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DESIGN AND IMPLEMENTATION OF RFID BASED HIGHWAY TOLL COLLECTION SYSTEM

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Declaration

We declare that this capstone project, entitled **"Design and Implementation of RFID Based Highway Toll Collection System,"** is the result of our project. This project has not been previously accepted for any degree and is not concurrently submitted in candidature for any other degree or diploma elsewhere.

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We hereby declare that we have read the project report. In my opinion, this project is sufficient in terms of scope and qualifies to meet the partial requirements for the Degree of B.Sc. in Electrical and Electronic Engineering.

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Approval

The capstone project entitled **"Design and Implementation of RFID Based Highway Toll Collection System"** was carried out by Rejaur Rahman (ID: EEE2002020009), Md Forhad Hosen (ID: EEE2203027064) Md. Abdullah Al Mamun (ID: EEE2202026027), Aminur Islam (ID: EEE2202026021) Md Ahasanul Haq (ID: EEE1701010038), to partially fulfill the requirements for awarding a B.Sc. in Electrical and Electronic Engineering degree. It was presented to the audience of the Oral Exam Committee and has been accepted as satisfactory.

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Abstract

The Smart Toll Management System is an advanced automated toll collection system designed to reduce traffic congestion, save time, and improve transportation efficiency. The system uses RFID technology to identify vehicles automatically at toll plazas without requiring vehicles to stop for manual payment. Each vehicle is equipped with an RFID tag that stores vehicle information, and the toll amount is deducted automatically according to the vehicle type. A GSM module is integrated into the system to send instant SMS notifications to vehicle owners after each transaction, ensuring transparency and preventing extra charges.

The proposed system also includes a weight sensing mechanism to detect overloaded vehicles and prevent them from crossing bridges or highways, helping reduce the risk of accidents and structural damage. All transaction data is stored in a central database for monitoring and management purposes. Cashless payment and automated processing minimize human error, reduce corruption, and increase government revenue collection efficiency.

This project provides a secure, reliable, and low-cost solution for modern toll management, especially suitable for Bangladesh and other developing countries. In addition, the system helps reduce fuel consumption, air pollution, and noise pollution caused by long waiting times at toll booths. The implementation of vehicle registration and RFID-based authentication also enhances security and supports anti-theft monitoring. Overall, the Smart Toll Management System offers a fast, transparent, and user-friendly approach to intelligent transportation management.

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List of Abbreviations

NodeMCU	Node MicroController Unit
SoC	System-on-a-Chip
SDK	Software Development Kit
SDA	Society Development Agency
SCL	Society for Computers and Law
PWM	Pulse with Modulation
LF	Low Frequency
HF	High Frequency
UHF	Ultra-High Frequency
GSM	Global System for Mobile Communications
RFID	Radio Frequency Identification
SIM	Subscriber Identity Module
IMEI	International Mobile Equipment Identity
ETC	Electronic Toll Collection
IoT	Internet of Things
LCD	Liquid Crystal Display
IR	Infrared Sensor

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Chapter 1

Introduction

1.1 Introduction

The traffic problem is one of the most serious problems in our country today. We face traffic jams every day in Bangladesh, lasting several hours at a time which is very annoying and creates a great deal of difficulty in our daily lives. The rash of vehicles is due to excessive traffic congestion and reckless driving. Many bridges, flyovers, and bypass roads have been built to reduce traffic problems. Whenever any vehicle crosses these structures, it must pay a toll. In our country, toll collection is conducted manually. This creates jams since it takes a long time to pass the vehicles. The idea is to utilize RFID technology to incorporate electronic toll collection systems, which will be automatic and will not stop vehicles [1].

In addition to improving traffic flow, this system will also reduce delays in the system. The payment will be taken from the vehicle owner's bank account, and he will receive a message from the server that the toll payment has been made. Furthermore, our system will also assist in preventing road accidents since excessive speed is a major contributor. This is because it is designed to slow down the vehicles' speeds when their RFID tags are read [2].

Time and fuel are wasted every year waiting at toll plazas due to the increase in vehicle numbers. A toll plaza can reduce this wastage of time and fuel, as well as enhance vehicle security. This is done by sending a text message to the owner's registered mobile number, displaying information about the vehicle on the screen, and automatically opening and closing the barricade. Vehicle owners' prepaid accounts are charged on tolls [3].

Figure 1.1: Toll collection of Padma bridge in Bangladesh

1.2 Motivation

This project seeks to solve traffic problems while maintaining transparency in toll collection. To sort the toll collection process more automated and less time-consuming, we are developing a digital toll collection system. Further, we have presented and compared a cost-effective exploration of the spontaneous toll collection arrangement of the manual ticketing base system. A weight sensor is also used to measure the weight of transport to keep up the well-being of streets and conduits.

The system will also aid to lessen transportation jams. A statement will be referred to the vehicle proprietor, notifying him of the toll payment. Also, our system can prevent severe traffic crashes, which are usually the result of speeding. This is because we use speed breakers to slow down vehicles when RFID tags capture vehicle information.

1.3 Statement of the Problem

Traditionally, toll collectors collect the toll in booths. This is the simplest form of toll collection. This method is slower and sometimes not completely accurate. A toll collection booth typically has one or two workers who stop each vehicle to collect the toll. Collectors provide toll payers with a memo as a record of their payments. Furthermore, in Bangladesh, there is a substantial amount of exploitation in this segment. For example, there is no central system that controls the collection of tolls. No database or website stores compensation or vehicle information. Corruption thus occurs, and the government does not receive all the toll money.

Problems:

- The system is too slow.
- All vehicles have to stop, resulting in traffic jams.
- There is corruption going on.

1.4 Objectives

The objectives of this project are

- Avoid fuel losses
- Saving time collecting tolls
- Financial loss should be avoided
- Reduce long waiting time in a toll queue

- Facilitate the payment of tolls for travelers
- Reduce illegal toll gate entry.

1.5 Limitation

Smart toll collection systems in Bangladesh have several limitations, including high initial costs, potential privacy concerns with RFID technology, and the need for widespread adoption and infrastructure upgrades. The initial investment in setting up and implementing a new system, including RFID readers, servers, and other equipment, can be substantial. Tag distribution and installation can be inconvenient for those not frequently using toll roads. Widespread implementation requires widespread adoption and integration with existing roads and infrastructure, which can be slow and costly.

