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MODELS AND CHARACTERIZATION OF INSTRUMENT TRANSFORMERS FOR ENERGY MEASUREMENT

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Abstract: The measurements of powers and energies on site imposes the use of the instrument transformers. The work presents the explanations of theories and proposes models for the characterization of accuracy of transformers.

Key words: instrument transformer, model.

1. INTRODUCTION

The errors of measurement of the U, I and φ determines errors of measurement for the P and Q powers and E_P and E_Q energies. The instrument transformers introduced in the measuring equipment, with their errors of amplitude and phase, determine strongly the results of measurements. In certain cases, when the current are small ($I<<I_n$), or a considerable phase between the current and the tension exists, or the current is not sinusoidal, one can note errors of 10-40% to the measure of energy.

It is well known that many instrument transformers may have a limited frequency response. In the IEC " General guide on harmonics and interharmonics measurements and instrumentation…"[1], some statements are made on what can be expected of current (instrument) transformers. This guide is the work of IEC SC77A. The CIGRE working group 05 of study committee 36 (interference) and the IEEE Power system working group also summarized what was known in the first half of the 1980's. References are frequently made to [2], [3] and [4].

2. MODELS FOR INSTRUMENT TRANSFORMER

To explain the frequency response of ordinary instrument transformers the equivalent circuit diagram of Figure 1 or a similar simplified circuit of Figure 2 are most often used [5].

These are common equivalent diagrams of a transformer except for the capacitors. The capacitors C_1 and C_2 are the lumped stray capacitance of the primary and secondary winding, respectively, and C_{12} is the stray capacitance between the windings. At low frequencies such as 50 Hz they may be negligible but for higher frequencies they may form several resonance circuits, together with the leakage and burden reactance, at various frequencies.

From Figure 1, it can further be deducted that grounding (that affects the voltage across C_{12}) as well as the loading (including long cables), especially inductive or capacitive loading, may well affect the frequency response [6].

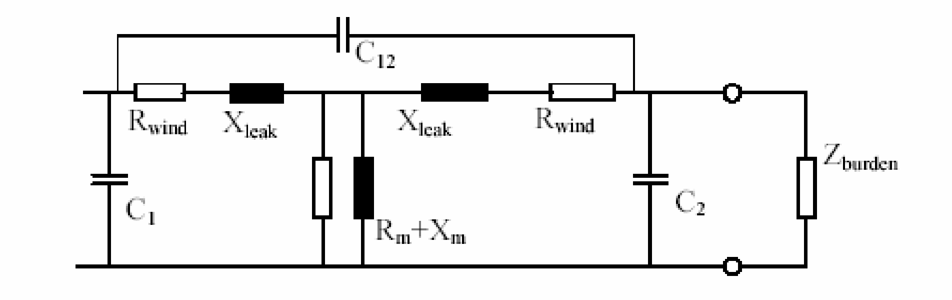

Figure 1. Model for instrument transformer at medium frequencies.

In some situations, the equivalent circuit diagram of Figure 1 may be reduced to the circuit diagram according to Figure 2 [7].

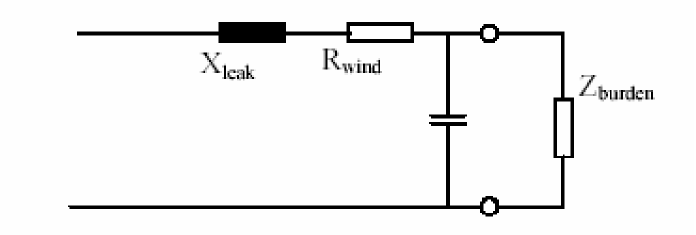

Figure 2. Simplified model.

The model for the characterization of instrument transformer is presented in Figure 3.

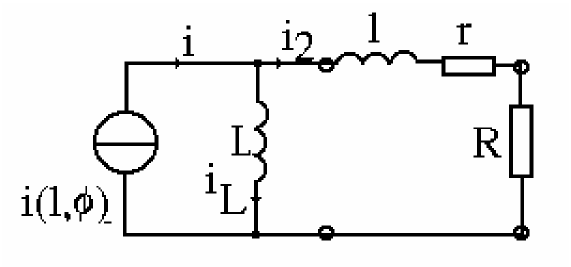

Figure 3. Instrument transformer model for the transformer coefficient.

