Guided Source of Current for the Helmholtz Coils

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Abstract—**described scheme of current stabilizer for the Helmholtz coils with programmatic set value of the magnetic field to 250 Gs. For the current stabilizing of the field tension Hall sensor is applied, and for the control of the set size of the field - NMR. Adjusting of current in coils in the range of 0¸30 A is carried out by a power block from 5 powerful field-effect transistors.**

Index Terms—**current stabilizer, Helmholtz coil, Hall sensor, magnetic field, programmable control**

I. INTRODUCTION

Researches of spectrums of double resonance (NMR-NQR), as a rule, conduct in the relatively low magnetic fields (0÷500 *Gs*) which can be reproduced by the Helmholtz coils [1]. With the help of the last the high spatial homogeneity of the magnetic field is provided. It gives to apply possibility for the analysis standards are comparative large volumes. Structurally the Helmholtz coils is executed as two similar to rings coils by diameter 40 *cm*.

For the receipt of resonances spectrums with high resolution the relative stability of the magnetic field and his spatial homogeneity in a working area must make a value no more than 10^{-5} [1].

If, spatial homogeneity in the set volume it is possible to provide by the structural parameters of Helmholtz coils, the magnetic field stability will depend as from current stability in coils so from constancy of geometrical sizes of coils. The coils at flowing of electric current as a result of heating-up can become deformed. It is needed to take into account at the long durations experiments. Because to carry out the control of the magnetic field strength and his division in the area of location of the explored standard it is important.

In this report the described device for creation of the stable magnetic field tension of which can be changed by the set program. Such mode often necessary at research of magnetic resonance in the weak fields (NMR-EPR, NMR-NQR and other kind of double resonances). For diminishing of influencing of heating-up on the geometrical parameters of coils the periodic short-time mode of operations it is applied. Duration of duty cycle by the relaxation times of the spin system and transitional processes in coils is determined. A signal proportional to tension of the magnetic
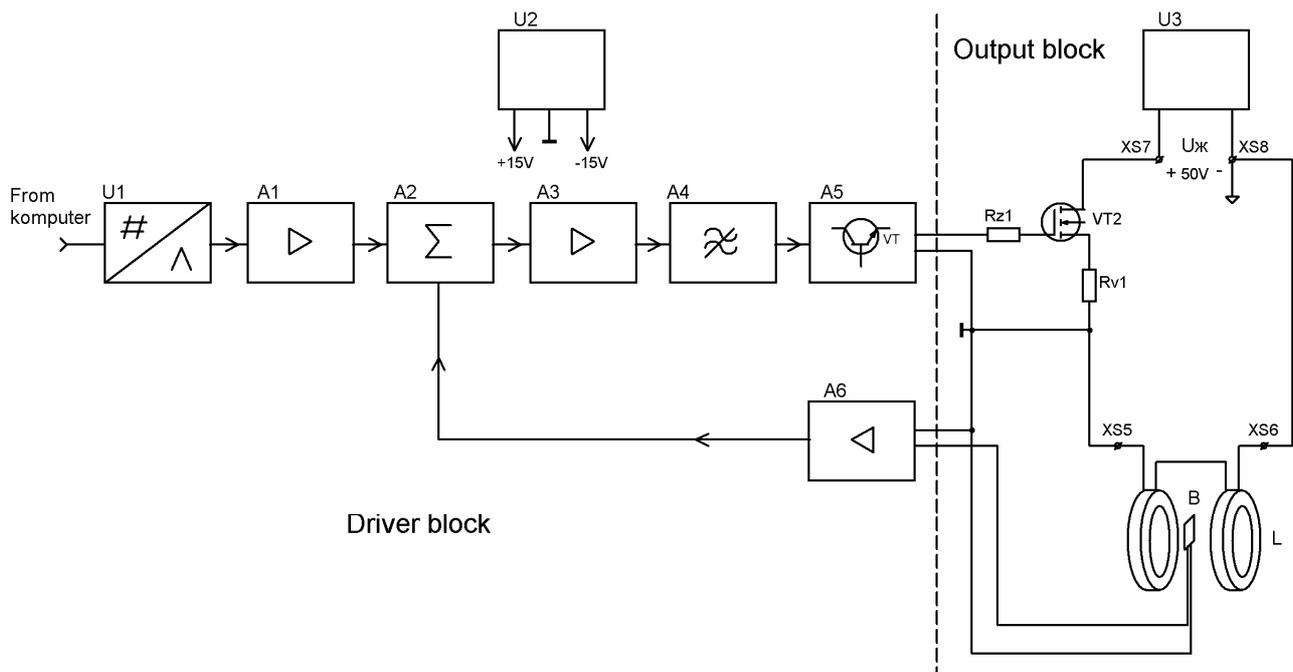
Figura 1. Functional scheme of Guided source of current for the Helmholtz coils.
A1 - amplifier of drive voltage, A2 - adder, A3 – amplifier of error signal, A4 – filter, A5 - buffer cascade, A6 - sensor signal amplifier, U1 – DAC, U2 - power supply unit of driver block, U3 - power supply unit of coil, B – Hall sensor, L – Helmholtz coils.