Technological considerations include RFID-based systems becoming outdated, security concerns, interoperability, maintenance, and user acceptance. Privacy concerns and technological lagginess can also lead to resistance. Other challenges include traffic congestion, uneven distribution of benefits, legal and regulatory challenges, and cybersecurity measures. Despite these challenges, the introduction of smart toll collection systems in Bangladesh offers potential benefits, but they also present challenges such as traffic congestion, legal and regulatory issues, and cybersecurity measures.

Chapter 2
Literature Review and Background

2.1 Introduction

Electronic toll collection is replacing manual transaction work with automatic toll collection through RFID technology. The main objectives are to reduce the waiting time in toll queues, reduce illegal toll gate entry, improve traffic flow, and save drivers' time. It reduces fuel consumption, paper consumption, and management efforts associated with the toll plaza because of these objectives. Today, the toll collection system uses RFID technology because of some disadvantages of image processing technology and infrared technology. The literature review explains the disadvantages of these two technologies. To make an online purchase, RFID readers scan the RFID tags assigned to users at toll booths. Since online transactions are enabled, the system makes the process transparent. Users can log in to the system using a web interface [4].

2.2 Related Works

This paper describes an automated ETC system using GPS. Motorists and toll authorities will no longer have to manually pay tickets or collect toll fees, thanks to this work. It is also possible to exchange data between motorists and toll authorities, thereby eliminating human errors for effective toll collection [5].

RFID reduces the cost of an entire project better than other technologies. Several high-end applications are used to build the system, which enables ease of use and speed of processing. RFID tags have been widely used to automate toll processes in vehicles since 1992, during which ETC research began [6].

This road zipper device is designed to help reduce traffic jams and improve lane management. This two-step toll collection system ensures vehicle specifications and eliminates the need for vehicles to stop for toll collection. The RFID tags hold the number plate information on vehicles. This model requires the digital number plates to be inserted into the vehicles. It describes a prototype device for the road toll collection with a road zipper that yields appropriate results. Due to its simplicity, this system requires no human intervention. Intelligent transportation becomes more feasible [7].

The toll zone on a bridge will be properly explored in this study project. Both the driver's and the vehicle's registration details are normally included in the data table that is available in the suggested model. The initial toll payment can be collected using the suggested digital toll management system, which will also offer a structure for toll management system appeasement. The accuracy validation of the research-based project is approximately 95.46%. The outcome of this strategy is the Bridge, which will assist the government in appropriately collecting toll money from each transport owner or driver. Toll bridges can employ the digital toll management system to provide smart technologies for citizens nationwide [8].

The current toll collection technologies, such as Radio Frequency Identification (RFID), still take a long time. This paper examines a GPS-based toll collection system as a solution to the aforementioned problems. The coordinates of the moving object would be tracked by this system each time a car changed from a highway to a service road. Because of this, the user can pay the toll anywhere on the freeway without getting stopped. Since blockchain technology has lately emerged as one of the most popular and has the potential to revolutionize the field of intelligent transportation systems, this system will use it to build a decentralized and intelligent mechanism for toll collection and tracking records [9].

This system is used for Electronic Toll Collection (ETC) of vehicles. The antenna topology is described and preliminary experimental results are reported, showing the ability to track vehicles in real time with low mean error and a spatial resolution below 1 meter, covering an area of 8 m x 8 m below the smart antenna system mounted on a 4.7 m high ETC gateway. These performances appear to be sufficient to accurately distinguish between two adjacent lanes and to resolve standard vehicle sizes in two dimensions and real time, both in stop-and-go and free-toll operation modes. The proposed ETC architecture eliminates the need for additional automated radio transponder devices because users' smartphones running popular BLE applications are sufficient, which lowers implementation costs, maintenance, and scalability [10].

2.3 Smart Toll

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2.4 The Toll Management System

To build new roads, repair and maintain existing roads, as well as pay for the costs associated with the installation of the toll management system, a Toll Management System is enacted. The type of vehicle, weight, and distance traveled determine the fee.

Highway projects must include a toll management system. Using this system, road users will be able to pay tolls efficiently and securely. Throughout the system, there are more than 13 pieces of hardware and software that work together to keep track of various functions of toll collection. These include User management, Float management, Toll Collection, Cash declaration, Transaction Audit, Vehicle Classification, ETC FASTag transaction processing, TC performance, and various other functions.

It is only a tiny fraction of the total project cost, but it is what has the potential to enable a toll operator to effectively recover their investment. Several built-in security features are built into the system, as well as features that enable easy toll collection in lanes and prevent, detect, and stop revenue leaks.

2.4.1 Toll Operation

The toll collection system or policy must be determined before the system or policy for toll collection can be considered or planned. The most common toll systems are those that use a flat rate (or an open system) as well as those that use distance-based tolls (a closed system) [14].

For ongoing road maintenance and improvements, tolls provide a sustainable income source. Adding tolls to our nation's transportation infrastructure provides safe and reliable options for the traveling public to reach their destinations innovatively and cost-effectively.

Since there is no need for calculating toll amounts under the "flat toll system", a manual collection can be used. The complexity of calculating tolls necessitates Smart Toll Collection (STC) if distance-dependent payments are adopted.

2.5 Manual Toll Collection (MTC)

Manual toll collection involves the payment of the toll amounts directly to the toll collectors. Flat tolls are commonly used in cases where doing so does not require calculating toll fees. The number of entrances and exits, as well as the length and type of collection, determine the stage of the manual collection [15].

Figure 2.1: The MTC system

a) Simple Manual Toll Collection

When flat tolling is implemented, toll collectors classify vehicles visually to collect tolls (usually at the entry point). The toll can be paid in cash or through a coupon (with a discounted rate for frequent users).

b) Tolls collected manually with tickets

A manual toll collection system may be employed if the number of entrances and exits to the system is not so significant. A ticket will be given to the driver at the entrance (or he/she may take it from a machine). At the exit, the driver gets a ticket indicating the distance from the entrance, from which the toll calculation is calculated.

c) The collection of tolls manually and computerized

Toll roads are becoming increasingly long and many exits and entrances are being added to the network. This makes it almost impossible for the toll collector to calculate the toll amount by hand. Hence, the use of a computer system would be necessary. A central computer often connects the ticket issuing machines at the entrances and the exits to track not only the toll amount of each vehicle but also data such as:

- Vehicle type-specific traffic volume,

- Check for illegal/abnormal vehicle travel by using the time from entrance to exit, and
- Toll revenue.