The basic equation for real transformer coefficient of instrument transformer will be:

$$H(\omega)=\frac{\sqrt{\omega^2 L^2 (R+r)^2+\omega^2 L^2 (\omega L+\omega l)^2}}{(R+r)^2+(\omega l+\omega L)^2}$$

The results of modeling are presented in Figure 4, for the different values of accuracy influence parameters.

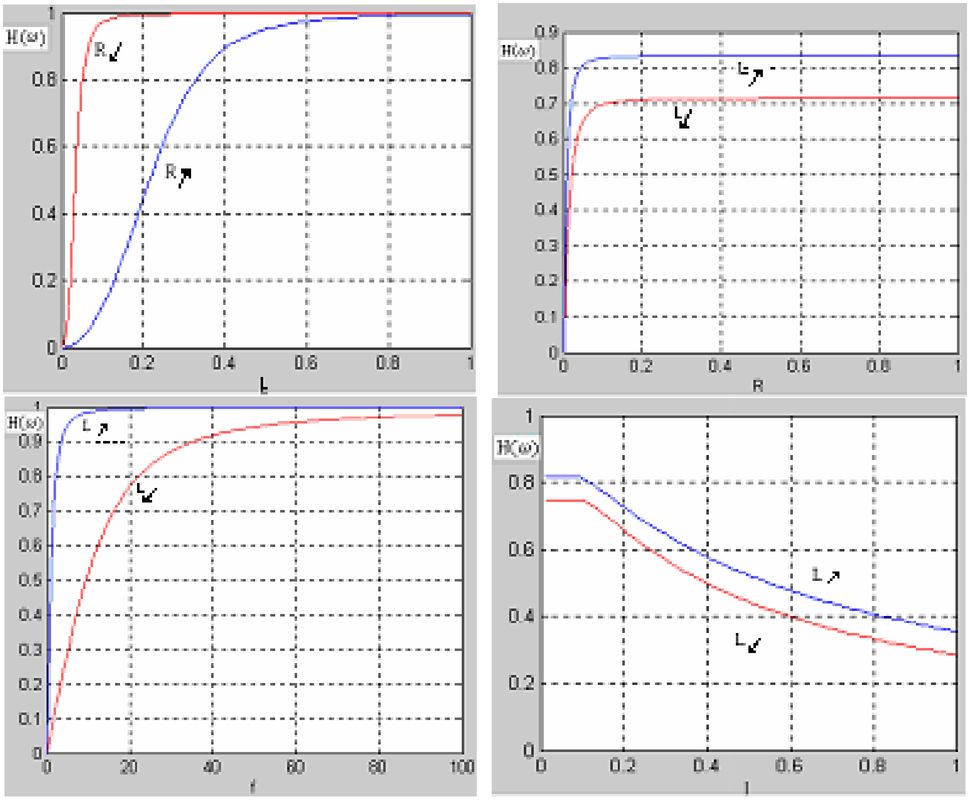

Figure 4. Errors in the measurement due to *H*.

The angle error of instrument transformer will be:

$$\Theta(\omega)=\mathrm{arctg}\left(\frac{R+r}{\omega L+\omega l}\right)$$

The effects of angle error and transformer coefficient in the accuracy of active power measurement are presented in Figure 5.

When designing the equipments for the power and energy measurement, the understanding of how the instrument transformer interacts within the system is the key to designing reliable and rugged systems. With the help of an adequate model, the effect can then immediately be visualized.

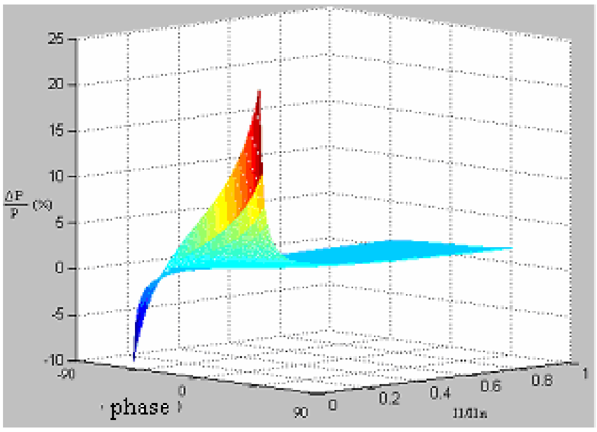

Figure 5. Effects of internal parameters of instrument transformer in the power measurement.

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