International Journal of Innovation in Computer Science and Information Technology
Vol.5, NO.1 , P:41-48
Received: 21 April 2024
Accepted: 15 February 2025

Simulation of Current Transformer under Two Conditions

Seyed Ahmad Hashemi Chelavi
Master of Electrical Power of Islamic Azad University Damghan Branch and Electrical Power Bachelor
Noushirvani Industrial University of Babol,
Lecturer of Islamic Azad University Juybar Branch
Member of Mazandaran Building Engineering ،Order, Amol County.
Sahmadhch@yahoo. Com

Abstract

This paper deals with simulation of current transformer under two conditions .they are transient conditions and steady state. At first an equivalent circuit of current transformer is displayed and explained then the nonlinear mathematical model of current transformer in accordance with transformer equivalent circuit is described. The mathematical model is simulated under Matlab/ Simulink program. It is true that a current transformer with the specified parameters of measurements is simulated. The steady state and transient conditions simulation is done that transient conditions due to a sudden short circuit in the network is assumed. The results of the simulation is certified that mathematical model is too close to the real behavior of the current transformer and therefore it can be used in larger model of the power network 22kv and a new method of analysis for identification and errors positioning and confirming of the theory findings. In the future this simulation for voltage transformer is recommended.

Keywords: Simulation, Current Transformer, Transient Conditions, Steady State.

Introduction

Current transformers (CT) rules are based on magnetic coupling. Plan a bar CT, the primary winding of a strip of copper or aluminum is solidly built that in the end, it leads as a flag and tail mass or it unites with a bar. The secondary winding consists of turns N. A typical AC CT is shown in Figure 1. For better effectiveness , current transformers cores are desired to have high permeability, high resistivity, low hysteresis and eddy current losses [1,2]. The current transformers are designed for normal operation which means that the B-H curve depending on the iron core is linear.

Under normal operation the difference between primary current i1 and secondary current i2 is obtained by their conversion ratio and the magnetizing current can be made regardless.

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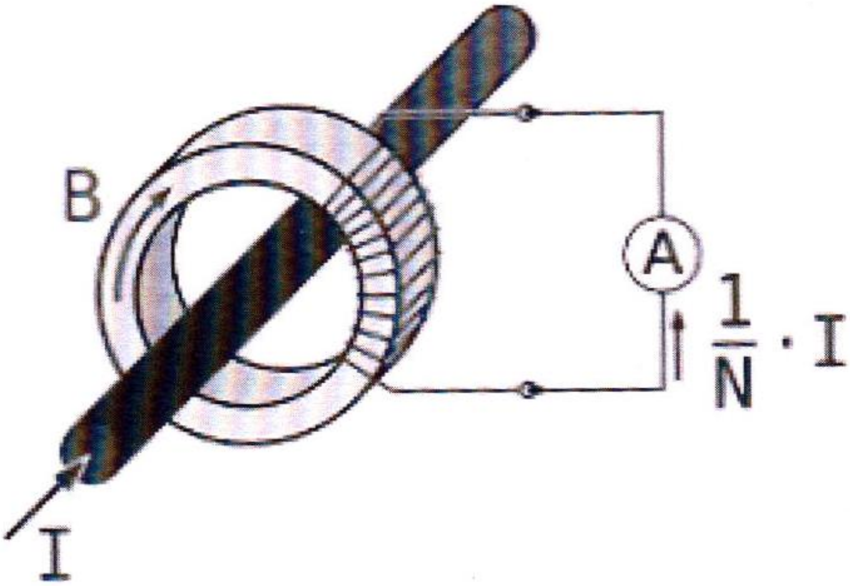

Figure(1) view the basic circuit of the current transformer

When the primary current of CT is several times higher than the normal operating mode, different condition is during short circuit in power network and it causes the non- linear behavior of the current transformer. DC offset in the fault current following into protective core of current transformer can cause saturation steel and produce a stimulator secondary current [3,4,5]. Actual knowledge of a primary current effect at the time that error occurs for the proper functioning of protective relays is very important and it also for the analysis focus on the identification and location of errors is used [1,2].

