CURRENT-TRANSFORMER TESTING WITH CPC 100

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ABSTRACT

This paper describes main problems of current-transformers measuring. There is description of parameters, which specifies an accuracy class of CT and also the method for determination of those parameters according to standard IEC 600044-1 (ČSN EN 600044-1) by a measuring system CPC 100. In the end, measured results are compared with CT nominal parameters.

1. INTRODUCTION

The instrument transformers or the current transformers (CT) are devices, whose primary current corresponds to secondary current and phases shifting of secondary current are inconsiderable in comparison with shifting of primary current. Its mechanical design brings about distortion of secondary current and its bad function. Reason of this incorrect function is its ferromagnetic circuit. To be able to use CT properly with respect of error in measurement, we have to know its rated transformation ratio, accuracy class and parameters of transformer magnetization curve (knee point, instrument security number).

2. THE MEASUREMENT OF ACCURACY CLASS

One of the transformer characteristic is that its primary current I_p is independent on burden value Z_b which makes it different from secondary current I_s. Relationship between primary and secondary currents is defined by nominal ratio K_n. This nominal ratio is always defined as rate of rated primary current I_{pn} and rated secondary current I_{sn}.

$$K_n = I_{pn} / I_{sn} \quad \text{e.g. } K_n = 100/5 \text{ A} \tag{1}$$

Figure 1. shows the equivalent circuit of the transformer. From this circuit is evident that CT is weight down by error which is made by magnetic current i_e. Value of error is specified as difference between rated transformation ratio and actual transformation ratio. The current error (ratio error) [1] is expressed in percentage by equation (2).

$$\varepsilon_i = \frac{\left(K_n \cdot I_s - I_p\right) \cdot 100}{I_p} \tag{2}$$

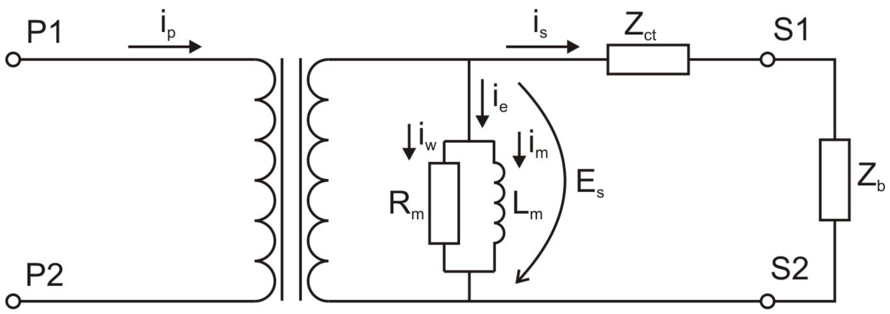

Figure 1: *Equivalent circuit of current transformer.*

The standard IEC 60044-1 (ČSN EN 60044-1) [1] defines the phase displacement δ_i in a similar way as current error. This is difference in vectors of primary and secondary currents and is supposed to be positive if the vector of secondary current is overtaking the vector of primary current[1]. Orientation of those vectors is defined as for an ideal transformer where is zero phase displacement.

The standard defines accuracy class of measuring and protective current transformer, which specifies maximum errors. The errors correspond to rated current in percentage. The maximum current and phase errors are shown at the Table 1 and Table 2 [1].

Třída přesnosti	± Chyba proudu (poměr) v procentech jmenovitého proudu uvedeného v následujícím řádku				± Chyba úhlu v procentech jmenovitého proudu uvedeného v následujícím řádku							
					Minuty				Centiradiány			
	5	20	100	120	5	20	100	120	5	20	100	120
0,1	0,4	0,2	0,1	0,1	15	8	5	5	0,45	0,24	0,15	0,1
0,2	0,75	0,35	0,2	0,2	30	15	10	10	0,9	0,45	0,3	0,3
0,5	1,5	0,75	0,5	0,5	90	45	30	30	2,7	1,35	0,9	0,9
1,0	3,0	1,5	1,0	1,0	180	90	60	60	5,4	2,7	1,8	1,8

Table 1: *The accuracy class of the measuring current transformer.*

Třída přesnosti	Chyba proudu při jmenovitém primárním proudu	Chyba úhlu při jmenovitém primárním proudu		Celková chyba při jmenovitém primárním nadproudu
	%	Minuty	centiradiány	
5P	±1	±60	±1,8	5
10P	±3	–	–	10

Table 2: *The accuracy class of the protective current transformer.*

The errors are proportional to a burden of current transformer. The burden is impedance of secondary circuit express as an absorbed apparent power (VA) with rated power factor. The errors dependence on the shunt impedance $\mathbf{Z_e}$ (R_m, L_m) and the burden $\mathbf{Z_b}$ is defined by equation (3) [2].