2.5.1 Advantages of MTC

In addition to allowing more money to be raised for road construction than could be done with conventional public funding, it is also beneficial to the environment. Moreover, it has been observed that such facilities provide better quality maintenance than comparable free facilities. A toll road can also serve as a congestion pricing method. This can encourage users to choose more efficient route choices or to use alternative modes of transportation.

2.5.2 Disadvantages of MTC

Collecting manually or in a non-automated manner is:

- Those with an automatic toll collection system open boom barriers automatically, but those with a manual system have to be lifted or slid/pushed.
- The documentation of vehicle details through manual collection is inefficient as the vehicle details are not recorded on a computer and are mostly written on log sheets. Retrievers have trouble finding them.
- There are fewer regulations, so booth operators can corrupt or collude with road users.

2.6 Smart Toll Collection (STC)

Toll roads, HOV lanes (high-occupancy vehicle lanes), toll bridges, and toll tunnels rely on STC to automatically collect the toll collected. Rather than stopping at toll booths, where vehicles must stop and pay the toll manually with cash or a credit card, a faster option is being offered. A radio transponder device is typically attached to the vehicles using the system. Toll reader devices are roadside devices that use radio signals to trigger the transponder. This transponder then transmits an identifier that registers the vehicle and charges the user for the toll. This method reduces traffic delays because the driver doesn't have to stop [16].

For a government or private road owner, electronic tolling is cheaper than manned toll booths. Variations in toll amounts allow for the adoption of road congestion pricing in high-occupancy lanes, toll lanes bypassing congested areas, and city-wide congestion charges. Signing up for the payment system requires users to load balances to a declining-balance account, which is debited whenever they pass a toll point.

2.7 Smart Toll Collection System (STCS)

Using an electronic toll collection system, a smart toll collection system minimizes the amount of time spent collecting tolls. It has several problems as it uses RFID technology. An automated license plate recognition system is implemented in this system to overcome that issue [17].

Reducing human intervention reduces human error. The primary advantage of automating societies is that machine/hardware dependency is expanded (more reliable) while human dependency decreases. Combining automation with daily life will simplify lifestyles and reduce stress. At present, most highway tolls are operated manually, where the operator collects cash from the motorist and provides a receipt. Our toll plazas often have traffic jams due to this method since it is a slow method. Automation can save money, energy, and manpower [18].

Toll booths create traffic jams when the manned operation takes up a considerable amount of time, and vehicles have to stop for change. This causes excessive fuel usage. Using the Automated Toll Management System, vehicles will pass toll points without stopping. This eliminates the need for barricades, which results in much higher efficiency of fuel and time [19].

Figure 2.2: A toll collection system utilizing RFID

Information is stored electronically on an RFID tag, which is made up of an antenna and an integrated chip. The RFID reader collects information from RFID tags through a component called a reader. This component transmits information using radio waves. See Figure 2.3 for a demonstration of RFID toll collection.

2.8 Smart Toll Collection System (STCS) in Bangladesh

Bangladesh Smart Toll Collection System (STCS) uses Bluetooth Low Energy (BLE) technology. Over Bangladesh, many bridges and flyovers cross rivers, and there are Asian highways. As part of the development of the country, governments should collect tolls (a charge for passing through a bridge, flyover, or highway) from drivers and passengers. There are two types of toll collection systems in Bangladesh: manual and computerized. Toll collection is a labor-intensive process in both systems, and both require a human operator [20].

It has a huge impact on every aspect of our lives and has greatly simplified our lives. Every day, as more vehicles pass over the roads, more traffic jams occur; a large amount of human energy is wasted. Our current manual system cannot be used to collect tolls in Bangladesh. An authority controls a centralized database that stores all vehicle information, which is linked to a prepaid license card. It is possible to recharge the card if the balance is insufficient [21].

The website offers information concerning the daily and monthly collected tolls, arrival and departure times of vehicles, and the announcement of illegal vehicles. A device for Android that notifies the driver how many toll plazas will be on his route. It also tells him what amount is required to cross them and where to find a recharge booth [22].

2.9 Summary

In this chapter, we present an energy meter with related works. It also discussed the energy meter and its types, smart grid, IoT, and the importance of a smart energy meter.

Chapter 3

Methodology

3.1 Introduction

This section will introduce the components that make up the Smart Toll management system and discuss their working and features. But before the discussion above, let's take a look at the quality of semiconductor devices. Conductors, such as wires, are designed to have a low resistance to transfer current most efficiently. Reducing electrical energy dissipation or altering how a circuit behaves are some of the functions of resistors. Materials with high conductivity, such as copper and aluminum, are used as conductors. The materials used to make resistors vary depending on factors such as the desired resistance, the amount of energy that it must dissipate, precision, and cost. This section will introduce the components that make up the Smart toll management and discuss their working and features.

3.2 Block Diagram

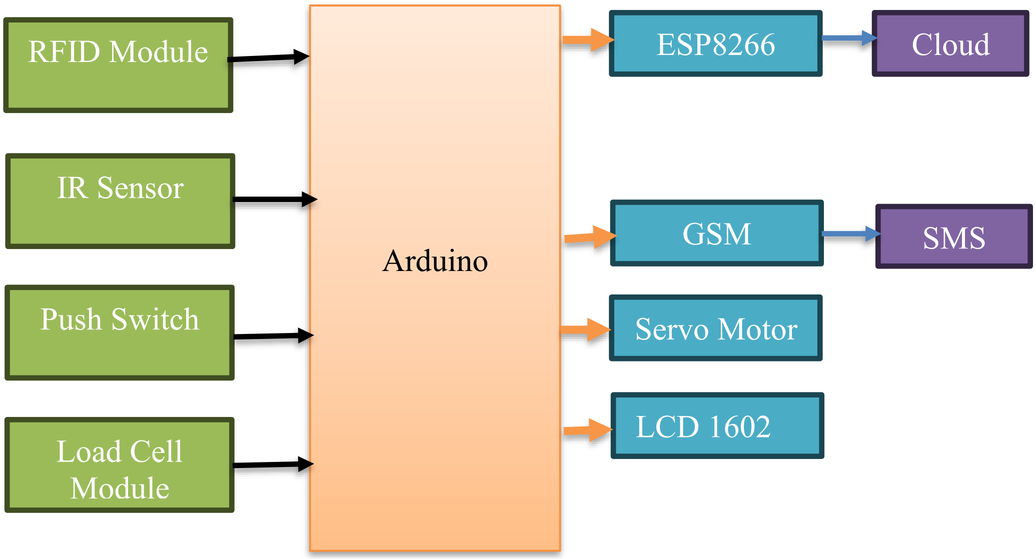


Figure 3.1: Block diagram of this project

In this block diagram, we can see that the Microcontroller is the brain of the whole system. It collects inputs and provides the outputs according to the program.

