Faculty of Engineering and the Built Environment
Department of Electrical Engineering

EEE4036A

Design Project (Team 14)

Benjamin Scholtz (SCHBEN011)
Jarushen Govender (GVNJAR002)
Isaac Lebogang Khobo (KHBISA001)
Nasko Stavrev (STVATA001)
4^{th} year BSc. (Eng.) Electrical Engineering Department
Lecturer: Riana Geschke
17th March 2016

Contents

Plagiarism Declaration

DECLARATION:

1. I know that plagiarism is wrong. Plagiarism is to use anothers work and to pretend that it is ones own.
2. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.
3. This assignment is my own work. I have not used the material in this assignment in any of my other assignments.
4. I have included internet article, book, or other material references used for this assignment.

Signed: Benjamin Scholtz (SCHBEN011), Jarushen Govender (GVNJAR002), Isaac Lebogang Khobo (KHBISA001), Nasko Stavrev (STVATA001)

Date: 17th March 2016

---

1 TASK CLARIFICATION

1.1 Background

UCT Upper campus has a number of parking areas for staff, students and visitors using cars to travel to campus. There are red, yellow, blue and unmarked bays on campus. In addition there are disabled and visitor parking bays on campus. These categories are assigned the highest priority.

For every user, a parking category is assigned, and an associated annual fee is charged. The purchase of a parking disk allows the staff member/student/visitor to search for a parking spot in the designated category on campus, but it is not guaranteed that one will be available, since parking bays are oversold. When arriving on campus, a driver of a car may spend some time searching for an available spot in the required category. Parking disks are generally linked to a person and only valid for the specific vehicle for which the disk has been purchased, except for student lift clubs.

The Traffic Department on Upper Campus administrates and manages all aspects related to parking of vehicles. [1]

1.2 Problem Statement

For a driver entering Upper Campus in a car, it is not immediately apparent where there are parking bays available. This is a particular problem during peak times when a large number of cars arrive on campus, looking for parking at the same time. The design assignment is to solve this problem using the electrical engineering skills of each of the team members in your group. [1]

The design assignment is:

- To provide information in an easily accessible format, to each driver of a car immediately on arrival on campus, on where all the vacant parking bays on campus are. This must be for the specific category of parking for this user.
- To determine whether a vehicle is parked on a bay not designated for this user, for example a yellow disk holder parks on a red bay, or a visitor parks on a disabled parking bay, and make this available to the traffic department in real time.
- To allow electronic reconfiguration of traffic bay allocations on special occasions, for example during the summer school period, when there are many visitors requiring parking on campus.
- To monitor and log the use of parking bays and the percentage of occupation of each parking area and make this available to the traffic department, for the purpose of planning. [1]

2 CONTEXT OF DESIGN

2.1 Macroeconomic Factors

STEEPLE.

2.2 Microeconomic Factors

3 DESIGN SPECIFICATION

3.1 Scope

This specification covers the analysis, design, production timeline and considerations, and lifecycle of the upgraded UCT parking system. The specification is for a parking system on upper campus to be used primarily in allocated parking zones rather than dispersed parking bays. The parking system specifications aim to meet the requirements introduced in the client problem statement.

3.2 Applicable Documents

The following documents are applicable to the project and are of importance to the ultimate specifications of the project:

- Group Allocation
- Group Project Assignment
- Design Notes

3.3 Characteristics

3.3.1 Functional Characteristics

Function 1: User interface
Information must be available in an easily accessible format to indicate to drivers where legal parking bays are located. **Function 2**
Interface Characteristics

3.3.2 Quality Assurance

Standards and Codes
The design must meet the following standards and codes:

- IEEE Standards.
- SABS Standards.
- ICASA RF Regulations.
- RF PCB Design Standards.

Methods of Testing

The design should be tested using the following method:

1. Periodic random parking bay testing.
2. HIL system testing.
3. Brute force user and operator interface testing.
4. Long term power system testing.
5. RF propagation testing.

Reliability Issues

3.3.3 Timescale

Design Schedule
The embodiment design should be completed within the given period of just under two months, in time for hand in after the first UCT term.

Development Schedule
Thereafter the final design should be developed and tested within a period of 4 months; and certified with the relevant organisations within a period of 2 months.

Production Schedule
The final design should be prototyped over a period of 1 month and then any necessary changes completed within 1 month thereafter - a final product will be sent for production over the course of 1 month. The necessary traffic department staff training and student/user familiarisation will be completed during the production time period over a period of 2 months.

