ECEN 3400, Fall 2013, Zoya Popovic

Project 2 (covers material in chapters 12-17)

Assigned: October 29, 2012

Due: November 18th, by class time, but you can turn it in earlier if you wish. You have plenty of time, but start soon, it takes more time than you think to make up a problem set.

For this first project, you are asked to

(1) design and solve a long homework problem set related to an electromagnet on a crane used for lifting steel rebars in construction.
(2) Learn about Ground Fault Circuit Interrupt (GFCI) and write a short paper about it.

Part (1)

A typical rebar (metric gauge #36) has a mass of 8kg/m and you can assume that each bar is 10m long and that 10 bars are tied and lifted at the same time. The nominal diameter of a #36 rebar is 36mm.

The homework set should have 8 problems. Please type up the problems, but you do not need to type the solutions. You can scan them and send everything electronically, or turn in hard copies, your choice. The following concepts that we have studied in magnetic fields need to be covered in the homework problem set you design:

1. Magnetic field intensity (H)
2. Ampere's law
3. Magnetic flux density (B)
4. Magnetic flux
5. B(H) dependence in linear and nonlinear materials
6. Inductance
7. Magnetic energy
8. Magnetic forces

Some assumptions you are allowed to make (please state them if you use them):

- A core with a high permeability has very low loss
- There is low leakage flux
- You can pick a core material for your electromagnet: either find a curve (give source) or make up a reasonable function for the magnetization curve.

Part (2)

For this part of the project, gather information about Ground Fault Interrupt and how it is done with a GFCI.

- Define the problem as clearly as possible.
- Make your own drawing that accompanies the text, after you have done all the research.
- Find as much quantitative information as you can related to the topic.

- State all your sources. Type everything up, and do any figures using a drawing program. Make sure you label everything in the figures. Use font Times New Roman, size 12pt, 1" margins. Figure captions should be complete and clear, and referred to in the text.
- Extra credit: make a quantitative homework problem with numbers from the data you collected.

You should work on these problems independently and challenge yourself. Do not work in groups, and do not copy from anyone. I will not be kind if you copy, I want everyone to do this at their level, the best they can. This is how you will learn the material. I will definitely give extra credit to those who do an exceptionally good job, but you will get full credit even for the simplest but fully correct assignment.

Example outline for Part (1)

Below is an example of what a problem might look like. I specified fewer items than in Project 1, because by now you know more about what is needed (I will return the graded Project 1 with comments on Monday, November 4^{th}).

- Define the core you are going to use. State your source. Define the dimensions. Solve for H field given dimensions and number of windings (Ampere's law).
- Find the B-field in the core, in the rebar bunch, and in any gaps that arise as you are trying to lift the rebar bunch.
- Find the magnetic flux through all the parts of your magnetic circuit.
- Find the energy in your electromagnet in terms of the parameters you have decided to give above.
- Find the force and make sure it can lift the rebars.
- What current and how many windings are needed for this? What wire will be used?

Note: I would approach this backwards in terms of specifying what is given, numbers, etc. Start with force that you need, then find energy, then B, etc.

Some other guidelines:

- You can use ideas from problems in the workbook, but do not copy them directly, at least change numbers or what is given.
- You are also welcome to use examples from other textbooks, but please reference them in that case (I would like to see if you read another book, so this is viewed as positive).
- Below is an example outline without the details, but you can make up your own. I would like to see some creativity, but it is more important that you understand the problem, use precise technical wording to formulate it, and do a correct solution.
- A good idea is to give your problem(s) to another student to read to make sure it is clear. Off course, it will help if you do not leave this for the last minute.
- Because you have plenty of time, I expect high quality and a professional job.