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RR COMPLEMENTARY CONTROL METHOD FOR TRANSISTOR BRIDGE CONVERTER

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Abstract: *The paper describes a new method of control of transistor power bridge converter. It provides the output voltage irrelevant of load, similar as the phase shifted control method. It is a new one, because of some original solutions and its difference comparing with existing methods. It is easy to realize using ordinary electronic elements. A significant advantage of method is the possibility of permanent output current monitoring by measuring the voltage sag on a pair of transistors. That allows a very quick current protection.*

Key Words: ***Bridge power converter, Phase shifted method, PWM***

1. INTRODUCTION

The transistor bridge power converters are in use by DC/DC converters (chopper type E, [1], [2]) and by DC/AC converters (invertors), also. The bridge structure makes four transistors, as its shown on fig. 1. The direct current input supply voltage is U_B.

The control, automated regulation, can be realized by use of voltage, or current.

In the case of voltage control, the output voltage is comparing with referent one, and the difference generates the control pulses for the transistors. The fast supply voltage variations, or the changes on the loading site, are detected just as an effect on output signal. This makes regulation slow.

The current feedback is faster. There are two ways of control: the mean current value and current spies. The second one is very important. By the sharp voltage changing, or in case of shortcuts it saves the converter. The current sensing is possible to obtain by sensors (current transformer and diode bridge, Hall element, shunt etc.). The measuring of voltage variations on the transistors as the consequence of current variations can be used for current detection. In that case there is no need for some sensors, and the design and realization are simpler.

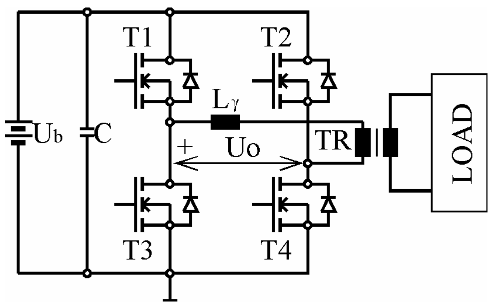


Fig.1 *The transistor bridge conoverter*

The output voltage regulation in DC/AC conversion is done by pulse width modulation (PWM). Mainly two ways are used to generate PWM pulses: classical and phase shifted method.

2. CLASICAL METHOD

This method provides the switching on and off the diagonal transistors at the same time, Fig 2. The control PWM voltage produces the same form of output PWM, when the pure resistance loading is connected only.

When already established inductive load on the output and all of transistors are switched off, the energy on the inductivity is transferred back to the power source via freewheeling diodes.

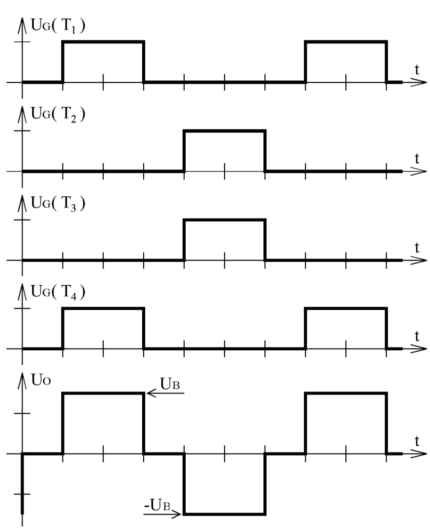


Fig. 2. – *Classical method*

After that, the transformer primary is not connected to the ends of power source any more, than it is free. Parasitic output voltage oscillations are occurring because of parasitic capacitance. The oscillations are reduced by implementing special snaber circuits that are increasing the converter power dissipation. Use of snaber circuit increase switching losses of the transistors, although that makes very simple way of regulation. If the control voltages for transistors are transfered via transformer, only one driver transformer is needed. This kind of control is useful when the pure resistance or a rectifier is coneccted on the bridge output or transformer secondary.

