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SMART TROLLEY

A Project Report Submitted to the APJ Abdul Kalam Technological University
in partial fulfillment of the requirements for the award of the degree of

Bachelor of Technology

in

Electronics & Communication Engineering

by

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Eighth Semester 2020 Admission

Sreepathy Institute of Management & Technology
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CERTIFICATE

This is to certify that the report entitled **"SMART TROLLEY"** is a bonafide record of the Project work presented by **Akshayraj A** (Reg. No. SPT20EC002), **Navya Das** (Reg. No. SPT20EC008), **Rushida Nasrin K** (Reg. No. SPT20EC011) under our supervision and guidance. The report has been submitted to the Department of Electronics & Communication Engineering of SIMAT Vavanoor, Palakkad-679533 in partial fulfillment of the award of the Degree of Bachelor of Technology in Electronics & Communication Engineering, during the year 2023-2024.

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ABSTRACT

Shopping and buying is an integral part of our daily lives. Big mega markets have a wide variety of items and different stores can have different deliveries of goods. Trolleys are used in supermarkets or grocery stores to make shopping simpler. However there are many struggles faced by customers while using trolley. Like it's hard to push the trolley when it's heavily loaded or it's hard for aged people and women carrying child to push the trolley . Even its hard for a normal healthy person to push a trolley which is heavily loaded. Also the customer is needed to stand in a long queue for the bill and payment process. This project introduces a groundbreaking RFID-based Smart Trolley system augmented with human-following capabilities to revolutionize the retail shopping experience. This reduces the customer's effort to pull the trolley and saves time for billing. The customer who has a specific tag with a pattern and a web camera installed in front of the trolley will recognize the tag and move the trolley to the customer. The integration of Radio-Frequency Identification (RFID) technology and image processing enables the development of an intelligent and autonomous shopping companion. This system not only automates the tedious aspects of the shopping process through RFID-based item recognition but also enhances user convenience by incorporating human-following technology.

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Chapter 1

INTRODUCTION

In the past few years, robotic technology has evolved substantially. To aid humans in their work, a robot must be able to recognize and follow them, necessitating the development of robots like the "SMART TROLLEY" that can interact and co-exist with them. Localizing the items in the surroundings as well as the robot itself is a significant problem in enabling the robot for executing a range of activities in the real-world. A robot need to be sophisticated to track a human through traffic regions, a vibrant atmosphere, and both indoors and out. The project's goal in building a human following trolley is for it to be able to carry objects alongside humans. It can be utilised in agriculture, construction, airports, and shopping malls. A Microcontroller is the overall system's controlling device. There is a technology called RFID (radio frequency identification) which helps to make our shopping much easier. RFID refers to the use of radio frequency wave to identify and track the tag implanted into an object or a living thing . It is a wireless mean of communication that use electromagnetic and electrostatic coupling in radio frequency portion of the spectrum to communicate between reader and tag through a variety of modulation and encoding scheme.RFID system usually consists of RFID reader and tag. It is very useful because it can uniquely identify a person or a product based on the tag incorporated. It can be done quickly and this usually takes less than a second.The RF signal transmitted by the object can be used by RFID readers to identify the objects[1]. Image Processing system and motors are used to aid in the recognition of the customer and following them. The microcontroller is connected to an RFID module and DC motors .The controller is loaded with programme to accomplish this operation. Raspberry Pi and a webcamera is used for image processing to identify the customer. A certain pattern is attahed to the customer in the form of a tag, jacket or any other form which can be detected by camera and the trolley then follows the customer. Motor helps in the movement of trolley .

Chapter 2

LITERATURE REVIEW

Zeeshan Ali's RFID-enabled smart shopping cart revolutionizes the retail experience by integrating advanced technology into the traditional shopping process. With RFID tags embedded in products, customers can manage their shopping lists in real-time, keeping track of items and their associated costs as they navigate the store. The self-checkout feature allows for quicker transactions, reducing wait times and enhancing customer satisfaction. For shop owners, this system offers significant cost savings by minimizing the need for cashiers while also providing better control over inventory management through real-time data updates. The seamless integration of RFID tags, sensors, and communication units ensures accurate cart location and product information retrieval. However, successful implementation relies on addressing scalability, security, and user experience concerns. Overall, Zeeshan Ali's innovation represents a leap forward in retail efficiency, promising to streamline operations and enhance the shopping experience for both customers and businesses alike[2].

Shopping is really fascinating and alluring, at the same time some people hate it mainly because of the crowd, long queues in the shop, billing etc. Tapan Das designed a smart trolley which can take care of shopping and billing. By this, the customer can walk straightaway into the shop, purchase products using the smart trolley and walk out of the shop. The customer gets the e-bill through the mail, and he/she can view his purchase details using the shop's website. The system uses an Arduino board, Radio-Frequency Identification (RFID) reader, RFID tag, LCD display, ESP8266 Wi-Fi module, database manager and a website to maintain product and customer details, which can be accessed by the admin anywhere in the world. It is an IOT based system where the trolley can interact with the network spread worldwide[3].

RFID, as an automatic technique of identification, is increasingly being used to identify and track objects through supply chain in industries and manufacturing process. Many manufacturing enterprises, are taking advanced technologies to ensure its ordered and correct product procedures.Zhang proposed a RFID based material tracking information system where two methods for the client application to communicate with the RFID readers are in- troduced, one of which is to build a RFID middleware server. The design of the RFID middleware is discussed. RFID reader and back-end database both help to automatically record and store the circulation history and current status of a tracked object, and they cooperate to synchronize

the information flow and material flow. It can be used in most manufacturing and circulation enterprises[4].

T S Lim's RFID-based attendance system presents a modern solution to the inefficiencies of traditional attendance-taking methods. By utilizing RFID tags embedded in ID cards, individuals can swiftly register their attendance by placing their cards on a reader. This approach minimizes time and effort compared to manual calling or signing, enhancing efficiency in educational institutions and workplaces. The system's real-time clock feature ensures precise recording of attendance times, improving accuracy for administrative purposes. Moreover, connectivity options such as RS232 or USB enable seamless integration with computers, facilitating convenient data storage and management within databases. Notably, the system's ability to uniquely identify each person enhances security, reducing the risk of fraudulent attendance records. Overall, Lim's RFID-based solution streamlines attendance tracking processes while bolstering security and accuracy, thus benefiting both institutions and individuals[5].

How to deploy commodities for sale in different shelves in a supermarket in order to obtain better benefit for merchants with considering convenience for customers is an important topic in the retail area.Hong-Bo Li present a new method for allocating commodity shelves in supermarket based on customers shopping paths and transactions data mining. Radio-frequency identification (RFID) data is used, which show the position of a shopping cart through an RFID tag attached to the shopping cart.The RFID data contain valuable information for marketing,such as shopping time and distance as well as the number of shelf visits. The authors analyse customers purchasing behaviour and in-store movement information using POS data combined with RFID data. The purpose of the study is to discover a promising shopping path that can distinguish customers' in store movements by sequential pattern analysis using RFID data. These shopping paths are extracted using a pattern mining method. Finally, shopping paths are used in the decision tree analysis to generate the rules that expressed customers' in-store movements and purchasing characteristics[6].

In the realm of retail innovation, Sarala T explores the concept of a smart electronic shopping trolley designed for use within commercial complexes housing multiple individual retail stores. The primary objective of this concept is to streamline the shopping experience, reducing time inefficiencies. Central to this innovation is the integration of an LCD (Liquid Crystal Display) screen, which serves to display product details and prices retrieved via barcode identification. This technology represents a significant advancement in enhancing the shopping process by providing real-time information to consumers during their shopping journey[7].

Complementing this discussion, Yoshiharu delves into the broader applications and advancements in LCD technology. Emphasizing the continual development of LCDs, Yoshiharu highlights key objectives such as thin form factors, lightweight construction, and low power consumption. Furthermore, the focus lies on leveraging LCD technology to differentiate products based on originality and technological advancements. This review underscores the versatility of LCDs in displaying both arbitrary and fixed images, catering to various applications ranging from general-purpose computer displays to specific devices like digital clocks.Together, these dis-

cussions shed light on the evolving landscape of retail technology, particularly in the context of enhancing the shopping experience through the integration of LCD displays and advancements in display technology[8].

Jandhyala introduces a proposal for an autonomous system tailored to meet the demands of professional sports involving ball-based activities. The implementation involves the utilization of 3 L293D dual motor driver shields, enabling the system to operate effectively. This contribution addresses the need for automation and precision in sports-related applications, offering potential advancements in training aids, performance analysis, and interactive experiences within the sporting domain[9].

