Email 1.

Hello Dr. Whites,

I recently read your class notes Lecture 5 which includes a few paragraphs on Displacement Current. I have been researching the role of Displacement Current in Electrical Energy propagation for a while and found your perspective to be intriguing. I'm sure you are a busy fellow, what with exams and so forth coming up with your students.

I have attached a brief overview and wondered if you could clarify the function, if any, that Displacement Current plays in the Digital Pulse propagation scenario I describe.

Thank you for your consideration,

Malcolm Davidson

Hope Valley
RI 02832

Attachment

Displacement Current in a Transmission Line

Malcolm Davidson March 2016

A Capacitor can be modelled as a parallel plate transmission line. Let us consider a lossless transmission line, say a twisted pair cable. For the purposes of the discussion we can consider this to be an ideal transmission line.

A 5 Volt step is propagating down the transmission line. The only change of signal is on the front end of the pulse, which is five hundred nanoseconds in length. Our cable is say, 1000 ft long. We observe the signal passing us at the speed of light for the medium, maybe half way down the transmission line. After the edge has passed we may observe a steady state signal moving at the speed of light which is approximately 1 ns/ft. We observe this until the trailing edge has passed.

What part, if any does Displacement Current play in this scenario?

Response to Email 1

Hello Malcolm,

I'm glad to hear you found those notes useful. Displacement current is a very important topic and one that seems to not receive the attention it should, in my opinion.

I looked through your document and, honestly, had a bit of a difficult time following it. For example, the first sentence didn't make tremendous sense to me. Perhaps you could refine your thoughts some?

Displacement current is present any time there is a time varying electric field. It is critical for wave motion in all electrical signals…digital pulses are but just one example.

I applaud your efforts and wish you every success.

With kind regards,

KW

Email 2

Hello Keith,

my apologies at not making the brief query clearer. I've updated the note and it is attached. In a nutshell, it is generally accepted by many people that a Capacitor is one particular kind of Transmission Line. The query is therefore based upon that basic tenet. I look forward to your considered reply.

Many thanks and Regards,

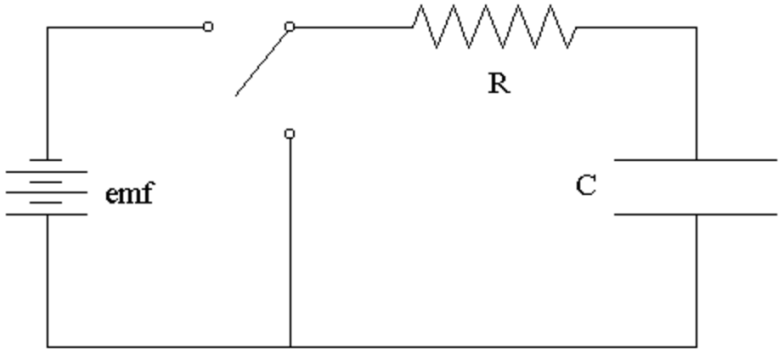
Malcolm

Attachment with Email 2

Displacement Current in a Transmission Line

Malcolm Davidson March 2016

A Capacitor can be modelled as a parallel plate transmission line. The image below shows some copper plates used to build one, the image following shows a Capacitor. Normally we described a Capacitor in a circuit as a point value of say 10 microfarads, not taking into account the distributed nature of the component.



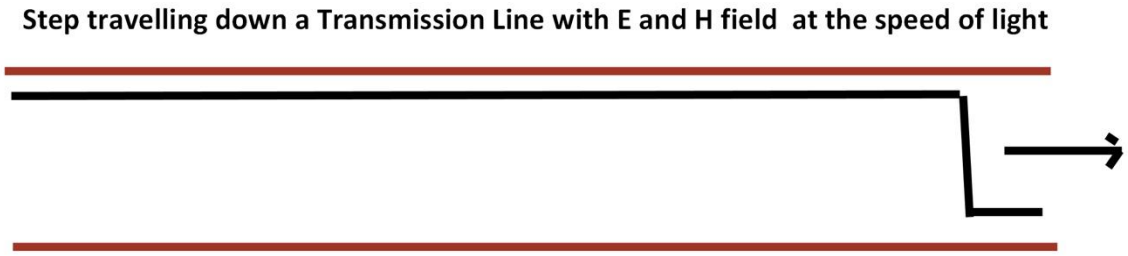
For the purposes of this query, we must make the following axiomatic statement;
A Capacitor is a Transmission Line.

Let us now consider another type of transmission line, say a twisted pair cable. For the purposes of the discussion we can consider this to be an ideal transmission line. It has a Characteristic Impedance of 120 ohms.

A 5 Volt step is propagating down the transmission line. The only change of signal is on the front end of the pulse, which is five hundred nanoseconds in length. Our cable is say, 1000 ft long. We observe the signal passing us at the speed of light for the medium, maybe half way down the transmission line. After the edge has passed we may observe a steady state signal

moving at the speed of light which is approximately 1 ns/ft. We observe this until the trailing edge has passed.

Here is an example of the pulse.



What part, if any does Displacement Current play in this scenario? Is Displacement current on the leading edge of the pulse, is it flowing across between the Transmission Line plates. (Twisted pair Wires)

As Mr. Keith Whites mentions in his Displacement Current notes;
‘

Importance of Displacement Current

Displacement current is just as important and just as relevant to an electrical circuit as conduction current. As we’ve just seen in the previous (and very simple) electrical circuit, there would be no (time varying) conduction current in the circuit were not displacement current present in the capacitor.

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http://whites.sdsmt.edu/classes/ee382/notes/382Lecture5.pdf

Keith Whites

Response to Email 2

Hello Malcom,

It looks like you're having some fun putting together this document. Good for you…and enjoy the process of discovery ☺

In the way of helpful feedback, I would say I agree with you that the distributed nature of the physical structure of a capacitor is usually neglected, and that can be a serious mis-assumption. But I would suspect this to be an issue when the electrical size of the capacitor becomes appreciable (i.e., not small). Luckily, we can usually ignore it's distributed nature when it's electrically small, or electrical circuit design would be much more complicated ☺

With kind regards,

KW

Email 3

Hello Keith,

I wondered if you'd had a chance to consider my question in the paper I had attached?

thanks and Best Regards,

Malcolm

Response to Email 3

Hello Malcolm,

No, I haven't. Sorry. And it's likely I won't be able to anytime in the near future. Totally swamped.

With best wishes,

KW