We are getting inputs from Infrared sensors to detect cars and falls on the Servo motor. RFID, besides the Load cell, detected the car's weight and unique identity and sent it to the server via IoT and sent an SMS via GSM. Also, the entire process is controlled via Arduino. If any car is overweight, that car cannot go out.

3.3 Circuit Diagram

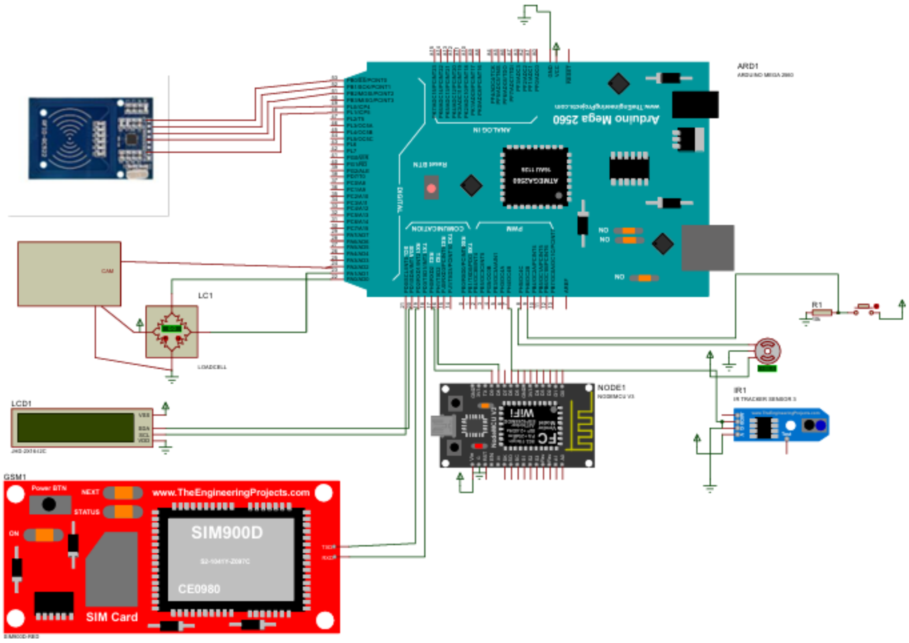


Figure 3.2: Circuit diagram of the project.

In this project, we have attached the GSM module, Infrared Sensor, ESP 8266, Servo Motor, LCD 16*2 Display, and an RFID card module connected with the Arduino microcontroller.

In this circuit diagram, the pin of LCD 16*2 SDA and SCL are respectively connected to D12 and D13 of the Arduino pin. The infrared Sonar Sensor is linked to Arduino pin D11. The Servo Motor is connected to the D09 pin of Arduino. GSM Module TX and RX pins are connected to A0 and A1 pins of Arduino, and ESP8266 is connected to A2 and A3 pins of Arduino. RFID is connected with D22, D23, D28, D25, and A15 pins of Arduino.

3.4 Hardware Descriptions

Those components have been used in this project. Here is the list of the components:

- LCD 16*2
- Arduino
- ESP8266
- GSM

- IR sensor
- Load Cell
- Load Cell Module
- RFID Card
- RFID module (rc522)
- Servo motor
- Buzzer.

3.4.1 Arduino Uno

The open-source platform is founded on a simple input/output panel and surroundings supporting the Processing language (www.processing.org). A standalone Arduino or an Arduino connected to a computer can build interactive objects. Using the Arduino IDE (Integrated Development Environment), boards can be built by hand or sold assembled. This embedded system uses the Atmel microcontroller clan with standard hardware on a board that has an inherent boot loader for plug-and-play software design. Arduino Software includes an IDE for writing, debugging, and creating programs. Serial data can also be easily retrieved from the board using the Serial Communication window in the IDE.

A Mega board is an ATmega2560-based microcontroller. A USB connector, a power jack, an ICSP header, plus a reset button are present, along with 54 input/output pins (16 of which can be cast-off as PWM productivities). Pin Mode (), digital Write (), and digital Read () allow each of the 54 digital pins to function as an output or as an input. The pins run on five volts. As noted in the working conditions, the pins have an extreme current rating of 20mA and a default inner pull-up resistor (cutoff) of 20-50k ohm. The maximum current that can be applied to whichever I/O pin is 40mA to prevent irreparable damage to the microcontroller.

Figure 3.3: Arduino Uno

Specifications:
Operative Voltage: 5V and 3.3V
Input Voltage: 5-12V (5V model) and 3.3-12V (3.3V model)
Digital I/O Pins: 14 Pins (6 are PWM output pins)
Analog Input Pins: 6 pins
DC Current per I/O Pin: 40 mA
Flash Memory: 32 kB (0.5 kB is taken by bootloader)
SRAM: 2 Kbytes
EEPROM: 1 Kbytes
Clock Speed: 16 MHz (5V model) and 8 MHz (3.3V model)

Table 3.1: ARDUINO Uno Configuration

Pin Group	Pin Name	Description
POWER SOURCE	VCC, GND, and RAW	VCC- Linked to +5V or +3.3V GND– Linked to Ground RAW– Linked to Unfettered power supply 5+V to +12V
Communication INTERFACE	UART Interface (RXD, TXD) SPI Interface (MOSI, MISO, SCK, SS) TWI Interface (SDA, SCL)	UART (Universal Asynchronous Receiver Transmitter) Interface can be used to program PRO MINI SPI (Serial Peripheral Interface) Interface can be used to program PRO MINI TWI (Two Wire Interface) Interface can be used to attach peripherals.
INPUT-OUTPUT PINS	PD0 to PD7 (8 pins of PORTD) PB0 to PB5 (6 pins of PORTB) PC0 to PC6 (7 pins of PORTC) ADC6 and ADC7 (2 extra pins)	They oblige various dedications, but they can be classified as data I/O pins.
ANALOG to DIGITAL CONVERTER	ADC0, ADC1, ADC2, … ADC7	They can be used for analog input and feature 10-bit resolution.
PWM	OC0A, OC0B, OC1A, OC1B, OC2A, OC2B	It delivers PWM outputs and 8-bit tenacity.
RESET	RESET	Resets the controller.
EXTERNAL INTERRUPTS	T0 and T1	Hardware interrupts are provided by these two pins.

