RFID-BASED INDOOR POSITIONING OF AUTONOMOUS AID FOR DISABLE PEOPLE

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ABSTRACT

Nowadays, global positioning system (GPS) is widely used in localization area because it's very capable and reliable. However, in indoor positioning, GPS capabilities are very limited since the satellite signals are typically strongly attenuated by walls and ceiling. Thus, this project introduced the concept which presents a self-localization of a mobile robot by fusing radio frequency identification (RFID) system and wireless communication using XBee module to be used in indoor environment. Two Xbee devices will be used to transfer data from the remote control unit to mobile robot. Aims of this project are to create a mobile robot that reacts to the remote control to go to the desired position as command. To meet the desired aim of this project, practical and compact design technique are emphasized in order to create a mobile robot and the remote control. Sixteen RFID cards are arranged in a fixed pattern on the floor. A unique code of each RFID card provides the position data to the mobile robot. An RFID reader act as antenna will be installed to read the card data on the below of the mobile robot. The user can make it come by easily pressing the remote control by informing the user location.

Keywords: RFID, RFID reader, RFID tag, indoor location identification, mobile robot, remote control, navigation, wireless communication.

ABSTRAK

Kini, sistem kedudukan global (GPS) digunakan secara meluas di kawasan penyetempatan kerana ia sangat berkebolehan dan boleh dipercayai ketepatannya. Walau bagaimanapun, dalam kedudukan tertutup, keupayaan GPS adalah sangat terhad kerana isyarat satelit biasanya lemah disebabkan oleh dinding dan siling. Oleh itu, projek ini memperkenalkan konsep penyetempatan robot mudah alih dengan menggabungkan sistem pengenalan frekuensi radio (RFID) dan komunikasi tanpa wayar menggunakan modul XBee untuk digunakan dalam persekitaran dalaman. Dua peranti Xbee akan digunakan untuk memindahkan data dari unit kawalan jauh kepada robot mudah alih. Matlamat projek ini adalah untuk mencipta sebuah robot mudah alih yang akan bertindak balas kepada alat kawalan jauh untuk pergi ke kedudukan yang dikehendaki seperti arahan. Untuk memenuhi matlamat projek yang diingini, teknik reka bentuk yang praktikal dan padat ditekankan dalam usaha untuk mencipta sebuah robot mudah alih dan alat kawalan jauh. Enam belas kad RFID disusun dalam corak yang tetap di atas lantai. Kod unik setiap kad RFID menyediakan data kedudukan kepada robot mudah alih. Pembaca RFID bertindak sebagai antena akan dipasang untuk membaca data kad di bawah robot mudah alih. Pengguna boleh membuat robot mudah alih datang dengan mudah iaitu menekan alat kawalan jauh dengan memaklumkan lokasi pengguna.

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CHAPTER 1

INTRODUCTION

This chapter will focus on the brief introduction of the project to be carried out. The important overview or description including the problem statement, project objectives, and project scopes are well emphasized in this part.

1.1 Overview

Nowadays, many activities are required reliably the location of a person and an object. It is whether in the form of physical coordinates or as a symbolic label[1]. In mobile robotics areas, localization is the main and complex problem. The localization capability becomes important for path-planning, motion control and positioning in any given environment[2].

Therefore, localization system in indoor environment becomes a hot research topic in the technology of location-aware[3]. This technology is very useful for the paraplegia patients especially as it can grant them freedom of movement[4].

There are two methods of localization which is relative localization and absolute localization[5]. Example of relative localization is dead-reckoning and inertial navigation. Dead-reckoning sensors such as encoders can estimate the displacement to the starting position and orientation[2, 6]. However, dead-reckoning has no external reference signal so it can't estimate error accumulate over time. In order to improve the accuracy of localization, many approaches combine external sensors such as cameras, beacon, laser range finder, sonar or global positioning system (GPS)[5]. For absolute localization, it uses a camera, GPS, ultrasonic or infrared sensors recognize the absolute location from reference point[2, 7].

Thus, an RFID technology has been applied for this project. Actually, an RFID is functioning as object recognition and recently it is applied to robotic for the localization system especially in indoor environment regarding to the features which can be used practically[2]. An RFID tag can provide location information of a robot within the classification of information by its unique code[5]. With these features, it's suitable for solving the problem of conventional sensor system and implement a new forming robot system for localization[2].

RFID tags are arranged in a fixed pattern on the floor. A unique code of each RFID tag provides the position data to the mobile robot. An RFID reader act as an antenna will be installed to read the tag data on the below of the mobile robot. The user can make it come by easily pressing the remote control by informing the user location. Then the user location data will emit by wireless.

There are several of wireless techniques that can be located in an indoor environment, but in this project, ZigBee technology is chosen. That is because of the advantages of this technology which is low-cost, small size, little energy and so on[8]. It's suitable to use in short range data transmission between electronic components.

1.2 Problem statement

1.2.1 GPS cannot be used for indoor positioning

Global Positioning System (GPS) is a capable and reliable localization system for outdoor environments[9]. However, in an indoor environment its capabilities are very limited since the satellite signals are typically strongly attenuated by walls and ceiling[10]. In addition, in indoor environments localization system it required to differentiate locations inside the room and therefore, the domain-meter accuracy is expected. Thus, RFID-based techniques were used to solve this matter.

1.2.2 Wheelchair and user matters problem

Wheelchair is widely used by patients with gait disorder because it is inexpensive and enables to move easily as long as a little muscle power is left in upper limbs[11]. However, wheelchairs have other problems with its hardware and user matters[12]. One of the problems of the traditional wheelchair, the user still needs their family member to bring his wheelchair before the user can use it[13]. Another type of transportation device that can solve this problem mentioned above should be developed for a better welfare society. If these problems could be solved, it can help the user to move freely without seeking the help of their family members. In addition, it can reduce the burden on users when handling a wheelchair.

1.3 Aim and objectives of the project

The aim of this project is to develop a self-localization in the indoor environment of a mobile robot as a prototype of mobility aid for disabled people using RFID technology with wireless network. In order to achieve this aim, the objectives are formulated as follows:-

i. To design a remote control for a mobile robot using microcontroller and wireless systems.

ii. To develop a remote control that could give commands to mobile robot to a desired location of RFID tag.

iii. To design a mobile robot that is capable of finding a desired location using RFID technology.

iv. To design dual mode of positioning which is manual mode and automatic mode.

v. To explore the functionality and system architecture of RFID.

1.4 Scope

The works undertaken in this project are limited to the following aspect:

i. Mobile robot will be controlled wirelessly by keypad 4x4.
ii. The wireless system module is XBee S1 1mW Wire Antenna with IEEE 802.15.4 networking protocol.
iii. Have 16 specific locations of passive RFID tag.
iv. Tag location is in a grid pattern.
v. The path is not disturbed by interferences and blocking caused by obstacle.