Nonlinear Mathematical Model of CT

The CT nonlinear mathematical model can be described in accordance with common equivalent circuit of transformer but the secondary winding is combined with load and it can be seen in Figure 2.

It contains the parameters of primary winding (resistance of primary winding R1, Leakage inductance of primary winding L1), Secondary winding (resistance R2, leakage inductance L2) that it is connected with load equivalent resistance Rb.

In real conditions, Rb is resistance of analogue or digital tester. The lumped parameters of secondary winding are referred to the primary side of transformer. The magnetizing branch is shown by a non- linear magnetic inductance LM which is a function of magnetizing current IM. The eddy current loss is regardless so there is no resistance for this power loss in the circuit. The mathematical model of current transformer contains the following equations:

$$i_1(t) = i2(t) + im(t) \qquad (1)$$

The induction voltage V1 is obtained by the following equation:

$$V_1(t) = N\frac{d\emptyset(t)}{dt} \qquad (2)$$

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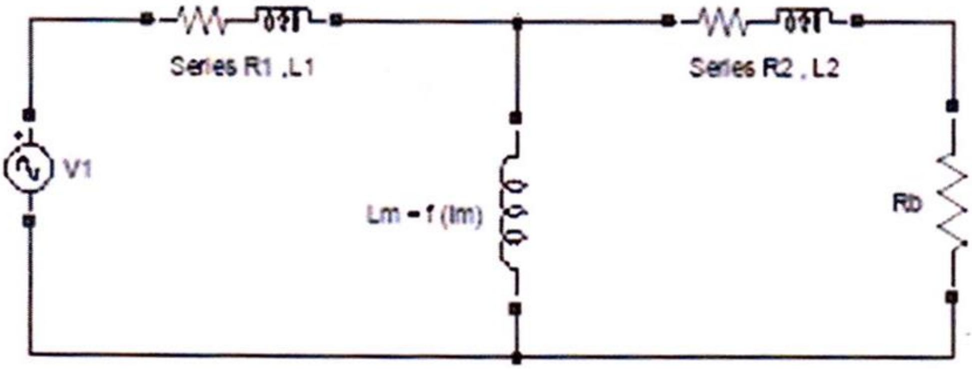

Figure (2) an equivalent circuit of current transformer

Here Φ is the magnetic flux and N is the turn ratio of transformer.

$$N \frac{d\Phi(t)}{dt} = i2\,(t)R + L\,\frac{di2(t)}{dt} \tag{3}$$

$$R = R2 + Rb \tag{4}$$

$$L = L2 + Lb \tag{5}$$

Here Lb is the inductance of load.
Magnetizing inductance is generally described:

$$L_m = \frac{N^2 A}{L}\,\frac{dB}{dH} \tag{6}$$

Here A is the area of ferromagnetic core of transformer and L is the length of the magnetic path and $\frac{dB}{dH}$ is the differential permeability or the slope of the B- H characteristic.
The equation (2) can be rewritten:

$$L_m \frac{dim}{dt} = V_1 \tag{7}$$

The combination of equations (1) , (3) and (7) can be expressed:

$$\frac{\dim(t)}{dt} = \frac{1}{L+L_m\,(im)}\left[Ri_1 - Ri_m\,(t) + L\,\frac{di_1(t)}{dt}\right] \tag{8}$$

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This mathematical model is simulated under Matlab/Simulink program [1,2].

Results Discussion

The simulation models have been created under transient conditions and steady state (Figures 3, 4). The transients were assumed as a sudden short circuit in network for line distance approximately 10km. In the model, the nonlinear dependence of magnetic inductance versus magnetizing current according to values has been taken.

