School of Electrical and Information Engineering

University of the Witwatersrand, Johannesburg

ELEN 4000/4011 Design II Project (2019)

Ver. 1.0

Introduction

This document lists the available projects for Design II (ELEN4000/4011) for 2019. The following pages details each of the projects and the summarised list of projects is shown in Table 1. Students should take note of the appropriate streams and listed prerequisites before making selections on projects.

Table 1: Summarised list of projects.

No.	Field	Supervisor	Proj Title
1	Antenna Design (EM)	R.L. Dreyer	Various 5G antenna design curves
2	Biomedical Engineering	D. Rubin	Design of a thermally controlled system for medications.
3	Control Systems	A. van Wyk	Controller design as part of an autonomous flight-control system for fixed-wing aircraft
4	Electronics	I. Hofsajer	Electronics design project: Dual mode single phase PV inverter
5	High Voltage	C. Gomes	Ground fault analysis of a 130 kV HV overhead line under different conditions
6	Power and Energy	C.S. Carlson	Dimensioning a renewable energy hybrid system with storage
7	Software	K. Nixon	Software system for campus bus transport logistics and analytics
8	Telecommunications	F. Takawira	Design of a robust codec for fading channel

Field of interest:
Antenna Design (EM)

Proposed title of project:
Various 5G Antenna Design Curves

Supervisor:
Dr. R L Dreyer

Stream:	**Pre-requisite courses (if any):**
EE	HF Techniques (ELEN4001)

Brief description of content and scope of project:

With the roll-out of 5G cellular networks a whole range of new applications are now possible. However, engineers have to design an antenna from scratch with each new application, wasting time on understanding the parameters of the antenna type. Design curves are intended to provide an easy way to determine the parametric values of an antenna for a specific application. In essence most of the simulation work is done for the engineer and presented in a collection of graphs/plots.

Students are required to choose one of the proposed 5G antenna designs (To be provided at the first meeting) and produce design curves. Their final report will consist of their design curves and an example on how to use them.

A visit to Alaris Antennas will be arranged for students to ask questions of engineers (week 3 or 4)

Students will have to think on how to compress data into 2 (or a maximum of 3) plots. Techniques such as parametric ratios, multiple plot lines or contour plots can be considered.

Field of interest:
Biomedical Engineering (Systems Design , Modelling and Electronics)

Proposed title of project:
Design of a thermally controlled system for medications.

Supervisor:
D Rubin

Stream:	**Pre-requisite courses (if any):**
IE, EE, BME	All relevant undergraduate courses.

Brief description of content and scope of project:

Many medications including vaccines and emergency injectables such as epipen are required to be kept at low temperatures. Some of these substances such as epipen must be kept on the patient's person or in an easily accessible place at all times.

The objective of this project is to design a wearable system to keep an injectable substance at a fixed, settable temperature which must be in the range of 3 ^{o}C to 15 ^{o}C. The design must include a thermally insulating container of cylindrical shape of dimensions that can hold a single epipen injection. In addition, the container must be fitted with electronics which can both measure and cool the contents using a peltier device, and provide a means by which to set and read the temperature, as well as a downloadable log of the temperatures over the last 4 months at 30 minute intervals.

The system must be battery and/or mains powered and the battery must be rechargeable. The battery must last for at least 1 month under the worst-case environmental conditions that are likely to occur. A suitable low-battery warning must be included.

The thermally insulating container must be modelled and simulated for a variety of environmental temperatures. This model may be treated as a lumped-parameter model with a single coefficient of thermal transfer.

The electronics of the system must be designed and a full analysis of power consumption must be carried out under typical environmental conditions to ensure that the design meets the specifications. An attempt must be made to minimise power consumption.

Field of interest:
Control Systems

Proposed title of project:
Controller Design as Part of an Autonomous Flight-Control System for Fixed-Wing Aircraft

Supervisor:
Prof Anton van Wyk

Stream:	**Pre-requisite courses (if any):**
EE and IE	Control II (ELEN4016)

Brief description of content and scope of project:

A control system has to be a designed for controlling an unmanned fixed-wing aircraft. The main objective is to model the airframe, actuators, and propulsion system and to design a controller and then simulate the closed-loop controlled system in Matlab.

The pre-study will also address among other things the UAV flight regulations that apply in South Africa from which a sensible specification for a general purpose system will be derived. The project has to take into consideration factors such as environmental factors (human health risk factors, green design, pollution etc.), flight stability and energy efficiency. Unfortunately it will not be possible to design a detailed and complete solution in the time available and therefore, as part of the detailed project plan to be proposed, the group has to identify relevant simplifications needed to satisfy the above objectives before commencing with the actual design.