1.5 Approach to the study

At the inception of the study, the overall approach has been described as follows: In addition to RFID-based indoor positioning of autonomous aid for disables people, there is several operational scenarios need to be considered. It consists of (1) strategies of RFID deployment (2) the detection method and (3) options to deliver the user's location information and communicating this information to the mobile robot. The RFID deployment and tracking aspects of the scenarios to be examined will include:

- The tradeoffs involved in the selection of RFID devices for this application, including cost, ease of programming, user friendly, and data capacity.
- Use various RFID location reference points to provide data for localization without the use of inertial sensors.
- The emphasis will be to make the maximum use of information and utilize software to facilitate hardware implementation. Aspects of the presentation and communication scenarios investigated include:
- Notifying the user positions to the mobile robot which consider any communication that is provided by a separate system.
- The communication system combines RFID reading and wireless network.

1.6 Significance of the study

This project arising from an idea of a difficult or impossible observations for disabled people to move or drive with a conventional wheelchair. This project is a study on the ability and suitability of using RFID technology together with wireless systems in the indoor environment so that it can be applied to improve the mobility aid. Thus, this project will design a self-localization of a mobile robot as a prototype of mobility aid for disabled people using RFID technology with wireless network. With the study of this project, hopefully it can contribute more ideas to improve the mobility aid for disabled people to enhance their range of mobility.

1.7 List of publication

I.S. Zakaria, B.S.K.K. Ibrahim (2012). Localization of Multifunction Electrical Stimula
tor (FES), National Conference on Engineering Education and Entrepreneurship (NCEEE) 2012, 8-10 May: University Tun Hussein Onn Malaysia (published).

CHAPTER 2

LITERATURE REVIEW

Literature review has been conducted prior to undertaking this project to obtain the information of the technology available and the method that used by other researchers on the same topic. This chapter provides the summary of literature reviews on key topics related to the indoor localization techniques.

2.1 Related work

Radio frequency identification (RFID) [14] technology has been utilized in the field of mobile robotics. Recent approaches in the area of mobile robot navigation have evidenced an increasing interest in the emerging RFID technology as a promising alternative due to ease of use, flexibility, and low cost[15].

Byoung-suk Choi et al. [2] reported an improved localization scheme for self-localization of an mobile robot by fusing RFID localization system and ultrasonic measurements. This novel localization system for an indoor mobile robot is proposed to improve the efficiency of the mobile robot system. The system is based on the RFID localization system, which removes the uncertainty of robot location using the distance measurements by ultra-sonic sensors. The RFID system has the same environmental-structure based on tag-floor using passive tags as depicted in Figure 2.1.

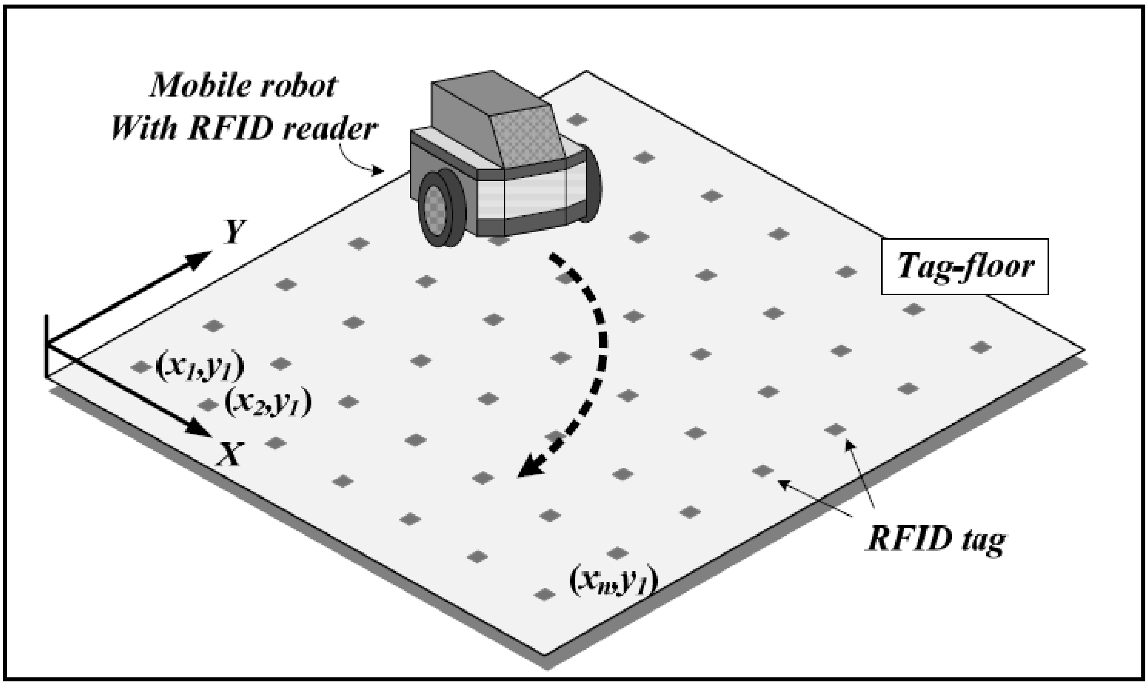

Figure 2.1: Localization system based on tag-floor for an indoor mobile robot [2].

Passive RFID tags are arranged in a fixed pattern on the floor. The absolute coordinates of the location has been stored in each tag to provide the position data to the mobile robot. An RFID reader has been installed to read the tag data on the bottom of the mobile robot. If the robot moves and stays on any tag, the RFID reader reads the coordinate value of RFID tags on the floor to localize the mobile robot. The additional localization system is required to compensate the limitation and uncertainty in an RFID system. In this paper, the additional system used is absolute-localization based on ultra-sonic range sensor system. The ultra-sonic localization systems based on the distance between the robot and environment can provide precise location, therefore they are widely used for mobile robot localization system with geometric algorithm.

Wail Gueaieb et al. [16] presented a navigation system that uses RFID tags. The technique relies on RFID tags placed in 3-D space so that the lines linking their projections on the ground virtually define the “freeways” along which the robot can navigate. The locations of the tags are unknown to the robot. The robot is pre-programmed with an ordered list of tag ID numbers defining its desired path. For instance, if the robot is given the list (4, 9, 1, 5), then it is supposed to navigate to the closest point it can reach to tag number 4, then move in a straight line to the closest point it can reach to tag number 9, and from there to tag number 1, and then to tag number 5.

The closest point to a tag that the robot can reach is usually the orthogonal projection point of that tag on the ground. During navigation, the robot continuously reads the ID's of all the tags within reach but will only process the signal coming from the destination tag at that time instant. The communication with the tags is performed through an RFID reader with two receiving antennas mounted on the robot. A high-level configuration setup of this system with two RFID tags is depicted in Figure 2.2. In this configuration, the robot's desired path is the straight line segment between the tags' orthogonal projection points on the ground, i.e., A and B.