In a related study, Pravin presents a study on the adaptive motion control of the Firebird V robot, employing the Atmega 2560 microcontroller and L293D motor driver. The research concludes that the L293D motor driver facilitates versatile motor movements, enabling the robot to navigate in multiple directions with precision and efficiency. This investigation underscores the significance of motor drivers in enhancing the agility and responsiveness of robotic systems, with implications for various fields, including robotics research, automation, and industrial applications[10]. Together, these studies contribute to the advancement of autonomous systems and motion control technology, showcasing the utility of motor drivers such as the L293D in enabling precise and versatile movements in sports-related applications and robotics.

Yao presents a foundational model of a conveyor system featuring a DC gear motor, elucidating the fundamental mechatronic structure and operational principles of such systems. The study offers insight into the essential components and functionalities involved in typical conveyor systems, laying the groundwork for further research and development in this domain. Additionally, Yao provides an analysis of the DC gear motor, highlighting its distinct characteristics compared to conventional DC motors. Notably, the study emphasizes the suitability of DC gear motors for conveyor systems due to their ability to deliver substantial torque at desired speeds. This literature contributes to the understanding of conveyor system dynamics and motor selection criteria, serving as a valuable resource for engineers and researchers engaged in conveyor technology and mechatronic system design[11].

Chen's study delves into the performance characteristics of Lithium Ion Batteries (LIBs) in Electric Vehicles (EVs), providing an overview of their usage and potentialities. By analyzing the suitability and effectiveness of LIBs in EV applications, Chen's work serves as a valuable resource for researchers and engineers in the field. The focus on the chemistry and composition of LIBs, particularly the utilization of graphitic carbon as anodes and various cathode selections, offers insights into optimizing battery performance for EVs[12].

In a related study, Keshan conducts a comparative analysis between lead-acid and lithium-ion batteries, highlighting their respective features and applications. Lead-acid batteries, though established and cost-effective, are characterized by their bulkiness and dependency on ambient temperature. Conversely, lithium-ion batteries represent a newer technology, boasting advantages such as compactness, lightweight, fast charging capabilities, and higher efficiency. Keshan's comparison underscores the superior attributes of lithium-ion batteries, particularly in portable electron-

ics and EVs, positioning them as a promising solution for modern energy storage needs[13]. Together, these studies contribute to the understanding of battery technologies in the context of EVs, offering valuable insights into performance characteristics, suitability, and potential applications. This literature review serves as a foundation for further research and development in the field of energy storage and electric vehicle technology.

Lokesh's proposal introduces a home automation and security system leveraging the NodeMCU-ESP8266 platform. The study addresses the need for enhanced home security and automation, aiming to provide a robust solution for managing daily activities and preventing misuse. By integrating IoT technology, the system offers precise control over home appliances, facilitating efficient energy usage and enhancing security measures.Central to the implementation is the NodeMCU-ESP8266, chosen for its affordability and extensive integrated features compared to other microcontrollers. This choice reflects a strategic approach to designing a cost-effective yet powerful solution for home automation and security needs. Lokesh's work contributes to the growing body of literature on IoT applications in smart home technology, providing valuable insights into the development and deployment of efficient and secure home automation systems.Overall, Lokesh's research serves as a foundation for further exploration and development of IoT-based home automation and security solutions, offering practical insights into the implementation of NodeMCU-ESP8266 in real-world applications[14].

In contemporary research, a trio of studies explores the multifaceted applications of image processing technology integrated with Raspberry Pi microcontrollers. Ariyanto pioneers an image processing system for a car model, enabling it to detect road edges, lines, corners, and red traffic lights. This innovation enhances road safety and autonomous driving capabilities, showcasing the potential of Raspberry Pi in automotive advancements[15].

Hanooja extends this concept to smart trolleys, upgrading traditional models with image processing capabilities to improve user experience and operational efficiency in retail and logistics settings. By minimizing computational complexity, Hanooja's design achieves cost-effectiveness while enhancing functionality[16].

Meanwhile, Vijayshree focuses on botanical classification, utilizing Raspberry Pi and image processing to classify plants based on their medicinal properties. By capturing and analyzing leaf patterns, this system aids in plant identification and research, offering insights into botanical diversity and medicinal applications[17]. Collectively, these studies underscore the versatility of Raspberry Pi in diverse domains, from automotive safety and retail automation to botanical science. By leveraging image processing capabilities, these innovations exemplify the potential for Raspberry Pi to drive advancements in technology, science, and everyday life.

Chapter 3

SMART TROLLEY

3.1 Problem Statement

Shopping malls are one of the most popular places for leisure activities, shopping, and entertainment, which attract a large number of people every day. But the customers face many challenges while using trolley in shopping malls. The customers with limited mobility or disabilities are facing a hard time on pushing the shopping trolleys on their own. Also the customer has to wait on long queue for checking out which causes in wastage in time. As a result, shopping malls have been looking for innovative ways to provide a more personalized shopping experience to attract and retain customers.

3.2 Problem Solution

The proposed system is designed to follow customers automatically, eliminating the need for them to push the cart manually and includes an automatic billing system to reduce the checkout time. This technology offers convenience and ease for shoppers, allowing them to focus on shopping and enjoying their experience. This approach uses image processing for the trolley to identify the customer by scanning a pattern attached to the customer in the form of tag or jacket using camera. Motors are used for the movement of trolley and RFID technology is used for the automating billing system. All the components are connected to the microcontroller.

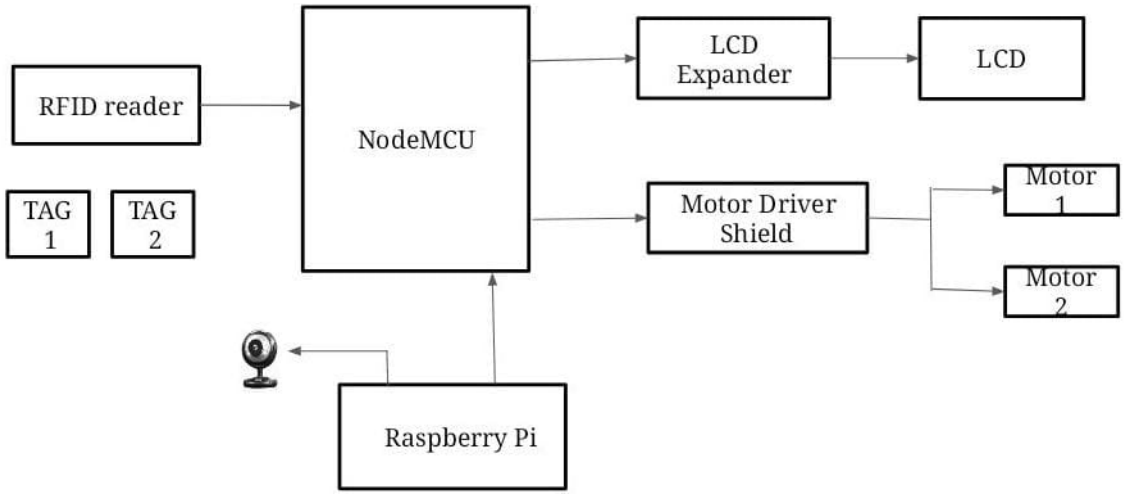

Figure 3.1: Block Diagram of Smart Trolley

The figure 3.1 shows the block diagram of the system. NodeMCU is the brain of the system where the codes are stored. The products in a shopping mall is attached with rfid tags which contains different unique identity. RFID Reader is connected to microcontroller which is used to identify the RFID tag placed in each product of unique identity. A LCD expander PCF8574 is also connected to transfer the data from the microcontroller to the LCD display. The LCD then displays the product, price and the total price purchased. Raspberry Pi is connected to the microcontroller and camera to identify the customer. According to the code loaded in the raspberry pi and microcontroller, the trolley identifies the customer. A L293D motor driver shield is also connected from the microcontroller to control and support the 2 geared dc motors each of 30 RPM. The motors help in the movement of trolley and follows the customer identified using image processing.

3.3 Familiarization of components

3.3.1 Hardware

a) NodeMCU

The NodeMCU (Node MicroController Unit) is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains the crucial elements of a computer: CPU, RAM, networking (WiFi), and even a modern operating system and SDK. That makes it an excellent choice for Internet of Things (IoT) projects of all kinds.Here we used for billing the products in the trolley and for the motor's movement according to the customer[18].

