Short reports

SINGLE-PHASE HALF-BRIDGE THYRISTOR INVERTER

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Single-phase half-bridge inverters are widely used in secondary power supply mainly with transformer load, for example, in small-scale inverter type devices [1].

The power part of such inverters represents an “artificial” bridge, two arms of which consist of two series-connected condenser groups, and the other two ones – of two series-connected thyristors or transistors in forward direction [2]. Together with the main circuit simplicity (two semi-conductor elements only) a high merit of the half-bridge inverter is the absence of the DC voltage component in the diagonal line of alternating current, i.e. under a load, at any unbalances and component values. It is this very merit that allows using a closed core transformer made of high induction material with rectangular hysteresis loop, for example, of anisotropic steel (“mopermalloy”).

The demerit of the transistor variant of such inverters is the limited capacity (current).Thus, the inverter type welding units are produced for the current up to (150÷160) A. The welding process high-amperage currents require parallel joint of transistors, that complicates the inverter and reduces its reliability.

There is no such demerit in the thyristor half-bridge inverter; however, the known thyristor half-bridge inverters on one-operation (usual) thyristors are able to work only in a limited range of loads: from about 0,3 of the nominal one and higher. At light loads the cross-plugging of one-operation thyristors becomes impossible. To extent the operability zone is possible using the forced commutation or two-operation (gate-controlled) thyristors, but it complicates and makes the inverter more expensive as a whole; the losses growing as well.

In the power circuit the classical single-phase half-bridge thyristor inverter contains a half-bridge in the form of series-connected thyristors and another half-bridge in the form of series-connected condensers, which is hooked up by means of the DC current diagonal to the power supply shunted with smoothing condenser and hooked up by means of the alternating current diagonal to the load, and also containing a standard control system as part of active oscillator and the inverter control system, the output of which is connected with the control inputs of the inverter thyristors, one input is hooked up to the output of the abovementioned active oscillator, and the second one – to the comparer, to the inputs of which the definition and feedback signals are hooked up on the principle of degenerative feedback.

It is offered to introduce a supplementary half-bridge in the form of two series-connected transistors and two bypass diodes into the inverter circuit, which is hooked up parallel with the thyristor half-bridge and loaded by the diagonal of the alternating current to the restrictor; the common point of the transistors, bypass diodes and restrictor of the supplementary half-bridge being not connected with the common point of the thyristors; the restrictor loose end being connected with the common point of the condensers and the control inputs of the supplementary half-bridge transistors being hooked up to the supplementary output of the abovementioned active oscillator [3].

As the capacitor voltage has an intermittent nature, by the end of every half cycle the corresponding thyristor manages to switch off, and the transformer core hysteresis loop rectangularity provides a rapid excitation current fall-off of the transformer within the circuit of the corresponding thyristor. At the load current appearing the on-load voltage integral begins decreasing. The restrictor current decreases accordingly, i.e. the current hogging takes place: the more the load – the less the restrictor circuital current. It should be noted that the energy circulating within the restrictor circuit has a purely reactive nature and, with the neglect of the resistance losses in the capacitors, restrictor and transistor half-bridge this energy doesn’t practically magnify the current consumed from the net. If the device is used, for example, as an electric welding bug, then the transformer secondary is connected to the load (electrode – weldment) through the rectifier and current filter. Then the voltage regulation characteristic of the device guarantees welding at constant power, that is ideally suited for a welding process in the air. So, the supplement of the single-phase half-bridge thyristor inverter “classical” circuit with a restrictor and transistored half-bridge for the current of not more than 30% of the load current allowes providing the workability of the device through the whole load range and also lifting the current restrictions imposed by the parameters of the existing transistors in transistor inverters (avoiding the necessity to shunt connection of transistors in the devices with the current of more than 200A).

References:

1. «Invertec» V – 130 – S-Linkoln, USA (catalog), 1998.

2. Pryanishnikov V.A. « Electronics », Saint Petersburg, p. 400, 1998.

3. Magazinnik L.T., Magazinnik A.G. Single-phase half-bridge thyristor inverter. Patentof the RF № 2294590, BI № 6 from 27.02.2007.