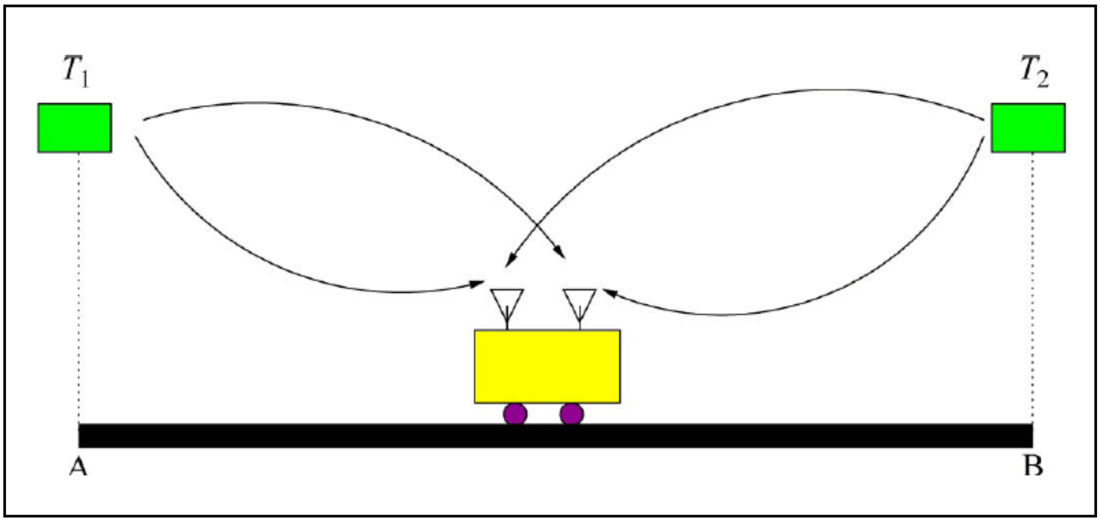

Figure 2.2: High-level system configuration with two RFID tags [16].

Sunhong Park et al. [5] developed a navigation system for mobile robots using passive RFID tags. The mobile robot consists of three main parts which is the personal computer (PC) for control, the RFID system for obtaining the location information of the robot, and the mobile base for navigation. It was developed based on an electric wheelchair for the elderly and disabled persons as a mobility device. The PC mounted on the mobile robot acts as a central controller that handles information of IC tags from the RFID system and sends commands to mobile base in order to reach the goal. The RFID system reads IC tags on the floor which allows the PC to roughly deduce the location and pose of the robot based on the proposed algorithms. Finally, the mobile base is controlled by the PC based on calculations result from information provided by the RFID system. This mobile robot has external sensors such as distance sensors and touch sensors (bumper switches) for detection of obstacles. The robot's front wheels are free rotating casters, causing some instability when moving.

The size of the antenna in the RFID system must be adjusted in accordance with the distance between IC tags. Circular antenna is constructed to detect IC tags on the 13.56MHz frequency band by using the S6350 Midrange Reader Module. It is possible to read IC tags within 6cm under the antenna. The antenna is attached to the underside of the mobile base, keeping the distance from the antenna to the floor approximately 5cm. The antenna is able to read IC tags which exist within about 17cm from the center of the antenna.

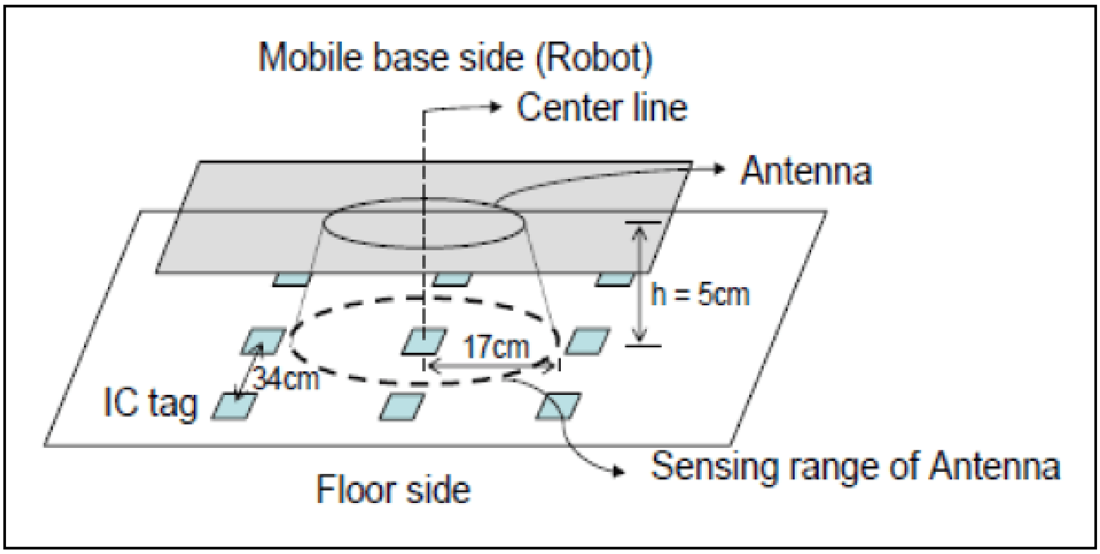

Figure 2.3: Scanning range of the RFID antenna[5].

Takehiro [17] proposed a location estimation system using UHF band RFID, with tags deployed on the ceiling. Location estimation is estimated from the radio field strength of the tag signals received at the readers. This system requires many RFID readers. The RFID used is 950MHz band passive system because it offers the communication over several meters.

Figure 2.4 shows the system outline. Each tag has a unique ID number. Tag IDs of reading tags are transferred to the server. The server has a location information mapping table that pairs each of with its coordinates. The server calculates the reader's position from the coordinates of detecting tags. This position calculation algorithm is the key advance of this paper. The design target is to not only browse the position information on real-time but also the past data with access via PC and/or mobile phone.