3. THE "PHASE SHIFTED" CONTROL METHOD

The "phase shifted" (Fig. 3) method is the better way of regulation. In that case, two halves of bridge are separately controlled. The duty cycle (D) for both half of bridge is D=0.5, bat for second half it is phase shifted. When both bridge sites are phase in (phase locked) they produce equal outputs and the difference is zero. If the phase of second site is moved, the voltage on the connected load is growing. The maximal value of output voltage is by phase difference of 180^0. This control method is more complex than previous one. It is realized by special circuits (UC3875, UCC3895, for example).

If and main inductive load is connected on the output, the accumulated energy is remaining in the circuit, rather than to transfer back to the source. At that time, the current circuit is closed via one of transistors in one bridge half and appropriate diode in the other half. The transistor and diode of positive group change those of negative one and vice versa. It makes more complicated current monitoring by transistors voltage drop measuring. The most simplest way is to do that on the transistors T_3 and T_4 because theirs sources (S) are on the same, common potential, Fig. 1.

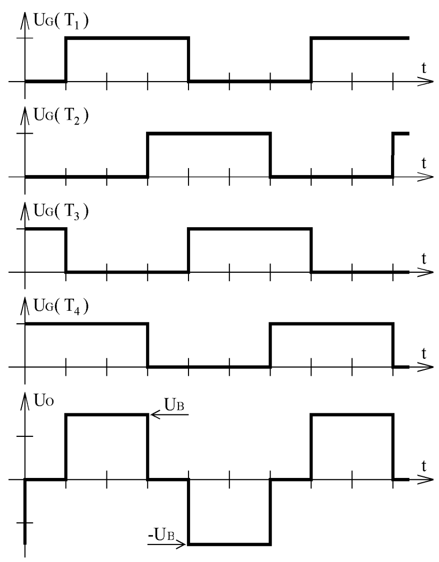


Fig. 3. – *Phase shifted method*

4. SOME ALTERNATIVE SOLUTIONS

Except these typical methods, there are some alternative solutions. One of them is to use D=50% for non-controlled transistors and the other two transistors control by PWM. It could be upper or lower pair of transistors. Such method uses Intersil [4] in own controllers ISL6551or ISL6752. Concretely, the upper pair is running by D=50% and the lower one is PWM controlled.

The other way of control is described in [3]. One half of bridge is driven by PWM and the other one uses D=50%.

But, the bridge transistor power converter control method, which will be explained below, is slightly different of any upper described.

5. RR COMPLEMENTARY CONTROL METHODE

This control method is based on driving both bridge halves by two complementary control voltages with phase difference of 180^0, Fig 4 a. The control PWM voltage is generated by one of standard PWM controllers. Its complementary voltage is produced by inversion itself. Of course, don't to have the situation that both transistors in the same bridge half are switched on and conduct contemporary, it must a 'dead time' (delay) be introduced.

From converter operating mode of view, it is totally irrelevant which part of bridge will be controlled by PWM signal, upper or lower one. But, related to output current monitoring, it is convenient the control PWM signal lead to upper pair of transistors, and complementary voltage to lower. The example of that solution is shown on Fig. 5.

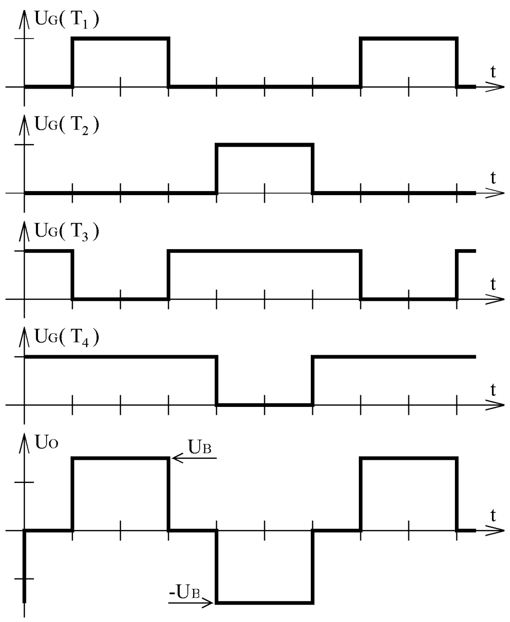
If the bridge converter is realized by MOSFET transistors, this solution may be more efficient then the other, because in some time intervals the current can flow through the MOSFET channel (in opposite direction) instead through diode.