ANALOG COMPARATOR	AIN0 and AIN1	An internal comparator connects these two pins.

3.4.2 Liquid Crystal Display (LCD)

Some of the furthermost LCDs linked to the Arduino Uno are 16*2. LCDs have 16 characters per line through two lines, so they have replaced LEDs. Fortunately, a really common standard exists that permits us to interconnect with the overwhelming mainstream of LCDs, notwithstanding their construction. The quality is said to be HD44780U, talking about the regulator chip that obtains information commencing an exterior supply besides interconnecting straight with the LCD. The four780 typically needs three controller outlines further as whichever four or eight I/O lines are aimed at the info bus. The operator might choose whether or not the LCD is to work with a 4-bit information bus or an 8-bit data bus.

A 4-bit data bus will be used, and then the LCD would necessitate an entire seven information lines (3 management lines and four lines for the info bus). If an 8-bit information bus is used, the LCD will necessitate a total of eleven information lines (three control lines and 8 lines for the data bus).

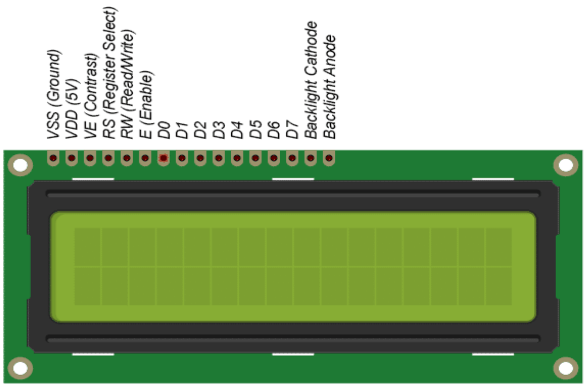


Figure 3.4: LCD 16*2

Features

- The presentation information RAM
- Character initiator ROM
- 160 different 57 dot matrix character patterns
- Microprocessors can access show information RAM besides a character initiator RAM
- Numerous lessons
- A flawless display, pointer home, the display on/off, the pointer on/off, flicker character, and also pointer shift
- The built-in reorganized circuit is generated at power ON

Table 3.2: Pin symbol description

PIN	Sign	Function
1	VSS	GND
2	VDD	+5V
3	V0	Contrast adjustment
4	RS	H/L Register select signal
5	R/W	H/L Read/write signal
6	E	H/L Enable signal
7	DB0	H/L Data bus line
8	DB1	H/L Data bus line
9	DB2	H/L Data bus line
10	DB3	H/L Data bus line
11	DB4	H/L Data bus line
12	DB5	H/L Data bus line
13	DB6	H/L Data bus line
14	DB7	H/L Data bus line
15	A	+4.2V for LED
16	K	Power supply for BKL (0V)

3.4.3 ESP 8266

Espressif Systems produces the ESP8266 ESP8266 a stumpy-rate Wi-Fi chip with GPIO and TCP/IP networking proficiency incorporated into a microcontroller, and it is available for purchase in Shanghai, China. English-speaking makers were first introduced to the chip through Ai-Thinkers' ESP-01 module.

Figure 3.5: ESP8266 Node MCU

The ESP8266 is a liberated Wi-Fi arranged controller proposing an allowance to the present small-scale regulator via Wi-Fi, as well as being able to run independent software programs. It has a built-in USB port and a variety of stick-outs. Using a lesser USB link, we can easily connect NodeMCU to our laptop and use it the same way as Arduino. It is also immediately inviting with its breadboard.

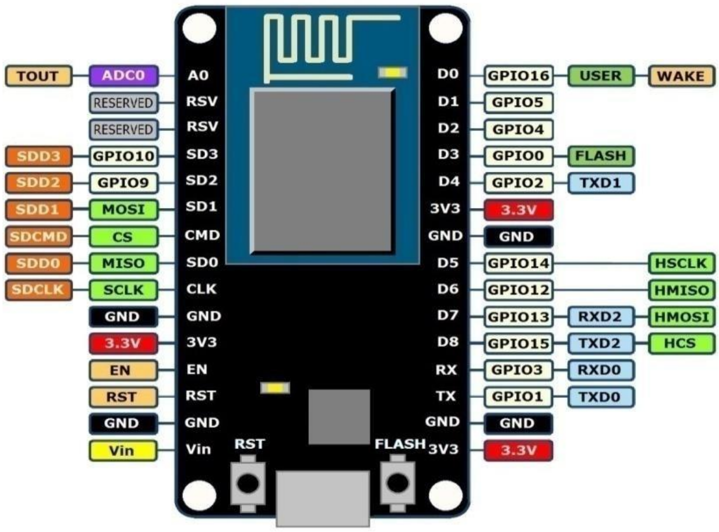


Figure 3.6: Pin configuration ESP8266 Node MCU

Description:

- Voltage: 3.3V.
- Wi-Fi Direct (P2P), soft-AP.
- Current ingestion: 10uA~170mA.
- Flashy memory removable: 16MB max (512K normal).
- Incorporated TCP/IP decorum pile.
- Processor: Ten silicaL106 32-bit.
- Processor speediness: 80~160MHz.
- RAM: 32K + 80K.
- GPIOs: 17 (multiplexed with other functions).
- Analog to Digital: 1 input with 1024 step determination.
- +19.5dBm output power in 802.11b mode
- 802.11 support: b/g/n.
- Extreme synchronized TCP associates: 5.

3.4.4 GSM

The SIM800L GSM/GPRS module is a miniature GSM modem that tin be cast-off in a large number of IoT plans. A cell phone tin accomplishes nearly anything this segment can; SMS script messages, building and delivering phone calls, between to the internet over GPRS, TCP/IP, also more. Finally, the module provisions

GSM/GPRS a quad-band link, so its mechanism is pretty much any place. Next to the center of the element possibly will be a SIM800L GSM cellular chip commencing Sim Com.

