturisation of circuits, and keep high resistant for electrical and thermal overload. Example one of this specialised circuits (ASIC) are shown on Fig. 6 (designed by authors).

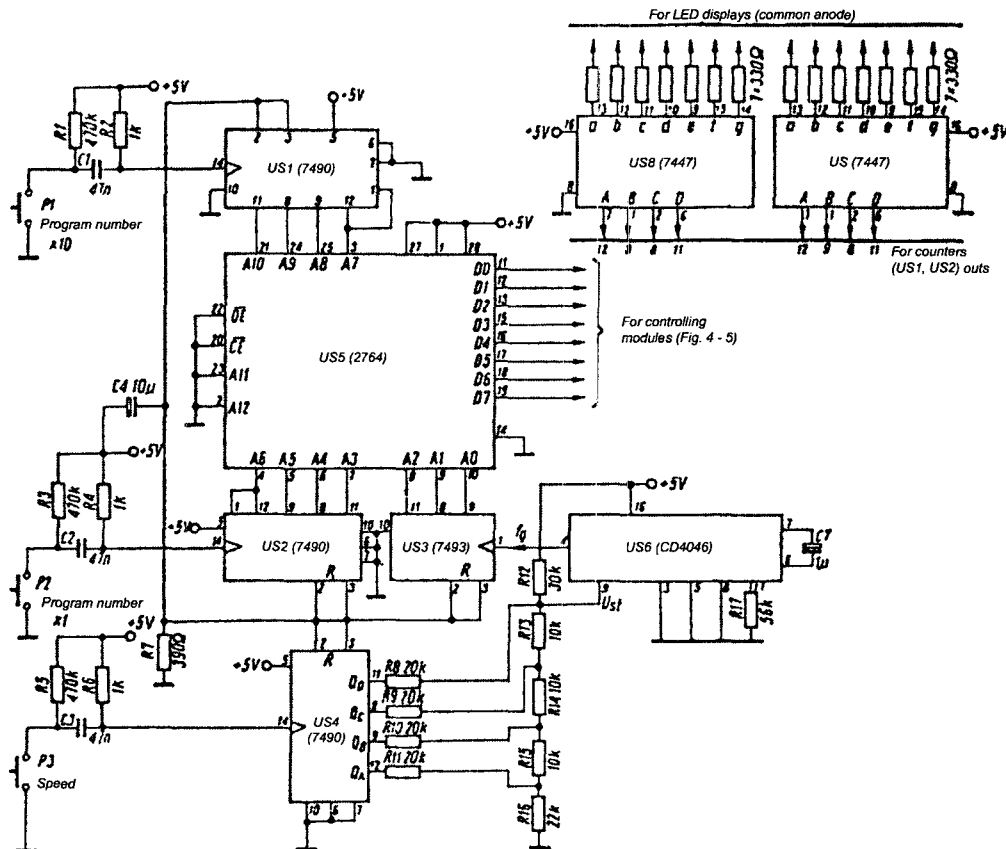


Fig. 6. Schematic diagram of 8-channels programmed control unit.

Technology of perform this electronic converters enables to use SMD elements and automation. It gives increase of reliability of hybrid circuits and service life. Thick-film technology enables to perform on ceramic base, resistors and connection net, and also protective elements type PTC and NTC in printed form, thanks to them we can profit big miniaturisation of electrical ballast. For the sake of good thermal conductivity of ceramic bases (96% Al_2O_3), it is possible compensation of thermal changes for individual elements. Electronic converters performed in this technology can be encapsulated before atmosphere influences, what is very important for fluorescent lamps working in very bad atmosphere conditions

It is planned, that as the production batch of these circuits will lengthen, their manufacture costs will bring closer or will be possible less then those manufactured by standard printed circuits board

technology. Taking into the account the necessity of environment protection, the hybrid technology should be preferred, because it doesn't produce wastes and all used and damaged hybrid circuits can be wholly utilised.

Prospects of Developments of Hybrid Electronic Converters

The application of hybrid technology, SMT, ASIC's, to manufacture of electronic converters and ballasts will allow to achieve high level of circuits miniaturisation, increase the reliability and durability. Also the energy consumption in manufacture processes as in the exploitation of lamps can be expected. The decreasing use of energy consuming materials will take place. From these reasons the environment friendly hybrid technology will be especially recommended as a contribution of electronic to the ecology.

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