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Contributions Concerning the Oscilloscopic Method, for Checking the Clock-Hour Figure of the Vector Group of a Three Phase, 50 VA Electric Transformer

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***Abstract*—The wiring diagrams, the vector groups and the clock hour figures of the vector group, are interesting aspects for designing, manufacturing and operating of, especially the power transformers. The achievement of a device for identifying the clock-hour figure for the three-phase transformer, built on the principles of oscilloscopic method and compensation method, represent the authors' contributions. The proposed solution leads to a major simplification of the oscilloscopic method, which, even if it bears the name used in the literature, does not use an oscilloscope, device considered expensive and complicated. This new approach leads to a higher precision of measurements, limiting the risk of errors, which can occur in case of small phase displacements.**

***Index Terms*—Electrical engineering, oscilloscopes, transformers, voltage measurement.**

I. INTRODUCTION

To identify the clock-hour figure of the vector group, for the group of connections of a three-phased transformer, the literature presents the voltmeters (the electricians), the phase indicator, the DC power supply and, the oscilloscopic method [1], [4]–[6]. In this paper our attention is focused on the last method.

The oscilloscopic method principle is based on the comparison of the primary voltages oscillograms with the second one, measured between the homologous terminals [1]. Also, it includes the identification of the phase difference between the curves corresponding to the two voltages. Figure 1 presents an experimentally fitting necessary for a proper investigation of oscilloscopic method principle.

The stand above includes the verified transformer, three measuring instruments for voltage, an autotransformer and an oscilloscope, useful to visualize the waveforms of compared voltages.

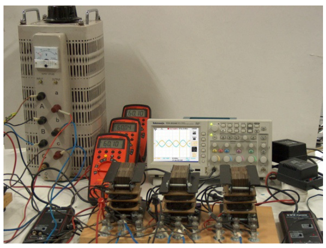

Fig. 1. An experimentally fitting for oscilloscopic method principle.

In this case, the waveforms of the two voltages are in opposition of phase. The phase difference between primary voltage and secondary, homologous, is in the clock-hour figures of the vector group 6.

II. THEORETICAL ASPECTS FOR THE CLOCK-HOUR FIGURE IDENTIFICATION

The clock-hour figure of the vector group of a power transformer can be expressed by a mathematical model [1], [2], represented as appropriate, by a code matrix or by a code equation given as:

$$\boldsymbol{G_i} = \begin{pmatrix} \eta_{11} & \eta_{12} & \eta_{13} \\ \eta_{21} & \eta_{22} & \eta_{23} \\ \eta_{31} & \eta_{32} & \eta_{33} \end{pmatrix}, \quad (1)$$

$$\boldsymbol{G_i} = \begin{pmatrix} \boldsymbol{sgnT_a} & \boldsymbol{sgnT_b} & \boldsymbol{sgnT_c} \end{pmatrix} \cdot \begin{pmatrix} \boldsymbol{M_{100}} \\ \boldsymbol{M_{10}} \\ \boldsymbol{M_1} \end{pmatrix}, \quad (2)$$

where η_{jk} designate the electrical signals, which according to the polarity, are denoted by „0", „1" or „-1"; M_{100}, M_{10}, and M_1 represent the matrices of following configuration.

