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WIDE-RANGE CURRENT TRANSFORMERS WITH NON-CONTACT REGULATION

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ABSTRACT

Several designs of wide-range current transformers (TT) have been developed. The analysis of their work has established that the most complete requirements of control and control systems are met by TT, in which the wide range is implemented by the implementation of a spiral core in the form of an Archimedean spiral. This leads to an increase in the stability of the TT. The developed TT consists of a fixed hollow core 1 in the form of a spiral made of non-magnetic and non-conductive material, a primary winding 2 applied according to the required functional law to a fixed core 1, a movable ferromagnetic magnetic core 3 that can rotate around a common axis 4 with the help of a holder 5, a secondary winding 6 located in the inner cavity of a movable ferromagnetic core 3 and a ferromagnetic liquid 7 filling the parts of a spiral hollow tube covered by a movable ferromagnetic core 3 of 1.

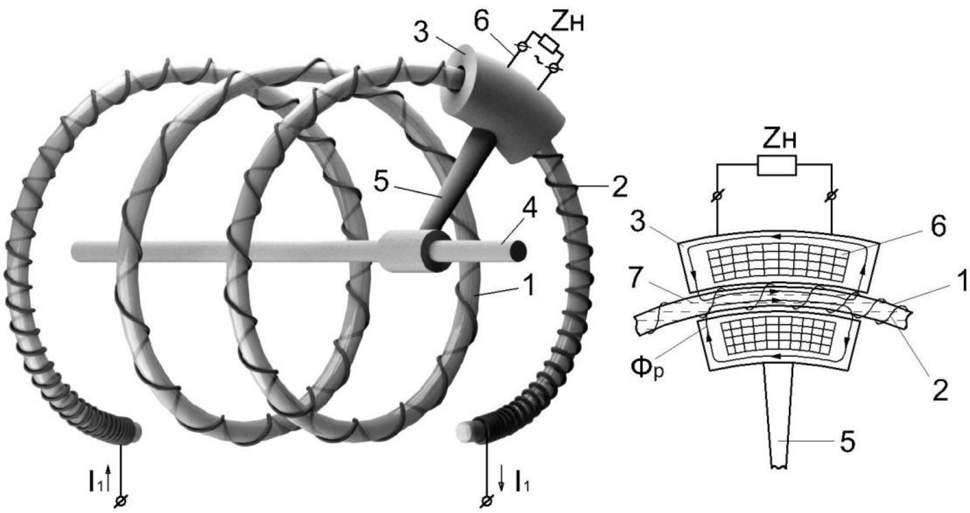
KEYWORDS: *Wide range, Current transformers, Magnetic circuit, Magnetic resistance, Stability, Ferromagnetic liquid.*

INTRODUCTION

As you know [4, 5, 6, 7, 9, 10, 11, 19, 20], the current transformer in which the wide-range is carried out by smoothly regulating the number of turns of the windings, has low reliability due to the presence of a sliding contact. Therefore, in this article, a new design with non-contact adjustment of the conversion range is proposed [5, 15, 16, 17, 19, and 20]. Figure 1 shows the developed wide-range TT: Figure 1, a is general view of the TT, and Figure 1, b is a movable magnetic core with a measuring winding.

FIRST PROPOSAL

The developed TT consists of a fixed hollow core 1 in the form of a spiral made of non-magnetic and non-conductive material, a primary winding 2 applied according to the required functional law to a fixed core 1, a movable ferromagnetic magnetic core 3 that can rotate around a common axis 4 with the help of a holder 5, a secondary winding 6 located in the inner cavity of a movable ferromagnetic core 3 and a ferromagnetic liquid 7 filling the parts of a spiral hollow tube covered by a movable ferromagnetic core 3 of 1. The primary winding 2 is wound on the spiral core 1 so that the specific number of turns per unit of the angle of rotation of the moving part increases from the center of the core 1 to its ends. The described transformer belongs to the class of low-power laboratory TT with an air gap.



