EQUIVALENT MODELS FOR STUDYING OHM'S LAW IN MONOPHASIC ALTERNATING CURRENT

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Abstract: *Ohm's law is well known from the school program. In this paper we analyze new studying methods of this law. We propose a software, which will allow graphical modeling of circuits for monophasic alternating current with specification of the number of components and their type.*

Keywords: *alternating current, Ohm's law, software, modeling.*

We study the circuit shown in Figure 1, which consists of: resistors (R), inductors (L), capacitors (C), switch (k), voltmeter (V), ammeter (A) and a source of alternating current with a potentiometer (p) for tension adjustment.

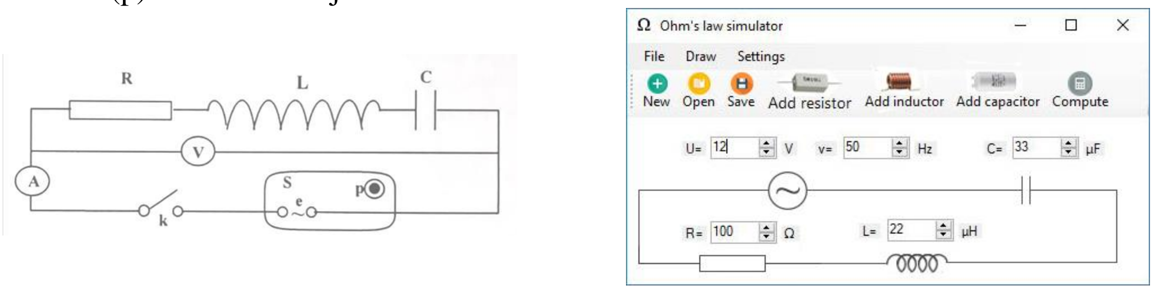

Figure 1. Left: Reference circuit; Right: Software simulation.

We consider the circuit from Figure 1 left, in the time interval dt, where e and i are the instantaneous values of the electromotive voltage $dW = e * i * dt$. This energy is distributed in the circuit in the following way: heat dissipated by the resistor R: $dW_1 = R * i^2 * dt$; magnetic field stored in the inductor L: $dW_2 = L * i * di$; electric field stored in the capacitor C: $dW_3 = u * i * dt = u * dq = u * C * du$. We obtain the value of $dW = R * i^2 * dt + L * i * di + u * i * dt$, therefore we calculated the differential equation of the alternating current through a RLC type of circuit: $e = R * i + L * \frac{di}{dt} + u$. Considering a sinusoidal electromotive voltage to the circuit's terminal $e = E_m \sin \omega t$, where ω is the amplitude, we obtain the equation: $E_m \sin \omega t = R \cdot i + L \cdot \frac{di}{dt} + u$. Deriving the formula, we get:

$$L\frac{d^2 i}{dt^2} + R \cdot \frac{di}{dt} + \frac{i}{C} = \omega E_m \cos \omega t. \tag{1}$$

Considering the phase shift φ and the equalities $du = dq/C$ and $\frac{dq}{dt} = i$, we get the equation:

$$R\cos(\omega t - \varphi) - (\omega L - \frac{1}{\omega C})\sin(\omega t - \varphi) = \frac{E_m}{I_m}\cos \omega t. \tag{2}$$

Furthermore, we can consider $\omega t_1 = \frac{\pi}{2}$ and $\omega t_2 = 2\pi$, to get the formulas:

$$\tan \varphi = \frac{\omega L - \frac{1}{\omega C}}{R} \quad \text{and} \quad I_m = \frac{E_m}{\sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}} = \frac{E_m}{Z}. \tag{3}$$

This way we obtained the formula for the circuit's impedance $Z = \sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}$. (4)

This equation is modeled accordingly to the scheme represented in Figure 1 left. As a result, we verify the Ohm's law in alternating current. We propose ourselves the experimental realization of the scheme presented in the simulation in Figure 1 right.

References:

1. *Series RLC Circuit Analysis* [online], 2014, [visited on 02.03.2020], [available on https://www.electronics-tutorials.ws/accircuits/series-circuit.html/]