DEVELOPMENT OF A DIGITAL ELECTRONIC TRANSFORMER TURN RATIO (TTR)

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Abstract: This work describes a digital instrument for measuring the transform ratio of three-phase and single-phase transformers. The operation technique allows to perform the test simultaneously in coils of the same tap. As the instrument is controlled by computer, the tests are made quickly, requiring only that the operator makes the commutation of the taps. Nowadays this instrument is being used by some manufactures of transformers, with quite satisfactory results.
Key-Words: Digital measurement, Transformer, Tests.

1 Introduction

Nowadays it is very laborious in industry to make the tests in order to obtain the transform ratio of the transformers. The mechanical instrument (Conventional Transformer Turn Ratio – TTR) demands a repetitive and exhaustive work.

So as objective to make more easy the tests, a digital electronic equipment based on microcomputer has been developed to ensure reliability, feasibility, efficiency and speed in the tests.

Three cables are connected to the low voltage terminals (X_1, X_2, X_3) and other three ones are connected to the high voltage terminals (H_1, H_2, H_3).

The other extremity of these cables is connected to the electronic equipment; the test is then automatically made and it is only necessary to make the manual tap commutation.

2 Used Method

The operation principle consists in applying a reduced voltage of approximately 7 [V] in each low voltage winding and measuring the induced voltage in the corresponding high voltage winding. The instrument has relays that are connected in an adequate way according to the windings which will be measured.

Figure 1 shows the basic diagram of the developed instrument.

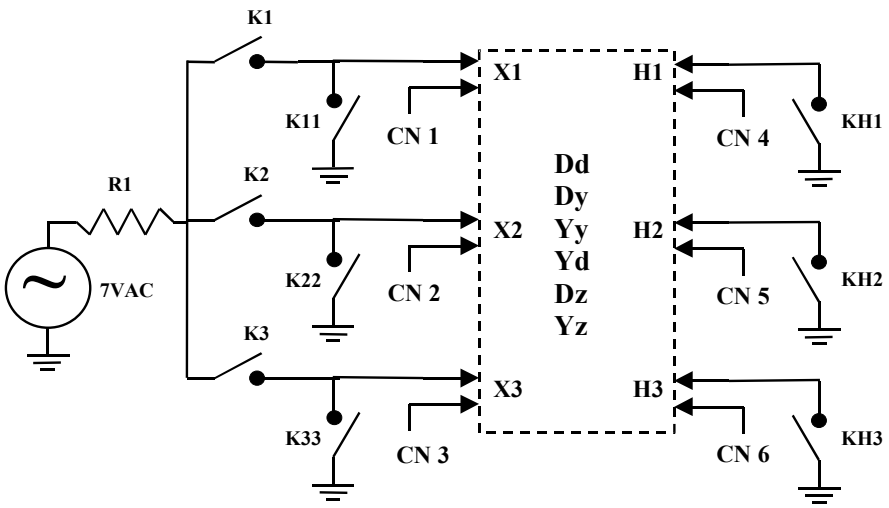

Fig. 1 – Basic diagram

Where:
R_1 – current limiting resistor in the case of short-circuit;
K_1, K_2, K_3, K_{11}, K_{22}, K_{33}, KH_1, KH_2, KH_3 – Relays
Channel 1 to 6: Analogical channels of the data acquisition card.

Figure 2 shows the delta/star (30^o) Dy1 transformer.

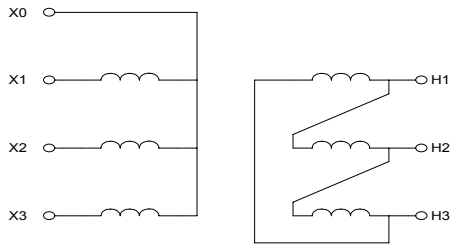

Fig.2 – Delta/star transformer Dy 1

The relays K_1, K_{22}, KH_2, KH_3 must be closed to measure the transform-ratio (TR) of the phase H_1/X_1. So the voltage source is applied to the winding X_1 in series with X_2.The relays KH_2 and KH_3 are closed, so there is no induction in the winding H_3 and X_3. The measured voltage in X_3 is the same as the X_0 measured value. By making the voltage reading of all terminals the (TR) is then obtained as follows:

$$H_1/X_1 = \frac{UH_1 - UH_3}{UX_1 - UX_3} \qquad (1)$$

For the phases H_2/X_2 the relays K_2, K_{33}, KH_1 and KH_3 are closed, so:

$$H_2/X_2 = \frac{UH_2 - UH_1}{UX_2 - UX_1} \qquad (2)$$

For the phases H_3/X_3 the relays H_3, H_{11}, KH_1 and KH_2 are closed, results:

$$H_3/X_3 = \frac{UH_3 - UH_2}{UX_3 - UX_2} \qquad (3)$$

3 Obtained Precision

The instrument is able to make tests in transformers for (T.R) in the range 30 to 300. The maximum obtained error has been about 0.15%.

This precision is typical of the conventional mechanical TTR instrument.

4 Conclusion

By properly switching the relays it is possible to obtain the (TR) for several transformer connections, such as:

- Single phase transformers;
- Three phase transformers which include: Dd; DY_1; DZ_0; DZ_6; Yy; Yd_1; YZ_1; YZ_{11}; where:
  - Dd - Delta/delta (0^o);
  - DY_1 - Delta/star (30^o);
  - DZ_0 - Delta/zig-zag (0^o);
  - DZ_6 - Delta/zig-zag (180^o);
  - Yy - Star/star (0^o);
  - Yd_1 - Star/delta (30^o);
  - YZ_1 - Star/zig-zag (30^o);
  - YZ_{11} - Star/zig-zag (330^o).

The instrument is controlled by using a microcomputer, so the implementation of the described method and its use in the tests is very simple and efficient. Besides, the obtained values are stored in the microcomputer, allowing the use of such values in an important program (Trans 4) that makes the calculation and printing of all transformer routine tests.

The equipment does also a fault diagnosis, such as:

- Open tap's, error more than 0.5 %, tap's in short circuit, polarity inversion.

At the present other tests, such as winding resistance measurement and temperature elevation are being implemented in laboratory.

The used programming language in Trans 4 program, has been Pascal. Nowadays this program has about thirty thousand programming lines. The developed equipment uses a simple Z 80 microprocessor, programmed in Assembly language, which commands the relays and makes the RMS voltage determination, processing 128 samples in the period. The (TR) is then obtained using the expressions (1),(2), (3).

Actually the developed equipment is being used by about ninety per cent of the Brazilian manufactures of distribution transformers.

References:

[1] – Brazilian Association of Technical Notes - *NBR5380 and NBR5356*;

[2] – James Bidle Co - USA – TTR User Manual – *Transformer Turn Ratio Test Set*;

[3] – TRIEL - Brazil – Specialized Electrical Equipment *TR 00 / Operating Manual*.

APPENDIX

Figures 3 and 4 show the developed equipment in test.

Fig. 3 – Developed equipment

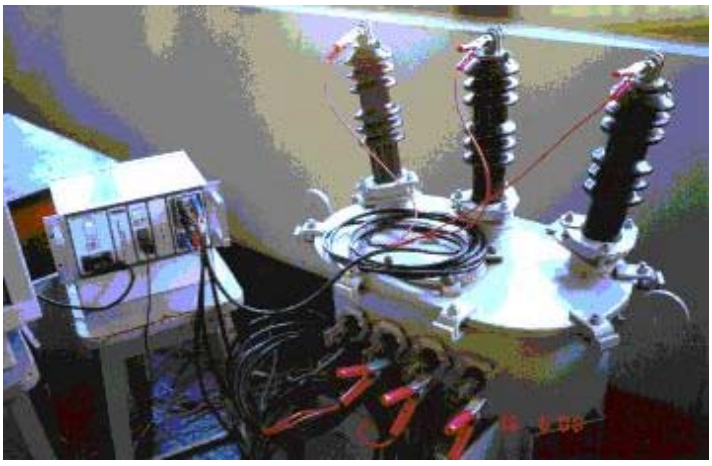

Fig. 4– Tested transformer connected to the equipment