А Б

Figure1. Design scheme of a wide-range TT according to [15]

The wide-range TT works as follows. When an alternating current passes through the primary winding under the influence of a magnetic field, the ferromagnetic liquid is held in the part of the spiral tube covered by the movable magnetic core due to the electromagnetic force. When moving the movable magnetic core along the spiral tube, the ferromagnetic liquid also moves. The production of a spiral core in the form of a hollow tube significantly reduces the mass and reduces the material consumption of the TT magnetic core.

The total magnetic resistance in the path of the working magnetic flux is found as [9, 12]

$$R_{\mu\Sigma} = \frac{l_{\mu c}}{\mu_c \mu_o S_{\mu c}} + \frac{l_{\mu ж}}{\mu_{ж} \mu_o S_{\mu ж}} + \frac{l_{\mu\delta}}{\mu_o S_{\mu\delta}},$$

где $l_{\mu\delta} = 2(\delta + \delta_C)$ – total non-magnetic gap in the path of the working magnetic flux; δ is the gap between the movable magnetic core 3 and the spiral hollow core 1; δ_C is the thickness of the spiral hollow core 1; $\mu_O = 4\pi \cdot 10^{-7}\ \frac{Гн}{м}$ is a magnetic constant; μ_c, $\mu_{жс}$ – magnetic permeabilities of steel and ferromagnetic liquid, respectively; $S_{\mu c}$, $S_{\mu жс}$, $S_{\mu \delta}$ – cross-sections in the path of the working magnetic flux of the mobile magnetic core, ferromagnetic liquid, and gap, respectively.

The primary current creates the MDS [12]:

$$U_{\mu 1} = I_1 w_2 = I_1 k\alpha ,$$

When $w_2 = k\alpha$ – the number of turns of the measuring winding per unit of the angle of rotation, α mobile magnetic circuit, k – the proportionality coefficient.

The described TT is designed to convert not very large currents. Wide-range (smooth adjustment towards the expansion of the lower limit of the conversion) is carried out by changing the number of turns of the primary winding by turning the movable magnetic circuit without breaking the primary circuit, which is very important when power outages in the system are undesirable [18].

At the same time, with a short-term sudden disconnection of the primary current, the ferromagnetic liquid flows out of the location of the mobile magnetic circuit with windings, and when the primary current is restored, the TT will work without the ferromagnetic liquid. This leads to a significant conversion error. Therefore, the task was set – to increase the stability of the TT.

SECOND PROPOSAL

The problem is solved by the fact that in a wide-range TT containing a spiral core made in the form of a hollow diamagnetic and non-conductive tube, on which the primary winding is applied according to the required functional law, and a movable magnetic core with a secondary winding covering a part of a spiral core with a ferromagnetic liquid, the core is made in the form of an Archimedean spiral and is located vertically with the possibility of rotation. The movable magnetic core is freely mounted on a vertically positioned guide with the possibility of movement.

Increasing the stability of the TT operation is achieved due to the fact that the spiral core is made in the form of a vertically installed Archimedean spiral with the possibility of rotation; while the movable magnetic core covers a part of the spiral core filled with a ferromagnetic liquid, and can only move vertically.

In the proposed TT, when the spiral core is rotated, the movable magnetic core with the secondary winding and the ferromagnetic liquid moves only along the vertical guide. Therefore, the ferromagnetic liquid is always held in the lower part of the Archimedean spiral core, which is covered by the movable magnetic core.

The implementation of the spiral core in the form of an Archimedean spiral and its vertical placement, as well as the free installation of the movable magnetic core on a vertically positioned guide with the possibility of movement, eliminates the leakage of ferromagnetic liquid from under the movable magnetic core with a secondary winding in the event of a short-term sudden shutdown of the power source and restoration of the power source, the TT continues to operate in the established mode, thereby maintaining the stability of operation.

Figure 2 shows the developed wide-range TT [1, 2, 3, 8, 13, 14]: in Fig. 2, a-front view, in Figure 2, b - side view in section, in Figure 2, c-view when the spiral core is rotated by 90°, in Figure 2, d-movable magnetic core with a secondary winding (in section).