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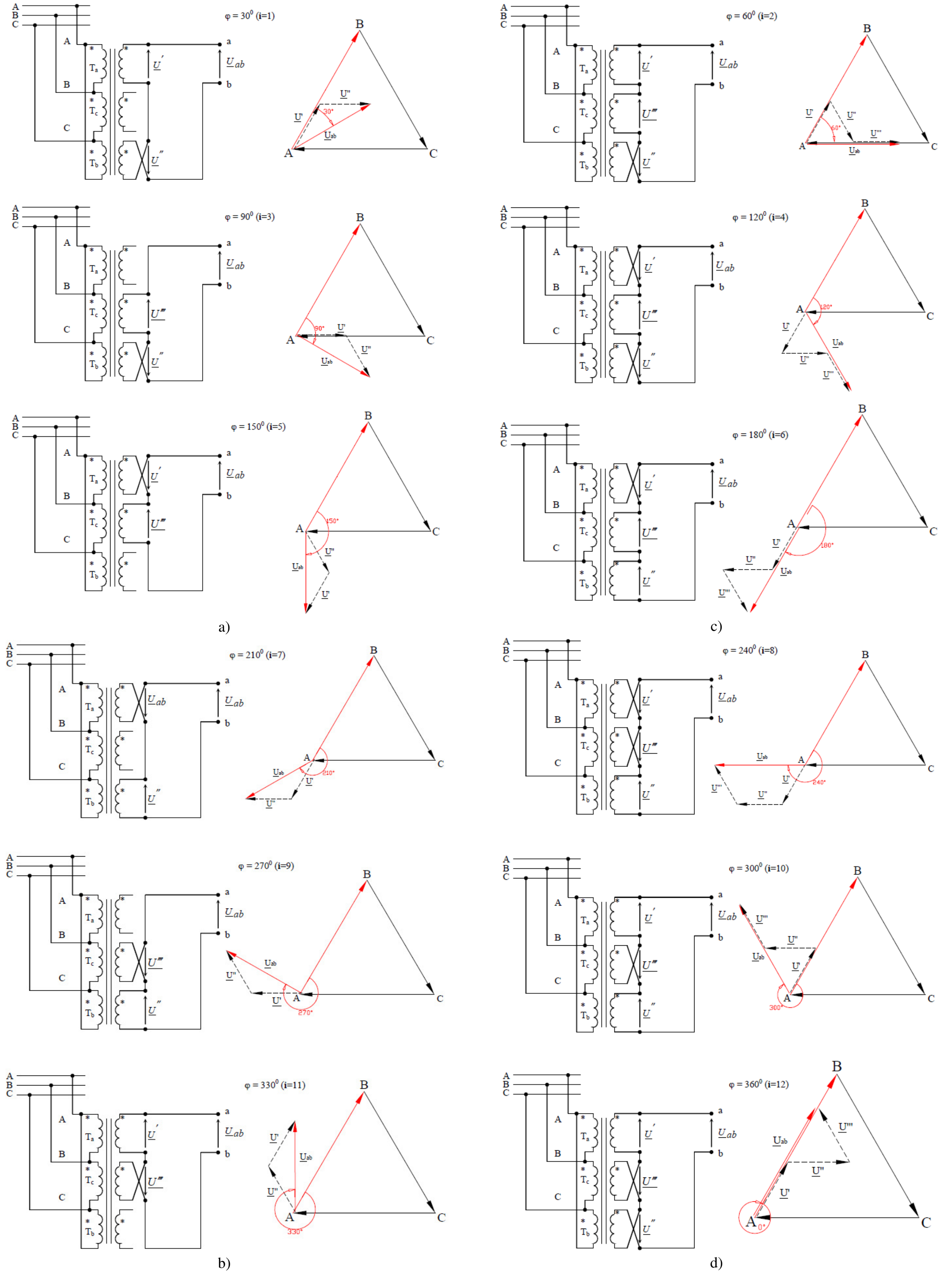

Fig. 2. The wiring diagrams for the transformer group, for 12 clocks hour-figure of the vector group: a-the clocks hour-figure of the vector group: 1, 3 and 5; b-the clocks hour-figure of the vector group: 7, 9 and 11; c-the clocks hour-figure of the vector group: 2, 4 and 6; d-the clocks hour-figure of the vector group: 8, 10 and 12.

$$M_{100}=\begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}, M_{10}=\begin{pmatrix}0&1&0\\0&0&1\\1&0&0\end{pmatrix}, M_{1}=\begin{pmatrix}0&0&1\\1&0&0\\0&1&0\end{pmatrix}. \quad (3)$$

In (2), $sgn\ T = 1$, when the transformer T does not reverse the polarity pulse applied to the input, $sgn\ T$=-1, when the transformer T reverses the polarity pulse applied to the input and, $sgn\ T$=0, when the transformer T blocks the transmission of the pulse applied to the input.

The smaller equivalent schemes and the phase diagrams, corresponding to the possible 12 clock-hour figures of the vector group, are shown in Fig. 2. Based on these findings, it is concluded that, any three-phased transformer may be represented by a modelling scheme, consisting of nine transformers with a single-phase, connected properly [1], [2], [7].