The chip's operative voltage ranges commencing 3.4V to 4.4V making it a viable contender for a straight LiPo battery offer. This marks it as an applicable substitute for implanting into projects without taking up numerous spaces. All the mandatory information pins of the SIM800L GSM chip are cracked resolute 0.1″ pitch captions. This comprises pins anticipated for communiqué with a microcontroller above UART. The segment maintenances a baud frequency of 1200bps near 115200bps through Auto-Baud recognition. The element wishes an exterior projection to attach to a net. The building block sometimes hails from a helical antenna besides welds onto the internet pin on PCB. Additionally, the board has a U.FL instrumentation port for when wishing to place the antenna away from the board.

Figure 3.7: GSM

Stipulations:

- Chip: SIM800L
- Voltage: 3.7-4.2V
- Support networks: China Mobile, China Unicom, and global quad-band network
- Module size: 2.5cmx2.3cm
- TTL serial port for the serial port can link directly to the microcontroller.
- Power module automatically boots, homing network.
- Onboard signals flash slowly when there is a signal, quickly when there isn't.

When an SMS command is received from a cell phone, the data is sent to the MC through serial communication. During the execution of the program, the GSM modem receives 'STOP' to output a contact point that, when pressed, disables the ignition switch.

3.4.5 The IR Sensor

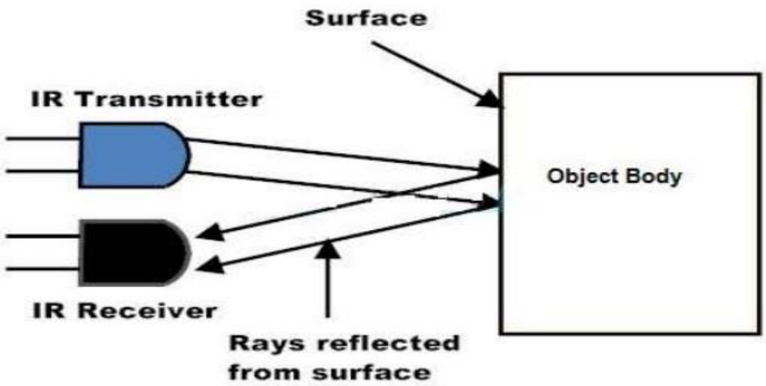


Figure 3.8: IR Sensor

IR Transmitter

IR transmitter appearances are similar to LED. IR rays are always emitted from this IR transmitter. The functioning voltage of this IR spreader is between 2 to 3V. These IR (infra-red) waves are too small to see near the humanoid sense. However, these IR rays can penetrate through the camera. A visible light wavelength is around 640 nm (430 THz) and an ultraviolet wavelength is 1000000 nm (300 GHz) (though societies can perceive warmth over that wavelength in experiments). Infrared radiation has longer wavelengths than visible light. Furthermost the thermal radioactivity emanated through substances close to chamber temperature is infrared. In trade, systematic, as well as medicinal applications, infrared radiation is used. Active near-infrared illumination is used in night-vision tools to allow observers to see animals or people without being seen.

IR Receiver (Photodiode)

A photodiode alters sunlight into the current. The current is engendered once photons are engrossed in the photodiode. A bit of current is also manufactured at what time no light is present. There are several types of photodiodes, including those with built-in optical filters and those with large or small surface areas. Increasing the surface area of a photodiode usually slows its response time. Traditional solar cells that generate electrical power are large area photodiodes. As with regular semiconductor diodes, photodiodes are often exposed to ultraviolet or X-ray radiation or wrapped up with a window or ophthalmic fiber so that sunlight can grasp the sensitive component. Photodiodes are frequently designed with PIN junctions rather than p-n junctions since they are more responsive. Photodiodes work in opposite bias.

Table 3.3: Photodiode order

FACTORS	VALUES
Wavelength	1250~1600
Dusky current	0.4 nA (typ),1.0 nA (max)
Capacitance(PF)	0.7(typ),0.9 (max)
Input power(MW)	2.0 (max)
Amputate frequency	2.0 GHZ
Functioning voltage	-5.0 v
Reverse voltage	20 v

The benefits of using an IR sensor are:

- Infrared sensors can discover ultraviolet light from large expanses over an inclusive zone
- No interference including with electrical devices
- Infrared tools are simple plus very inexpensive
- The shield is simple
- No licenses are obligatory.

3.4.6 The Load Cell

A load cell deals with motorized force, chiefly heaviness. A load cell is used to measure weight in almost all electronic scales today. Weight scales are widely used because of their accuracy in measuring weight.

Force and load can be measured with load cells, a type of sensor. Electrical signals are generated from the force. In many cases, strain gauges are used in the load cells. With a change in compression, the strain gauges change resistance, which results in a change in output.

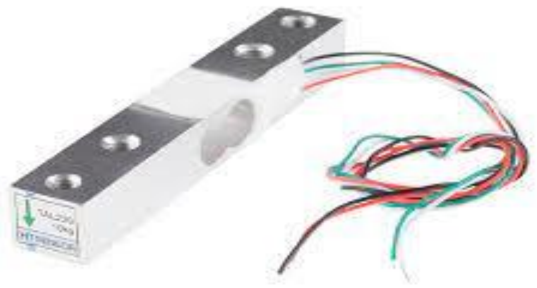


Figure 3.9: Load cell

3.4.7 The Load Cell Module

A load cell amplifier breakout board for the HX711 IC. The HX711 module is capable of reading load cells for weight measurement. 24 high-precision A/D converters are used in this module.

Designed for weighing scales and industrial control applications, the HX711 is a 24-bit analog-to-digital converter (ADC). Specifically, it is designed for amplifying cell signals and sending them to another microcontroller.

Mechanical input forces such as load, weight, tension, compression, or pressure are converted into another physical variable, in this case, an electrical output signal. This allows them to be measured, converted, and standardized.

Among the most commonly used weight sensors are strain gauges, capacitance sensors, hydraulic sensors, and pneumatic sensors. Sensors comprising the first two types are electrical transducer devices. It is a sensor that generates a voltage as an output in response to a physical stimulus.

An electronic scale module, HX711, converts resistance changes measured on the scale into electrical signals through a conversion circuit. A TTL RS232 interface converts these signals to electrical signals.