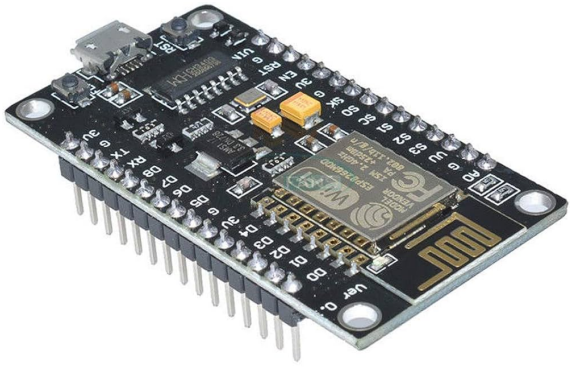

Figure 3.2: NodeMCU ESP8266

b) RFID

RFID tag is used as the customer purchases those as we know all of the products in the supermarket are now covered by barcode, which have many disadvantages over RFID. RFID is fast and no sight transaction required. If all the products have RFID transaction, and it will completely minimize the time complexity of billing. Because scanning barcode is a time consuming process. It consists of two RFID Tags one receiver in each tag will store the information of different products. When the customers purchase the product into the trolley, The RFID receiver gives the information to the NodeMCU then stores it[19].

Figure 3.3: RFID Reader

c) LCD expander

This is a 8-bit input/output (I/O) expander for the two-line bidirectional bus (I2C) is designed for 2.5-V to 6-V VCC operation. The PCF8574 device provides general-purpose remote I/O expansion for most microcontroller families by way of the I2C interface .The device features an 8-bit quasi-bidirectional I/O port , including latched outputs with high-current drive capability for directly driving LEDs. Eachquasi-bidirectional I/O can be used as an input oroutput without the use of a data-direction control signal[20].

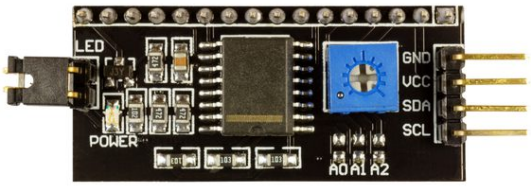

Figure 3.4: PCF8574

d) LCD

LCD (Liquid Crystal Display) is a type of flat panel display which uses liquid crystals in its primary form of operation. LEDs have a large and varying set of use cases for consumers and businesses, as they can be commonly found in smartphones, televisions, computer monitors and instrument panels. Here lcd display is used for the billing.The total amount of the products are shown in the display for customers[21].

Figure 3.5: LCD

e) Motor Driver Shield

A motor driver is an integrated circuit chip which is usually used to control motors in autonomous robots. Motor driver act as an interface between NodeMCU and the motors . The most commonly used motor driver IC's are from the L293 series such as L293D, L293NE, etc. These ICs are designed to control 2 DC motors simultaneously. L293D consist of two H-bridge. H-bridge is the simplest circuit for controlling a low current rated motor. Here we used L293D motordrivershield. L293D has 16 pins[22].

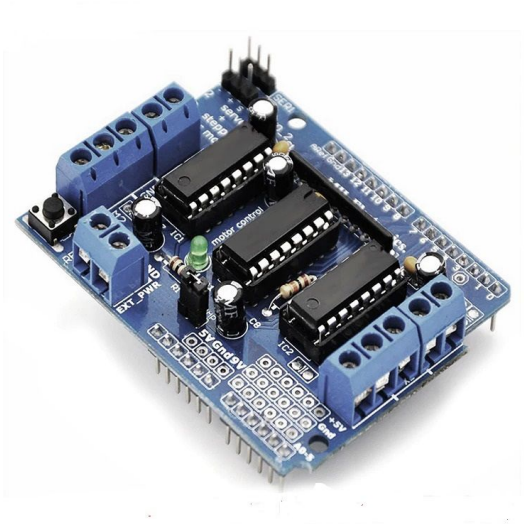

Figure 3.6: L293D

f) Motor

Two gear motors of 30 rpm placed or attached to the two back wheels of the trolley. The two gear motors will help the trolley to move or follow the customer. When the camera module the color tag of the customer, the raspberry pi gives the instruction to the motor to rotate. Suppose the customer moves from the left side, the trolley also moves left side[23].

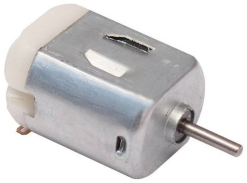

Figure 3.7: Motor

g) Raspberry pi

Raspberry pi is the core part of our system. The main advantages include low cost, high-speed processing, ability of I/O ports and the memory unit. The specifications of pi processing speed range from 700 MHz to 1.4 ghz,1GB RAM, BCM 43438 wireless LAN and Bluetooth Low Energy (BLE) on board 100 Base Ethernet, 40-pin extended GPIO ports, four USB 2 ports, four Pole stereo output and composite video port full size HDMI cable, Micro SD port for operating system and storing data and Micro USB power source up to 2.5A. All the codes are written in python and opencv during implementation. The proposed system used opencv to track the color of the customer tag[24][25].

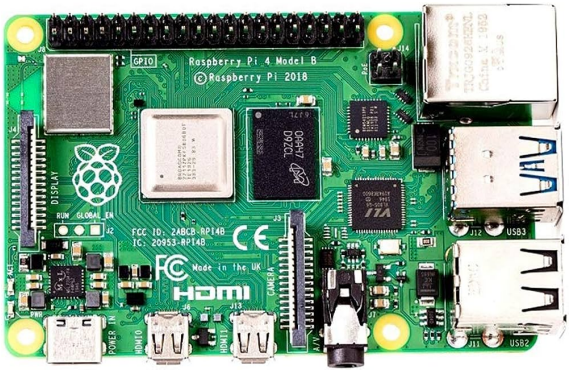

Figure 3.8: Raspberry Pi

h) Camera

A webcam is a video camera which is designed to record or stream to a computer or computer network. They are primarily used in video telephony, live streaming and social media, and security. Webcams can be built-in computer hardware or peripheral devices, and are commonly connected to a device using USB or wireless protocols.To identify or track the color of the tag that customer have web camera, web camera gives x and y coordinates to the raspberry pi if the color is matches with the customer tag.

Figure 3.9: Web camera

3.3.2 Software

a) Arduino IDE

Arduino IDE offers full compatibility to any Arduino-based software board. It makes it easy to write code and upload it to the board. here it is used to control NodeMCU.Main features of Arduino are Sketch Editing Tools, Libraries,Serial Monitor, Programmer Functions, Burn Bootloader, Sketches Management, Sharing, and AutoFormat[26].

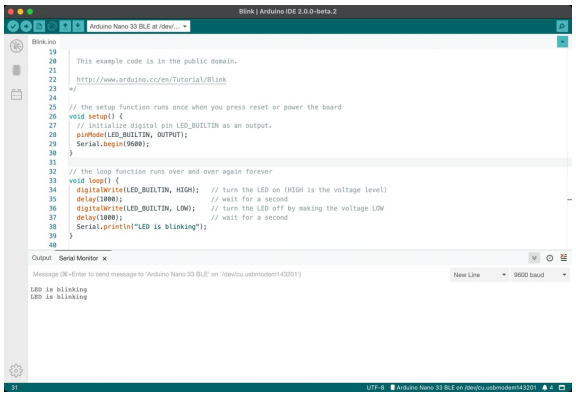

Figure 3.10: Arduino IDE

b) Real VNC viewer

As a single-board computer, Raspberry Pi devices can be used with a display or as headless devices, both of which can be used with RealVNC Connect remote connections. Read on for a thorough explanation and a set-up guide for using Raspberry Pi and RealVNC together. RealVNC Connect is platform-independent, you can remote into Raspberry Pi from Windows, macOS, or Linux devices, as well as smartphones and tablets – it's as easy as completing the remote login to your Raspberry Pi device[27].

