Division of Computer Science

Department of ~~Trade and~~ Industry
NATIONAL PHYSICAL LABORATORY
Teddington Middlesex TW11 0LW

Telex 262344 Telegrams Bushylab Teddington Telex
Telephone 01-977 3222 ext 4044

Mr I Catt
"Hartspring"
17 King Harry Lane
St. Albans
Herts, AL3 4AS

Your reference

Our reference

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Dear Ivor

I've given a lot of thought to the meeting we had about electromagnetic theory.

It seems to me that any theory is neither more nor less than a model. In this context I define a model as a device designed to predict future experience. If I am driving a car along the road, and reach a bend, it is very important to me to be able to predict future experience. I want to be reasonably sure that if I behave in a suitable way, the car will get successfully round the corner. To this end I have a "model" in my head. I "turn the handles" on this and it tells me that if I keep my speed within certain limits and steer in a certain way all will be well. The model does not always give me exactly the right answer. Once, when the road was icy, the prediction was quite wrong. But in the main the model has worked pretty well. To my mind all "models" are like this, be they mathematically based or not. One "turns the handle" and they predict future experience. A perfect model predicts perfectly, a good model pretty well, and a bad model rottenly. There is however no absolute truth about a model. It is an expedient.

In the same way there is, to my mind, no absolute truth about concepts. To my mind "displacement current" is neither more real, or less real than ordinary current, or fields, or energy, or action at a distance. Such concepts should not be judged by the criterion "absolute truth", but merely by the expediency criterion of "are they useful as components of models".

If one wishes to apply classical electromagnetic theory in detail, one first has to break all space into infinitesimally small regions, each surrounded by infinitesimally small surfaces. The equations are time dependant - they depend on rates of change. They relate rates of change of charge (current - real or displacement!) to the curl of magnetic field, and similarly they relate rate of change of magnetic current to the curl of the Electric field.

$$\frac{j_q}{j_t} + \frac{j_D}{j_t} = \frac{\nabla \times B}{\pi}$$

$$-\frac{j_\beta}{j_t} = \nabla \times E$$

They also relate divergence of charge or displacement, and of magnetic charge, to instantaneous charge or "magnetism" density.

Finding the result of these relations involves solving a set of partial differential equations, with boundary conditions determined by the circuit. To solve all the equations, even in the simple case of the condenser, would take a month of Sundays. So I have not done it. But the equations would certainly not give precisely a "CR" curve. In fact I suspect they would give the right answer.

What I am saying is that to debate whether your EM theory is more true than the traditional theory is meaning-less. The question as to whether, in all cases your model predicts more accurately than the classical one would be very difficult to resolve. But the fact that, in some cases at least, your theory will enormously more readily provide sufficiently correct answers than will the classical one is very easy to demonstrate.

For these reasons, were I writing your paper I would alter it in certain respects. I would leave the first paragraph as it is. I would alter the second paragraph quite a lot.

I would say something like:-

It will be noticed in the above example electric current entered the capacitor at one point only on the capacitor plate. We must then explain how the electric charge flowing down the wire became distributed uniformly across the whole capacitor plate. We know this could not have happened instantaneously since charge cannot flow out across a plate at a velocity in excess of the velocity of light. The computation of this short term effect given classical theory is complex. So in practice short term effects are usually ignored. Work on high speed logic design (1) has shown that any model treating the capacitors as lumped components is faulty.

The next paragraph starting "the true model", I find very satisfactory.

The paragraph beginning - The exclusion of "displacement current" I would leave out. I would give graphs showing (and write a paragraph, showing the difference - in the high speed case - between the "lumped parameter" concept and the "transmission line" concept. These graphs should be real life graphs, calculated for a specific capacitor working on a definite time scale.

Yours sincerely

Ted.

E A NEWMAN