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# Test Methods For Current Transformers For Protection With Low Residual Magnetization Intended For Operation Under Transient Short-Circuit Conditions.

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***Abstract****- This article discusses changes in the parameters of current transformers in the magnetization processes. Also analyzed are the cases of dependence of transient processes on magnetization, capacitance and inductance in the current transformer.*

**Keywords:** current transformer, magnetization coefficient, voltage regulator, flux linkage, charger, magnetization inductance.

**Introduction**

Before measuring the characteristics of the current transformer windings must be demagnetized. It is allowed to check the characteristics by other methods that should be set in the standards for specific types of transformers, if during tests of qualification, type or for the purpose of type approval, it is proved that this method provides results that do not differ by more than 10 %.

Determination of the residual magnetization coefficient $K_r$ is performed by the method of discharge of the capacitor to the secondary winding of the current transformer with the primary winding open. The test procedure is shown in figure . 1.

The contour parameters are selected so that the frequency of the oscillating process in the L – C contour differs from the nominal frequency by no more than ±10 %.

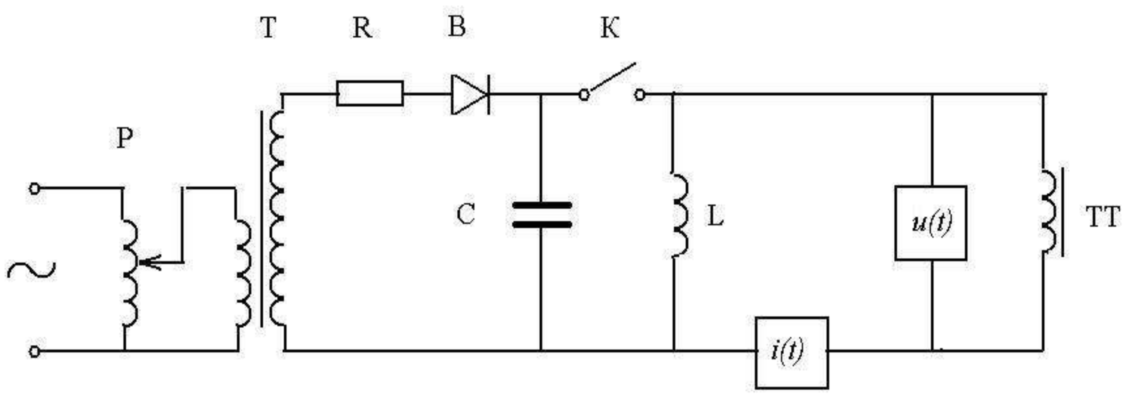


**Figure 1.** Scheme for determining the residual magnetization by the capacitor discharge method.

There are P-voltage regulator, T-charging transformer, R-charging resistor, C-capacitor, L-adjusting (discharge) inductance, TT-tested current transformer, u( t), i(t) – current and voltage registration devices, B - rectifier, K - switching device (key).

The capacitor C is charged from the charging transformer T to the voltage required to saturate the test current transformer TT. After that, the key K is closed and the capacitor C is discharged to the secondary winding of the test current transformer TT and the discharge inductance L (may be absent). The values of the current through the secondary winding i(t) and the voltage drop at its terminals u(t) are recorded by a digital oscilloscope.

The degree of saturation is considered sufficient if the amplitude coefficient of this half-wave (the ratio of the amplitude value to the RMS value) is at least 2.5.

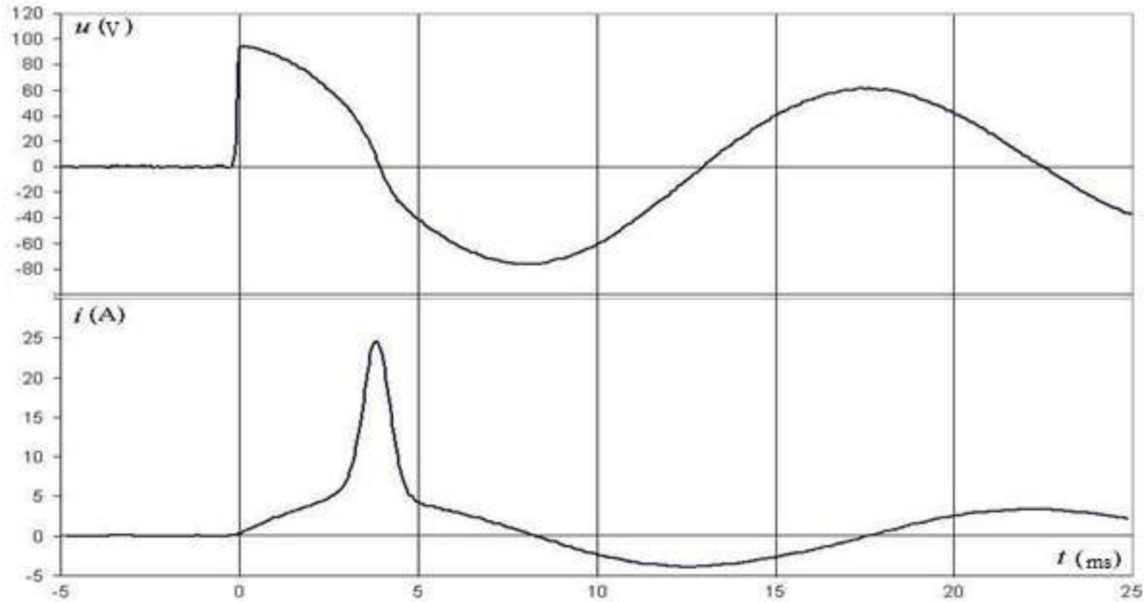


**Figure 2.** Characteristic waveform using the capacitor discharge method.

Flux linkage is calculated using the formula:

$$\Psi(t)=\int_0^t (u(t)-R_2 i(t))\,dt, \quad (1)$$

$R_2$ - DC resistance of the secondary winding.
*u(t)* and *i(t)* are instantaneous values of voltage and current that are oscillographed in the experiment.

