



**UNIVERSITY OF CAPE TOWN**  
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

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<sup>th</sup> year BSc. (Eng.) Electrical Engineering Department

Lecturer: Riana Geschke

28th March 2016

---

# Contents

<b>1</b>	<b>Plagiarism Declaration</b>	<b>4</b>
<b>2</b>	<b>TASK CLARIFICATION</b>	<b>5</b>
2.1	Background . . . . .	5
2.2	Problem Statement . . . . .	5
<b>3</b>	<b>CONTEXT OF DESIGN</b>	<b>6</b>
3.1	Macroeconomic Factors . . . . .	6
3.2	Microeconomic Factors . . . . .	6
<b>4</b>	<b>DESIGN SPECIFICATION</b>	<b>7</b>
4.1	Scope . . . . .	7
4.2	Applicable Documents . . . . .	7
4.3	Characteristics . . . . .	7
4.3.1	Functional Characteristics . . . . .	7
4.3.2	Quality Assurance . . . . .	7
4.3.3	Timescale . . . . .	9
4.3.4	Economic Factors . . . . .	10
4.3.5	Ergonomic Factors . . . . .	10
4.3.6	Life-cycle . . . . .	10
4.4	Acceptance Test Requirements . . . . .	10
<b>5</b>	<b>CONCEPTUAL DESIGN</b>	<b>11</b>
5.1	Design One . . . . .	11
5.1.1	System Diagram . . . . .	11
5.1.2	System Components . . . . .	11
5.1.3	Requirement Satisfaction . . . . .	12
5.1.4	Evaluation . . . . .	12

5.1.5	Risk Assessment . . . . .	12
5.2	Design Two . . . . .	13
5.2.1	System Diagram . . . . .	13
5.2.2	System Components . . . . .	13
5.2.3	Requirement Satisfaction . . . . .	13
5.2.4	Evaluation . . . . .	13
5.2.5	Risk Assessment . . . . .	13
5.3	Weighted Selection . . . . .	14
5.4	Recommendation . . . . .	14
<b>6</b>	<b>EMBODIMENT DESIGN</b>	<b>15</b>
6.1	System Overview . . . . .	15
6.1.1	System Description . . . . .	15
6.1.2	System Diagram . . . . .	15
6.2	System Analysis . . . . .	15
6.3	Software Design . . . . .	15
6.4	Mechanical Design . . . . .	15
6.4.1	Mechanical Requirements . . . . .	15
6.4.2	Technical Drawings . . . . .	15
6.5	Electrical Design . . . . .	15
6.5.1	Power Requirements . . . . .	15
6.5.2	Schematics . . . . .	16
6.5.3	PCB Design . . . . .	18
6.5.4	RF Design . . . . .	18
6.5.5	Bill of Materials . . . . .	18
6.6	Assumptions . . . . .	18
6.7	Failure Modes . . . . .	18

6.8	System Lifetime . . . . .	19
6.9	Worst Case Calculation . . . . .	19
<b>References</b>		<b>20</b>
<b>Appendix A: Contributions</b>		<b>21</b>
<b>Appendix B: Progress Reports</b>		<b>21</b>

# 1 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:** 28th March 2016

---

## 2 TASK CLARIFICATION

### 2.1 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]

### 2.2 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]

## **3 CONTEXT OF DESIGN**

### **3.1 Macroeconomic Factors**

STEEPLE.

### **3.2 Microeconomic Factors**

## 4 DESIGN SPECIFICATION

### 4.1 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.

### 4.2 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

### 4.3 Characteristics

#### 4.3.1 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: Vehicle location**

Real time location and classification of vehicles in UCT parking areas based on user parking privileges.

##### **Function 3: System back-end**

Traffic department should be able to access data about vehicles and users on a database as well as reconfigure traffic bay allocations. The use of parking bays should be monitored and logged to be processed to show percentage occupation of parking area and get historical data. **Interface Characteristics**

Function 1, 2 and 3 should be linked with a wireless communication method.