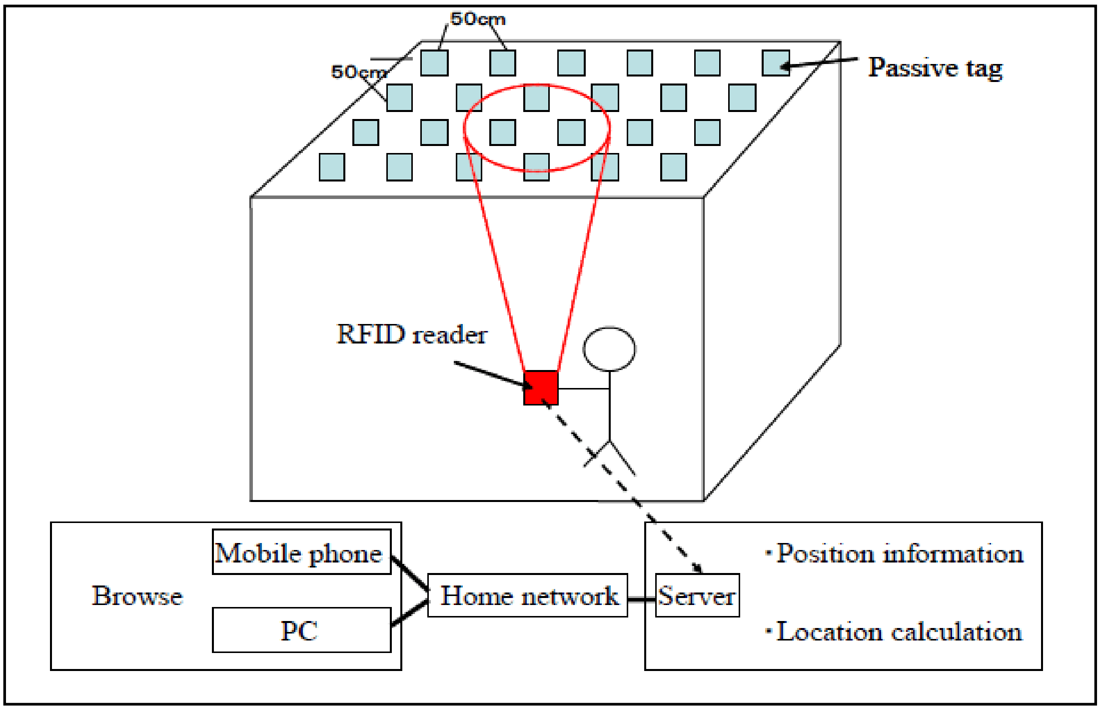

Figure 2.4: Position tracing system [17].

Prathyusha et al. [18] proposed a mobile robot navigation technique using a customized RFID reader with two receiving antennas mounted on the robot and a number of standard RFID tags attached in the robot's environment to define its path. It used the RF signal from the RFID tags as an analogue feedback signal which can be a promising strategy to navigate a mobile robot within an unknown or uncertain indoor environment. The ARM Microcontroller of Microchip LPC 2148 is used to control the autonomous mobile robot to communicate with an RFID reader. By storing the moving control commands such as turn right, turn left, speed up and speed down into the RFID tags beforehand and sticking the tags on the tracks, the autonomous mobile robot can then read the moving control commands from the tags and accomplish the proper actions.

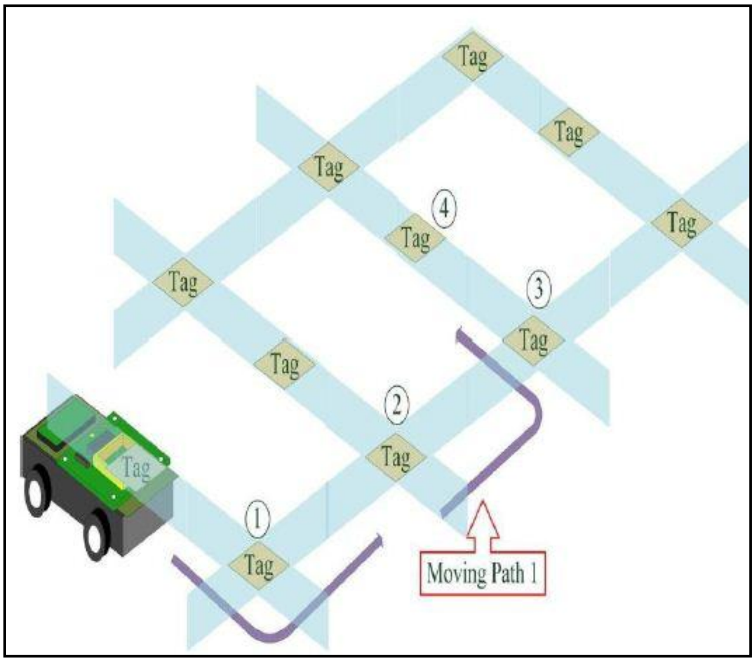

Figure 2.5: Driving circuit for the mobile robot [19].

According to the Figure 2.5, while the robot moves to tag 1 and receives the commands of turn left and speed up, then the ARM microcontroller will make some control actions to let the robot conform the commands [19].While the robot moves to tag 2, the commands of go straight and slow down were received, the ARM microcontroller will once again make some control actions to let the robot conform the commands. Therefore, the robot will then move in moving path 1 automatically.

2.2 Research comparison

The comparison for each of the previous studies regarding the RFID system in indoor positioning is summarized in Table 2.1.

Table 2.1: Comparison between each research

No.	Research Title	Advantages	Disadvantages
1	An Improved Localization System with RFID Technology for a Mobile Robot (Byoung-Suk Choi, 2008)	More precise location of the robot.	Not economical because required ultrasonic sensor.
2	An Intelligent Mobile Robot Navigation Technique Using RFID Technology (Wail Gueaieb, 2008)	The lines linking the projections on the ground virtually define the "freeways" along which the robot can navigate.	Use active IC tags which require maintenance by humans, such as a periodical battery exchange.
3	Indoor Localization for Autonomous Mobile Robot Based on Passive RFID (Sunhong Park, 2009)	Reduce the localization error without the use of external sensor or a vision system to modify the location of the robot.	PC mounted on the mobile robot and there is no separate system for communication.
4	Indoor Location Estimation Technique using UHF band RFID (Takehiro Shiraishi, 2008)	More cost effective because use the passive tags that do not need any battery which greatly improves serviceability.	Suffers from a variety of obstacles such as lighting fixtures, piping, and ventilation ducts.
5	Design And Development Of A Rfid Based Mobile Robot (Prathyusha, 2011)	Have a moving control command which can speed up or speed down the mobile robot.	Not cost effective because using ARM Microcontroller of Microchip LPC 2148

CHAPTER 3

METHODOLOGY

This chapter will describe the method that will be used for this project in order to achieve the desired objectives. This project development is divided into two phases that is phase A and phase B. Phase A represented the study of the project in semester 1 and phase B will reflect on the design and development of a system that has been studied in phase A. Phase B will be conducted in semester 2. Figure 3.1 compressed the project development.

The project developments shown in Figure 3.1 begin by identifying the problems that exist in indoor positioning. Extensive literature reviews were done on related knowledge to assist in any ways that it may. Such reviews are based on international publications, websites, and engineering books. Detail research in hardware is needed for the robot electrical and electronic development in terms of availability, performance and technical supports. The system requirement was then determined to proceed with this project.

The next step is followed by planning in the design of the hardware and software part of the robot system. The low-level software is an interfacing subroutine for associated components that consist of an XBee wireless module, RFID reader, motor control, and keypad. The interface testing has to be done to ensure the functionality of the hardware and software modules are compatible with the microcontroller. If the tests fail, the problem should be verified either it is due to components or software parameters.