The derived specification, platform selection, controller design and system simulation of the system must be presented in a typed report in accordance with the School of Electrical and Information Engineering's requirements for this course.

Field of interest:
Electronics

Proposed title of project:
Electronics Design project: Dual Mode Single Phase PV inverter

Supervisor:
Prof Ivan Hofsajer

Stream:	**Pre-requisite courses (if any):**
EE and IE	None

Brief description of content and scope of project:

In a residential area a PV installation could operate in one of two modes. Either the grid is absent and the inverter needs to act as a voltage source to generate a stable supply (grid forming), or the grid is present and the inverter needs to operate as a current source injecting any PV power into the grid (grid tie).

These two modes of operation require quite different characteristics in the control and operation of the inverters. This design project requires a 1kW inverter design and supervisory control system that will be able to switch between the two modes of operation depending on conditions.

The supply to the inverter can be considered constant and the MPPT of the PV system need not be incorporated.

Field of interest:
High Voltage

Proposed title of project:
Ground fault analysis of a 130 kV HV overhead line under different conditions

Supervisor:
Prof. C. Gomes

Stream:	**Pre-requisite courses (if any):**
EE	Power Systems (ELEN4018) and/or High Voltage (ELEN4003)

Brief description of content and scope of project:

A 130 kV overhead transmission line (OHL) is connected at one end to a stiff network.

At a tower situated along the line at a point X (where X is in tens of kilometres) from the stiff network connection interface, a line to earth fault takes place. The phase conductors are made of an aluminium alloy and the shielding wires are made of steel. Making any suitable and reasonable assumptions (both factual and numerical), analyse the fault current condition and voltage distribution under various scenarios such as

- under lightning overvoltage and sustained overvoltage
- in the presence and absence of shielding wires
- soil conductivity varies from infinity to small finite values
- the arcing taking place to both tower and shielding wires.

You may analyse the possible fault current conditions assuming a tower model and insulators and conductor arrangement suitable to a 130 kV transmission system. Using suitable software/analytical methods optimize the tower model and select insulators to minimize the fault conditions discussed. Provide justification for all engineering decisions made.

Field of interest:
Power and Energy

Proposed title of project:
Dimensioning a renewable energy hybrid system with storage

Supervisor:
Mr C.S. Carlson

Stream:	**Pre-requisite courses (if any):**
EE (IE only after consultation with supervisor)	None

Brief description of content and scope of project:

Based on real-life consumption pattern data for a particular application, the student is required to design a feasible renewable energy hybrid system including an energy storage facility, if a wind-turbine and/or a photo-voltaic array are available as sources of renewable energy. The fluctuations in the availability of the renewable energy sources as well as the load must be taken into account. A cost analysis has to be done for the system in order to arrive at a reasonable commercially acceptable system.

Field of interest:
Software

Proposed title of project:
Software system for campus bus transport logistics and analytics

Supervisor:
Prof Ken Nixon

Stream:
EE and IE

Pre-requisite courses (if any):
None

Brief description of content and scope of project:

The sustainable use of energy, especially with respect to transport systems, is becoming increasingly important in the global context. Locally, the University of the Witwatersrand is a relatively large organisation where transport forms an important part of the day-to-day running of the institution. In this project students will be required to design a software system that can be used within a university context to plan, operate and maintain a bus transport system.

It is very important that the proposed design solution:

1) is able to record and present data on the current bus fleet such that informed decisions can be made in migrating to an electric fleet,
2) can be used for full analytics once the migration has happened,
3) caters for all stake-holders (students, academics, operations and management, etc).

The substantial size of the system involved means that each student will be required to focus on one or more specific sub-components of the design, but also be able to contextualise their solution in the broader design.

Field of interest:

Telecommunications

Title of project:

Design of a robust codec for fading channel.

Supervisor:

F Takawira

Stream: EE / IE / both

IE

Pre-requisite courses (if any):

Brief description of content and scope of project:

Design a codec that achieves a rate of at least 2 bits/Hz operating over a Raleigh fading channel. To combat the effect of fading, the designed system must employ some form of MIMO technology. The data rate must be at least 10Mbits/s. Your design should specify and justify your choice of the following:

- Modulation scheme and its corresponding demodulation
- A channel encoding scheme and its corresponding decoding.
- Appropriate MIMO architecture

The chosen modulation/coding/MIMO scheme must be mathematically described, tested and analysed. Sensible assumptions about transmit frequencies must be made. Matlab/Octave/C++ simulation results for transmission over the Raleigh fading channel must be provided.