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UNFORTUNATE DILEMMAS IN THEORY OF ELECTRICAL ENGINEERING

ING. PETR PREUSS, CSC

Abstract: *The paper represents (to some extent in the form of a feuilleton) an essay on some essential postulates of the theory of electrical engineering. Although nowadays their modification is already no longer real and desirable, it is possible to notice that their opposite versions would probably bring somewhat simpler and more understandable portrait of laws of electric circuits and also electromagnetic field.*

Key words: *Theory of electrical engineering, appliance system, flux density, electric field strength, voltage orientation*

INTRODUCTION

The founders of the theory of electrical engineering got more times into situation that required from them a definitoric decision between two alternatives that could be considered practically equivalent. With some exaggeration we can state that their selection (from the present viewpoint) was beyond the laws of probability, according to which they should be at least in 50% cases good. Of course, only on the assumption that the selection of two possibilities was always of more or less accidental character.

Let us show several examples when the founders of electrical engineering had not too lucky hand when postulating the fundamental concepts. It is clear that the established definitions of general validity are so deeply rooted among the experts and in the literature that nowadays it is no longer possible to think of their possible correction. Nevertheless, it might be useful to discuss several items that are seemingly absolute and often identified with the physical reality itself, but, in fact, they are mere relative human products, tributary to the starting phase of their research.

On the other hand, it is impossible to say that these choices would be directly bad – when it is necessary to decide between two equivalent options, than no one selection can be bad. But in the following cases the second option would always be more understandable, formally simpler, intuitively more acceptable and more consistent with general mathematical and physical habits.

1 APPLIANCE SYSTEM

In the nineteenth century the source system of the orientation of voltages and currents still competed with the today's appliance system. The final decision came in the twentieth century – preferred was uniquely the appliance system employing the consonant orientation of voltages and currents at the passive elements and opposite orientation of both quantities at the sources.

This lead to the consequence that energy delivered from the sources is characterized by a negative output, while the losses of energy in the lines and load (I mean its electromagnetic form) are characterized by a positive output. This is in a contradiction with the mathematical concept of divergence that is positive when the flow of a vector is oriented out of the element.

One illusory advantage of the appliance system is the absence of an opposite sign in the Ohm law. This gives rise, however, to another inconsistence in the whole conception of physics. Mechanics know that the force action of a spring is always oriented against the variation from the starting state. That is why the corresponding law contains the negative sign ($\boldsymbol{F} = -K\boldsymbol{y}$). It is, however, a general property of all passive (linear) elements that their physical effects act against any change of their state. Otherwise they would not be the passive elements. Consequently, the mathematical models of all passive elements including resistances, capacitances and inductances should contain the negative sign.

2 FIELD STRENGTH E AND VOLTAGE U

Natural (i.e. passive) flows of energy or mass are always oriented in such a direction that the energy of the system becomes minimal. In case of the electrostatic or current field it means that the dielectric flux density (or current density) is oriented against the direction of the gradient of potential, i.e. from the place of higher potential to the spot with lower potential.

The creators of contemporary theory of electrical engineering did not recognize the above source system. As they did not have in mind introducing the negative sign in relation $\boldsymbol{D} = \varepsilon \boldsymbol{E}$ or $\boldsymbol{J} = \gamma \boldsymbol{E}$ (that should, nevertheless, belong to them as to passive interactions) they had no other possibility but to define electric field strength $\boldsymbol{E}$ in accordance with $\boldsymbol{D}$ or $\boldsymbol{J}$, and thus $\boldsymbol{E} = -\text{grad}\, \varphi$.

Electric field strength belongs, however, to the same group of quantities as the voltage and potential. For the sake of logic, understandability and consistence with the mathematical rules the electric field strength (its module) should grow together with the potential.

In the area of the symbolism the acceptance of the source system would also bring order. The voltage arrows would be oriented in the opposite direction than now, i.e. in the direction of the voltage growth. The orientation of currents would not change. At the sources the arrows would be oriented consonantly, at the passive elements oppositely.