field is taken off from Hall sensor type SS94A1E [2] with the sensitiveness of 5 *mV/Gs*. For the current control of tension of the field and calibration of sensor in the magnetic field the spin-detector of NMR ions of hydrogen is applied ^{1}H in water with addition of paramagnetic salt FeCl$_3$.

II. FUNCTIONAL SCHEME

A scheme consists of two blocks: driver block and output cascade block (Fig.1). The driver block consists of the amplifier of drive voltage, comparator, adder, filter, buffer cascade and sensor signal amplifier.

Each of blocks feeds from the separate voltage sources. Control block - from the bipolar voltage source ±15 *V*, output block - from the unipolar voltage source 50 *V*. Both blocks have the general point of grounding, that lowers the level of the undesired signal aiming in coils. Such circuit design allows to carry out the management by the field-effect transistors regardless of falling of voltage on active resistance of coils [3,4].

III. SCHEMATIC CIRCUIT

Schematic circuit of driver are shown on fig.2.

Voltage drive from DAC makes from 0 to 5 *V*. But on adder (DA2.2) voltages are compared by amplitude to 12 *V*. That is why for expansion of comparative range voltages on the input of DA2.2 the voltage drive amplifier (DA1.1) with the amplification factor of *K*=3 is included.

The sensor signal amplifier (DA3.1, DA3.2, DA1.2) is

also needed for amplification of voltage of proportion of the magnetic field strength to the necessary level on adder. In addition it is possible to set proportion of output current to voltage drive by a resistor R4.

Increased error signal by the error signal amplifier (DA2.1) on 60 *dB* (1) follow on a buffer cascade realized on a transistor VT1, which manages work of output cascade transistors.

$$U_\Sigma = U_0 + (U_0 - U_r) \cdot K \qquad (1)$$

where U_0 it is adjusting voltage; U_r is sensor voltage; K is the amplification factor of error signal.

Before a transistor VT1 included filter on elements R14, R15, C9, C14 for prevention of self-excitation of all scheme.

Switch J1 allows to carry out tuning (verification) of chart.

Schematic circuit of output block shown on Fig.3.

In an output cascade the applied powerful field-effect transistors IRFP3710 of International Rectifier firm [6].