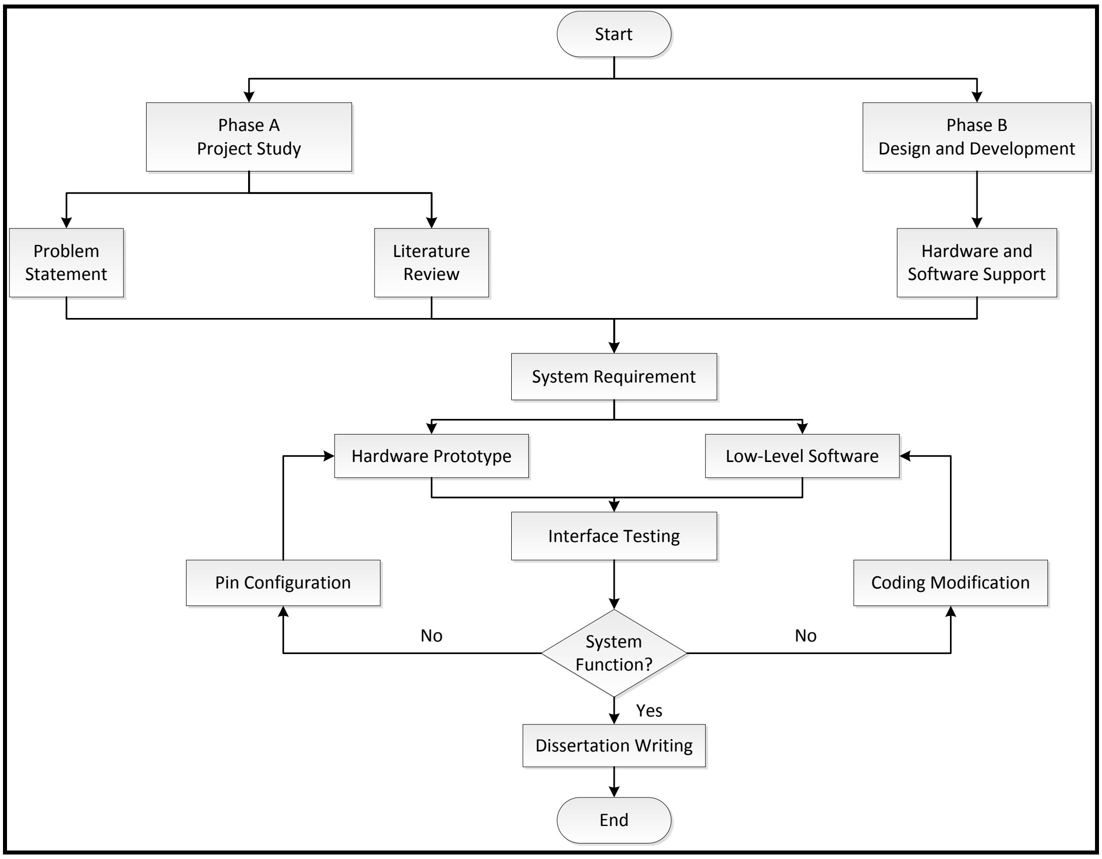

Figure 3.1: Flowchart of project activities.

3.1 System Architecture

Figure 3.2 shows the interface between all devices that will be implemented for this project by using the remote control and mobile robot control setup. The remote control part is used for the user gives the desired location signal to the mobile robot. It will send command to mobile robot in order to reach the desired location of the tag. The input command is coming from the keypad 4x4. While mobile robot control receives the signal from remote control, the RFID reader in mobile robot will start reads IC tags on the floor for obtaining the location information of mobile robots. PIC16F777 will act as a controller that handles information of IC tags on the floor and will determine the path for mobile robot will go through. Connection between remote control and mobile robot control will be made by using the XBee wireless module which provides low transmission power rate and is suitable to use in short range data transmission.

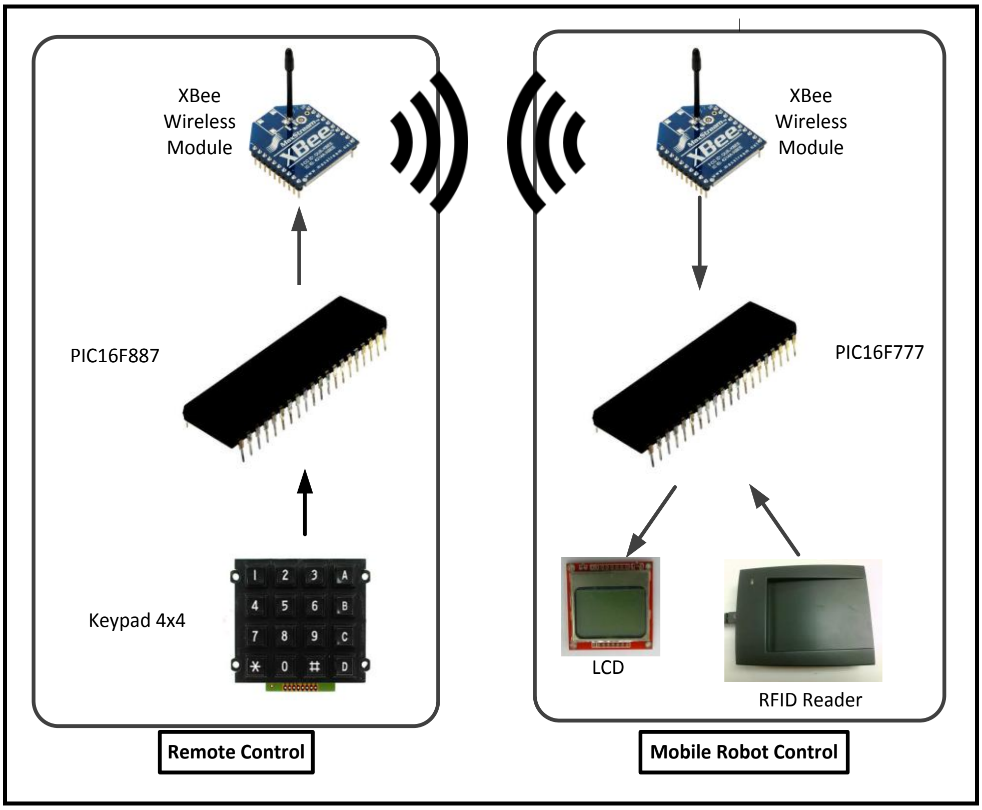

Figure 3.2: Device configuration.