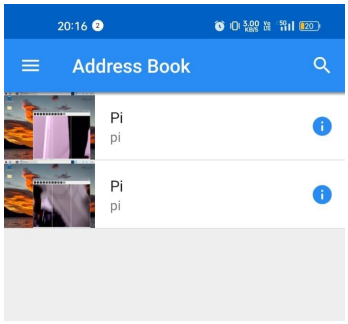

Figure 3.11: Real VNC viewer

3.4 Circuit Diagram

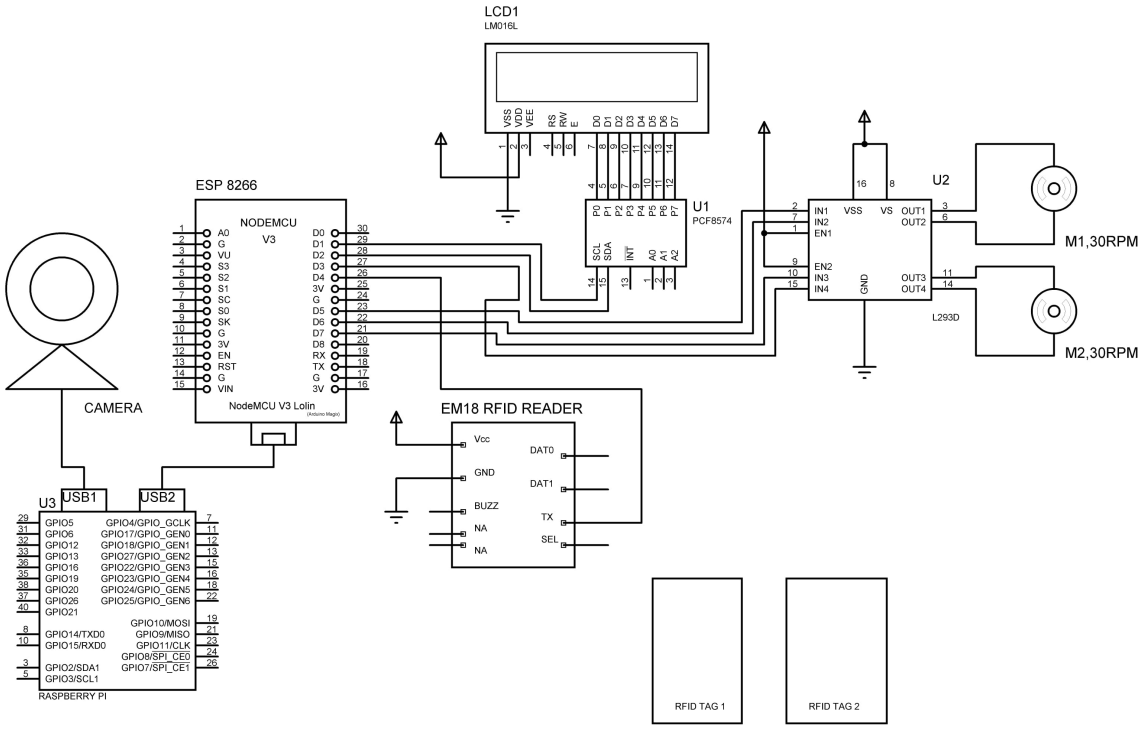

Figure 3.12: Circuit Diagram of Smart Trolley

The circuit diagram in Fig 3.10 shows the detailed electrical connections and components of the system. Initially when the customer enters , he/she is provided with a jacket, tag or any other object which contains a pattern. The transmitter pin of EM18 RFID reader is connected to the NodeMCU .When the customer keep a product on the smart trolley, the RFID reader reads the RFID tag and sends it to the NodeMCU. 2 pins of NodeMCU is connected to the SCL and SDA pin of PCF8574. So according to the programme loaded in NodeMCU, it sends the data to PCF8574 , which coverts the data into 8 bit data. The 8 bit data is then send to LCD which displays the product name, price and the total calculated price[28].

The input pins of the L293D is connected to NodeMCU and output pin connected to 2 motors of each 30RPM. NodeMCU and a camera is connected with Raspberry

Pi[29]. The camera captures the above mentioned pattern and is processed using Raspberry Pi. According to the program loaded in NodeMCU and Raspberry Pi, the command to move "forward-f", "right turn-r", "left turn-l" and "stop-s" is send to the motors. That is, the incoming signals controls the movement of motors and the smart trolley follows the customer.

3.5 Flow Chart

a) Billing system

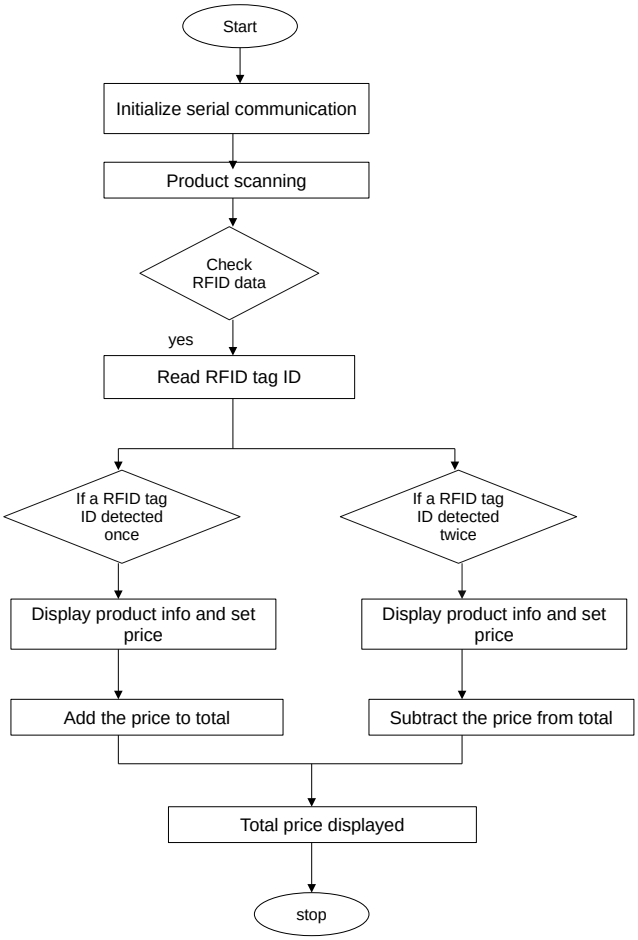

Figure 3.13: Flow chart of automatic billing system

Figure 3. shows the flowchart of automatic billing system. Firstly Initialize the serial communication for RFID reader , and LCD display. When the Products are scanned,check if data is available from RFID reader.If it is available, read the RFID tag ID from the reader , compare the ID with predefined values and if the ID matches the predefined RFID tag , display the corresponding product information on LCD and set the price.Then Clear the LCD after a delay .Flags are used to keep track of whether a product has been detected once or twice. When a product is detected once (flag 1 or flag 2=1), add its price to the total and displays the updated total on LCD display . When a product is detected twice (flag 1 or flag 2=2), subtract its price from the totaland displays the updated total on LCD display . And they final amount of the products is shown in the display. For the control of motors Check if data is available from the serial port[30].

b) Human following system

Initially Import required libraries such as yolo, initialize serial communication with a device and Define object class (pattern) ,colours and load the object detection model.The code captures video from the webcam using OpenCV Ie,open computer vision. Then the Screen is divided into 3 columns using vertical lines and object detection is performed on a frame which is read from the webcam.This webcam is attached to the trolley for detecting the pattern. If a pattern is detected , a bounding box is drawn around the object.The centroid of the bounding box is calculated and marked on the frame. Depending on the position of centroid, commands are sent through serial communication.the centroid is present in the middle column it will activate f command in NodeMCU. The centroid is in left column, the l command is activate and trolley moves to the left side. The centroid is in right column, the r command is activate and the trolley move towards the right side.If there is no pattern is detected,a stop command sent through serial communication.If the ‘q’ key is pressed, exit the loop .

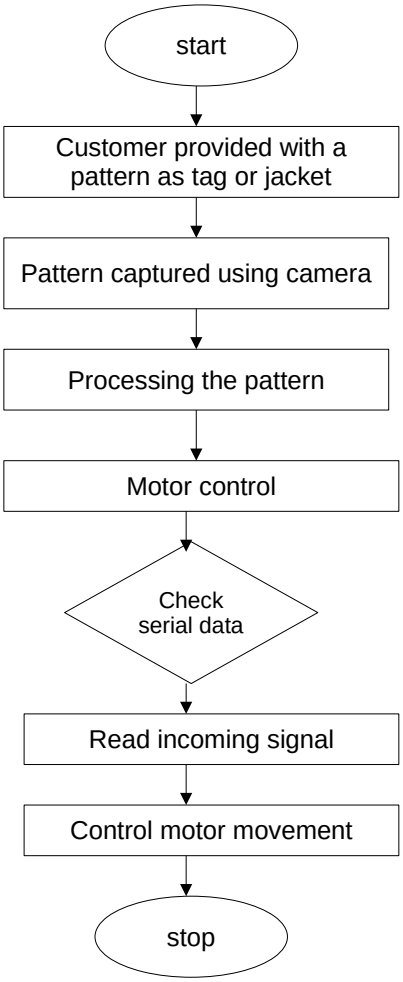

Figure 3.14: Flow chart of automatic human following system

Chapter 4

RESULTS AND DISCUSSION

The Smart Trolley has been developed for a more efficient shopping experience, to help the customers to reduce the checkout time and to reduce strain while pulling the trolley.The prototype has been tested and functioned successfully. The following are the major results of the system:

- The product name, price and total price is displayed on the LCD screen.
- When a product is added or removed from the trolley , the corresponding total price is displayed on the LCD screen.
- The pattern is identified and the trolley follows the customer automatically.