The necessary magnetic field strength (250 *Gs*) are providing when a current in coils makes not less than 30 *A*. For diminishing of the dispersed power on regulative transistors it is applied parallel coupling of such transistors. With the purpose of more even division of loading on power transistors a careful selection is conducted for the identity of their characteristics, and in to the sources the included additional current alignment resistances Rv1 - Rv5. For the
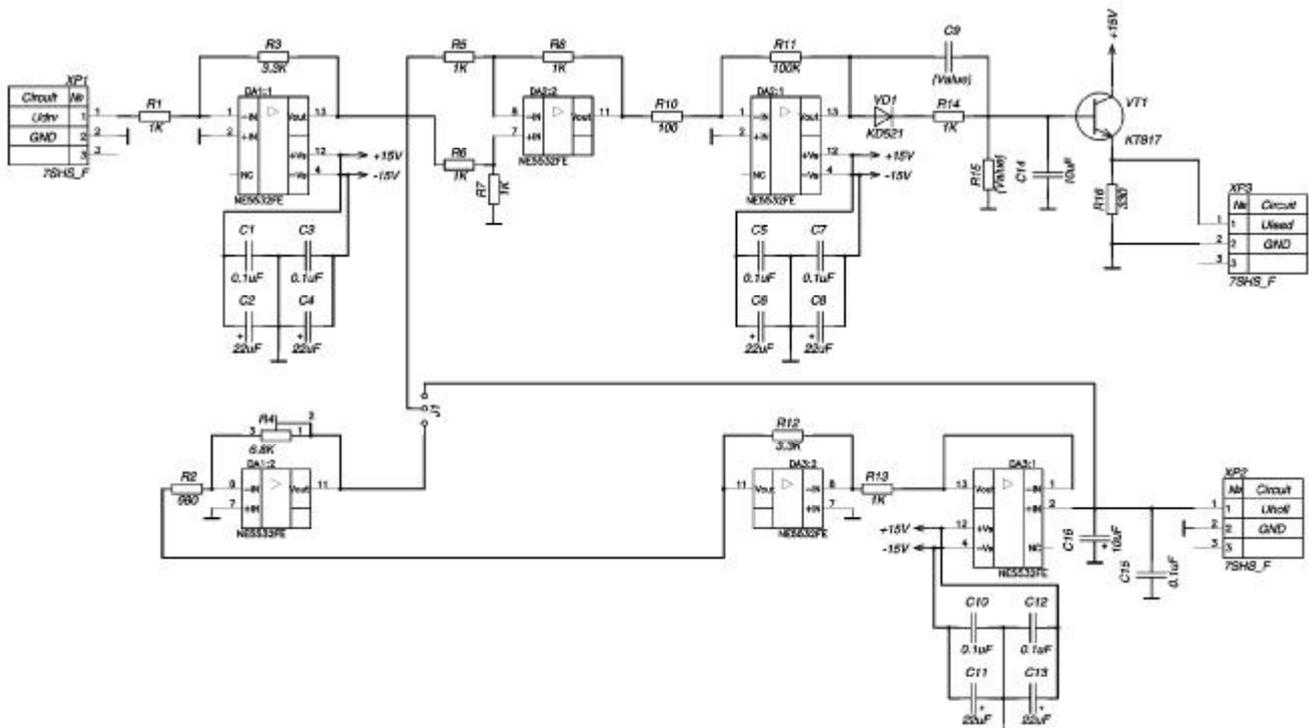
Figure 2. Schematic circuit of driver block DA1…DA3 – NE5532, VT1 – KT817A

effective taking of heat the transistors are set on a massive radiator with the forced air-cooling.
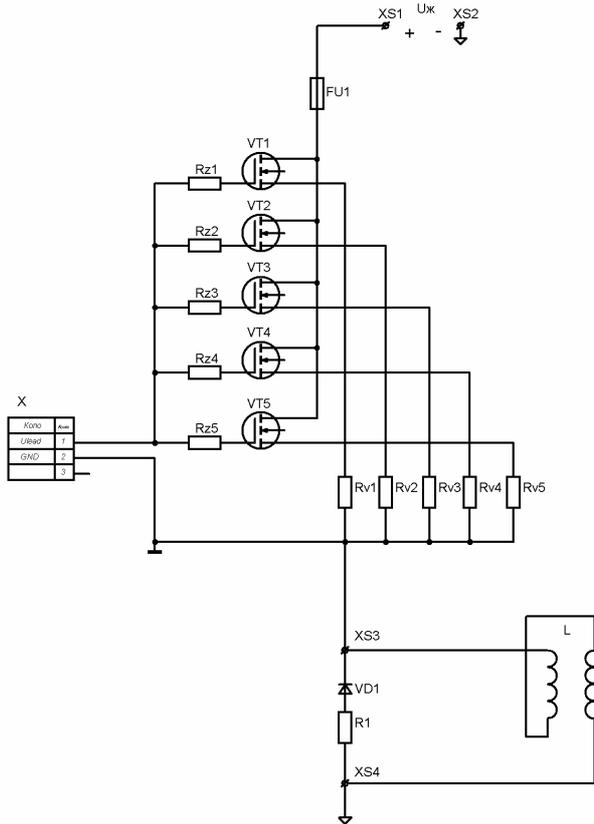
Figure 3. Schematic circuit of output block VD1 - 40EPS08PBF VT1.VT5 - IRFP3710, Rz1.Rz5 - 620 Ohm Rv1.Rv5 - 0.1 Ohm

For prevention of breakdown of transistors by voltage of self-induction of coil parallel to it the included diode in

reverse direction.

Resistors Rz1 - Rz5 plugged in the circles of gates of transistors for defence of driver scheme in the case of breakdown of the gate [7]. As resistance of these resistors far less than input resistance of the field-effect transistor, on the process of management it is possible to ignore their influence.

IV. CONCLUSION

This device allows to provide a current by a value to 30 *A*, that equivalent to magnetic field strength in the working area of Helmholtz coils ≈250 *Gs*. The drift of current ≈1 *mA/hour* during a hour from time power-up.

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