Probably everybody knows the complications with drawing phasor and even more topographic diagrams associated with the direction of the graphical symbol – arrow. Should it be oriented to the origin of the coordinate system, such as the corresponding voltage to the reference point or in the opposite manner? Usual is the second option that brings about, however, a lot of mistakes at drawing the difference voltages. Even this problem would not exist when we accepted the source system and drawing of arrows always in the direction of the voltage growth.

3 CHARGE AND CURRENT

In one respect the positive and negative charges differ quite essentially – for the flow of charges in metal conductors are responsible only the negative ones – electrons. Indeed, the electrical practice and circuit theory mostly deal with the circuits with electron conductivity. Electromagnetic field is usually derived from the spatial and temporal distribution of the electrons. With respect to the fundamental significance of the electrons for the whole electrical engineering there is no doubt that they would deserve assigning a positive charge. This would lead, at the latest, to the formal simplification of considerations about their surplus or lack in some spots of the space.

Similarly, the accordance of orientation of electric current with the flow of electrons in the conductor would surely become a welcomed contribution for the students and pupils that would like to orientate themselves in the fundamental concepts of electrical engineering.

4 STRENGTHS AND FLUX DENSITIES

It belongs to the good reputation of the founders of the theory of electrical engineering that they did not introduce four different names for the fundamental vectors of the electromagnetic field, but that they made use of repetition of two identical concepts – flux densities and strengths. But they gave in to the symmetry of material relations and strengths became both quantities in the product with permeability or permittivity. If it were not for this unfortunate decision, the magnetic field theory might be substantially more objective and explicative.

The electrostatic field manifests itself (we could say exists) in one manner – by force effects among unmoving charges. Proportionally to the mutual velocity of individual charges there appears another part of the force effects denoted as the magnetic field.

The filed of forces (from the viewpoint of a charge that is located in this field) is proportional to the strength of external electric field and magnetic flux density (multiplied by the velocity). Both mentioned quantities depend on the local properties of media and produce the electric voltage. With respect to the fact that they determine the force that would affect the unit charge at the given place, both of them should be called the strengths.

On the contrary, the dielectric flux density and magnetic field strength are independent of the local properties of space. These quantities are also close one another and should be called the flux densities.

5 CONCLUSION – DEVELOPMENT OF THE THEORY OF ELECTRICAL ENGINEERING

It is not true that the theory of electrical engineering could praise by no development. Discussed are, for example, fundamental concepts accompanied, among others, by the elimination of the redundant terms. In this way, several decades ago, the electrical engineering was purified of superfluous and confused concepts such as impressed forces, electromotive force and electromotive voltage.

The goal of this effort is creation of a minimized and unified (coherent) system of linearly independent quantities and units.

In the frame of precisioning of the terms we learned distinguishing, for instance, two-ports and four-ports (even when from far no everybody understands correctly where to use the former or latter term…).

We experienced a symmetrized access to the orientation of currents of both gates of two-ports.

More and more are used in Czech terms resistor, capacitor and inductor.

Positively may be evaluated forgetting of Nepers and substitution of this unit by a universal (because dimensionless) logarithmic unit decibel with decimal base.

Maybe that some day we will experience cancellation of the term “input” that will be replaced by a more general term “power” with the corresponding sign.

A small progress can be seen also in the symbols, where, for instance, I consider useful and reasonable to orient voltage of all elements in the same way, i.e. by asymmetric voltage arrow (instead of the positive and negative signs).

Every scientific discipline requires a sufficient extent of stability and changes should take place only in those cases where they bring obvious and significant rationalization. In the theory of electrical engineering, anyway, we need not to be afraid of a too fast velocity of development. This is documented even by the declination of units derived from foreign names (Volt, Amper, Watt). The way of their Czech declination was decided in the frame of establishing the rules of the Czech language, shortly after establishment of the first Czechoslovak Republic. But up to now the prevailing part of Czech electrical engineers did not take this fact into consideration and uses the habits valid in the Austrian-Hungarian monarchy.

Ing. Petr Preuss, CSc.

University of West Bohemia
Faculty of Electrical Engineering
Univerzitní 26, 306 14 Plzeň

E-mail: preuss@kte.zcu.cz