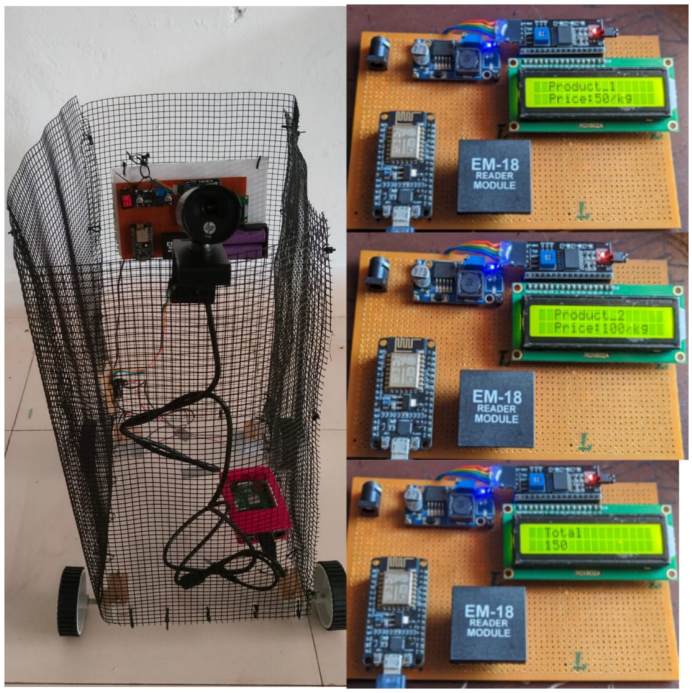

Figure 4.1: Smart Trolley

Chapter 5

CONCLUSION AND FUTURE SCOPE

Human Friendly Smart Trolley with Automated Billing System is a system that follows the customer and gives the bill of the product that is inserted in it. It will be much easier for aged customers and children to use trolleys without any effort. By using the product, we can save time for the customer especially in the billing part. The proposed system is a unique solution by utilizing the low cost electronic components and the structural design can be implement on existing trolley. As the proposed design is less complicated, existing normal trolley can be converted to smart trolley with lesser investments. It is sure that the system is very much helpful for the customers and without bothering about their trolley; they can make their purchase easy. Trolley and the customer will be provided with the same color tag and the matching enables the customers to use their trolley easily. Carrying trolley along with the customers is a very difficult task for the customers. The proposed system provides an easy way to reduce all these problems. In future, we hope that we can provide a system, which is more user-friendly.

There are numerous intriguing applications in various fields, including military and medical. To make the robot more versatile and controllable from a distance, wireless communication functionality can be added. We can monitor the surroundings by mounting a camera on the top. We can also make changes to the algorithm and structure to make it suitable for other purposes. There are various other applications where we can apply this mechanism for following the object or a human. Further use of Vision based sensors such as video sensors and processing them increases the accuracy.

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Appendix

1. General Overview

1.1. Introduction

Espressif Systems' Smart Connectivity Platform (ESCP) is a set of high performance, high integration wireless SOCs, designed for space and power constrained mobile platform designers. It provides unsurpassed ability to embed WiFi capabilities within other systems, or to function as a standalone application, with the lowest cost, and minimal space requirement.

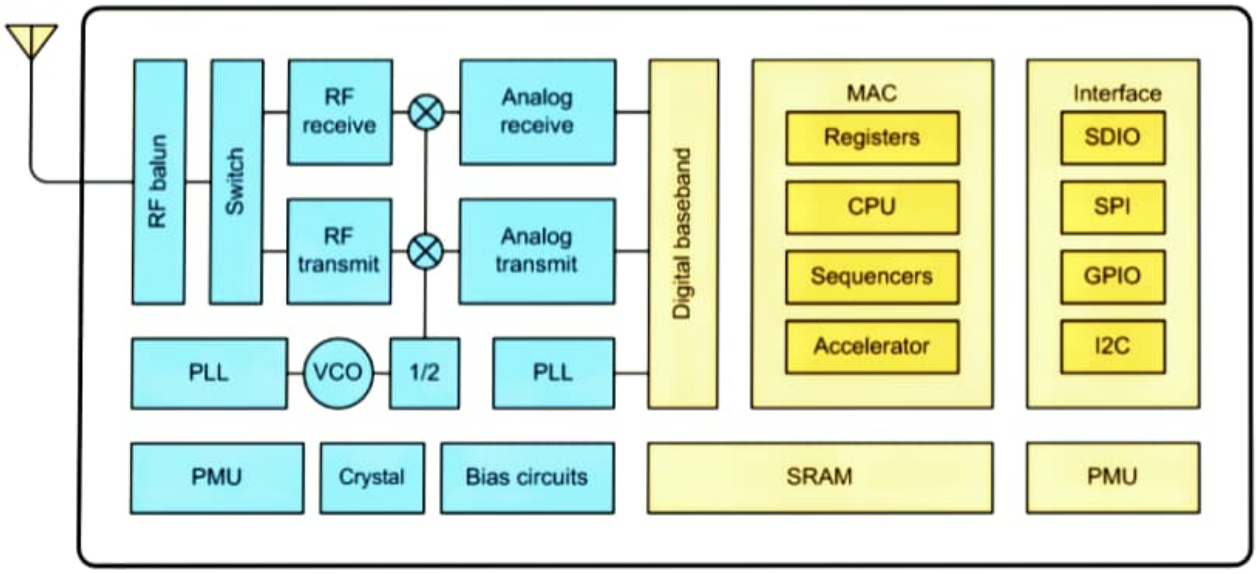


Figure 1 ESP8266EX Block Diagram

ESP8266EX offers a complete and self-contained WiFi networking solution; it can be used to host the application or to offload WiFi networking functions from another application processor.

When ESP8266EX hosts the application, it boots up directly from an external flash. In has integrated cache to improve the performance of the system in such applications.

Alternately, serving as a WiFi adapter, wireless internet access can be added to any micro controller-based design with simple connectivity (SPI/SDIO or I2C/UART interface).

ESP8266EX is among the most integrated WiFi chip in the industry; it integrates the antenna switches, RF balun, power amplifier, low noise receive amplifier, filters, power management modules, it requires minimal external circuitry, and the entire solution, including front-end module, is designed to occupy minimal PCB area.

ESP8266EX also integrates an enhanced version of Tensilica's L106 Diamond series 32-bit processor, with on-chip SRAM, besides the WiFi functionalities. ESP8266EX is often integrated with external sensors and other application specific devices through its GPIOs; sample codes for such applications are provided in the software development kit (SDK).

Espressif Systems' Smart Connectivity Platform (ESCP) demonstrates sophisticated system-level features include fast sleep/wake context switching for energy-efficient VoIP, adaptive radio biasing for low-power operation, advance signal processing, and spur cancellation and radio co-existence features for common cellular, Bluetooth, DDR, LVDS, LCD interference mitigation.

1.2. Features

- 802.11 b/g/n
- Integrated low power 32-bit MCU
- Integrated 10-bit ADC
- Integrated TCP/IP protocol stack
- Integrated TR switch, balun, LNA, power amplifier and matching network
- Integrated PLL, regulators, and power management units
- Supports antenna diversity
- WiFi 2.4 GHz, support WPA/WPA2
- Support STA/AP/STA+AP operation modes
- Support Smart Link Function for both Android and iOS devices
- SDIO 2.0, (H) SPI, UART, I2C, I2S, IR Remote Control, PWM, GPIO
- STBC, 1x1 MIMO, 2x1 MIMO
- A-MPDU & A-MSDU aggregation & 0.4s guard interval
- Deep sleep power <10uA, Power down leakage current < 5uA
- Wake up and transmit packets in < 2ms
- Standby power consumption of < 1.0mW (DTIM3)
- +20 dBm output power in 802.11b mode
- Operating temperature range -40C ~ 125C
- FCC, CE, TELEC, WiFi Alliance, and SRRC certified

2. Hardware Overview

2.1. Pin Definitions

The pin assignments for 32-pin QFN package is illustrated in Fig.2.

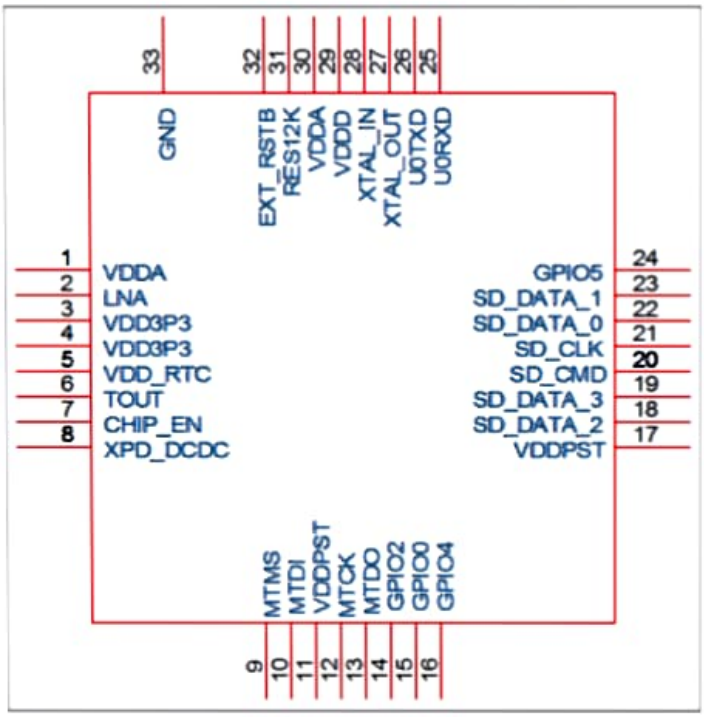


Figure 2 Pin Assignments

Table 2 below presents an overview on the general pin attributes and the functions of each pin.

