University of Alaska Fairbanks
Electrical and Computer Engineering Department
EE 408 – Power Electronics Design
Spring 2013

Senior Power Electronics Capstone Design Project

Objective:

The objective of this project is to design, simulate using PSPICE, build, and test a power electronic conversion device capable of being fed from a single-phase 120VAC source or a 12VDC battery that meets the design requirements listed below. The design project will make use of the knowledge and skills acquired in previous course work and incorporate "***multiple realistic constraints*** and ***engineering standards***". The ***IEEE code of ethics*** will also be addressed in the design process. You will need to combine what you learn in the class lecture and laboratory and additional literature such as technical articles and/or materials from the textbook to complete this project. The laboratory focuses on the design project with six labs during the first half of the semester to address the step-by-step design process and concepts required to build a power electronic conversion device.

Design Problem Statement:

You work for WIES Power Electronics Design and your boss has asked you to work in design teams of two or more (depends on the total number of students) on one of the following projects:

1) Design a maximum power point tracker (MPPT) system for a 75-W photovoltaic (PV) panel for a fixed mount arctic region application using remains from the Greenland project. The MPPT PV system will use the available voltage and current from a 75-W PV panel mounted at a fixed tilt angle to supply maximum available dc power to charge a battery and serve a dc load.
2) Design a regulated dc source to power a 1TB ESATA hard drive in a server to store power systems data that is being uploaded from remote monitoring sites in remote communities of Alaska. Each 1TB drive requires a constant 12 Vdc to operate the motor and a constant 5Vdc to operate the drive electronics with a typical average power consumption model *P typ* = (Idle *90%+ Write *2.5%+ Read *7.5%)/100% and a maximum average power consumption model *P max* = (Write + Seek + Read *3)/5 with idle, write, read, and seek power depending on the model. The available supply is single phase 120 Vac +/- 5% at 60 Hz with an unknown supply inductance L_S.
3) A project idea of your own that I must approve via a pre-proposal submitted on Monday, January 30, 2011. It must satisfy the design requirements/standards. Examples include motor controls and drives (Ecocar, EATV, and ESMV) and renewable energy related power conversion equipment.

Design Requirements:

1) The device must operate from a single-phase 120VAC source or a 12VDC battery.
2) Simulate the design in PSPICE before construction.
3) Construct, test, and verify the circuit on a breadboard. Document all results and demonstrate to the instructor for approval to proceed with CAD, ISO tool and milling.
4) Mill the circuit board(s) on the TTech J5 milling machine.
5) The proper amount of additional supply inductance must be employed to meet the German VDE standards (inductive reactance is a minimum of 5% of the base impedance).
6) A design specific high frequency isolation transformer is required with leakage reactance less than 10% based on its ratings. Cores, forms, clamps, and magnet wire supplies are available to build the transformers.
7) The percent voltage ripple at the output of the dc-dc converter must be less than 10%.

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Design Standards:

1) Follow IEEE Std 519 at point of common coupling for AC supplies:
    a. IEEE Std 519 establishes harmonic limits on voltage as 5% for total harmonic distortion THD_v and 3% of the fundamental voltage for any single harmonic.
    b. IEEE Std 519 establishes the harmonic limits for total harmonic distortion THD_i and total demand distortion TDD_i of the AC line current (see attached paper).
2) Follow IEEE Std 299-1997: Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures for proper shielding against electromagnetic EMI and radio frequency RFI interference.

Team Approach:

You will be working in teams of two on this design project and each of the team members will have specific tasks that will be documented in a project workplan as part of the proposal. The instructor will sign off on each task in the workplan as it is completed.

Reports:

You are required to write a proposal, three major project reports, and four bi-weekly progress reports as part of the design project.

1) ***Proposal (Due: Monday, Feb. 6, 2012): You are required*** to write a project proposal which lays out your intended design based on the given requirements. ***You will be required*** to submit a project workplan outlining the tasks for each team member as part of the proposal. You will meet with the instructor to discuss the proposal.
2) ***Bi-weekly Progress (Due: Jan. 30, Feb. 20, Mar. 5, Mar. 26): You are required*** to write and submit four bi-weekly project progress reports (1-2 pages) which briefly discuss the current status, results, and adherence to the project timeline. If the instructor determines that a team is not making sufficient progress on the design, the instructor will meet with that team to discuss possible avenues for moving forward to successful project completion.
3) ***Midterm Progress (Due: Monday, Mar. 19, 2012): You are required*** to write a midterm progress report which discusses your progress up to the time of the mid-term progress presentations. You will meet with the instructor to discuss the mid-term progress.
4) ***Draft Report (Due: Monday, Apr. 9, 2012): You are required*** to write a draft project report explaining your design based on the given requirements. Make sure to include any references and annotate them in order of reference within the report. You will meet with the instructor to discuss edits to the draft report.
5) ***Final Report (Due: Wednesday, May 9, 2012): You are required*** to complete a final project report explaining your design based on the given requirements and making final conclusions and edits from the draft report. Make sure to include any references and annotate them in order of reference within the report.

Report Format:

The specific written format requirements with section labels for the proposal, three major project reports (midterm, draft & final), and four bi-weekly progress reports will be provided in separate documents. The proposal and three major project reports should be sufficient in length to cover the required sections and be divided equally between the two team members. The reports should give background on the specific application and explain how it applies to power electronics. Your report should also include any