The conclusion that the phase difference φ, which corresponds to a clock-hour figure of the vector group, can be obtained by a simplified scheme, consisting only of three transformers, equivalent with one of the outputs **ab**, **bc**, **ca**, can be reached by complete equivalent diagram mentioned above (extended – Fig. 3).

In [1] the author explains how the wiring diagrams for the transformers were obtained.

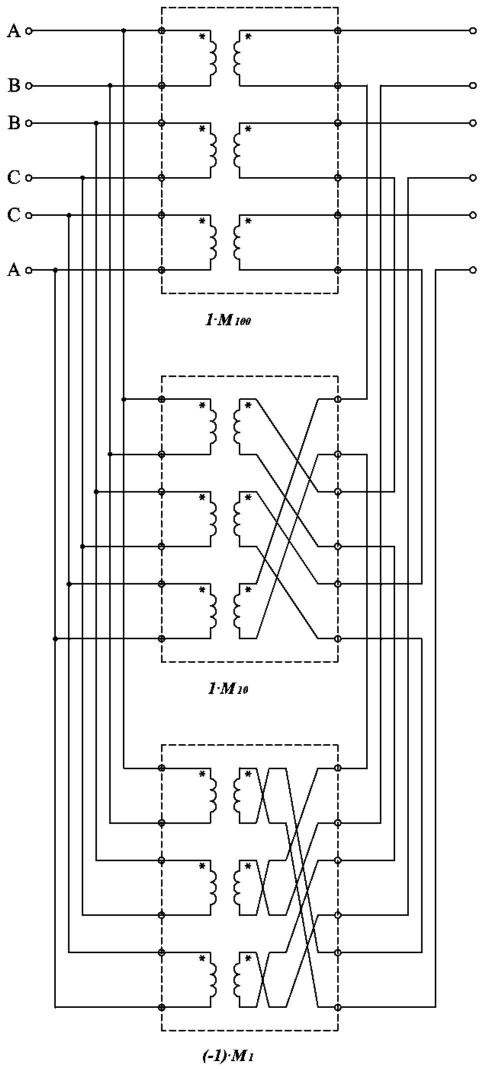

Fig. 3. The explanatory diagram (extended) for modelling of the code matrix associated to the clock-hour figure of the vector group i=10.

III. CONTRIBUTIONS TO THE OSCILLOSCOPIC METHOD PRINCIPLE

Considering a multiple switch with 12 positions and multiple sections, which makes all the 12 schemes, presented in the Fig. 2, it is possible to obtain, at the output, a voltage which has a different phase from the supply voltage of the transformer group, with an angle φ. This angle corresponds, depending on the position of the switch, to one of the 12 possible clock-hour figures of the vector group.

In Fig. 4 we present a schematic diagram of a device in order to identify the clock-hour figure of the vector group, for a three-phased transformer [3]. This is designed based on the oscilloscopic method principles and no less important on the compensation method principles.

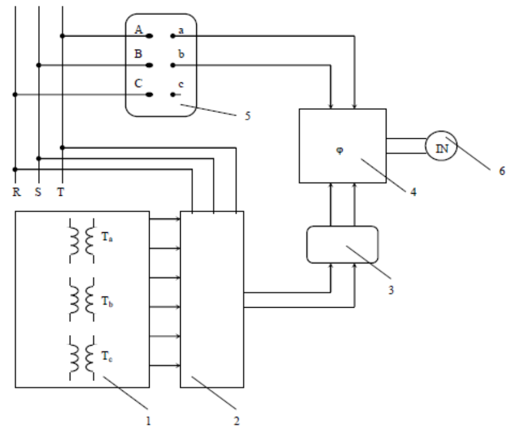

Fig. 4. The schematic diagram of the device proposed for patenting [2]. 1 – group transformers; 2 – switch; 3 – voltage adaptor; 4 – phase discriminator; 5 – tested transformer; 6 – null indicator.

The device for identifying the clock-hour figure of the vector group, for the three-phase transformer (Fig. 4 and Fig. 5) consists mainly of group transformers 1, composed on three single-phase transformers T_a, T_b, T_c.