[1] This definition is true only for harmonic voltage.

$$\varepsilon_i + j\delta_{i\ rad} = \frac{\mathbf{z_b}}{\mathbf{z_e} + \mathbf{z_b}} \tag{3}$$

The secondary winding has to be short-circuited (has not to be no-loaded) when the CT is measured. It is very important for safety reasons. If this precondition is not realized, there are generated high-voltage peaks. These peaks can damage or destroy the transformer, but an accident hazard is more dangerous. The next reason, why secondary winding has to be short-circuited, is influence of remanent flux. If the CT is working with no-load secondary winding its iron core will be magnetized.

The measured CT has two different burdens, the first is used for a CT as the measuring current transformer (5VA) its accuracy class is 0,5. The second burden is used for the protective current transformer (10VA) its accuracy class is 5P. Both secondary windings (1S1-1S2 and 2S1-2S2) have to correspond to choice of accuracy classes, because it is double-core current transformer. Therefore the measuring has to be done for both CT cores with rated burdens 5VA and 10VA. The standard [1] defines power factor $\cos\varphi = 1$ for the burden into 5VA and $\cos\varphi = 0{,}8$ for the burden over 5VA. For measuring of accuracy class are used burdens with power factor $\cos\varphi = 1$ (burden 5VA is replaced by resistance 0,2Ω and burden 10VA is replaced by resistance 0,4Ω). The CT has been demagnetized before the measuring starts. The measures errors of current and phase are shown on the Figure 2. and Figure 3. There are limits which matched the accuracy class 1 and 0,5 (Table 1).