The short circuit secondary current isc has been calculated from following equation:

$$isc = \sqrt{2}\ Isc\,[e^{\frac{-t}{T}} - coswt] \qquad (9)$$

[1,2,6]

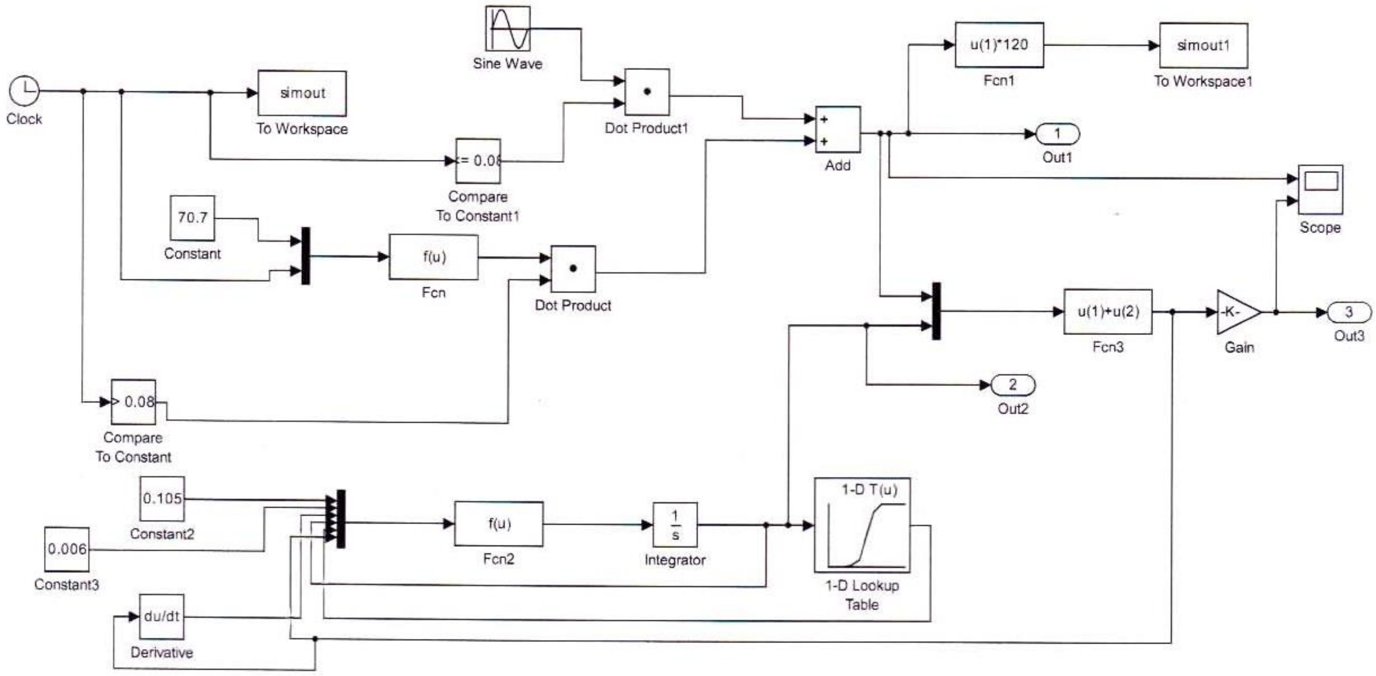

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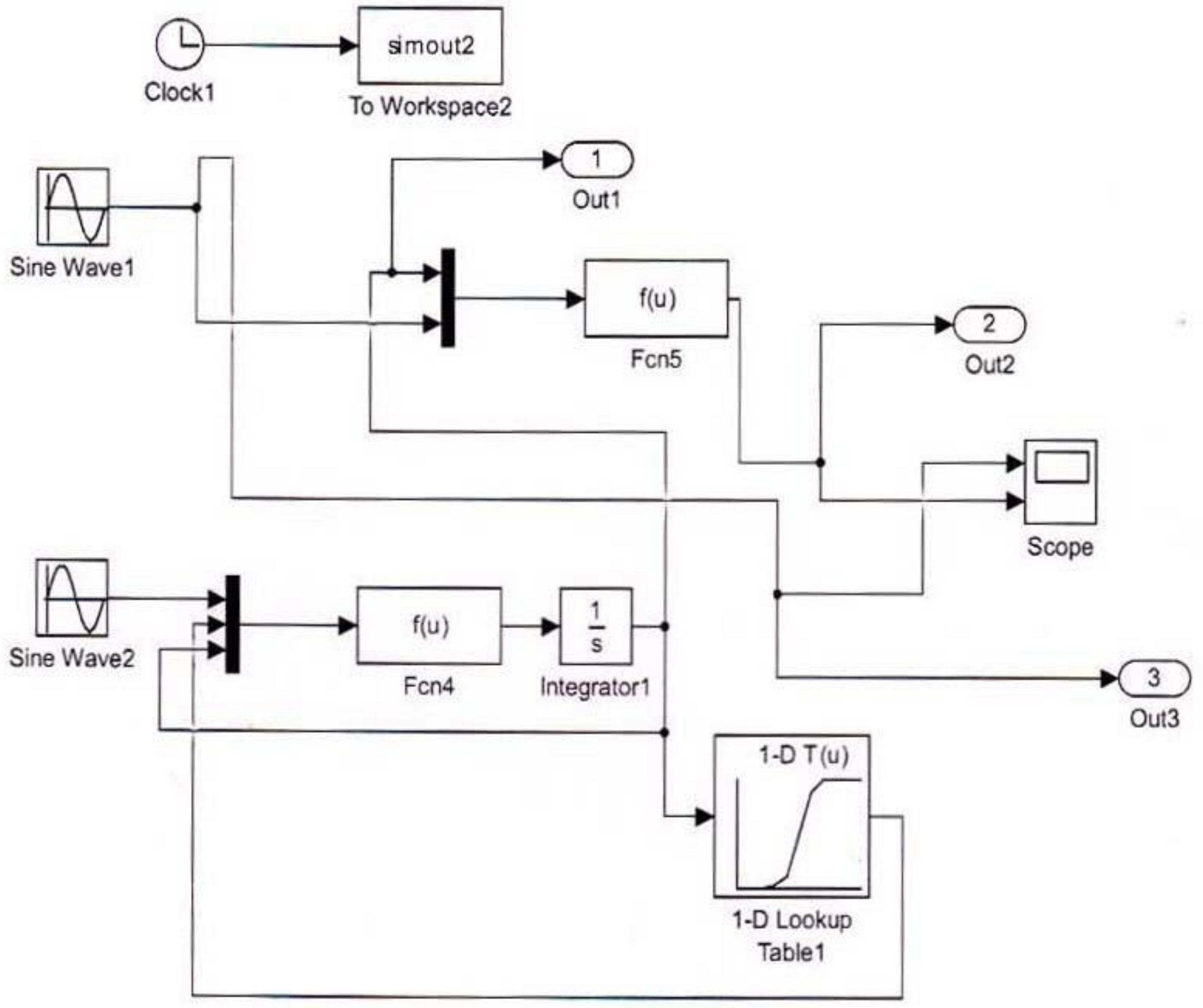
Figure (3) transient simulation model of CT under simulink



1.2 mH. km^{-1} were used in simulations. The operation of protection relays was regardless in presented simulations. The simulated primary and secondary currents of transient conditions and steady state are shown in Figures 5 and 6 [1,2,6].

Isc is steady state short circuit secondary current ten times higher than its rated current and T is time constant given by parameters of network. Network's resistance Rn= 0.43 $\Omega.\ km^{-1}$ and inductance Ln=

