The Contribution Concerning the Algebra Applications of Trivalent Elements in the Study of Possibilities for Modifying the Clock Hour Figure to the Connection Group

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Abstract **– This paper presents a study over the clock hour figure mathematical model identified through the direct current supply method. In these paper, for the identification of the clock hour figure resulted from the modification of the transformer main windings shape, it is proposed the clock hour figure mathematical model solution.**

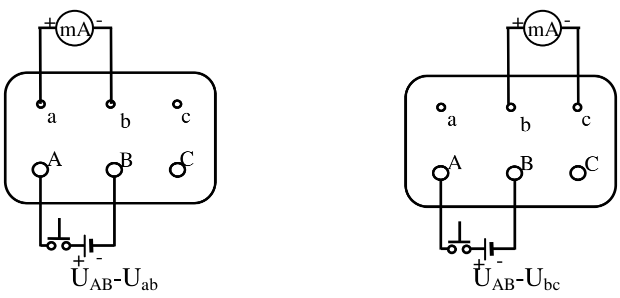
Keywords **– clock hour figure, code matrix, trivalent element, connection group, transformer.**

I. INTRODUCTION

One of the most used methods to identify the vector group clock hour figure is the “direct current supply method”. Its application involves the usage of a direct current source, a switch and a magneto electric apparatus, preferably with “0” on the middle of the scale. The direct current source is connected through a switch at the terminal couple of the verified transformer, while for each position of the power supply, the apparatus is connected successively at the terminal couple of the other winding, always respecting specific polarity.

The direct current source is placed on the high voltage winding and is connected successively to terminals couple AB, BC, CA, while for each source position the magneto electric apparatus is connected successively to terminals couple ab, bc, ca, with “+” terminal to a, b respectively c. This is justified by the need to limit the impulse range, in the case of a transformer having a high ratio of the windings.

The connecting diagram of “direct current method” for all nine successive measurements is shown in Fig. 1:



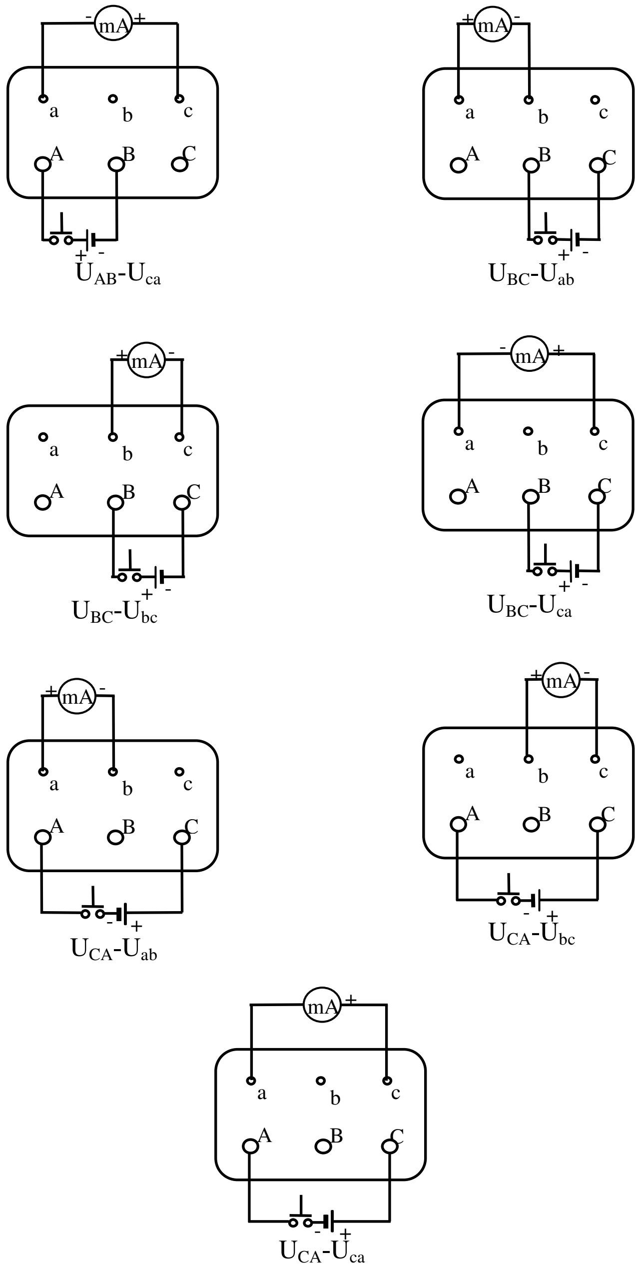


Fig. 1 Measurement succession for to determine the clock hour figure

Initially the signals that compose the clock hour figure code has been marked with: (+) when the indicator needle shift to right; with (-) when the indicator needle shift to left; with 0 when the indicator needle remains immobile or is shift just a few. With that coding the numerical applications are excluded; to make that possible, mathematically, the current or voltage pulse polarity can be configured by the function sgn as follows:

$$\operatorname{sgn} a_{ij} = \frac{a_{ij}}{|a_{ij}|}; \quad (1)$$

$$\operatorname{sgn} a_{ij} = \begin{cases} 1 & where \quad a_{ij} > 0; \\ -1 & where \quad a_{ij} < 0; \\ 0 & where \quad a_{ij} = 0. \end{cases} \quad (2)$$

The matrix code chart associated to the clock hour figure has the form:

$$G_i = \begin{pmatrix} \eta_{11} & \eta_{12} & \eta_{13} \\ \eta_{21} & \eta_{22} & \eta_{23} \\ \eta_{31} & \eta_{32} & \eta_{33} \end{pmatrix} \quad (3)$$

Using the mentioned simulation can be made the following modification: the signal (+) became (1); signal (-) because (-1) and the signal 0 remains unchanged. The matrix code chart for twelve connection types are presented below:

$$G_1 = \begin{Vmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{Vmatrix}; \quad G_2 = \begin{Vmatrix} 1 & -1 & 1 \\ 1 & 1 & -1 \\ -1 & 1 & 1 \end{Vmatrix};$$

$$G_3 = \begin{Vmatrix} 0 & -1 & 1 \\ 1 & 0 & -1 \\ -1 & 1 & 0 \end{Vmatrix}; \quad G_4 = \begin{Vmatrix} -1 & -1 & 1 \\ 1 & -1 & -1 \\ -1 & 1 & -1 \end{Vmatrix};$$

$$G_5 = \begin{Vmatrix} -1 & 0 & 1 \\ 1 & -1 & 0 \\ 0 & 1 & -1 \end{Vmatrix}; \quad G_6 = \begin{Vmatrix} -1 & 1 & 1 \\ 1 & -1 & 1 \\ 1 & 1 & -1 \end{Vmatrix}; \quad (4)$$

$$G_7 = \begin{Vmatrix} -1 & 1 & 0 \\ 0 & -1 & 1 \\ 1 & 0 & -1 \end{Vmatrix}; \quad G_8 = \begin{Vmatrix} -1 & 1 & -1 \\ -1 & -1 & 1 \\ 1 & -1 & -1 \end{Vmatrix};$$

$$G_9 = \begin{Vmatrix} 0 & 1 & -1 \\ -1 & 0 & 1 \\ 1 & -1 & 0 \end{Vmatrix}; \quad G_{10} = \begin{Vmatrix} 1 & 1 & -1 \\ -1 & 1 & 1 \\ 1 & -1 & 1 \end{Vmatrix};$$

$$G_{11} = \begin{Vmatrix} 1 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & -1 & 1 \end{Vmatrix}; \quad G_{12} = \begin{Vmatrix} 1 & -1 & -1 \\ -1 & 1 & -1 \\ -1 & -1 & 1 \end{Vmatrix}.$$

II. CONTRIBUTION CONCERNING THE CODE MATRIX SIMULATION WITH TRIVALENT ELEMENTS ALGEBRA

Knowing the vector group of the electrical three-phase transformers is very important, especially when the transformers are going to function in the same time. Checking the transformers vector group is necessary for setting up the transformer or after any check or repair.

The code matrix reflects with accuracy the modification accomplished over the rotary-current transformer connection diagram.

To obtain a relatively new mathematical model, every indication of the milliampermeter is coded through the instrumentality of trivalent elements as follows:
2 – when the needle indicator indication is in the measure direction:
1 – when needle move opposite the indicator measuring;
0 – for the needle indicator immobility.