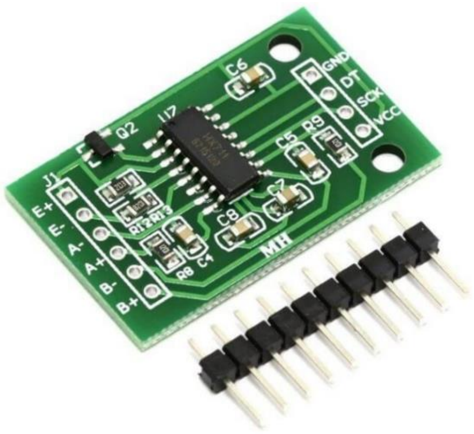


Figure 3.10: The load cell module HX711

Features:

- Separator Input Voltage: ± 40mV
- Data Accuracy: 24-bit (24-bit A/D Converter Integrated)
- Refresh Frequency: 80 Hz
- Operating Voltage: 5V DC
- Operating current: <10mA
- Size: 38mm*21mm*10mm

3.4.8 RFID Card

"Radio-frequency identification" refers to reading digital data from RFID tags or smart labels (as defined below), which is transmitted by radio waves. Data collected from a tag or label are stored in a database, just as barcodes are. In contrast to barcode asset tracking software, RFID offers several advantages. Rather than having to align a barcode scanner to analyze RFID tag data, barcodes can be read without line-of-sight.

Automatic Identification and Data Capture (AIDC) refers to a group of technologies including RFID. In AIDC, objects are automatically identified, their attributes are collected, and they are entered directly into computers without any human intervention. RFID technology makes this possible through radio waves. The RFID system is made up of three components: an RFID tag or smart label, an RFID reader, and an antenna. These tags, also called RFID readers or interrogators, have an integrated circuit and an antenna that transmit data to the RFID reader. In the reader, radio waves are then converted into more usable data.

Through a communications interface, the data collected from the tags is then fetched and transferred to a host computer. Data is stored on a host computer and can be analyzed later using a database.

Integrated circuits and antennas are both parts of an RFID tag, as previously stated. A protective material also forms part of the tag, which holds the pieces together and shields them from the elements. Depending on the application, the protective material may vary. Employee ID badges, for example, usually contain RFID tags sandwiched between layers of durable plastic.

Figure 3.11: RFID card

3.4.9 The RFID Module

The NXP MFRC5a22 controller is the core of the 13.56MHz RC522 module. Modules packed with RFID cards and key fobs typically support I2C, SPI, and UART. They are commonly used to track attendance as well as to identify people and objects. The RC522 is an RF Module that consists of an RFID reader, an RFID card, and a vital chain. The element works at 13.56MHz, which is an industrialized (ISM) band and hence requires no license. The module operates at 3.3V, so it is typically incorporated into 3.3V schemes. It's usually used in solicitations that require a definite individual or object to be known with a singular ID.

The key chain has a 1kB memorial that can be accustomed to store vital information. The RC522 reader module reads plus writes data into these memorial portions. The reader will read information merely from inactive devices that transmit at 13.56MHz.

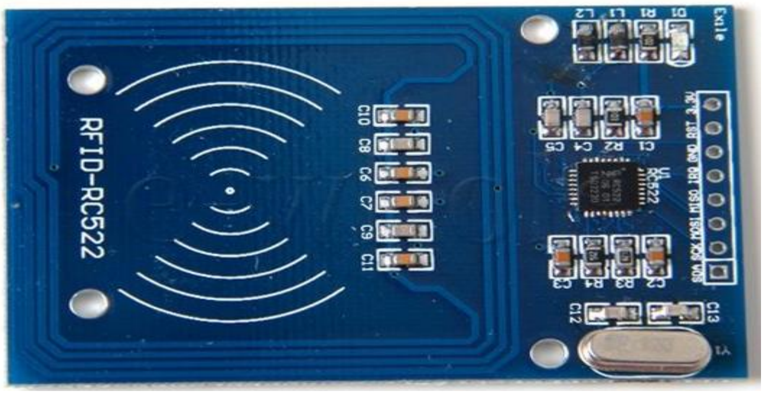


Figure 3.12: The RFID module

RC522 Structures

- A 13.56MHz RFID segment
- Functioning voltage: 2.5V to 3.3V
- Statement: SPI, I2C protocol, UART
- Extreme Information Ratio: 10Mbps
- Read Variety: 5cm
- Current Ingestion: 13-26mA
- Power despondent approach ingestion: 10uA (min)

Applications

- Automatic advertising systems.
- Appearance systems.
- An authentication/Documentation system.
- Access control systems.

3.4.10 The Servo Motor

Servo motors are rotating actuators or motors that provide precise control of position, acceleration, and velocity. Normal motors cannot do this. There is no such thing as a servo motor; they are a combination of specific components, including both DC and AC motors, that are designed to operate in closed-loop systems. Automated assembly lines, robotics, and CNC machining applications have all used them. Position feedback controls the rotational speed and position of a closed-loop servo mechanism. Inputs such as analog or digital signals represent the position commands for the shaft. Encoders act as sensors, providing information about speed and position. The position is generally reported from encoders. If there is a discrepancy between the final position reported to the controller and the initial position, the motor will be moved to get to the correct position.

Simple servo motors use DC motors with a potentiometer for position sensing, as well as big-bang controls, so the motor runs at maximum speed until it reaches the designated position or stops. Despite being quite inaccurate, this servo motor is commonly employed in radio-controlled devices such as model aircraft and toy cars. A sophisticated servo motor for industrial use will be able to sense both position and speed and use proportional-integral-derivative control algorithms. The shaft speed can also be controlled, so the motor can be brought to its position faster and more accurately, devoid of overreaching.

Figure 3.13: The Servo Motor

3.5 Flow Chart

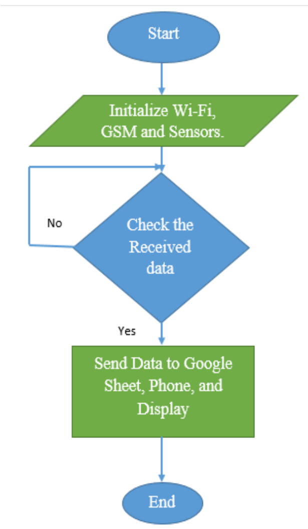


Figure 3.14: Flow Chart

3.6 Working Principle

The first step is for the car to stand on the weight sensor. Cannot carry more than the specified weight. As a demonstration, we gave 2 kg. If it is more than 2 kg, the car will not be able to carry the load.