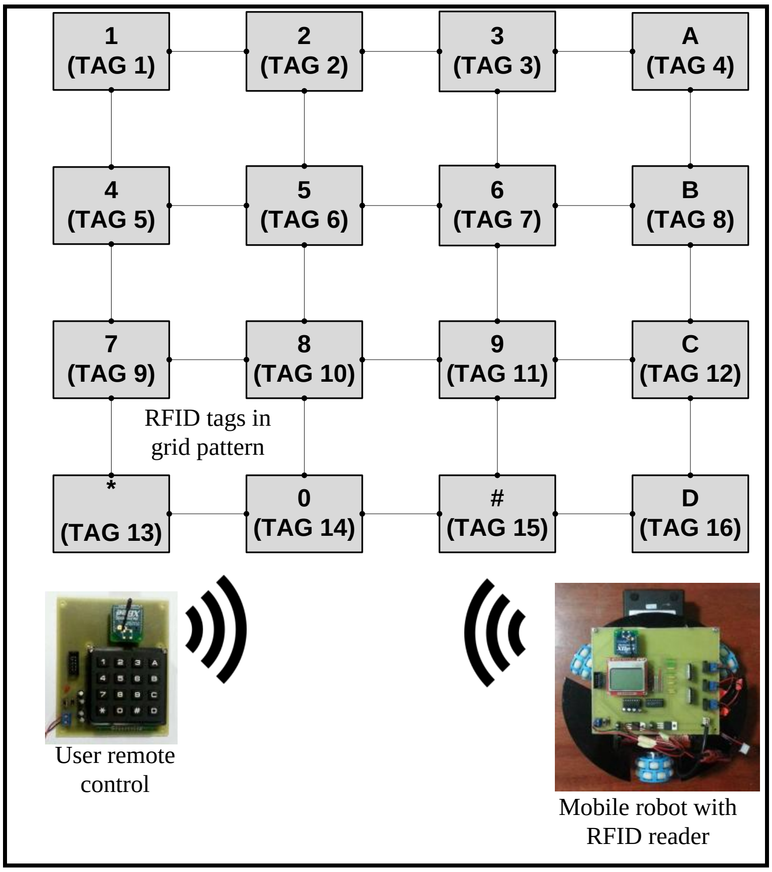

Figure 3.3: System architecture.

Figure 3.3 shows the system architecture of this project which the RFID reader is mounted below the mobile robot itself, whereas the tags are pasted at a particular location on the floor. Upon the mobile robot receive the commands from remote control, the RFID reader reads the unique tag identification numbers and infers the necessary actions (turn left, right, or remain straight) to reach the desired position. At these points, the robot has to decide on the next action according to a plan stored in the microcontroller to reach the target position. The robot then follows certain paths using based on RFID tag until a desired tag is found.

3.2 Hardware design

The hardware design in this section gives further explanations on electronic parts that will be used to design this project. The entire component and the essential tools will be listed down in the Table 3.1.

Table 3.1: List of components.

No.	Component	Quantity
1	PIC16F887	1
2	PIC16F777	1
3	4X4 Keypad	1
4	XBee S1 1mW Wire Antenna	2
5	RFID reader	1
6	RFID tag	16
7	LCD	1
8	Terminal block	5
9	Mini slide switch	2
10	3mm led	1
11	Diode 1N4001	2
12	Diode 1N4148	2
13	Voltage regulator 7805	2
14	Voltage regulator LM1117	2
15	Crystal 20Mhz	2
16	Max232	1
17	Motor driver L298N	2

18	Multiplexer/demultiplexer 74HC4052	1
19	Bridge diode KBP306G	3
20	Buzzer	1
21	Resistor 10k ohm	7
22	Resistor 330 ohm	5
23	Resistor 100 ohm	6
24	Capacitor 10uF	12
25	Capacitor 0.1uF	2
26	Capacitor 22pF	4
27	IC socket 40 pin	2
28	IC socket 16 pin	2
29	10 ways straight box header	2
30	Straight female header 10 ways	7

3.2.1 Types of Microcontroller

PIC16F777 and PIC16F887 were used in this project. This powerful 8-bit microcontroller packs into a 40 pin package. Both microcontroller features 256 bytes of EEPROM data memory, self programming, an in circuit debugging function (ICD), 2 Comparators, and 14 channels of 10 bit Analog-to-Digital (A/D) converter. The main difference between these microcontrollers is PIC16F777 has three PWM functions compare to PIC16F887 has only one PWM function.

3.2.2 4X4 Keypad

Keypad is an array of switch. There will be 2 wires connected each time a button is pressed. There is no connection between rows and also columns. The buttons make it connect. For this kind of keypad, it consists of 8 pins and the internal connection is illustrated in Figure 3.4 and Figure 3.5.

Figure 3.4: 4x4 keypad.

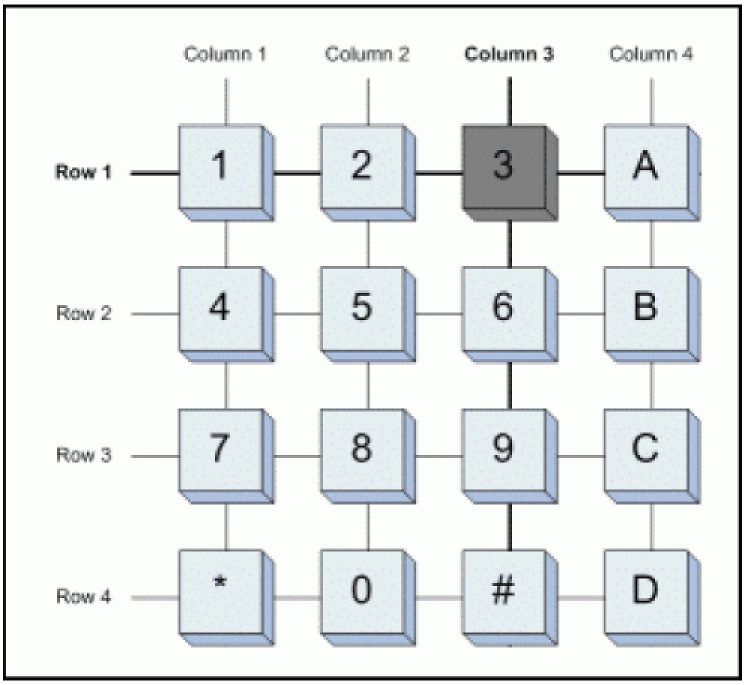

Figure 3.5: Internal structure of the 4X4 keypad.

To scan which button is pressed, users need to scan it column by column and row by row. Make rows as output and columns as input. For example, when button 3 is pressed, the column 3 and row 1 will short while the others are open.

For keypad wiring, keypads pins need to pull up or pull down to avoid floating case happen. Pull up normally connect to 5V and pull down connects to ground. 4x4 Keypad pin can directly connect to microcontroller or keypad decoder IC for decodes purpose. In this project, the 8 pins are separated into 2 groups, 4 pins K1 to K4 connect to the input of microcontroller and 4 pins K5 to K8 connect to the output as illustrated in Figure 3.6. Input must be pulled high to 5V using a resistor and this configuration will result an active-low input.