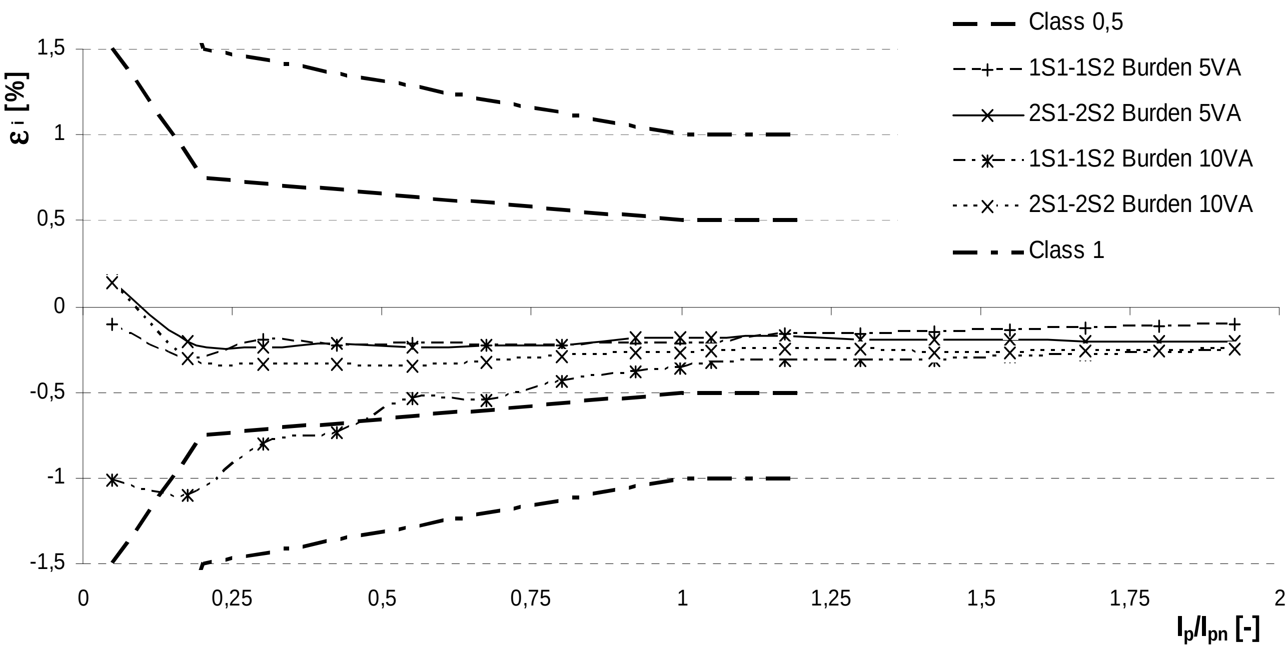

Figure 2: *The current error of the double-core CT.*

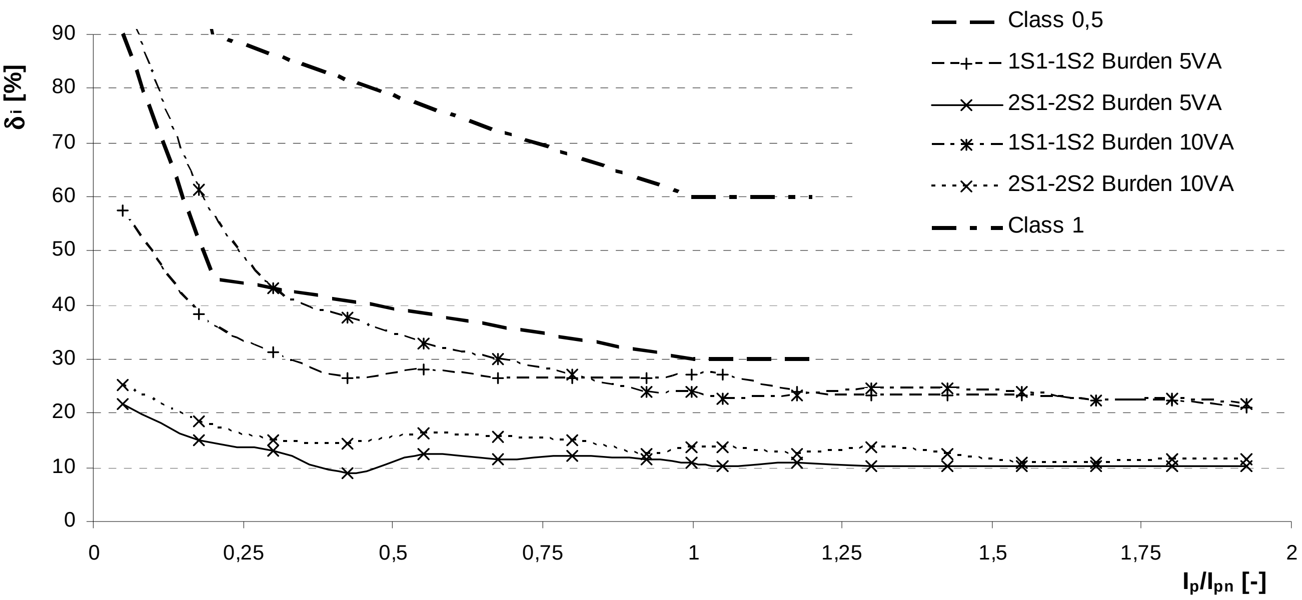

Figure 3: *The phase displacement of the double-core CT.*

2.1. THE MEASUREMENT OF MAGNETIZATION CURVE

The information about the current transformers iron-core is given by a magnetization curve. The ideal current transformer has no linear dependence between exciting voltage E_s and exciting current I_m, which is necessary for excitation secondary current. This is the reason why the exciting voltage E_s has to be increased if bigger burden is connected. This voltage can be increased into limited (maximum) voltage E_{lim}. If the exciting voltage E_S exceeds limited voltage E_{lim}, the CT will be saturated and its function will be incorrect.