In that case, the control pulses generation is quite simple. Practically, any of PWM controllers can be used.

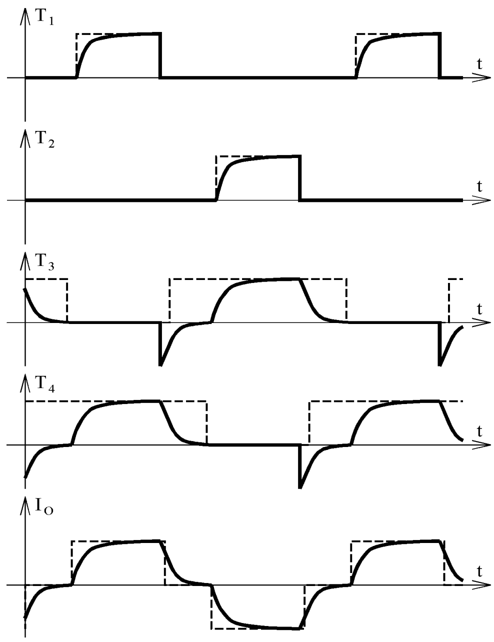
The PWM pulses are lead to the upper transistors (T1 and T2) via drivers. The control pulses for the lower bridge part are generated by inversion of previous signal and introducing the dead time. Most of drivers have both of those functions. The typical example for PWM pulse generation is SG3525 circuit and IR2111 driver. Regarding to the Fig. 1, both transistors connections (T3 and T4) are on the common minus (–) potential of power source. At the every time, one of transistors is switched on. When the voltage is zero, both transformer connections are on the potential approximately the same as minus pole of power source.
By prevalent inductive load, it means that current flow through one of transistors and the other site diode.

6. AN EXAMPLE OF RR COMPLEMENTARY CONTROL

Figure 5 shows an example of a control circuit. The integrated module SG3525 generates PWM control pulses agreed with regulation voltage made by control logic. Those two modules are galvanic separated. The



a) The voltage diagram



b) The current diagram

Fig. 4. – *RR Complementary methode*

regulation voltage can contain a current regulation from current feedback. The driver circuits IR2111 are driven only by one pulse that is lead to the upper transistor in the bridge. The control voltage for the lower transistor is produced by inversion and adding of dead time. The dead time interval takes 700 ns for that specific circuit. The fast and immediate overcurrent protection is achieved by monitoring of voltage variations on the lower pair of transistors. In concrete case it is done via diodes D2, D, D4 and D5 and resistances R3, R4 and R5, Fig. 5. The very fast overload appearance (or short-circuit) disables the control pulses and switches off the transistor momentarily via pin 10, Fig. 5. All those activities take not more than 1 μs. It should be consider as a momentary overcurrent protection. The quick overcurrent protection, which shorts the consecutive pulses - 'soft start', could be achieved by discharging of capacitor C10 via transistor T1.

7. CONCLUSION

The new control concept has been introduced and experimentally verified. The described method of transistor power bridge converter control is interesting because of its specific way of operation. This method enables to obtain the same voltage shape as at "phase shifted" type of control. The main advantage is the simple realization using available low cost components. The complete current supervision is done without additional current sensors. It is achieving by observation of voltage sag on the lower transistors only.

Using that method the 3 kW power converter is realized. The type IGBT transistors are in use on the bridge output. The signal power is slightly increased, and a circuit for resonance maintaining is added. It is using to power the parallel resonance inductive furnace.

The practical usage of described solution has shown very good results. The system has been tested with different loads and permanent short-circuit. It is in function in Mining and Metallurgy Institute in Bor.