#### 4.3.2 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**

### 4.3.3 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.

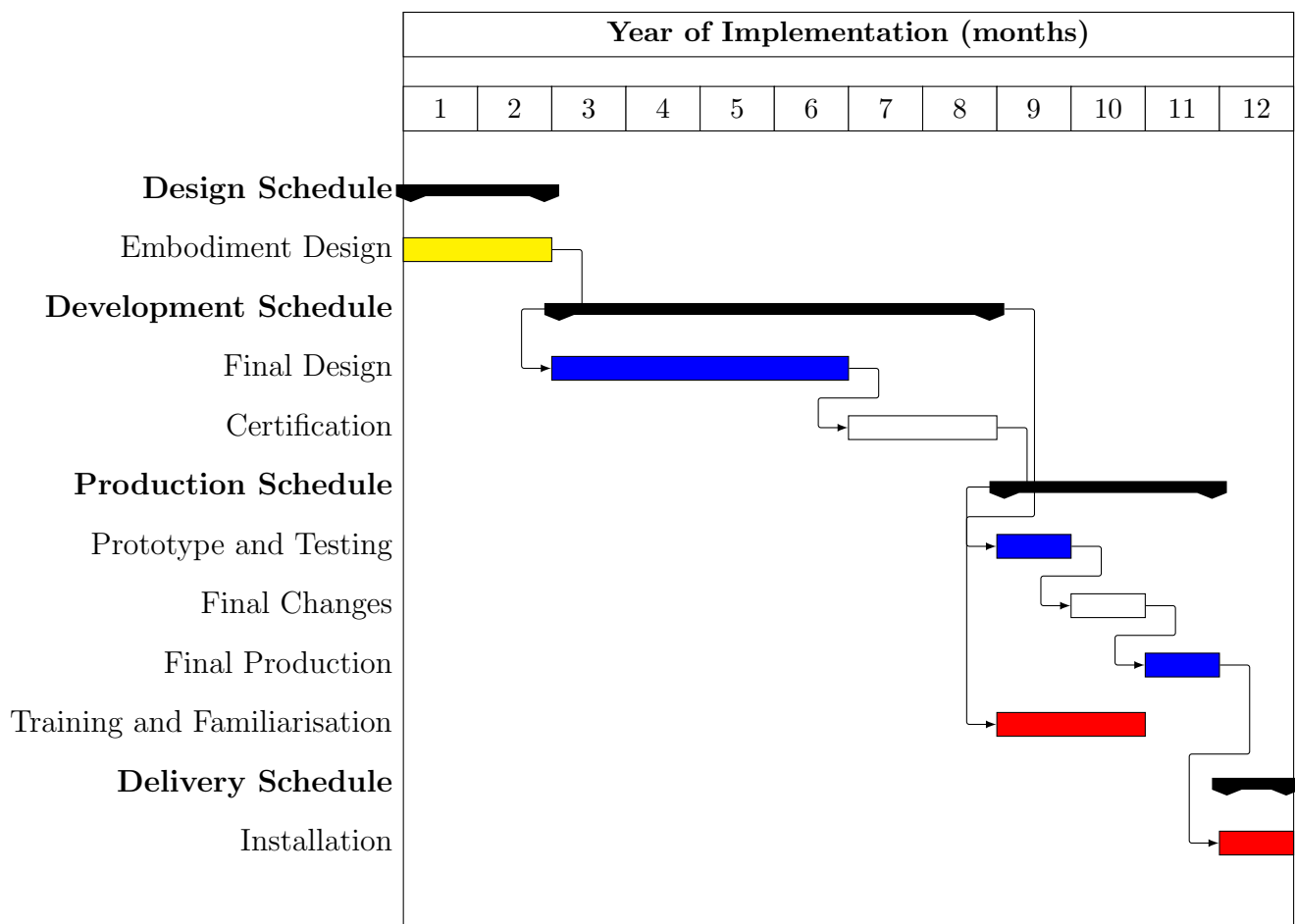


Figure 1: Project Gantt Chart.

#### 4.3.4 Economic Factors

##### Market Analysis

UCT allocates about 2.8 users per parking bay, with about 5000 parking bays available on campus. This means UCT has approximately 14000 parking disk holders who pay R500 each to park on campus for the year. This means the cash flow coming into the traffic department, assuming no external funding is received, is approximately R13.4 million per year.

808 red 1046 yellow student 2757 total 4611

unmarked 960 red 1524 yellow 960

##### Design Costs

Development, Manufacturing, Distribution Costs

#### 4.3.5 Ergonomic Factors

User needs

Ergonomics

Controls

#### 4.3.6 Life-cycle

Distribution

Operation

Maintenance

Disposal

### 4.4 Acceptance Test Requirements

#### Function Test Requirements

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

## 5 CONCEPTUAL DESIGN

### 5.1 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.

#### 5.1.1 System Diagram

#### 5.1.2 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 micro-controller.

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 micro-controller. 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.