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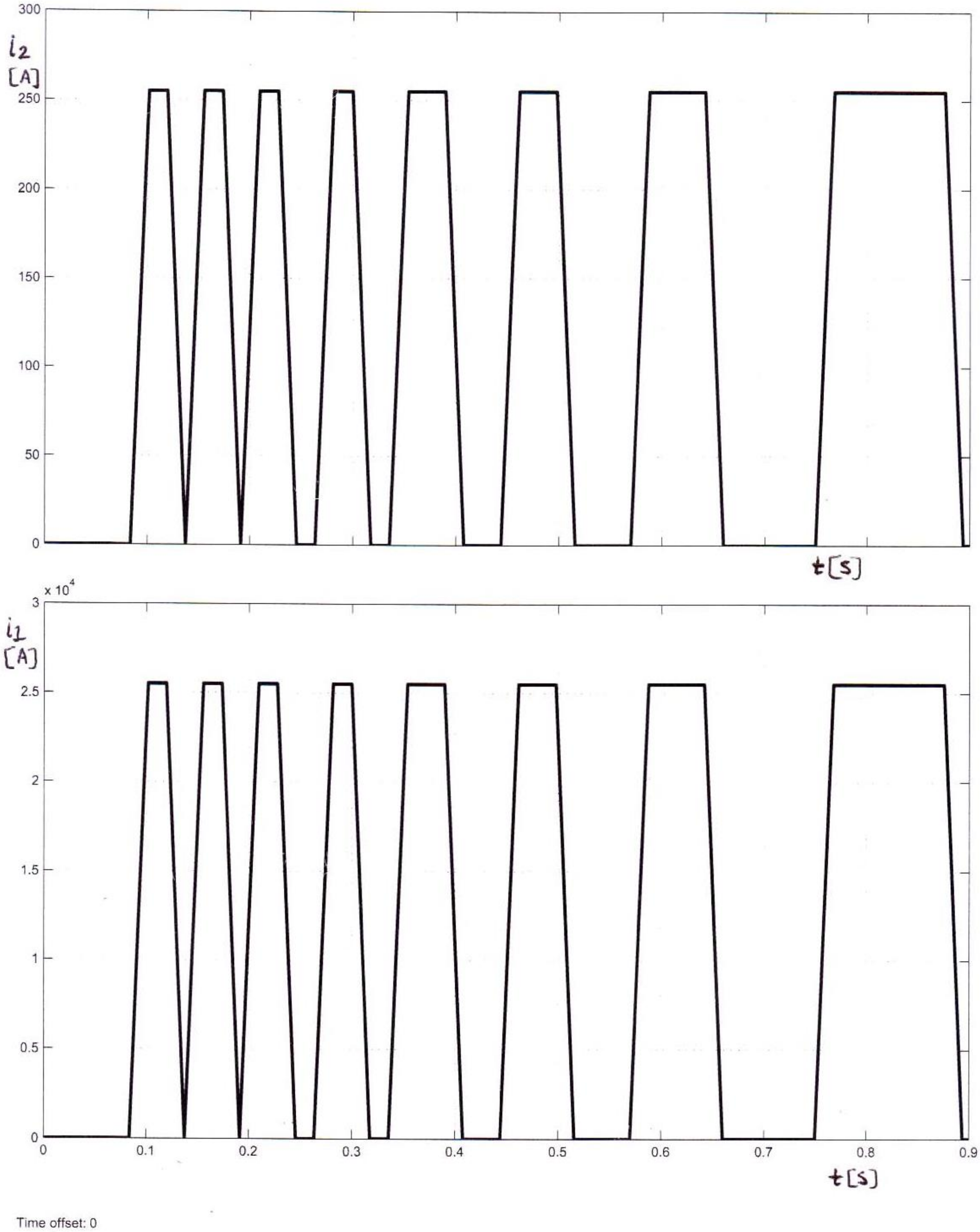

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Figure (5) transient simulated wave forms of secondary current and primary current to ampere according to time to second in order from top to bottom