The dependence of the flux linkage $\Psi(t)$ determined by formula 1 on the current $i(t)$ graphically represents a part of the hysteresis loop (figure. 3). The value of the residual flux linkage $\Psi_r$ is calculated at the moment when, after the flux linkage reaches the saturation value $\Psi_{sat}$, the current becomes zero. $\Psi_{sat}$ are detected at the maximum instantaneous current value.


**Figure 3.** Part of the hysteresis loop reproduced by the capacitor discharge method

The residual magnetization coefficient is defined as:

$$K_r = \frac{\Psi_r}{\Psi_{sat}} 100\ \%, \quad (2.)$$

**Determination of the magnetization inductance $L_m$ and the time constant $T_C$.**

The magnetization inductance $L_m$ is defined as the ratio of $\Delta\Psi$ to $\Delta i$ on a section of the magnetization curve that, with a sufficient approximation, can be considered linear (figure 4.)

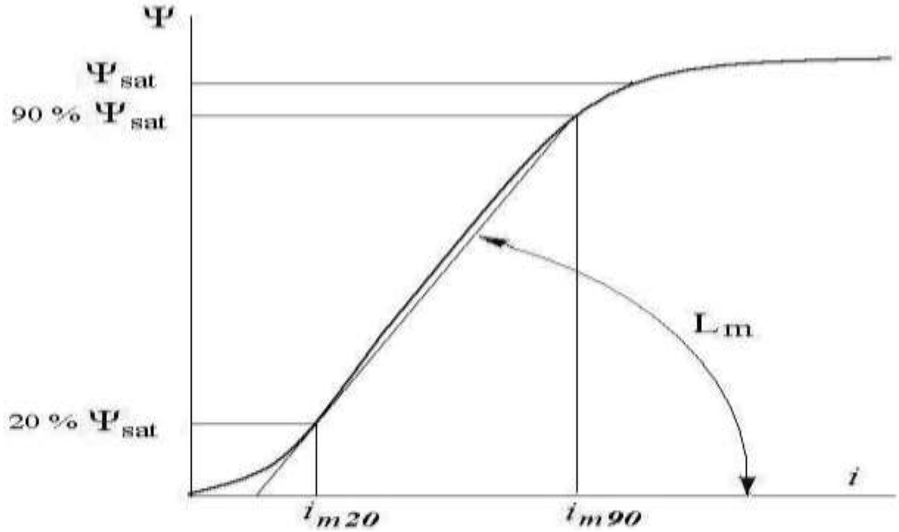


**Figure 4.** Determination of the magnetization inductance

As the boundaries of this section, the values of 20% and 90% of the flux linkage $\Psi_{sat}$ are taken, corresponding to the magnetization voltage $U_{mag.volt}$.

The magnetization inductance is assumed to be equal:

$$L_m = \frac{0{,}9 \cdot \Psi_{sat} - 0{,}2 \cdot \Psi_{sat}}{i_{m\max 90} - i_{m\max 20}} = \frac{0{,}9 \cdot U_{mag.volt} - 0{,}2 \cdot U_{cal.volt.}}{\omega \cdot (I_{m90} - I_{m20})}, (3)$$

where $I_{m90}$ and $I_{m20}$ are the effective values of the currents measured at voltages equal to 90 % and 20% of the voltage $U_{cal..volt}$ calculation, respectively; $i_{mmax\ 90}$ and $i_{mmax20}$ are their amplitude values.

The time constant of the secondary circuit is defined as the ratio of the magnetization inductance to the active resistance of the secondary circuit:

$$T_S = \frac{L_m}{R_S}, \quad (4.)$$

where:

- $L_m$ - magnetization inductance calculated by the formula (3);

- $R_s$ - resistance secondary circuit of the DC;

$$R_s = R_2 + Z_{2lvw.} \cdot cos\varphi_2 \quad ,(5)$$

$R_s$ - resistance of the secondary winding to direct current, reduced to the temperature at which the magnetization currents are measured, Ohms;

**Determination of error in transient short-circuit mode**

A power frequency current is passed through the primary winding. The rated load must be connected to the secondary winding. The effective value of the periodic component of the test primary current must be within:

$$I_{1test} = (1{,}0 \div 1{,}05) \cdot I_{1nom} \cdot K_{nom}. \quad (6)$$

Регистрируется мгновенная величина тока погрешности:

The instantaneous value of the error current is recorded:

$$i_\varepsilon = n_{nom} \cdot i_2 - i_1 \quad , (7)$$

The absolute error of measuring the error current must not exceed 10 % of the margin of error corresponding to the class of transformer being tested.

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