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IMPROVEMENT OF POWER TRANSFORMERS TESTING EFFICIENCY IN OPERATION CONDITIONS

The paper considers the device, based on the usage of analog liquid crystal indicator. It enables to define transformation ratio, simultaneously reducing time for measurement, enhances labor productivity of the staff, that performs tests of the transformers.

Key words: transformer, transformation ratio, resistance box, potential, voltage oscillations, range of measurements.

Introduction

For determination of the transformation ratio of the transformers the method of two voltmeters is used, when measurement on the transformer windings with further processing of the obtained results is performed. If voltage variations occur, then, measurements must be performed not more than two times. That is why, it is necessary to perform several experiments and mathematically process the results obtained, that is time consuming.

Among other methods, intended for determination of transformation ratio, method of the bridge, based on compensation principle is used [1, 2], that enables to measure rather accurately transformation ratio, irrespective of voltage variations in the grid. However, the determination of transformation ratio is performed by the selection of the position of 5 decimal switches for setting to zero the arrow of galvanometer, that requires much time. In this case, in all the known devices their readings do not exactly determine transformation ratio.

Determination of transformation ratio of the transformers using analog liquid-crystal indicator

Researchers of Vinnytsia National Technical University (VNTU) developed the device, that uses analog liquid-crystal indicator (LCI) enabling to determine the transformation ratio of the transformer. The scheme of the device is shown in Fig. 1.

The device has a source of alternating voltage 1, first and second resistance boxes 2, and analog liquid crystal indicator (ALCI) 3. Start of HV winding is connected to the first input, of the device, finish of HV winding is connected to the second input, start of LV winding is connected to the third input of the device, and finish of LV transformer 4, which is tested, is connected to the fourth input.

The device operates i following way. After connection the source of alternating voltage 1 with the circuit, that consist of resistance boxes 2 and high -ohmic electrode APKI 3, connected in series, the output voltage of this source is applied to HV winding of the transformer 4. Current I_1 flow across HV winding of the transformer 4, and current I_3 flows across the circuit, that consists of resistance boxes 2. For the given circuit we can write:

$$\dot{I}_1 = \frac{\dot{U}_1}{Z_1};$$

$$\dot{I}_3 = \frac{\dot{U}_1}{R_1 + R_2 + r},$$

where Z_1 – is the resistance of HV winding of the transformer 4; R_1 – is the resistance of the first resistance box 2; R_2 – is the resistance of the second resistance box 2; r – in the resistance of electrode APKI 3.

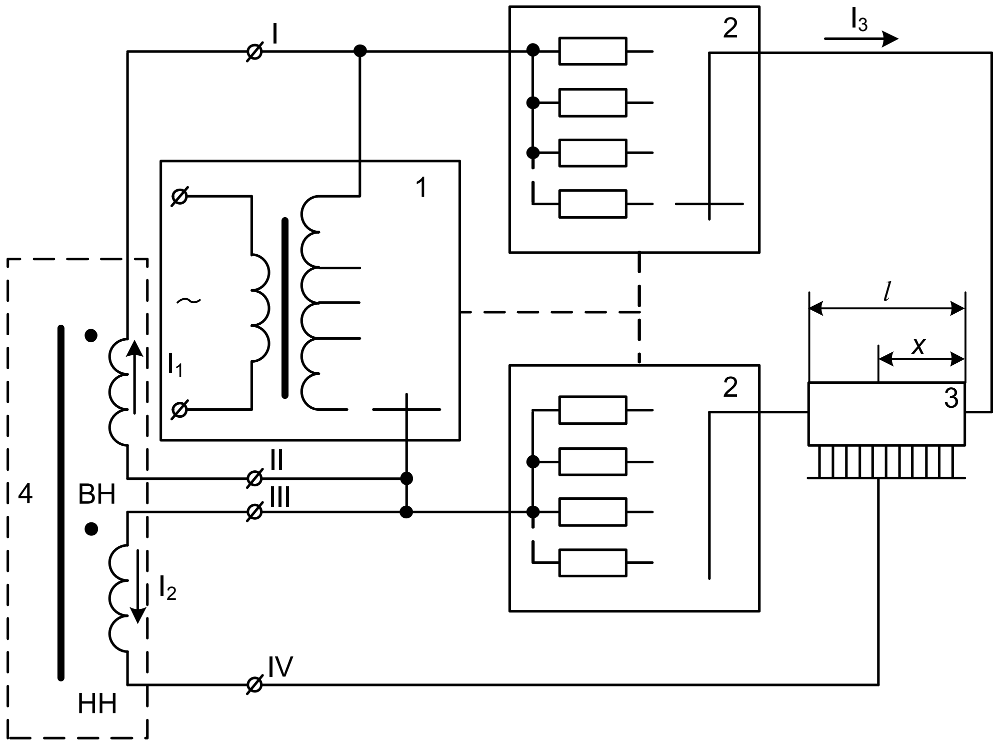

Fig. 1. Diagram of the device for determination of transformation ratio of the transformers

In LV secondary winding of the transformer 4 EMF E_2 is induced, it equals:

$$\dot{E}_2 = \frac{\dot{E}_1}{K_T},$$

where $\dot{E}_1$ – is EMF of HV winding of the transformer 4; K_T – transformation ratio of the transformer.