**5.1.3 Requirement Satisfaction****5.1.4 Evaluation****Cost**

(implementation, maintenance, energy consumption)

**Strong/weak Points****5.1.5 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)

## **5.2 Design Two**

### **5.2.1 System Diagram**

### **5.2.2 System Components**

### **5.2.3 Requirement Satisfaction**

### **5.2.4 Evaluation**

#### **Cost**

(implementation, maintenance, energy consumption)

#### **Strong/weak Points**

### **5.2.5 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)

### 5.3 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
<b>Total score (100):</b>			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
<b>Total score (100):</b>			68

### 5.4 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.

## **6 EMBODIMENT DESIGN**

### **6.1 System Overview**

#### **6.1.1 System Description**

#### **6.1.2 System Diagram**

### **6.2 System Analysis**

Analysis of system operation, interfaces, use etc.

### **6.3 Software Design**

### **6.4 Mechanical Design**

#### **6.4.1 Mechanical Requirements**

Durability, forces, dynamics.

#### **6.4.2 Technical Drawings**

### **6.5 Electrical Design**

#### **6.5.1 Power Requirements**

Battery life etc.



## 6.5.2 Schematics

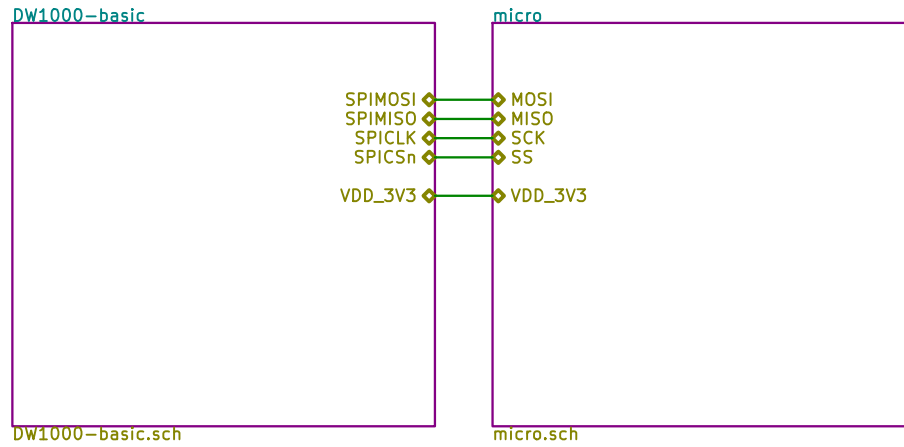


Figure 2: Parking system tag schematic diagram: interface connections.

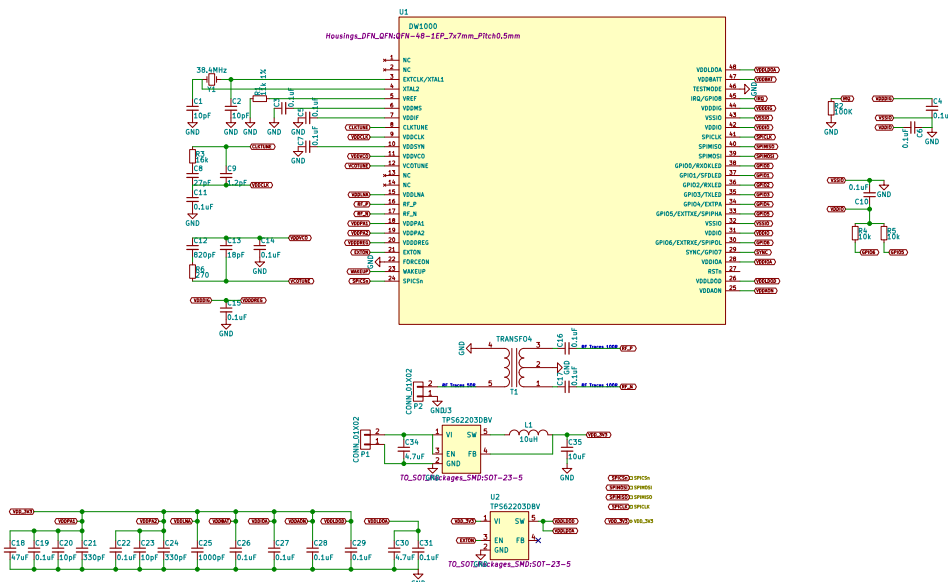


Figure 3: Parking system tag schematic diagram: transceiver chip.

