Perspectives - Summer School 2014

Engineering

The Technology of Wireless Energy

The Oxford University Malaysia Club is proudly sponsored by Shell Malaysia

Perspectives – OUMC Summer School 2014

'Wireless Energy'

Engineering Module Tutorial Sheet

Introduction

The tutorial sheet contains background information regarding the topic, simple questions to get you to recall some of the things that you would have been taught in school/college, and some other questions that will get you to think about the concepts at a deeper level. The questions are in red.

My intended style for this tutorial is unlike a conventional tutorial, where students complete the set work and discuss their approaches and their answers with their supervisors. I will begin with a breakdown into the concepts to bring everyone up to speed with the necessary things that constitute the transmission of wireless energy. Theory rarely matches practice, and this is something that engineers are trained to deal with, so, I will be talking through some of the considerations that need to be kept in mind in order to produce a more true-to-life model.

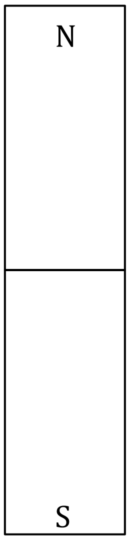
Wireless Energy

Imagine buying a mobile phone, and never needing to plug it into the power socket to charge it. Appliances that no longer require batteries, because all of the energy it needs to run itself can be harvested from the air around it.

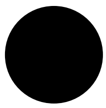
But we forget. Less than 50 years ago, all of our communications and information transfer was done either by wire or by post. Everything changed when we discovered waves. Waves themselves are beautiful things, allowing us to beam information to faraway places without needing a physical link between the two terminals.

The concept behind wireless energy transfer is closely related to transformer technology. I will introduce the necessary constituents of wireless energy technology in this handout, and will discuss how all of this ties together on Saturday.

Magnets and Magnetic Fields



Please draw the magnetic field lines around this bar magnet that most of you have (hopefully) seen plenty of times before. Notice how it looks rather similar to a pattern exhibited by a solenoid.



Please also attempt to draw the magnetic field around the point charge moving into the page. This is to assist future mathematical modeling.

I will now introduce a concept called the magnetic flux density, B (measured in Tesla). Essentially it is a measure of how many field lines there are in a unit area. Imagine that you have a small square that you consider to be a unit area, and you are moving it around the magnetic field of the point charge. How does the density of the field vary with the radius from the point charge? Is there a mathematical relation that can be used to explain it?

Faraday's Law of Induction

There is a lot of explanation online about how all of this works, and I do recommend that you take a look at a Wikipedia page, but what I would like to say is that it is a relation between the magnetic flux lines (magnetic field lines) and the coil of wires intersecting said field lines. These junctions are the magnetic flux linkages, and are the ones that allow the induction an e.m.f. in an electrical circuit.

Magnetic flux or Φ, is closely related to B, the unit which I had introduced not too long ago, and if you think of the dimensions of B, the formula for Φ would be pretty straightforward. I have attached a few simple questions for you to visualize this.

A square plate of $5cm^2$ is exposed to a magnetic field with a flux density, B of 0.5 T. What is the magnetic flux within the plate, Φ if the square plate is:

Perpendicular to the field lines?

Parallel to the field lines?

At an angle to the field lines?

It is important to note that I have not supplied any diagrams as it would be rather simple to figure it out then. I would also like to mention that perpendicularity is important in this regard, but I will leave it up to you to figure that out.

Moving on to induction, you would have read that it is defined as the rate of change of magnetic flux linkage. Which is exactly right. I will be talking through it on Saturday in a bit more detail, but this should suffice for now.

Transformers

This is basically the last step on the road to achieve wireless energy transfer. Most of you may have heard of it already, but transformers consist of 2 separate coils of wires, and an iron core between them.

The coils themselves are electrically isolated from the iron core, so there is no actual electrical connection between the two coils, but energy is transferred by the magnetic field produced by the primary coil.

The next question would be, how is there a change in magnetic flux linkage when the magnetic field produced by the wire is constant?

The voltages are either stepped down or stepped up by varying the number of coils in the secondary and primary sides of the transformer. How is that achieved? Does this still conserve energy within the circuit?

Wireless energy basically follows the same principle of the transformer, except for the fact that it uses an air core instead of an iron core. What advantage does an air core have over an iron core and vice versa? (Bring yourself back to the variation of magnetic field strength for a moving point charge)

Real World Applications

If everything goes according to theory, it would mean that the air-cored transformer achieves 100% efficiency, which is absolutely untrue. Based on the field lines of a solenoid, where can you see energy being lost? (I will be introducing more concepts on Saturday, this is my trying to get you to think a little, read up if you wish)

Conclusion/Points to Take

I have hopefully managed to provide some insight into how this technology works, but the important thing to take away from this is the process that an engineer goes through, taking familiar concepts, identifying key parameters, understanding the behavior of these parameters, and applying them to solve a problem. I will attempt to conduct my class with a lecture to bring all the concepts (the ones above and more) to the table, and then use the rest of the time to engage in discussion.

End of Tutorial Sheet

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