End of electric charge and electric current as we know them.

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Abstract

Under Faraday's Law, $\left(V = -\frac{d\phi}{dt}\right)$, which forbids superposition but whose mathematics permits it, we end up with two electric currents travelling in opposite directions down the same conductor.

[End of Abstract

Introduction.

A fundamental problem for the classical association of electric current with magnetic field has been exposed by the study of the TEM Wave in high speed digital electronics.

[End of Introduction

A very narrow voltage spike was injected between the left hand conductor and the ground plane in a surface conductor Figure 1 (microstrip).

The bottom trace in photo 3 shows the introduced voltage spike, and the bottom trace in photo 4 shows the smaller spike immediately resulting in the right hand conductor. The later second and first traces show how the signal develops further down the pair of conductors. It separated out into, first, an Odd Mode signal with equal and opposite voltage spikes on the pair of lines, followed by a slower Even Mode signal of equal positive spikes.

In the case of buried conductors Figure 2 (stripline), the two modes travel at the same velocity and did not separate out, as shown in photos 5 and 6.

Now let us look at the case of surface conductors Figure 1 when the front end of the right hand passive conductor was shorted to ground so that there could be no voltage there.

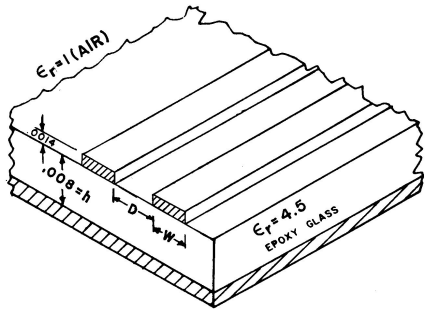
In photos 7 and 8 we see that in the earliest, bottom traces the initial zero voltage in the right hand conductor must have been two equal and opposite voltages

superposed. There must have been equal and opposite charges on the surface of the right hand conductor, and equal and opposite electric currents flowing in and out of this conductor. As we see below in the field patterns 9, in the Even Mode, the right hand conductor is positive and so electric current flows into the paper, generating the field pattern shown. Meanwhile, in the Odd Mode, the right hand conductor is negative so electric current flows out of the paper. Looking back, this must have been happening in all traces in photos 5 and 6 and in the bottom traces in photos 3 and 4.

It is simpler to think of four conductors rather than two conductors and a ground plane.

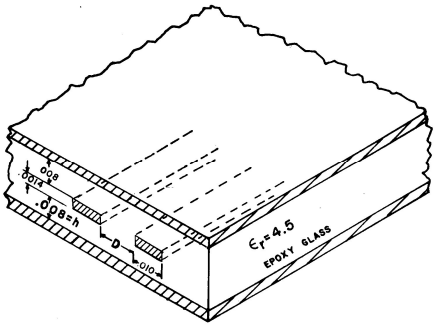
This article develops from Ivor Catt; “Crosstalk (Noise) in Digital Systems”, pub. IEEE Trans. Comput., vol. EC-16, no. 16, December 1967, now at http://www.ivorcatt.co.uk/x0710.htm and http://www.ivorcatt.org/x0710.htm . which contain the relevant mathematics in Appendices I and II.

[No Figure Captions]
Figure 1



Surface conductor (Microstrip).

Figure 2



Buried conductor (Stripline).

Photo 3

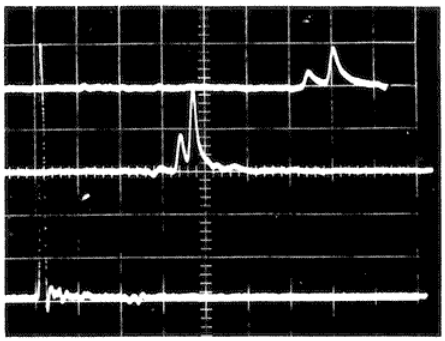


Photo 4

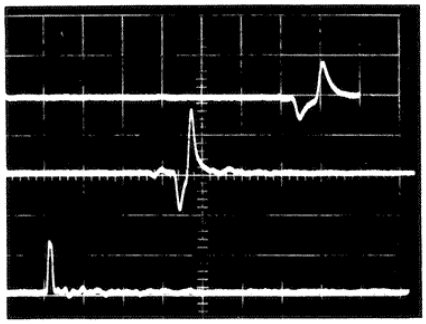


Photo 5

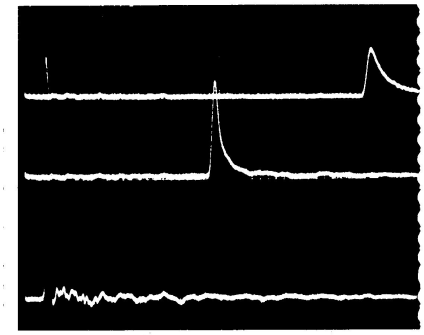


Photo 6

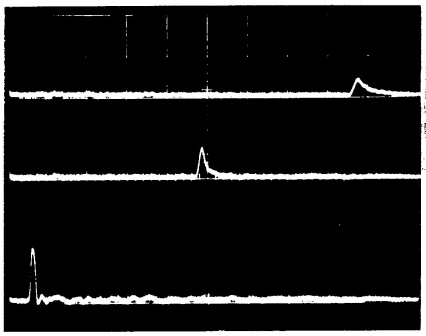


Photo 7

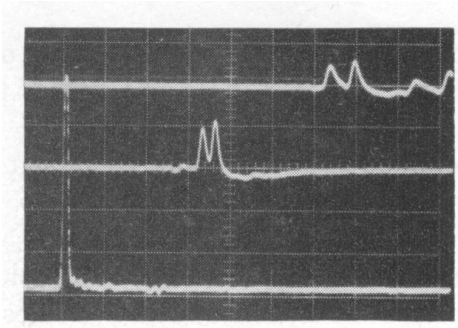
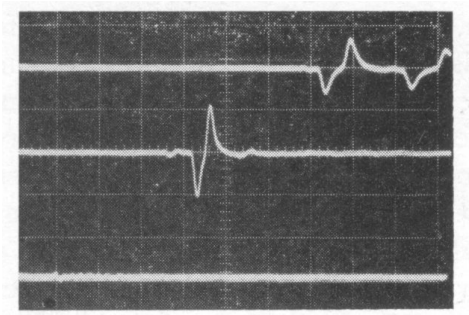
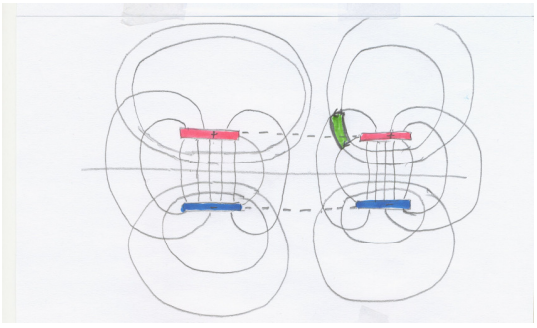


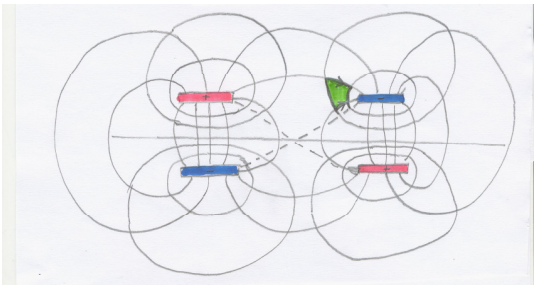
Photo 8



Field Patterns 9



Even Mode



Odd Mode