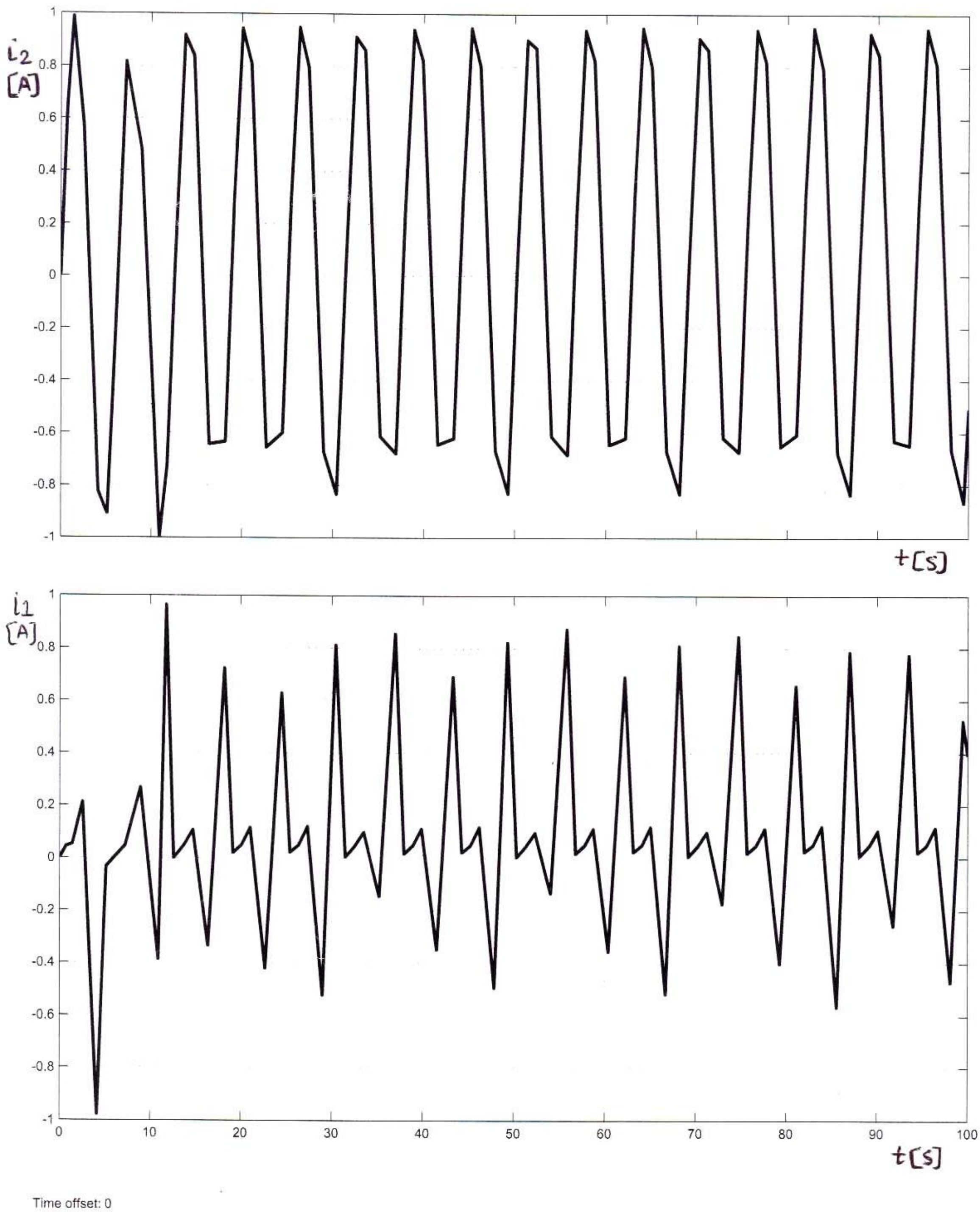

Figure (6) Steady state simulated wave forms of secondary current and primary current to ampere according to time to second in order from top to bottom

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Conclusions

In this paper a current transformer was analyzed by simulation. The mathematical nonlinear model was defined, created and described. Simulations were performed for transient and steady state. The results confirm that created mathematical model is too close to the behavior of current transformer. Created current transformer model will be used in bigger simulation model of medium voltage network that a new method of analysis for fault identification and positioning was created. In the future this simulation for voltage transformer is recommended.

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