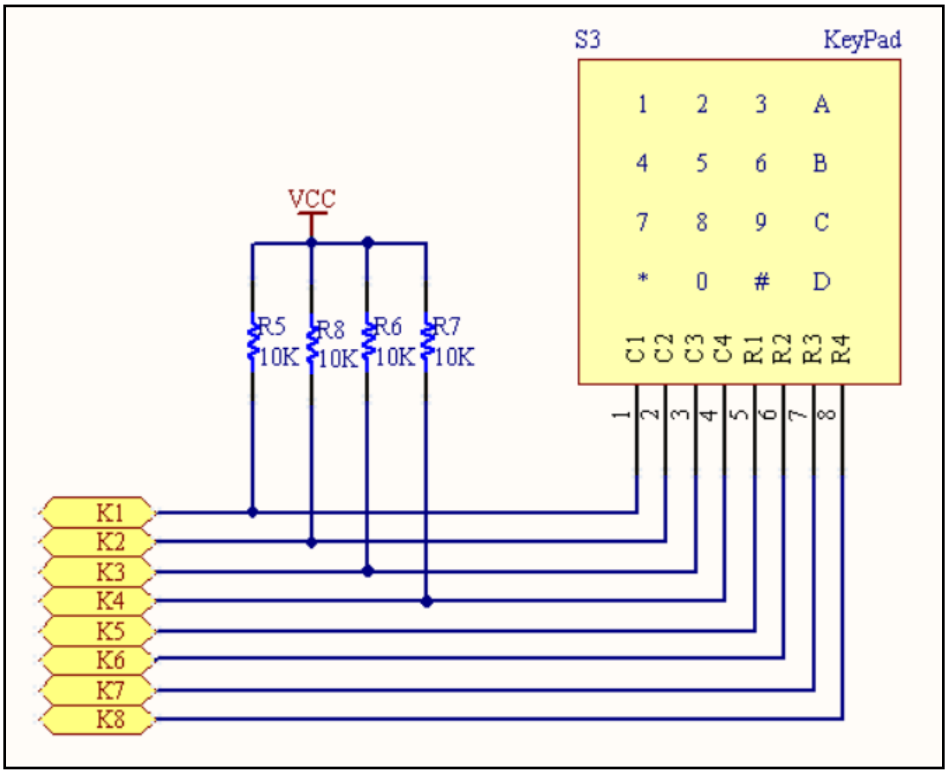

Figure 3.6: Interface PIC with keypad.

3.2.3 Xbee OEM RF Module

An Xbee OEM RF module has been used in many robotic applications worldwide to offer wireless communication, point to point and also mesh network. No more searching for surrounding the device and request for connection, it can send data wireless after powering up without any extra configuration. Additionally, the communication range is very good which 100 meters for outdoors and 30 meters in an indoor environment for a 1mW low powered device. Its small form factor saves valuable board space. It’s suitable to use in short range data transmission with a low cost device and low data rate[8]. There is also a special application programming interface (API) mode, where the modules accept bytes of data from the host to transmit into the network [20].

No configuration is necessary for out of box RF communications. Xbee module comes with application software to ease user in editing configuration and also for functional testing. 3.3V supply voltage is required for Xbee module. Pin assignment for the Xbee module will be listed down in Table 3.2. The minimum connection for Xbee module is 4 which power supply, UART data out , UART data in and ground.

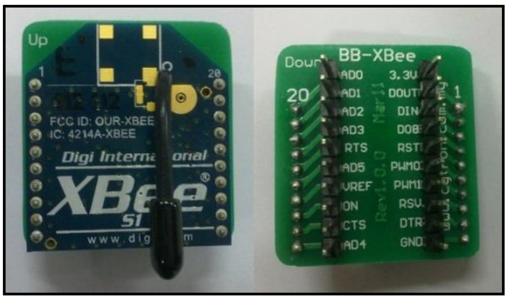

Figure 3.7: Xbee wireless module.

Table 3.2: Pin signals of Xbee wireless module.

Pin	Name	Description
1	VCC	Power supply
2	DOUT	UART data out
3	DIN	UART data in
4	DO8*	Digital output 8
5	RESET	Module resets
6	PWM0/RSSI	PWM output 0 / RX signal strength indicator
7	PWM1	PWM output 1
8	[Reserved]	Do not connect
9	DI8	Digital input 8
10	GND	Ground
11	AD4/DIO4	Analog input 4 or digital I/O 4
12	DIO7	Digital I/O 7
13	ON/SLEEP	Module status indicator
14	VREF	Voltage references for A/D inputs
15	associate/AD5/DIO5	Associated Indicator, Analog Input 5 or Digital I/O 5
16	AD6/DIO6	Analog Input 6 or Digital I/O 6

17	AD3/DIO3	Analog Input 3 or Digital I/O 3
18	AD2/DIO2	Analog Input 2 or Digital I/O 2
19	AD1/DIO1	Analog Input 1 or Digital I/O 1
20	AD0/DIO0	Analog Input 0 or Digital I/O 0

3.2.4 RFID system

Radio frequency identification (RFID) system generally consists of reader and a tag. It uses radio waves to communicate between reader and tag. RFID communication is the same as two way radio communication in the sense that information is transmitted or received via a radio wave at a specific frequency[21]. However, one of the major differences is that RFID systems detect the presence of the other remote device, namely the tag which also known as transponder[18]. In addition, passive or un-powered tags can be powered remotely for a short period of time by the reader[22].

In this project, the compact and inexpensive RFID reader RFID-IDR-232N was adopted as shown in Figure 3.8. It operates at a frequency of 125kHz. It has been designed with the capabilities and features of low cost solution for reading passive RFID transponder tags, 9600 baud RS232 serial interface to PC, fully operation with 5V power supply from the USB port, buzzer as a sound indication of activity, red and green color LED for visual indication of activity, 2cm reading range, 0.1s response time, and 12 bytes of data received include start of heading, RFID ID and start of text.

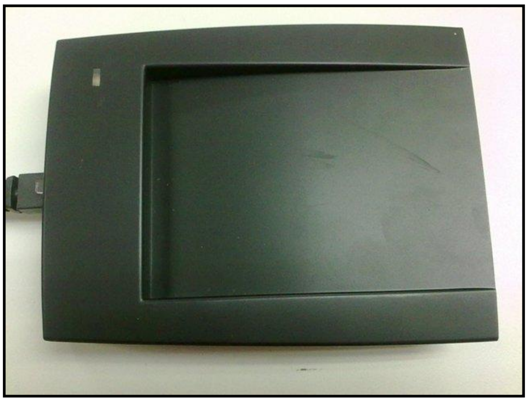

Figure 3.8: RFID reader.