Delivery Schedule
The complete system will be installed and in use over the period of 1 month.

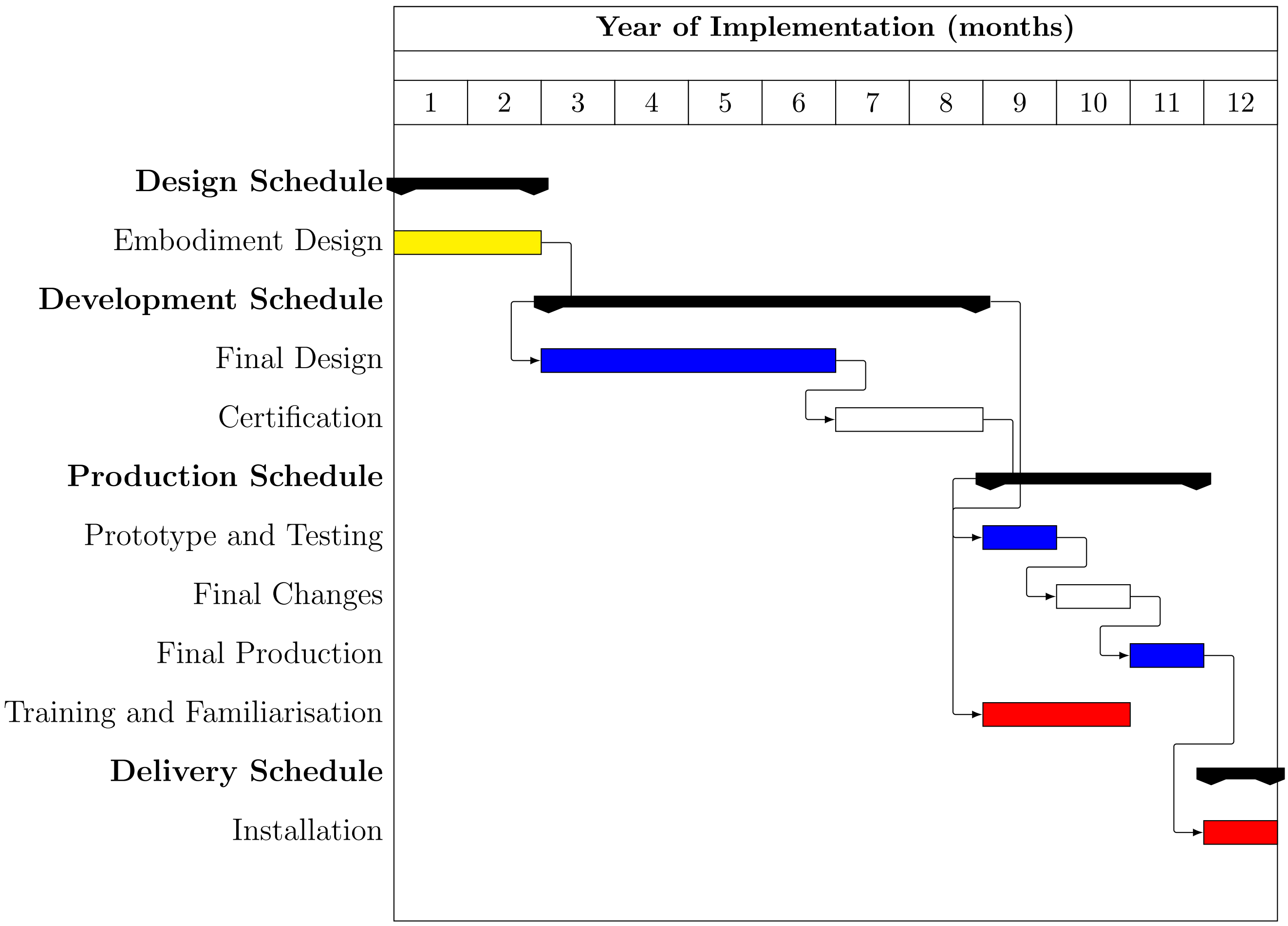

Figure 1: Project Gantt Chart.

3.3.4 Economic Factors

Market Analysis
Design Costs
Development, Manufacturing, Distribution Costs

3.3.5 Ergonomic Factors

User needs
Ergonomics
Controls

3.3.6 Life-cycle

Distribution
Operation
Maintenance
Disposal

3.4 Acceptance Test Requirements

Function Test Requirements
Test methods: Could be by inspection, theoretical modelling, simulation, laboratory functional demonstration, field trials, in-service measurements, etc.

