Materials of the Conferences

THE ANALYSIS OF VARIANTS OF INVERTER CONTROL FOR SECONDARY POWER SUPPLIES

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Recently the push-pull bridge and half-bridge inverters are being used more and more in secondary power supplies (SPS) within the limits of power from the dozen of W to a few kW, for example, in electronic welding machine, single-phase plasmatron, electronic voltage stabilizer and so on.

The bridge inverters include Transistor Bridge in the power part; this bridge is shunted with bypass Diode Bridge and connected by the DC diagonal to the mains rectifier, and by the AC diagonal to the load [1]. The half-bridge inverters have one half-bridge consisting of two transistors and two bypass diodes, this half bridge is the same as the half-bridge of the bridge transistor. The other half-bridge is formed by 2 condensers connected in series; the load is put in between the point of these 2 condensers and the point of the first half-bridge.

The feature of the half-bridge circuits is a principal lack of steady component in the load diagonal that makes this circuit more preferable for the transformer load.

The second feature of the half-bridge is that most of the load range is functioning at the constant power; the energy of condensers while constant voltage of the power supply:

$$W = \frac{CU^2}{2} = const .$$

Hence it appears that the half-bridge inverter is ideally suited for the electro welding in the air, i.e. at the constant arc power.

The mains rectifiers as in the push pull inverters as in the known single-ended inverter of the examined SPS at the high power under 1 kW – it is an ordinary diode transistor bridge.

The controllability is necessary for the inrush current limitation, while the smoothing condenser charging at the output of the mains rectifier.

So, the common structure of the SPS contains two adjustable (regulated) units: the mains rectifier and the inverter. Therefore, there are three variants of forming SPS control circuit:

1. The concurrent control over the mains rectifier (phase) and inverter – the pulse-width modulation (PWM).
2. The control only by the inverter (the rectifier is controlled only in case of starting and short control).
3. The control only by the rectifier.

The controlling systems for the push-pull bridge and half-bridge inverters were developed on the level of the standard (sample) microcircuits, where the outputs are conjugated (coupled) with the middle driver, or directly with power optoelectronic modules. The optoelectronic bypass is necessary because the PWM driving pulse relative duration is changing, and the galvanic separation become practically impossible because of the pulse transformer; at the control area it is very difficult to provide the negative bias at the power transistors of the inverter.

Note that for example the price of a bipolar transistor IRG4 with commutating power up to 200 W is about 5 dollars, at the same time the optoelectronic module with the same output capacity costs more than 40 dollars, i.e. the optoelectronic modules in the controlled inverters mostly determine the price of all the inverter.

In the third case (the control only by the rectifier), there is a possibility for direct manipulation of the power transistors realized by the self oscillator, that makes the inverter more simple and not so expensive, and the SPS on the whole[2]. The review of this case is the object of the article.

The common SPS circuit with uncontrolled inverter contains the net half controlled mains rectifier the mains rectifier control system and the bridge inverter, for example, bipolar-fet integrated circuit. The inverter control system consists of the self oscillator with the output matching transformer, self-saturating reactors (by the number of control channels) and the control pulse formers, also by the number of control channels.

The inverter is functioning in the following manner.

The oscillator transmits the voltage of the intended frequency through the matching transistor in the control current of the transistor inverter. The transformer scales the potential difference (voltage) to the desired value necessary for manipulating of the chosen type of transistors. Each control channel has a saturated reactor. When the impulse from the matching transformer has a direct polarity, i.e. opens transistor, the opening happens only after the saturation of the reactor, because the magnetizing current creates the voltage drop less than the stabilizing voltage of the stabilitron. When the impulse has a reversed polarity, the power transistor gets the negative voltage even while the saturated reactor, because the stabilitron is connected in the direction of the back impulse. Let us remark here that if we chose the power transistor as the bipolar transistor, than there is no need of stabilitron, because the minimum voltage while the opening of these transistors no less than 3 volts. According to the chosen resistors resistance the time of reactor saturating by the back impulse will be within the following limits: $t_в$ « t < 0,5 T, where T is the period of the oscillator voltage. In this case the reactor voltage integrals were the same for the both half-waves. By the moment of opening of the next diagonal (bias) pair of transistors, the pairs which were at the back-bias (negative) voltage. This period should be longer that the recovery period of the turnoff characteristics of the used power transistors. Particularly the bipolar transistors IRG4 have the total turn-off and turn-on period about 0,5 microseconds, and the control voltage (gate-source) about 15 volts that let us to count the reactors by the formula:

$$U = 4{,}44 \cdot f \cdot B \cdot S \cdot W,$$

where U = 15 B, f = (50÷100) kHz (usual frequency of inverters, for example, in electronic welder transformers), $t \approx 0{,}5^{-6}$ c, $B \approx$ (0,2 ÷ 0,4) T S – for ferrite cores and W – turn number of the choke coil.

The evaluation shows that the adequate $t_в$ provides the core $S \approx (5 \div 7)$ mm^2 with turn number W≈15.

Thus, the adequate $t_в$ is achieved with 4 pigmy ferrites, and the power part of inverter become simpler and less expensive.

According to the $t_в$ value it follows that even at the frequency of 100 kHz the relative pulse duration of the on-load voltage is about 0,9 (figure 6). It is obvious that if the direct current load is the same as in the electronic welding machines than the rectified voltage filter becomes rather lighter than while using the PWM method.

At the same time this method has a disadvantage: the speed of operation realized with the rectifier is much lower than while operating with the PWM inverter load.

However, as the practice of engineering and production of the electric welding machines shows, the speed of the rectifier control system is enough for stabilizing of the electric arc; and in this case it is easier to provide the influence of selective protection of the inverter on the active oscillator as it is realized in the well-known engineering.

CONCLUSION

Most of the secondary power supplies (SPS) with controlled mains rectifier and the push-pull inverter control and regulate the output parameters: phase – with the mains rectifier and the pulse-duration, and the optoelectronic transistor module as the power switching sells, which provide the galvanic separation and connection with the output of control system.

The SPS controlled only by the rectifier is suggested in the article. That gives a chance to desist from the use of optoelectronic modules and to control the power transistors by direct use of the active oscillator and also to simplify filtration of the rectified current for the DC load.

The given decision totally makes the SPS simpler and less expensive, and can be recommended for the loads successfully controlled with the mains rectifier, for example for the electronic welding machines.

REFERENCES

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