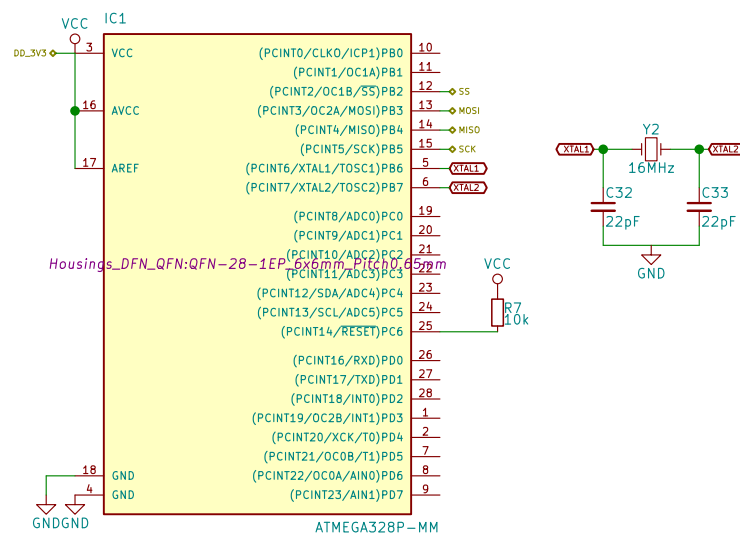


Figure 4: Parking system tag schematic diagram: micro-controller.

### 6.5.3 PCB Design

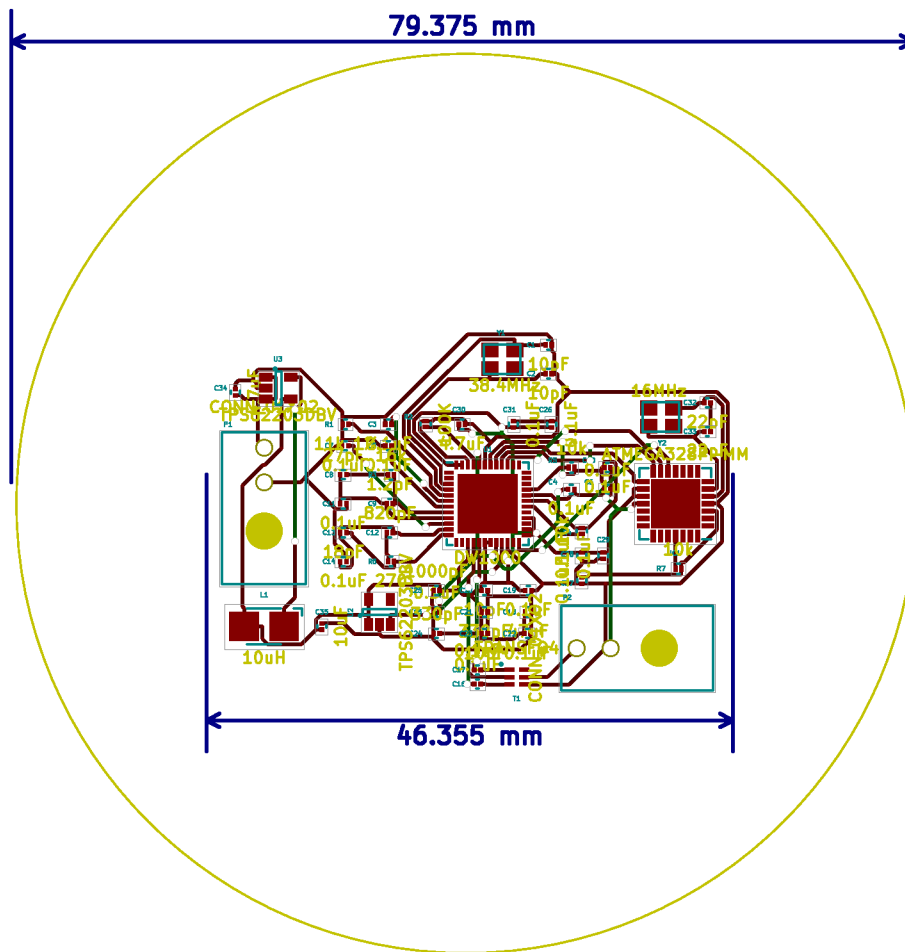


Figure 5: Parking system tag PCB layout.

### 6.5.4 RF Design

### 6.5.5 Bill of Materials

## 6.6 Assumptions

Identify and show that checked validity.

## 6.7 Failure Modes

Probabilities, Consequences, Mitigation

## **6.8 System Lifetime**

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

## **6.9 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](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**