4 CONCEPTUAL DESIGN

4.1 Design One

Design One (D1) uses a triangulation system to locate the registered vehicle within the parking area. Each registered vehicle has a tag with a unique ID - this ID has the user data linked to it in a database on the server back-end. The location of each parking space is known, and with the knowledge of where the vehicle is located it can be determined whether the vehicle is legally parked or not.

4.1.1 System Diagram

4.1.2 System Components

Tags and Beacons
Due to a triangulation system being used, in every parking area there are at least three beacons - with four being used to try to eliminate signal propagation issues. The tags and beacons make use of a Decawave DW1000 ultra-wideband transceiver chip that is controlled via SPI from a Atmel microcontroller.

The master beacon sends a signal out to synchronise all the beacons to the same time reference. Each tag sends a signal periodically with the unique user ID, transmit time and battery level which is received by each of the beacons. The beacons all relay time of flight data back to the master beacon which performs a time difference of arrival (TDOA) calculation to determine where the tag is located. [2]

The tags transmit with a period of 5-10 minutes. This reduces power consumption and signal noise level interference with other tags. The tags do not receive data. The tags will be accurate to within 10cm giving more than enough accuracy for the application. The initial conservative battery life estimate is 5 years with proper power management in software. They will be powered with a LiPo battery that will need to be replaced or charged when discharged.

The beacons will use the same circuitry, but with different software running on the Atmel microcontroller. They will be required to both transmit and receive. The beacons will be mounted on poles (both light and installed) distributed across the UCT campus - this will allow the location of vehicles in any area. They will be powered with LiPo batteries which will be charged with solar panels - or wired in cases where this is not practical.

Server Back-end
The server back-end connects with the master beacon via WiFi and receives the tag location, unique ID and battery level for every new vehicle. This is updated on a database every 5-10 minutes. Further calculations and visualizations are performed and stored in the database to send to the end user. The following data will be available for each unique ID:

- User privileges.
- Tag location (updated periodically).
- Tag battery level (updated periodically).

User Interface
The user interface will connect with the server back-end to access the database and will relay the following data to the end user via a smart phone application or web application:

- Indication of privilege level and violations.
- Tag battery level.
- Vehicle location.
- Location of open parking bays.
- Recommended parking area.
- Number of free parking bays in parking area.
- Traffic heat-map on campus.

4.1.3 Requirement Satisfaction

4.1.4 Evaluation

Cost
(implementation, maintenance, energy consumption)
Strong/weak Points

4.1.5 Risk Assessment

External Causes
(weather, vehicle impact, human interference)
Intended Life
risk of failure during intended life
Mitigation
mitigation (steps you will take to reduce the risk)

4.2 Design Two

4.2.1 System Diagram

4.2.2 System Components

4.2.3 Requirement Satisfaction

4.2.4 Evaluation

Cost
(implementation, maintenance, energy consumption)
Strong/weak Points

4.2.5 Risk Assessment

External Causes
(weather, vehicle impact, human interference)
Intended Life
risk of failure during intended life
Mitigation
mitigation (steps you will take to reduce the risk)

4.3 Weighted Selection

The following weighted selection tables were formed and weights given to each aspect of the system design in order to determine which design meets the requirements outlined in the design specification:

Table 1: Weighted selection: Design One [3]

Aspect	**Score (1-5)**	**Weight**	**Total**
Functionality / User satisfaction	5	20	20
Cost of implementation / Maintenance	5	40	40
Reliability / Safety	4	10	8
Ease of installation / Maintenance	5	20	20
Life span	3	10	6
Total score (100):			94

Table 2: Weighted selection: Design Two [3]

Aspect	**Score (1-5)**	**Weight**	**Total**
Functionality / User satisfaction	3	20	12
Cost of implementation / Maintenance	3	40	24
Reliability / Safety	4	10	8
Ease of installation / Maintenance	4	20	16
Life span	4	10	8
Total score (100):			68

4.4 Recommendation

Based on the weighted selection and evaluation above, Design One should be further developed as a viable parking system solution for UCT upper campus. The embodiment design should be completed along with the necessary analysis and system testing.

5 EMBODIMENT DESIGN

5.1 System Overview

5.1.1 System Description

5.1.2 System Diagram

5.2 System Analysis

Analysis of system operation, interfaces, use etc.

5.3 Software Design

5.4 Mechanical Design

5.4.1 Mechanical Requirements

Durability, forces, dynamics.