Table 2 Pin Definitions

Pin	Name	Type	Function
1	VDDA	P	Analog Power 3.0 ~3.6V
2	LNA	I/O	RF Antenna Interface. Chip Output Impedance=50Ω No matching required but we recommend that the n-type matching network is retained.
3	VDD3P3	P	Amplifier Power 3.0~3.6V
4	VDD3P3	P	Amplifier Power 3.0~3.6V
5	VDD_RTC	P	NC (1.1V)

6	TOUT	I	ADC Pin (note: an internal pin of the chip) can be used to check the power voltage of VDD3P3 (Pin 3 and Pin4) or the input voltage of TOUT (Pin 6). These two functions cannot be used simultaneously.
7	CHIP_EN	I	Chip Enable. High: On, chip works properly; Low: Off, small current
8	XPD_DCDC	I/O	Deep-Sleep Wakeup; GPIO16
9	MTMS	I/O	GPIO14; HSPI_CLK
10	MTDI	I/O	GPIO12; HSPI_MISO
11	VDDPST	P	Digital/IO Power Supply (1.8V~3.3V)
12	MTCK	I/O	GPIO13; HSPI_MOSI; UART0_CTS
13	MTDO	I/O	GPIO15; HSPI_CS; UART0_RTS
14	GPIO2	I/O	UART Tx during flash programming; GPIO2
15	GPIO0	I/O	GPIO0; SPI_CS2
16	GPIO4	I/O	GPIO4
17	VDDPST	P	Digital/IO Power Supply (1.8V~3.3V)
18	SDIO_DATA_2	I/O	Connect to SD_D2 (Series R: 200Ω); SPIHD; HSPIHD; GPIO9
19	SDIO_DATA_3	I/O	Connect to SD_D3 (Series R: 200Ω); SPIWP; HSPIWP; GPIO10
20	SDIO_CMD	I/O	Connect to SD_CMD (Series R: 200Ω); SPI_CS0; GPIO11
21	SDIO_CLK	I/O	Connect to SD_CLK (Series R: 200Ω); SPI_CLK; GPIO6
22	SDIO_DATA_0	I/O	Connect to SD_D0 (Series R: 200Ω); SPI_MSIO; GPIO7
23	SDIO_DATA_1	I/O	Connect to SD_D1 (Series R: 200Ω); SPI_MOSI; GPIO8
24	GPIO5	I/O	GPIO5
25	U0RXD	I/O	UART Rx during flash programming; GPIO3
26	U0TXD	I/O	UART Tx during flash progamming; GPIO1; SPI_CS1
27	XTAL_OUT	I/O	Connect to crystal oscillator output, can be used to provide BT clock input
28	XTAL_IN	I/O	Connect to crystal oscillator input
29	VDDD	P	Analog Power 3.0V~3.6V
30	VDDA	P	Analog Power 3.0V~3.6V
31	RES12K	I	Serial connection with a 12 kΩ resistor and connect to the ground
32	EXT_RSTB	I	External reset signal (Low voltage level: Active)

EM-18 RFID Reader

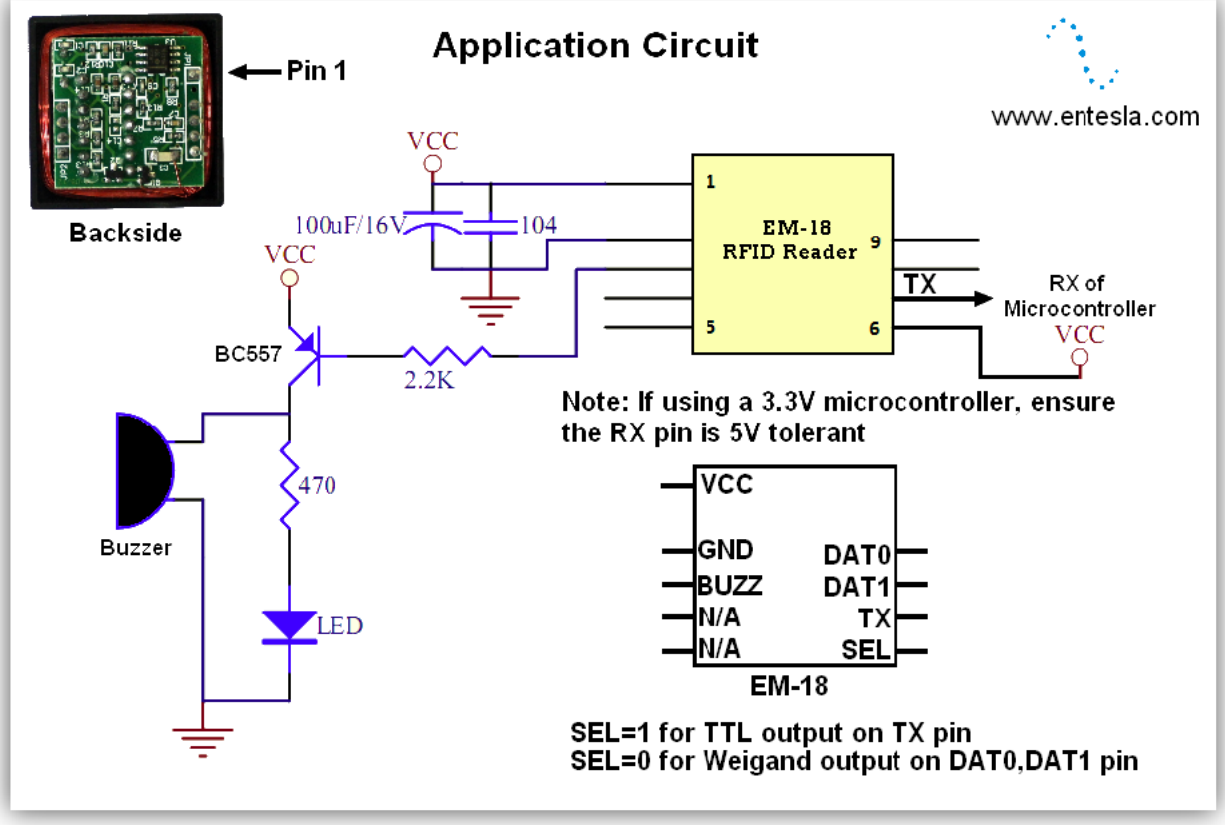
The EM-18 RFID Reader module operating at 125kHz is an inexpensive solution for your RFID based application. The Reader module comes with an on-chip antenna and can be powered up with a 5V power supply. Power-up the module and connect the transmit pin of the module to recieve pin of your microcontroller. Show your card within the reading distance and the card number is thrown at the output. Optionally the module can be configured for also a weigand output.

Typical Applications

- e-Payment
- e-Toll Road Pricing
- e-Ticketing for Events
- e-Ticketing for Public Transport
- Access Control
- PC Access
- Authentication
- Printer / Production Equipment

Features

RF Transmit Frequency	125kHz
Supported Standards	EM4001 64-bit RFID tag compatible
Communications Interface	TTL Serial Interface, Wiegand output
Communications Protocol	Specific ASCII
Communications Parameter	9600 bps, 8, N, 1
Power Supply	4.6V - 5.5VDC ± 10% regulated
Current Consumption	50 mA < 10mA at power down mode.
Reading distance	Up to 100mm, depending on tag
Antenna	Integrated
Size (LxWxH)	32 x 32 x 8mm



L293x Quadruple Half-H Drivers

1 Features

- Wide Supply-Voltage Range: 4.5 V to 36 V
- Separate Input-Logic Supply
- Internal ESD Protection
- High-Noise-Immunity Inputs
- Output Current 1 A Per Channel (600 mA for L293D)
- Peak Output Current 2 A Per Channel (1.2 A for L293D)
- Output Clamp Diodes for Inductive Transient Suppression (L293D)

2 Applications

- Stepper Motor Drivers
- DC Motor Drivers
- Latching Relay Drivers

3 Description

The L293 and L293D devices are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, DC and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications.

Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo-Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN.