RFID tags in RFID systems can be classified into three types which is passive, semi-passive or also known as semi active, and active[23]. In this project, the passive tags as shown in Figure 3.9 are adopted because consideration of no maintenance and low cost. All tags contain a small amount of memory that can be read from over the air by the reader. Most of the time, the piece of memory contains some type of unique identification information or unique serial number. The serial number is read only. It is programmed to send a serial number that is related to the position of the tag in a database stored on the mobile robot.

Figure 3.9: RFID tag.

There are two RFID tag arrangement patterns that are random and the regular distribution. The regular distribution pattern can be classified to grid pattern and the triangle pattern[5]. Although the RFID tags need to arrange for maintaining the regular distance and pattern in the environment, it is easy to get the location information without an additional special algorithm. In this project, the regular distribution method is used and 16 tags arranged in the square grid-like pattern.

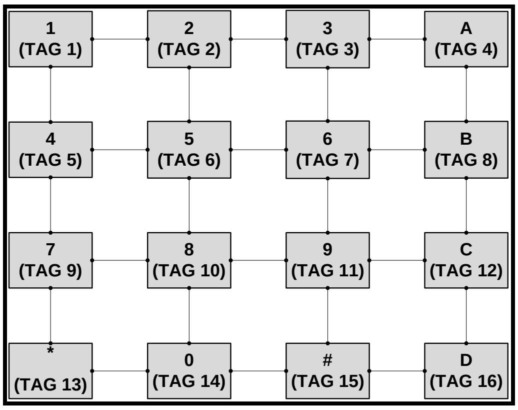

Figure 3.10: RFID tag distribution pattern.

3.2.5 Graphic LCD 84x48

The LCD that is used in this project is from the model 3310 manufactured by Nokia. The Nokia 3310 is a basic graphic LCD screen for lots of applications. It was originally intended for as a cell phone screen. This one is mounted on an easy to solder PCB.

It uses the PCD8544 controller, which is the same used in the Nokia 5110 LCD. The PCD8544 is a low power CMOS LCD controller/driver, designed to drive a graphic display of 48 rows and 84 columns[24]. All necessary functions for the display are provided in a single chip, including on-chip generation of LCD supply and bias voltages, resulting in a minimum of external components and low power consumption. The PCD8544 interfaces to microcontrollers through a serial bus interface. The pin assignment is given in Table 3.3 below.

Table 3.3: Pin signals of LCD Nokia 3310.

Pin	Name	Description
1	Vcc	Power supply 3.3V
2	GND	Ground
3	SCE	Chip enables
4	RST	Reset
5	D/C	Mode select
6	SDIN	Serial data input
7	SCLK	Serial clock input
8	Vcc	Power supply 3.3V

3.3 Circuits Schematic

There are two electrical circuits prepared in this project named as mobile robot board and remote control board. It was fabricated in single layer in the PCB Laboratory. Figure 3.11 shows the schematic design of the mobile robot board.

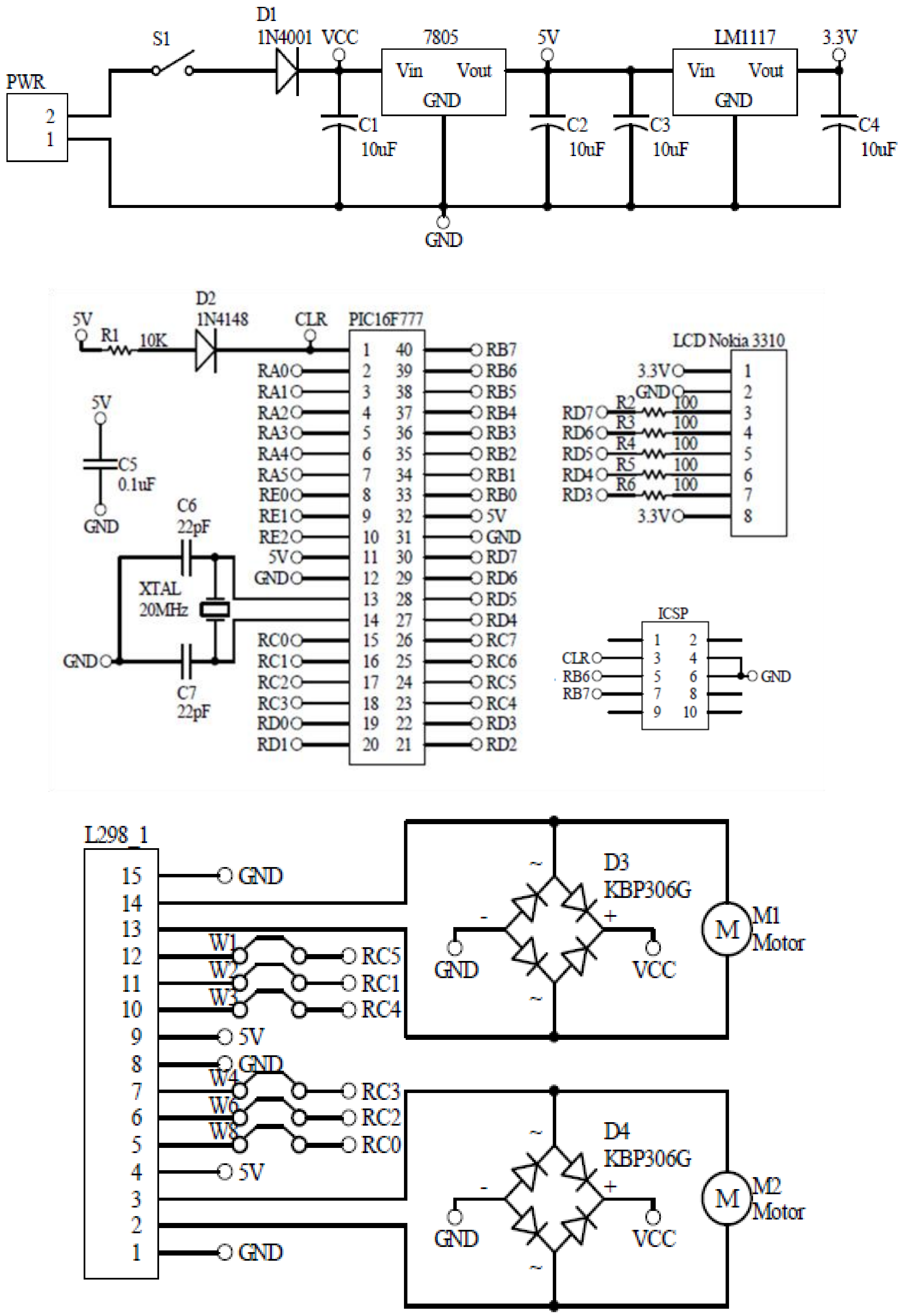

Figure 3.11: Mobile robot board schematic design.

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