The matrix code chart is obtained for the twelve groups of connection:

$$G_1 = \begin{Vmatrix} 2 & 1 & 0 \\ 0 & 2 & 1 \\ 1 & 0 & 2 \end{Vmatrix}; \quad G_2 = \begin{Vmatrix} 2 & 1 & 2 \\ 2 & 2 & 1 \\ 1 & 2 & 2 \end{Vmatrix};$$

$$G_3 = \begin{Vmatrix} 0 & 1 & 2 \\ 2 & 0 & 1 \\ 1 & 2 & 0 \end{Vmatrix}; \quad G_4 = \begin{Vmatrix} 1 & 1 & 2 \\ 2 & 1 & 1 \\ 1 & 2 & 1 \end{Vmatrix};$$

$$G_5 = \begin{Vmatrix} 1 & 0 & 2 \\ 2 & 1 & 0 \\ 0 & 2 & 1 \end{Vmatrix}; \quad G_6 = \begin{Vmatrix} 1 & 2 & 2 \\ 2 & 1 & 2 \\ 2 & 2 & 1 \end{Vmatrix}; \quad (5)$$

$$G_7 = \begin{Vmatrix} 1 & 2 & 0 \\ 0 & 1 & 2 \\ 2 & 0 & 1 \end{Vmatrix}; \quad G_8 = \begin{Vmatrix} 1 & 2 & 1 \\ 1 & 1 & 2 \\ 2 & 1 & 1 \end{Vmatrix};$$

$$G_9 = \begin{Vmatrix} 0 & 2 & 1 \\ 1 & 0 & 2 \\ 2 & 1 & 0 \end{Vmatrix}; \quad G_{10} = \begin{Vmatrix} 2 & 2 & 1 \\ 1 & 2 & 2 \\ 2 & 1 & 2 \end{Vmatrix};$$

$$G_{11} = \begin{Vmatrix} 2 & 0 & 1 \\ 1 & 2 & 0 \\ 0 & 1 & 2 \end{Vmatrix}; \quad G_{12} = \begin{Vmatrix} 2 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 2 \end{Vmatrix}.$$

To change the connection group clock hour figure transformer are known the following solutions:

- reversal the beginning with the end or the end or the reverse direction for the phase winding wrapping (in primary or secondary);
- the triangle conversion from N in Z or inverse;
- the circular permutation of connection between windings and terminal;
- the circular permutation of the terminals notation;
- the conversion between them of two terminal connection at the primary winding and secondary winding;

- the conversion between them of two terminal connection at the primary and secondary winding.

The study of the technical literature [8, 11] shows us that throughout the circular permutation of a rotary-current transformer's jams we get a change of the clock hour figure of ± 4 hour, which can be emphasized using the code matrix whose columns and rows will be permuted in the same direction with the permutation done in the transformers circuit connection, we will determine the resulting clock hour figure.

For example, the clock hour figure that resulted at the end of the direct circular permutation of the high – tension winding's jams can be determined through the rows circular permutation in a straight direction.

$$G_i = \begin{pmatrix} \eta_{11} & \eta_{12} & \eta_{13} \\ \eta_{21} & \eta_{22} & \eta_{23} \\ \eta_{31} & \eta_{32} & \eta_{33} \end{pmatrix} \Rightarrow \begin{pmatrix} \eta_{31} & \eta_{32} & \eta_{33} \\ \eta_{11} & \eta_{12} & \eta_{13} \\ \eta_{21} & \eta_{22} & \eta_{23} \end{pmatrix} = G_{i+4} \tag{6}$$

The same will happen in the case of the opposed permutation.

The circular permutation of the columns in a straight direction will lead to a code matrix, which represents the same clock hour figure measured on a transformer, which has been modified as a result of a direct circular permutation of the low tension's jams.

$$G_i = \begin{pmatrix} \eta_{11} & \eta_{12} & \eta_{13} \\ \eta_{21} & \eta_{22} & \eta_{23} \\ \eta_{31} & \eta_{32} & \eta_{33} \end{pmatrix} \Rightarrow \begin{pmatrix} \eta_{13} & \eta_{11} & \eta_{12} \\ \eta_{23} & \eta_{21} & \eta_{22} \\ \eta_{33} & \eta_{31} & \eta_{32} \end{pmatrix} = G_{i-4} \tag{7}$$