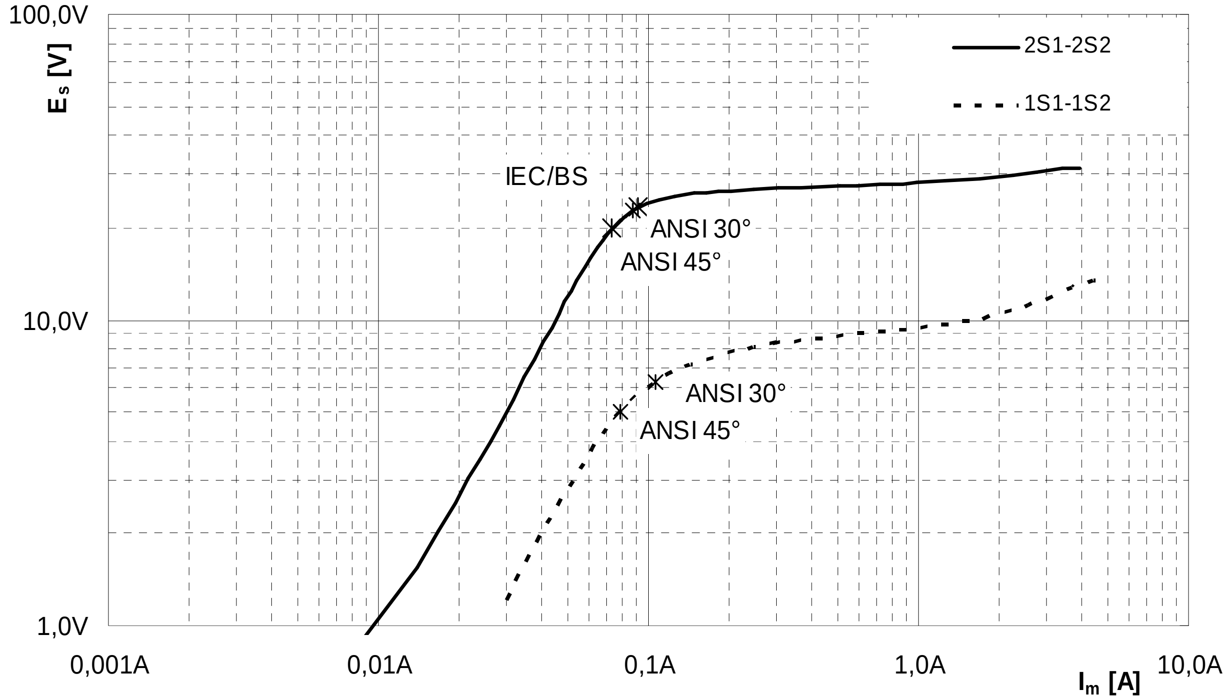

Figure 4: *Magnetization curve of current transformer.*

The E_{lim} value is determine by a knee point. This point is defined by three basic methods [3]:

IEC/BS – According to IEC 60044-1, the knee point is defined as the point on the curve where a voltage increment of 10% increases the current by 50%.

ANSI 45^0 – According to IEEE C57.13, the knee point is the point where, with a double logarithmic representation, the tangent line to the curve forms a 45^0 angle.

ANSI 30^0 – Like ANSI 45^0 but forming a 30^0 angle.

Magnetization curves both windings are shown at the Figure 4, with its knee point (IEC/BS, ANSI 45^0, ANSI 30^0).

Parameters of measure current transformer produce by ABB company [4]:

Type:	TPU 40.13		
Serial number:	1VLT5106019176	Knee point S1 U/I:	7,69V/0,192A
80//5/5 A	ext. 120%	Knee point S2 U/I:	23,43V/0,089A
1S1-1S2	5VA cl.0,5 FS10		
2S1-2S2	10VA cl.5P 10		

Table 3: *Nominal parameters of ABB company current transformer.*

3. CONCLUSION

There were determined accuracy classes for both windings of double-core current transformer for the burdens 5VA and 10VA, with the help of measuring system CPC100. The accuracy class of secondary winding 1S1-1S2 is selected 0,5 for values of burden 5VA and accuracy class 1 for burden 10VA. The accuracy class of the next secondary winding 2S1-2S2 is 0,5 for burdens 5VA and 10VA. The knee point IEC/BC of winding 1S1-1S2 was not able to be measured in contrast to the next winding. The knee point IEC/BC of the winding 2S1-2S2 has limited voltage E_{lim}=23,4V and exciting current 91,8mA, this knee point corresponds with the rated (nominal) knee point Table 3. The winding 2S1-2S2 (which is used as protective current transformer) has better accuracy then the winding 1S1-1S2 (which is used as measuring current transformer). This is the main divergence between rated and measured accuracy class.

REFERENCES

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