Supplement 1. Maxwell Equations with Magnetic Charges

It is known that Heavyside was the first to introduce the magnetic charges and magnetic currents in Maxwell electrodynamics [1, 2]. A review of electromagnetic systems properties with hypothetical magnetic charges is given in monographs [3, 4].

Let us denote:

E - electric field intensity,
H - magnetic field intensity,
μ - magnetic permeability,
ε - dielectric permittivity ,
φ - electrical scalar potential,
ϑ - electro conductance,
ϕ - magnetic scalar potential,
ς - permeance,
ρ - electric charge density,
σ - magnetic charge density.

Let us consider a Maxwell equations system in Cartesian coordinates and in the following form [2]:

1.	$\frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z} - \varepsilon \frac{\partial E_x}{\partial t} + \vartheta \frac{d\varphi}{dx} = 0$	
2.	$\frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x} - \varepsilon \frac{\partial E_y}{\partial t} + \vartheta \frac{d\varphi}{dy} = 0$	
3.	$\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y} - \varepsilon \frac{\partial E_z}{\partial t} + \vartheta \frac{d\varphi}{dz} = 0$	
4.	$\frac{\partial E_z}{\partial y} - \frac{\partial E_y}{\partial z} + \mu \frac{\partial H_x}{\partial t} - \varsigma \frac{dL}{dx} = 0$	
5.	$\frac{\partial E_x}{\partial z} - \frac{\partial E_z}{\partial x} + \mu \frac{\partial H_y}{\partial t} - \varsigma \frac{d\phi}{dy} = 0$	
6.	$\frac{\partial E_y}{\partial x} - \frac{\partial E_x}{\partial y} + \mu \frac{\partial H_z}{\partial t} - \varsigma \frac{d\phi}{dz} = 0$	
7.	$-\frac{\partial E_x}{\partial x} - \frac{\partial E_y}{\partial y} - \frac{\partial E_z}{\partial z} + \frac{\rho}{\varepsilon} = 0$	
8.	$\frac{\partial H_x}{\partial x} + \frac{\partial H_y}{\partial y} + \frac{\partial H_z}{\partial z} - \frac{\sigma}{\mu} = 0$	

(1)

Let us point to some distinctive features of the equation system (1):

1. the existence of magnetic charges and current is being assumed,
2. instead of electric and magnetic currents scalar potentials and conductivities are introduced, and not only electro conductance but also magnetic permeances.
3. it is assumed that the densities of magnetic and electric charges may change with time,
4. these equations are further extended also to physical systems, in which there exist macroscopic bearers of magnetic and electric charges.

The introduction of scalar electric and magnetic potential permits to treat the system of 8 Maxwell equations as a system with 8 unknown functions - 6 intensities and 2 scalar potentials. The existing methods (as far as we know) assume that both the charges densities and currents densities are known, and so the unknown variables are 6 intensities In this sense the Maxwell equations system is indeterminate.

In Supplement 3 we describe a method for solution of such equations system based on the variation principle for electromechanical and electrodynamical systems.

In the solution of these equations there appear the products $\vartheta\varphi$ and $\varsigma\phi$. The reader who doesn't accept the concept of magnetic resistance ς of the environment and of scalar magnetic potential ϕ, may notice that for $\varsigma = \infty$, $\phi = 0$ the value of product $\varsigma\phi$ isn't defined and may be taken equal to the value required according to the conditions of the problem. Then another paradox emerges: the existence of magnetic current in the absence of magnetic permeance and scalar magnetic potential. Nevertheless, if we accept the concept of magnetic resistance and of scalar magnetic potential, we would be able to find the solution of some problems of great physical significance. We must note also that some materials with big magnetic permeability μ, as, for instance, soft iron, behave approximately in the same way as magnetic conductors [38].