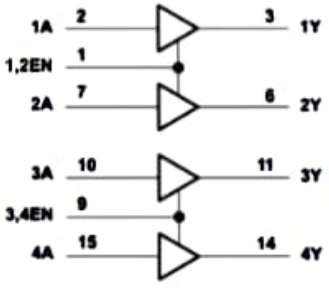
The L293 and L293D are characterized for operation from 0°C to 70°C.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
L293NE	PDIP (16)	19.80 mm × 6.35 mm
L293DNE	PDIP (16)	19.80 mm × 6.35 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Logic Diagram



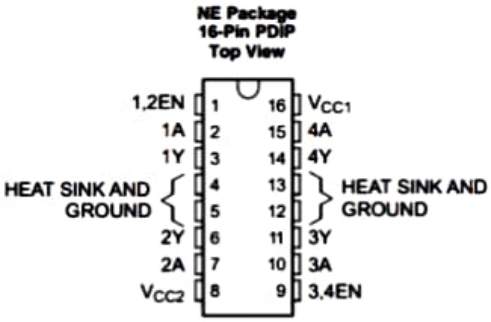
6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[1]

	MIN	MAX	UNIT
Supply voltage, V_{CC1}[2]		36	V
Output supply voltage, V_{CC2}		36	V
Input voltage, V_I		7	V
Output voltage, V_O	–3	V_{CC2} + 3	V
Peak output current, I_O (nonrepetitive, t ≤ 5 ms): L293	–2	2	A
Peak output current, I_O (nonrepetitive, t ≤ 100 µs): L293D	–1.2	1.2	A
Continuous output current, I_O: L293	–1	1	A
Continuous output current, I_O: L293D	–600	600	mA
Maximum junction temperature, T_J		150	°C
Storage temperature, T_{stg}	–65	150	°C

5 Pin Configuration and Functions



Pin Functions

PIN		TYPE	DESCRIPTION
NAME	NO.		
1,2EN	1	I	Enable driver channels 1 and 2 (active high input)
<1:4>A	2, 7, 10, 15	I	Driver inputs, noninverting
<1:4>Y	3, 6, 11, 14	O	Driver outputs
3,4EN	9	I	Enable driver channels 3 and 4 (active high input)
GROUND	4, 5, 12, 13	—	Device ground and heat sink pin. Connect to printed-circuit-board ground plane with multiple solid vias
V_{CC1}	16	—	5-V supply for internal logic translation
V_{CC2}	8	—	Power VCC for drivers 4.5 V to 36 V

8.4 Device Functional Modes

Table 1 lists the fuctional modes of the L293x.

Table 1. Function Table (Each Driver)(1)

INPUTS (2)		OUTPUT (Y)
A	EN	
H	H	H
L	H	L
X	L	Z

(1) H = high level, L = low level, X = irrelevant, Z = high impedance (off)
(2) In the thermal shutdown mode, the output is in the high-impedance state, regardless of the input levels.

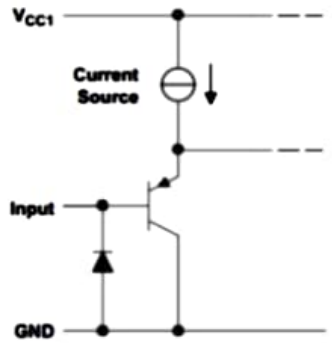


Figure 3. Schematic of Inputs for the L293x

TEXAS INSTRUMENTS

PCF8574 Remote 8-Bit I/O Expander for I²C Bus

1 Features

- Low Standby-Current Consumption of 10 µA Max
- I²C to Parallel-Port Expander
- Open-Drain Interrupt Output
- Compatible With Most Microcontrollers
- Latched Outputs With High-Current Drive Capability for Directly Driving LEDs
- Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II

2 Applications

- Telecom Shelters: Filter Units
- Servers
- Routers (Telecom Switching Equipment)
- Personal Computers
- Personal Electronics
- Industrial Automation
- Products with GPIO-Limited Processors

3 Description

This 8-bit input/output (I/O) expander for the two-line bidirectional bus (I²C) is designed for 2.5-V to 6-V V_{CC} operation.

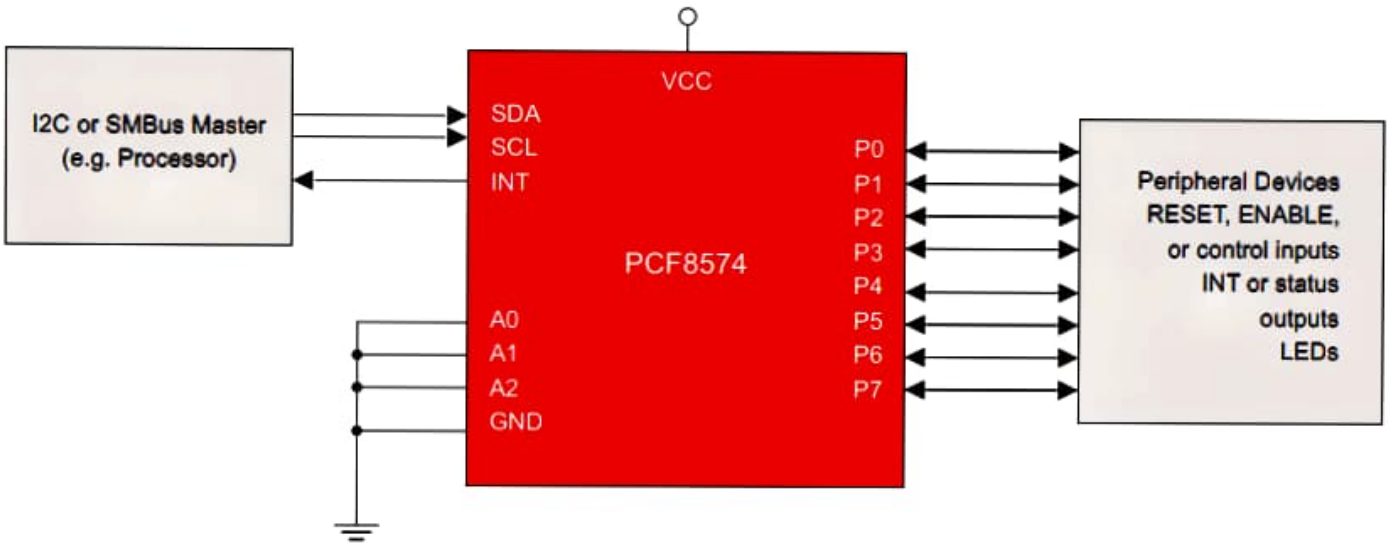
The PCF8574 device provides general-purpose remote I/O expansion for most microcontroller families by way of the I²C interface [serial clock (SCL), serial data (SDA)].

The device features an 8-bit quasi-bidirectional I/O port (P0–P7), including latched outputs with high-current drive capability for directly driving LEDs. Each quasi-bidirectional I/O can be used as an input or output without the use of a data-direction control signal. At power on, the I/Os are high. In this mode, only a current source to V_{CC} is active.

Device Information(1)

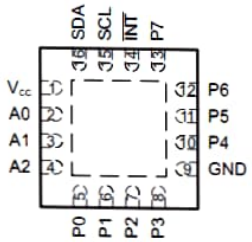
PART NUMBER	PACKAGE (PIN)	BODY SIZE (NOM)
PCF8574	TVSOP (20)	5.00 mm × 4.40 mm
	SOIC (16)	10.30 mm × 7.50 mm
	PDIP (16)	19.30 mm × 6.35 mm
	TSSOP (20)	6.50 mm × 4.40 mm
	QFN (16)	3.00 mm × 3.00 mm
	VQFN (20)	4.50 mm × 3.50 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

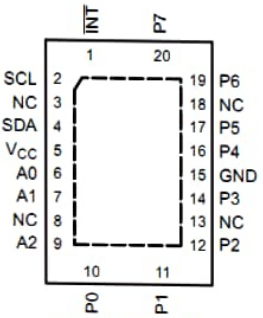


5 Pin Configuration and Functions

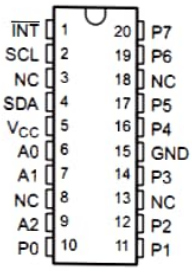
RGT PACKAGE
(TOP VIEW)



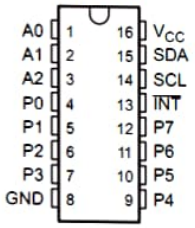
RGY PACKAGE
(TOP VIEW)



DGV OR PW PACKAGE
(TOP VIEW)



DW OR N PACKAGE
(TOP VIEW)