5.4.2 Technical Drawings

5.5 Electrical Design

5.5.1 Power Requirements

Battery life etc.

5.5.2 Schematics

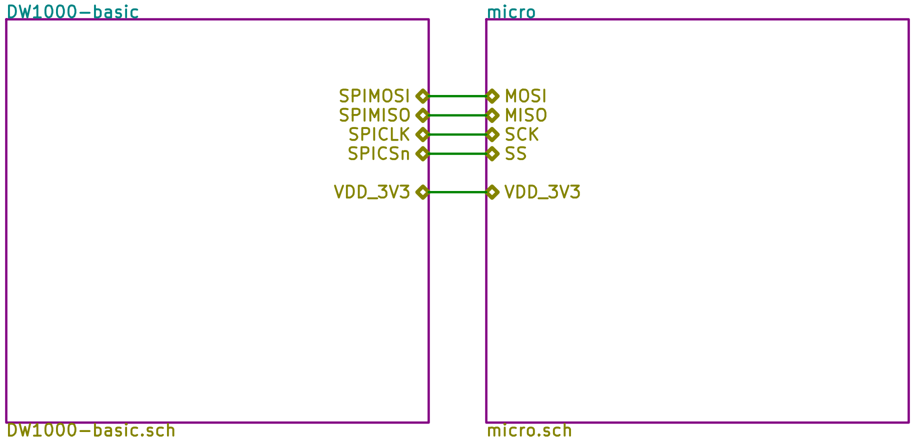

Figure 2: Parking system tag schematic diagram: interface connections.

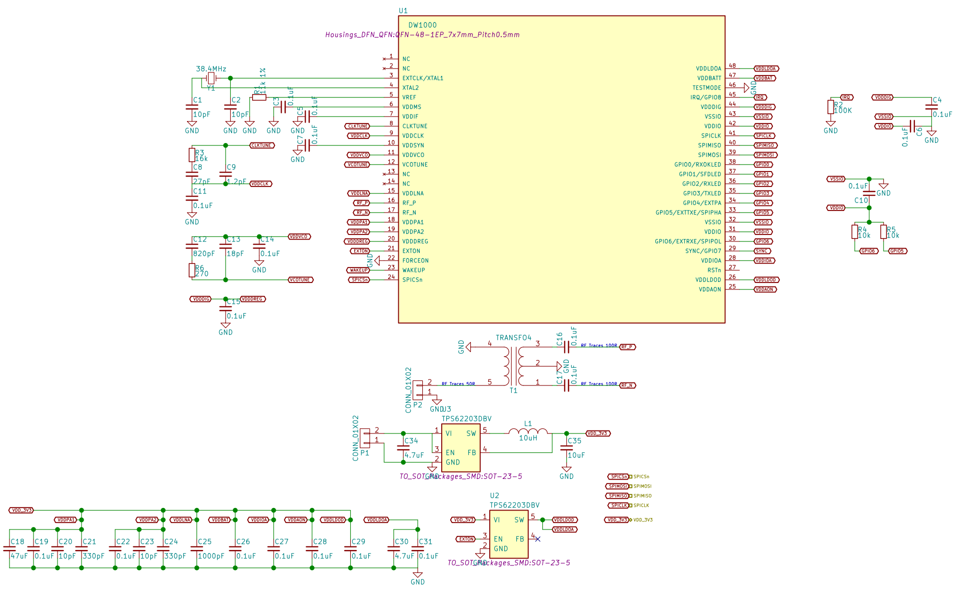

Figure 3: Parking system tag schematic diagram: transceiver chip.

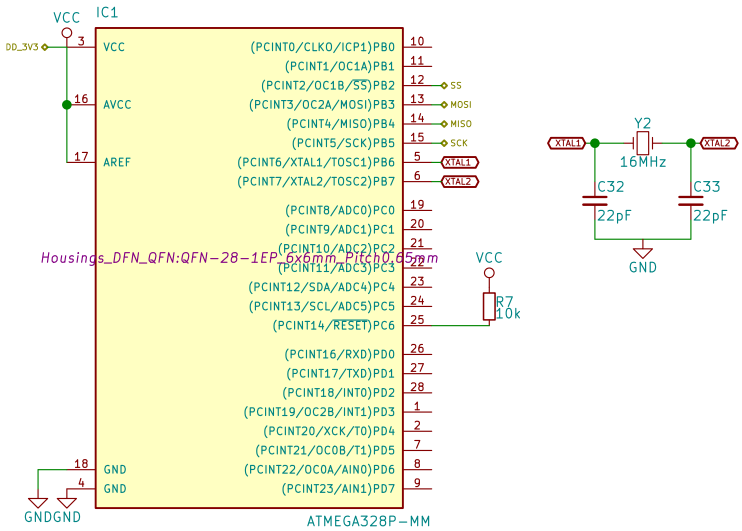

Figure 4: Parking system tag schematic diagram: micro-controller.