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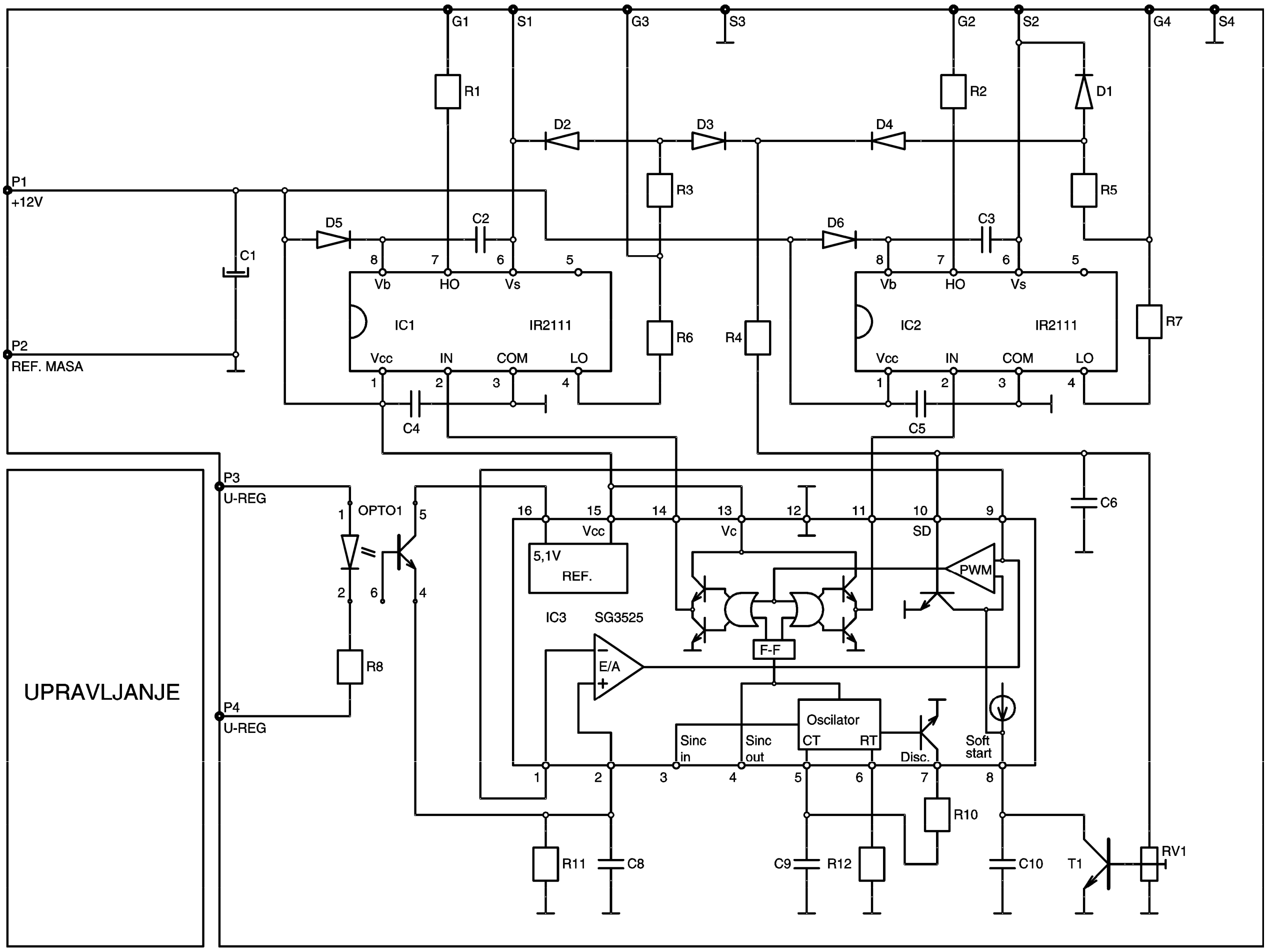

Fig. 5. – The electrical scheme for RR Complementary control method