Pin Functions

PIN					TYPE	DESCRIPTION
NAME	RGT	RGY	DGV or PW	DW or N		
A [0..2]	2, 3, 4	6, 7, 9	6, 7, 9	1, 2, 3	I	Address inputs 0 through 2. Connect directly to V_{CC} or ground. Pullup resistors are not needed.
GND	9	15	15	8	—	Ground
$\overline{INT}$	14	1	1	13	O	Interrupt output. Connect to V_{CC} through a pullup resistor.
NC	-	3, 8, 13, 18	3, 8, 13, 18	-	—	Do not connect
P[0..7]	5, 6, 7, 8, 10, 11, 12, 13	10, 11, 12, 14, 16, 17, 19, 20	10, 11, 12, 14, 16, 17, 19, 20	4, 5, 6, 7, 9, 10, 11, 12	I/O	P-port input/output. Push-pull design structure.
SCL	15	2	2	14	I	Serial clock line. Connect to V_{CC} through a pullup resistor
SDA	16	4	4	15	I/O	Serial data line. Connect to V_{CC} through a pullup resistor.
V_{CC}	1	5	5	16	—	Voltage supply

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

			MIN	MAX	UNIT
V_{CC}	Supply voltage range		−0.5	7	V
V_I	Input voltage range(2)		−0.5	V_{CC} + 0.5	V
V_O	Output voltage range(2)		−0.5	V_{CC} + 0.5	V
I_{IK}	Input clamp current	V_I < 0		−20	mA
I_{OK}	Output clamp current	V_O < 0		−20	mA
I_{OK}	Input/output clamp current	V_O < 0 or V_O > V_{CC}		±400	μA
I_{OL}	Continuous output low current	V_O = 0 to V_{CC}		50	mA
I_{OH}	Continuous output high current	V_O = 0 to V_{CC}		−4	mA
	Continuous current through V_{CC} or GND			±100	mA
T_J	Junction temperature			150	°C
T_{stg}	Storage temperature range		−65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings

2 Features

2.1 Hardware

- Quad core 64-bit ARM-Cortex A72 running at 1.5GHz
- 1, 2 and 4 Gigabyte LPDDR4 RAM options
- H.265 (HEVC) hardware decode (up to 4Kp60)
- H.264 hardware decode (up to 1080p60)
- VideoCore VI 3D Graphics
- Supports dual HDMI display output up to 4Kp60

2.2 Interfaces

- 802.11 b/g/n/ac Wireless LAN
- Bluetooth 5.0 with BLE
- 1x SD Card
- 2x micro-HDMI ports supporting dual displays up to 4Kp60 resolution
- 2x USB2 ports
- 2x USB3 ports
- 1x Gigabit Ethernet port (supports PoE with add-on PoE HAT)
- 1x Raspberry Pi camera port (2-lane MIPI CSI)
- 1x Raspberry Pi display port (2-lane MIPI DSI)
- 28x user GPIO supporting various interface options:
  - Up to 6x UART
  - Up to 6x I2C
  - Up to 5x SPI
  - 1x SDIO interface
  - 1x DPI (Parallel RGB Display)
  - 1x PCM
  - Up to 2x PWM channels
  - Up to 3x GPCLK outputs

2.3 Software

- ARMv8 Instruction Set
- Mature Linux software stack
- Actively developed and maintained

5 Peripherals

5.1 GPIO Interface

The Pi4B makes 28 BCM2711 GPIOs available via a standard Raspberry Pi 40-pin header. This header is backwards compatible with all previous Raspberry Pi boards with a 40-way header.

5.1.1 GPIO Pin Assignments

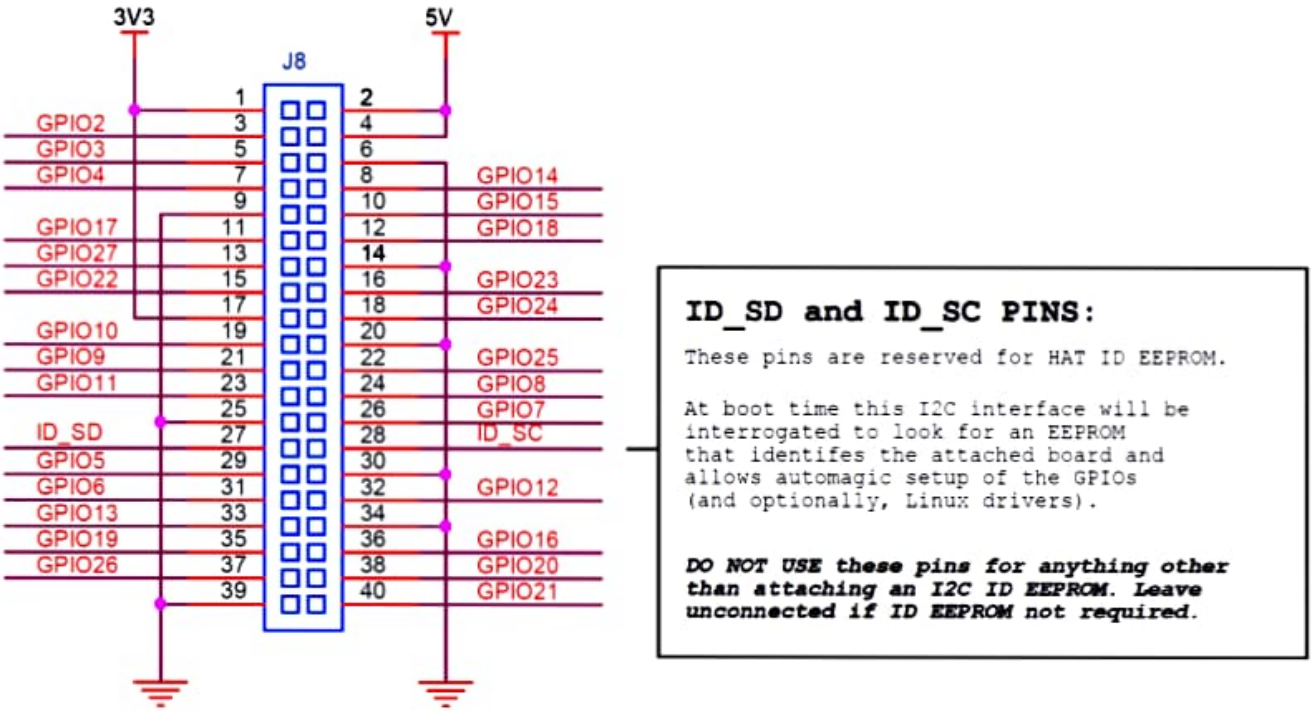


Figure 3: GPIO Connector Pinout

As well as being able to be used as straightforward software controlled input and output (with programmable pulls), GPIO pins can be switched (multiplexed) into various other modes backed by dedicated peripheral blocks such as I2C, UART and SPI.

In addition to the standard peripheral options found on legacy Pis, extra I2C, UART and SPI peripherals have been added to the BCM2711 chip and are available as further mux options on the Pi 4. This gives users much more flexibility when attaching add-on hardware as compared to older models.

4 Electrical Specification

Caution! Stresses above those listed in Table 2 may cause permanent damage to the device. This is a stress rating only; functional operation of the device under these or any other conditions above those listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Symbol	Parameter	Minimum	Maximum	Unit
VIN	5V Input Voltage	-0.5	6.0	V

Table 2: Absolute Maximum Ratings

Please note that VDD_IO is the GPIO bank voltage which is tied to the on-board 3.3V supply rail.

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Unit
V_{IL}	Input low voltage[a]	VDD_IO = 3.3V	0	-	0.8	V
V_{IH}	Input high voltage[a]	VDD_IO = 3.3V	2.0	-	VDD_IO	V
I_{IL}	Input leakage current	TA = +85°C	-	-	10	μA
C_{IN}	Input capacitance	-	-	5	-	pF
V_{OL}	Output low voltage[b]	VDD_IO = 3.3V, IOL = -2mA	-	-	0.4	V
V_{OH}	Output high voltage[b]	VDD_IO = 3.3V, IOH = 2mA	VDD_IO - 0.4	-	-	V
I_{OL}	Output low current[c]	VDD_IO = 3.3V, VO = 0.4V	7	-	-	mA
I_{OH}	Output high current[c]	VDD_IO = 3.3V, VO = 2.3V	7	-	-	mA
R_{PU}	Pullup resistor	-	18	47	73	kΩ
R_{PD}	Pulldown resistor	-	18	47	73	kΩ

[a] Hysteresis enabled
[b] Default drive strength (8mA)
[c] Maximum drive strength (16mA)

Table 3: DC Characteristics

Pin Name	Symbol	Parameter	Minimum	Typical	Maximum	Unit
Digital outputs	t_{rise}	10-90% rise time[a]	-	TBD	-	ns
Digital outputs	t_{fall}	90-10% fall time[a]	-	TBD	-	ns

[a] Default drive strength, CL = 5pF, VDD_IO = 3.3V

Table 4: Digital I/O Pin AC Characteristics