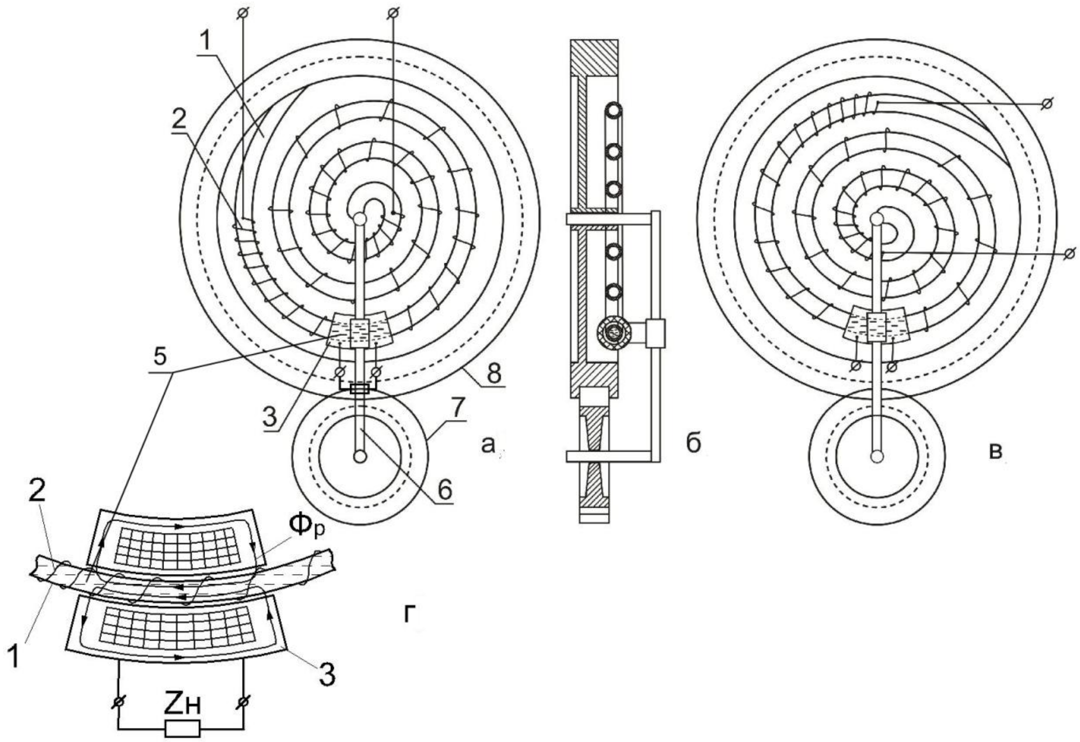


Figure 2 Multi range TT by [3]

The proposed wide-range TT consists of a core 1 made in the form of a vertically arranged Archimedean spiral of a hollow diamagnetic and non-conductive tube, on which the primary winding 2 is applied according to the required functional law, and a movable magnetic core 3 with a secondary winding 4 covering a part of the spiral core 1 filled with ferromagnetic liquid 5.

The movable magnetic core 3 with winding 4 is mounted on a vertically located guide 6 with the possibility of moving in the vertical direction when turning the spiral core 1. The core is rotated by means of auxiliary gears 7 and 8.

The movable magnetic core 3 is used to create a magnetic flux. It is a hollow cylinder with a curved axis that coincides with the axis of the wire wound on the hollow core 1, and covers only a part of the core 1 with the winding 2. The principle of operation of this TT does not differ from the principle of operation of the previous TT.

The rotation of the spiral core 1 is carried out by means of an auxiliary gear. In this case, the ferromagnetic liquid 5 under the influence of the electromagnetic force created by the magnetic field is held in the lower part of the coils of the spiral core 1 covered by the movable magnetic core. The movement of the movable magnetic core 3 with the winding 4 when the spiral core 1 is rotated occurs only along the guide 6.

CONCLUSION

Thus, the positive effect is achieved by the fact that the execution of the spiral core in the form of an Archimedean spiral and its vertical placement with the possibility of rotation, as well as the free installation of the movable magnetic core with a winding on a vertical guide with the possibility of movement when the spiral core is rotated, does not allow the ferromagnetic liquid to flow out from under the movable magnetic core with a winding during a short-term sudden power outage and restoration of the power source, the TT continues to operate in the established mode. This leads to an increase in the stability of the TT.

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