The columns circular permutation, in a reverse direction, will lead to a code matrix analogically obtained as above. The reverse of two terminals of one of the windings or the terminal plate's bindings or the terminals symbol inversion will be reflected through the change of the code matrix's configuration. These inversions will determine a switch corresponding between two rows of the code matrix, followed by the switch corresponding between two columns, just as it is presented in the following example:

$$G_i = \begin{pmatrix} \eta_{11} & \eta_{12} & \eta_{13} \\ \eta_{21} & \eta_{22} & \eta_{23} \\ \eta_{31} & \eta_{32} & \eta_{33} \end{pmatrix} \Rightarrow$$

$$\begin{pmatrix} \eta_{21} & \eta_{22} & \eta_{23} \\ \eta_{11} & \eta_{12} & \eta_{13} \\ \eta_{31} & \eta_{32} & \eta_{33} \end{pmatrix} \Rightarrow \begin{pmatrix} \eta_{23} & \eta_{22} & \eta_{21} \\ \eta_{13} & \eta_{12} & \eta_{11} \\ \eta_{33} & \eta_{32} & \eta_{31} \end{pmatrix} \tag{8}$$

In consequence, it is possible to obtain the clock hour figure of a transformer that is modified in the manner that is described, using only the code matrix. The alteration upon the matrix will be enough, and the resulting matrix expresses the clock hour figure obtained as a result of the alteration.

The matrix code chart study reveals the possibility of decomposition in three elementary matrixes.

$$G_i = M_a + M_b + M_c$$

where the three elementary matrix are expressed under the following form.

$$M_a = \begin{pmatrix} \eta_{11} & 0 & 0 \\ 0 & \eta_{22} & 0 \\ 0 & 0 & \eta_{33} \end{pmatrix}$$

$$M_b = \begin{pmatrix} 0 & \eta_{12} & 0 \\ 0 & 0 & \eta_{23} \\ \eta_{31} & 0 & 0 \end{pmatrix} \tag{9}$$

$$M_c = \begin{pmatrix} 0 & 0 & \eta_{13} \\ \eta_{21} & 0 & 0 \\ 0 & \eta_{32} & 0 \end{pmatrix}$$

where: - M_a can be expressed:

$$M_a = 2 \cdot M_{100} \qquad M_a = 1 \cdot M_{100} \qquad M_a = 0 \cdot M_{100} \tag{10}$$

$$M_{100} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

- M_b can be written through:

$$M_b = 2 \cdot M_{10} \qquad M_b = 1 \cdot M_{10} \qquad M_b = 0 \cdot M_{10} \tag{11}$$

$$M_{10} = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{pmatrix}$$

- M_c can be expressed through:

$$M_c = 2 \cdot M_1 \qquad M_c = 1 \cdot M_1 \qquad M_c = 0 \cdot M_1 \tag{12}$$

$$M_1 = \begin{pmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{pmatrix}$$

Following the clock hour figure mathematical model can be expressed through a relation like:

$$G_i = \begin{pmatrix} KT_a & KT_b & KT_c \end{pmatrix} \cdot \begin{pmatrix} M_{100} \\ M_{10} \\ M_1 \end{pmatrix} \tag{13}$$

where: KT_a, KT_b, KT_c – are trivalent constants with value 0, 1 or 2.

It is preferred this decomposition because the M_a, M_b, M_c matrix preserve the general properties of the code matrix:

- the elements that are placed on the principal diagonal and the elements that are placed on the parallel directions with the principal diagonal are always equal:

- the elements of a row or a column results through a circular permutation of the preceding row or column.

III. CONCLUSION

The study of clock hour figure verification shows that the trivalent element usage offer the possibility of clock hour figure display for all the variants presented in the preamble.

The elaboration of a mathematical matrix model was possible through the exploitation of the experimental results offered by the supplying with direct current method. The research that was carried out shows that between a transformer's diagram of connections and the code matrix's configuration there is a well established connection it is showed that the terminals and the matrix's rows correspond to the high – tension windings of the terminals, and the matrix's columns correspond to the terminals low tension windings.

The code matrix study emphasizes some remarkable properties, the most important being related to the fact that a row's elements or a column's elements results from the preceding row or columns, after a direct circular permutation upon its elements.

The research carried out shows that any alteration on the diagram of connections of the transformer is reflected on the change of the code matrix can be used to identify some major flaws, represented by breaks in the circuit's diagram of connections or by short – circuits that appear in the phase windings the transformer.

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