WOUND-ROTOR SLIP RECOVERY SYSTEM EFFICIENCY UPGRADING

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The asynchronous motor rate control in the valve stage and double-fed motor schemes is performed by the sliding motion change of the motor at the constant electromagnetic field rotation rate. The main idea - is a beneficial use of the slip power stepped in to the rotor circuit. In the valve stage schemes the wound-rotor induction motor rotor current is rectified by means of the uncontrolled rectifier and a supplementary electromotive force of the DC current from the inverter is introduced into the rectified current circuit of the rotor. For the circuit and rotor voltage concord an impedance-matching transformer is used.

A wound-rotor slip recovery system [1] containing a wound-rotor induction motor, diode three-phase bridge connected by the alternating current outputs to the rotor rings and by the DC current outputs through the series-connected restrictor – to the corresponding outputs of the bridge thyristor inverter DC current outputs, is known. The abovementioned inverter is connected with the AC network through the impedance-matching transformer, and the inverter thyristors are controlled by the system of the pulse-phase control.

The demerits of this wound-rotor slip recovery system are in the following:

1. To increase the phase factor coefficient 4 the impedance-matching transformer 5, the relative capacity of which is equal to the motor speed relative control range, is needed. For example, if the rotation frequency is controlled within the range from the nominal to 70% of design the impedance-matching capacity will make some more than 30% of the motor output. At a wider control range the impedance-matching transformer capacity increases accordingly. It is for this very reason that the wound-rotor slip recovery system utilization area was traditionally restricted by turbo-mechanisms, wherein the required rotation frequency range is not that large.

2. Even in the presence of the impedance-matching transformer in the area of motor speed close to the nominal, when the inverter 4 electromotive force decreases with the sliding motion reduction, the phase factor decreases accordingly.

For diminishing the enumerated demerits it is offered [2] to perform the pulse control of the rotation frequency at small sliding motions of the motor by a short-time translating of the inverter into the mode of deep conversion, however, this very method is applicable in a small speed range only and, besides, results in torque pulsations of the motor and low-frequency harmonics production into the feeder line.

The author offers a scheme [3] quoted in Fig.1 allowing excluding the abovementioned demerits.

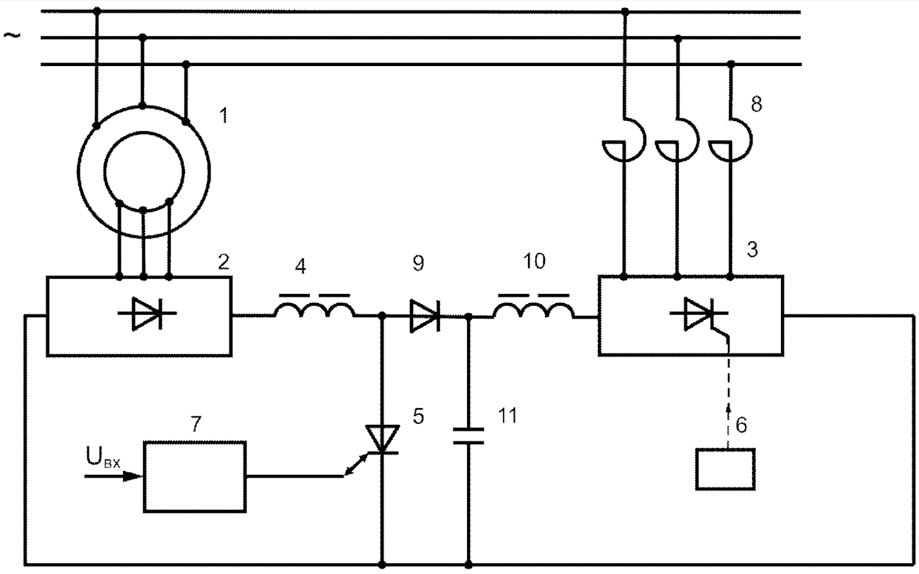

Fig. 1. 1 - asynchronous motor, 2 - three-phase diode bridge, 3 – thyristor inverter, 4-10 – smoothing inductors, 5 – key, 6 – pulse-phase control system, 7 – key 5 control system, 8 – current-limiting reactors, 9 –cut-off diode, 11 - capacitor.

The device functions as follows. At the input signal absence, i.e at $U_{in} = 0$ the key 5 is locked. The electromotive force of sliding motion of the blocked asynchronous motor 1 is maximal, but it is much less, than that of the back electromotive force of the bridge thyristor inverter 3, as the system of pulse-phase control 6 provides the minimal and constant switching on advance angle of the bridge thyristor inverter 3. This angle β min $\approx 20^0$, therefore, the bridge thyristor inverter back electromotive force