5.5.3 PCB Design

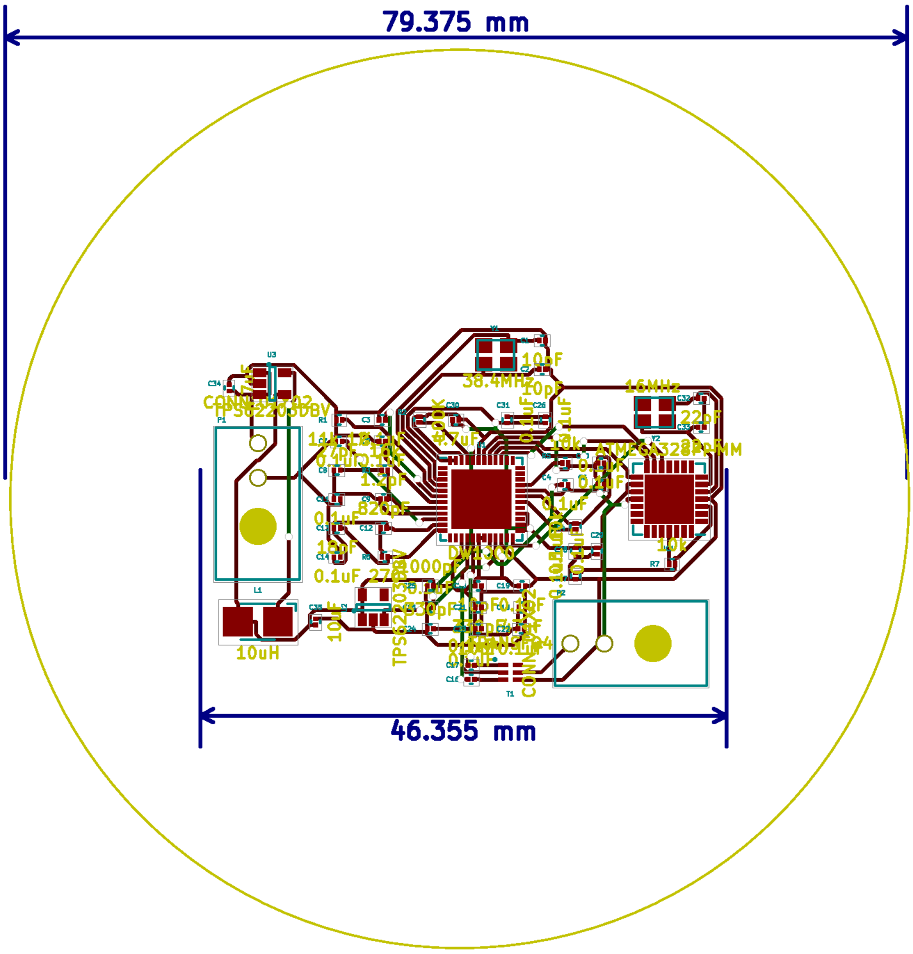

Figure 5: Parking system tag PCB layout.

5.5.4 Bill of Materials

5.6 Assumptions

Identify and show that checked validity.

5.7 Failure Modes

Probabilities,Consequences,Mitigation

5.8 System Lifetime

A statement of the design life time, with explanation of what (if anything) will limit it.

5.9 Worst Case Calculation

For at least one component / sub-system

References

[1] Riana Geschke. (2016, February) EEE4036A Electrical Engineering Design 2016. [Online]. Available: Private

[2] Luc Darmon, Gerry O'Grady, Mike Clancy. (2013, November) DecaWaves ScenSor DW1000: The Worlds Most Precise Indoor Location and Communication CMOS Chip. [Online]. Available: http://www.decawave.com/sites/default/files/resources/decawave_scensor_presentation_santa_clara_1.pdf

[3] Riana Geschke. (2016, February) EEE4036A Class Handout. [Online]. Available: Private

Appendices

Appendix A: Contributions

Appendix B: Progress Reports