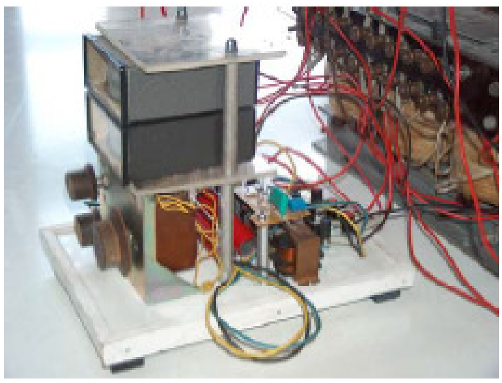

Fig. 5. Device for identifying the clock-hour figure of the vector group for the three-phase transformer – side view.

The transformer connections are modified using a switch with 12 positions and several sections. The phase equilibrium of the tensions obtained at the switch output (2) and, at the homologous terminals of the tested transformer 5, is compared with a phase discriminator 4 and a null indicator 6.

In another version, the device for identifying the clock-hour figure of the vector group for a three-phase transformer can be made by replacing the phase discriminator mentioned above, by a two-channel oscilloscope. If, when we start the experiment, the two compared voltages are not in phase (Fig. 6), we will have to successively modify the switch position, until the two oscillograms overlap (Fig. 7).

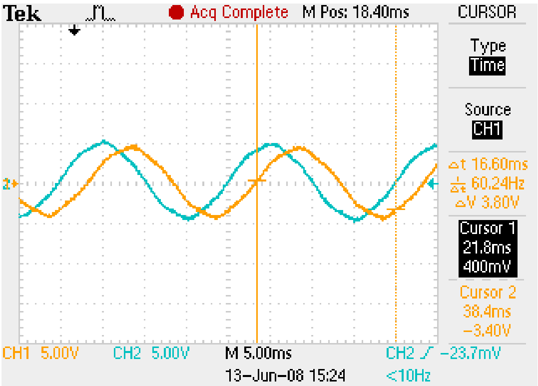

Fig. 6. The image on the oscilloscope screen, when the compared voltages are not in phase.

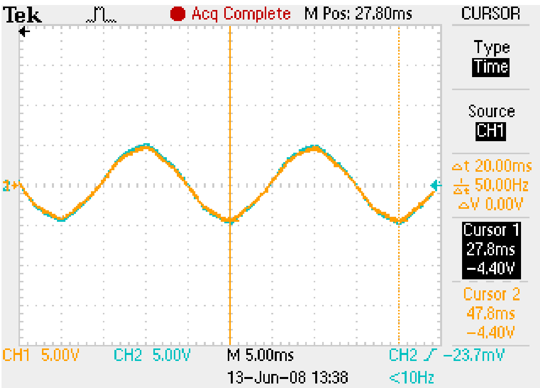

Fig. 7. The image on the oscilloscope screen, corresponding to the searched clock-hour figure of the vector group.

In the mentioned situation, the number indicated on the knob switch with 12 positions, represents the searched clock-hour figure of the vector group. The installation used to investigate this version is presented in Fig. 8.

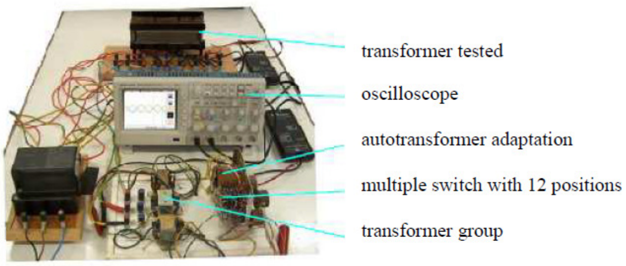

Fig. 8. Device solution for identifying the clock-hour figure of the vector group for a three-phase transformer.

This installation is achieved, as can be seen in Fig. 8, in a group transformer, a transformer verified, a multiple switch with 12 positions and an oscilloscope, necessary to compare the waveforms of the voltages from those two transformers.

IV. CONCLUSIONS

The solution presented in this paper leads to a considerable simplification of the oscilloscopic method, which, although bears the name used in the literature, does not use an oscilloscope, considered expensive and complicated.

By using the proposed solutions we obtain a higher precision of the measurements, limiting the risk of errors, which can occur in case of small phase displacements. Obviously, the risk of error increases when the two curves of checked voltage have different variation laws.

Another important aspect refers to easily accessible and low-cost components, used to achieve the described installations.

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