The current in this winding is determined by the expression:

$$\dot{I}_2 = \frac{\dot{E}_2}{Z_2 + R_1 + r_к},$$

where Z_2 – is the resistance of LV winding of the transformer 4; $r_к$ – is inter electrode resistance APKIS 3 .

As the resistance $r_к$ has great value, the current in LV winding of the transformer 4 is so small, that the transformer operates practically in idle mode. In this case, voltage drop in HV winding may be neglected, because this voltage drop in case of small excitation is the fraction of per cent, and, correspondingly, in LV winding of the transformer 4. Then, it can be written:

$$\dot{U}_1 = \dot{E}_1 = \dot{I}_3 \cdot \left(R_1 + R_2 + r\right); \quad (1)$$

$$\dot{U}_2 = \dot{E}_2 = \dot{E}_1 / K_T, \quad (2)$$

where $\dot{U}_2$ – is the voltage at the taps of LV winding of the transformer 4 .

Assuming that the potential at the start of HV winding and finish of HV winding of the transformer equal 0, taking into account (1) and (2) we obtain:

$$\left.\begin{aligned} \varphi_e &= \dot{E}_2; \\ \varphi_x &= \dot{E}_1 - \dot{I}_3 \cdot \left(R_2 + r_0 \cdot x\right), \end{aligned}\right\} \quad (3)$$

where φ_e – is the potential of low ohmic electrode APKI 3; φ_x – is the potential at any point of high ohmic electrode APKI, that is located at the distance *x* from the end of the electrode, $r_0 = r / l$ – is the specific resistance of electrode APKI.

Resistances R_1, R_2 of resistance boxes are chosen, so that transformation ratio of the transformers be within the range of APKI 3 measurements, i. e. on the high ohmic electrode of this indicator, there is a point with $\dot{\varphi}_x$ potential, that equals $\dot{\varphi}_{\hat{a}}$ potential of low ohmic APKI electrode. In the point, where the voltage between the electrodes is lower than the voltages of the threshold of emergence of electro optical effect U_{th}, liquid crystals, keeping their structure, remain transparent for light.

In other points of APKI liquid crystals are excited and changing their structure become opaque for light, that is, light spot appears at the distance *x* from its edge. Transformation ratio, taking into account (1) and (3) is determined from the expression:

$$\varphi_e = \varphi_x = \dot{E}_2 = \dot{E}_1 \cdot \frac{R_1 + r - r_0 \cdot x}{R_1 + R_2 + r}$$

and, taking into account that $K_T = \dot{E}_1 / \dot{E}_2$, we obtain:

$$K_T = \frac{R_1 + R_2 + r}{R_1 + r - r_0 \cdot x}. \tag{4}$$

It follows from the expression (4) that transformation ratio of the transformer is determined by the parameters of the circuit of the device and coordinate *x* of light spot on APKI. Thus, having calibrated the scale of APKI according to (4), we obtain directly the value of transformation ratio.

Resistance box is intended for the selection of measurement range of transformation ratio. It follows from (4):

if x=0: $$K_{T.\min} = 1 + R_2 / \left(R_1 + r\right);$$

if x=l: $$K_{T.\max} = 1 + \left(R_2 + r\right) / R_1,$$

where $K_{T.\min}$, $K_{T.\max}$ – minimal and maximal values of measurement range.

While switching of measurement range for maintaining minimal width of light window on APKI scale, to reach maximum accuracy, it is necessary to vary the output voltage of alternating voltage source 1 and according to the expression:

$$\dot{U}_1 = \dot{I}_0 \cdot \left(R_1 + R_2 + r\right),$$

where $\dot{I}_0$ – is the current, flowing across high ohmic electrode APKI, that provides minimal size of light window at its scale.

In the considered device the switching of measurement ranges is carried out simultaneously with the switching of taps of alternating voltage source, as a result, constancy of current I_0 = const .is achieved and the necessary accuracy in all measurement ranges is kept, since the dimensions of light window on APKI scale remains constant

Conclusions

Usage of the analog liquid- crystal indicator enables to replace the operation of exact setting of the device arrow on zero, that is performed using the known devices, by more simple operation – selection of measurement range. It allows to reduce the time of measurement, and improve the labour productivity of the personnel, that performs testing of the transformers.

REFERENCES

1. Испытание мощных трансформаторов и реакторов / [Алексеенко Г. В., Ашрятов А. К., Веремей Е. В. и др.] – М.: Энергия, 1978. – 519 с.

2. Справочник по наладке электрооборудования электростанций и подстанций: [под ред. Э. С. Мусаэляна]. – М.: Энергоатомиздат, 1984. – 344 с.

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