If all goes well, the card will punch. Amounts have been determined according to the type of car on the card. The survey gate will be closed after the car leaves.

This data will be stored on Google Sheets. SMS will also be sent through GSM.

Chapter 4

Results Analysis

4.1 Introduction

It was an embedded systems platform that was utilized to implement the smart toll management system. To accomplish this goal, a micro-controller-based RFID solution was employed in this study.

4.2 Project Overview

Information about their transactions will be added to a central database. The use of internet transactions eliminates the need to carry cash. Human error is therefore reduced at the toll booths. The system is more transparent due to cashless transactions. It provides high security, ease of use, and low costs as proposed. The design reduces the noise and pollution from all toll stations, and an anti-theft solution has been implemented. To manage and implement the system, Proteus software systems, Arduino Mega, ESP8266, RFID Card, and RFID Module were used.

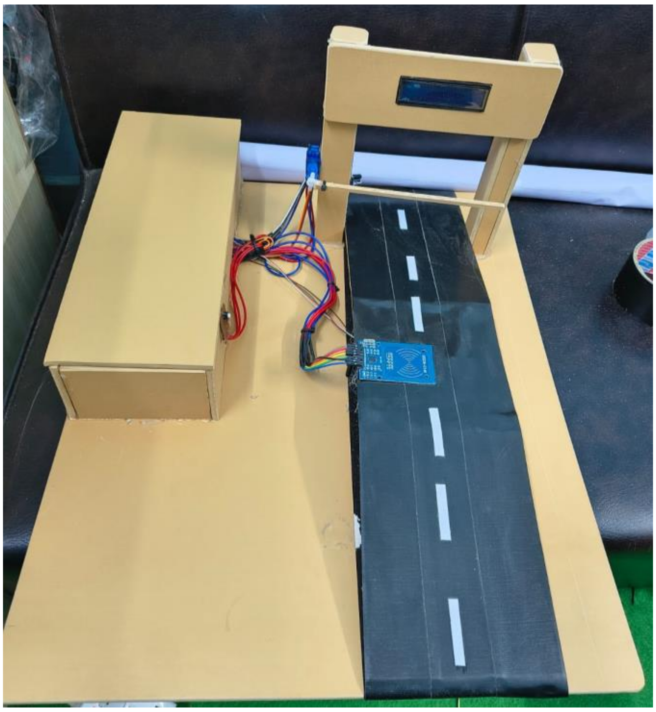


Figure 4.1: Smart toll management system

Only the smart toll management system setup is shown here.

4.2.1 Project Outcome

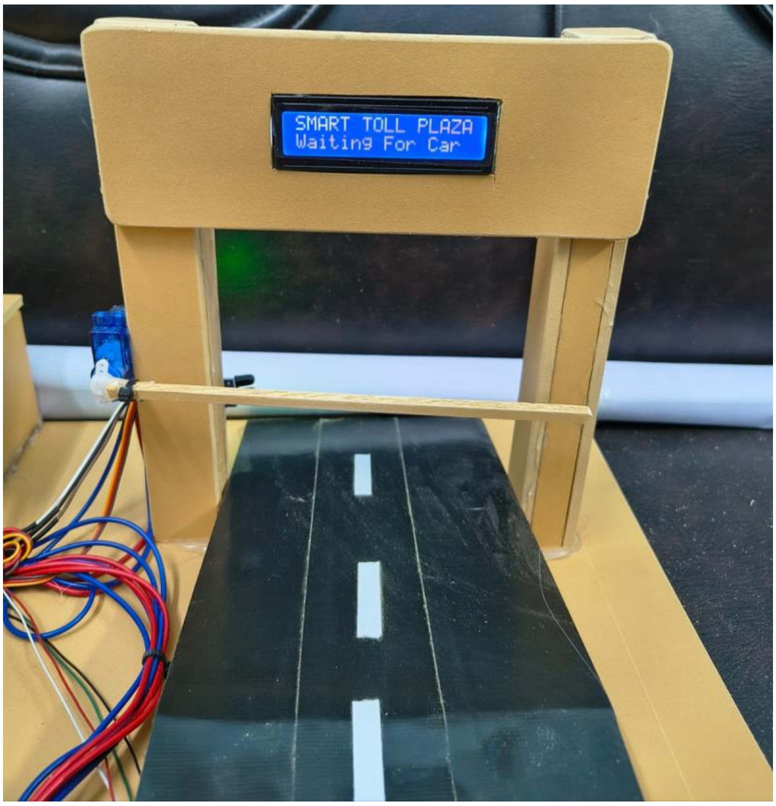


Figure 4.2: Waiting for the car

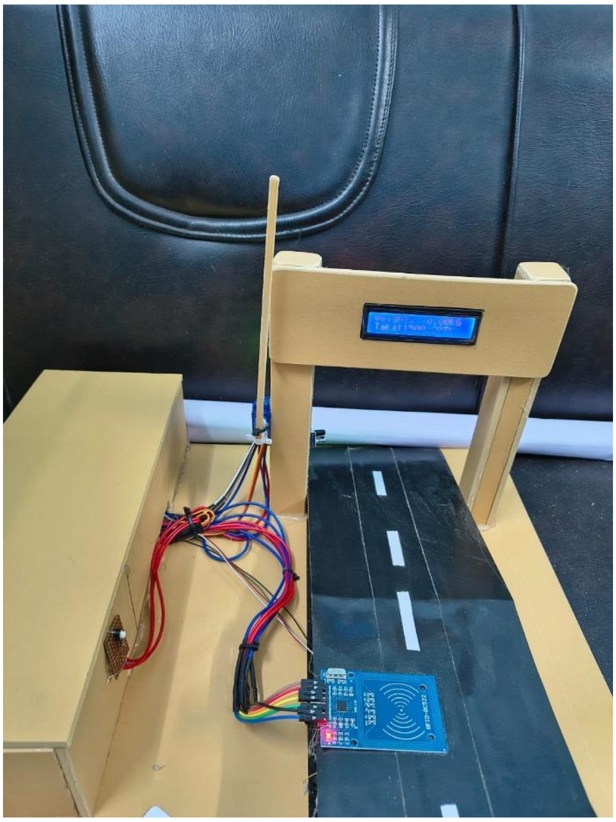


Figure 4.3: Weight Measurement of Car

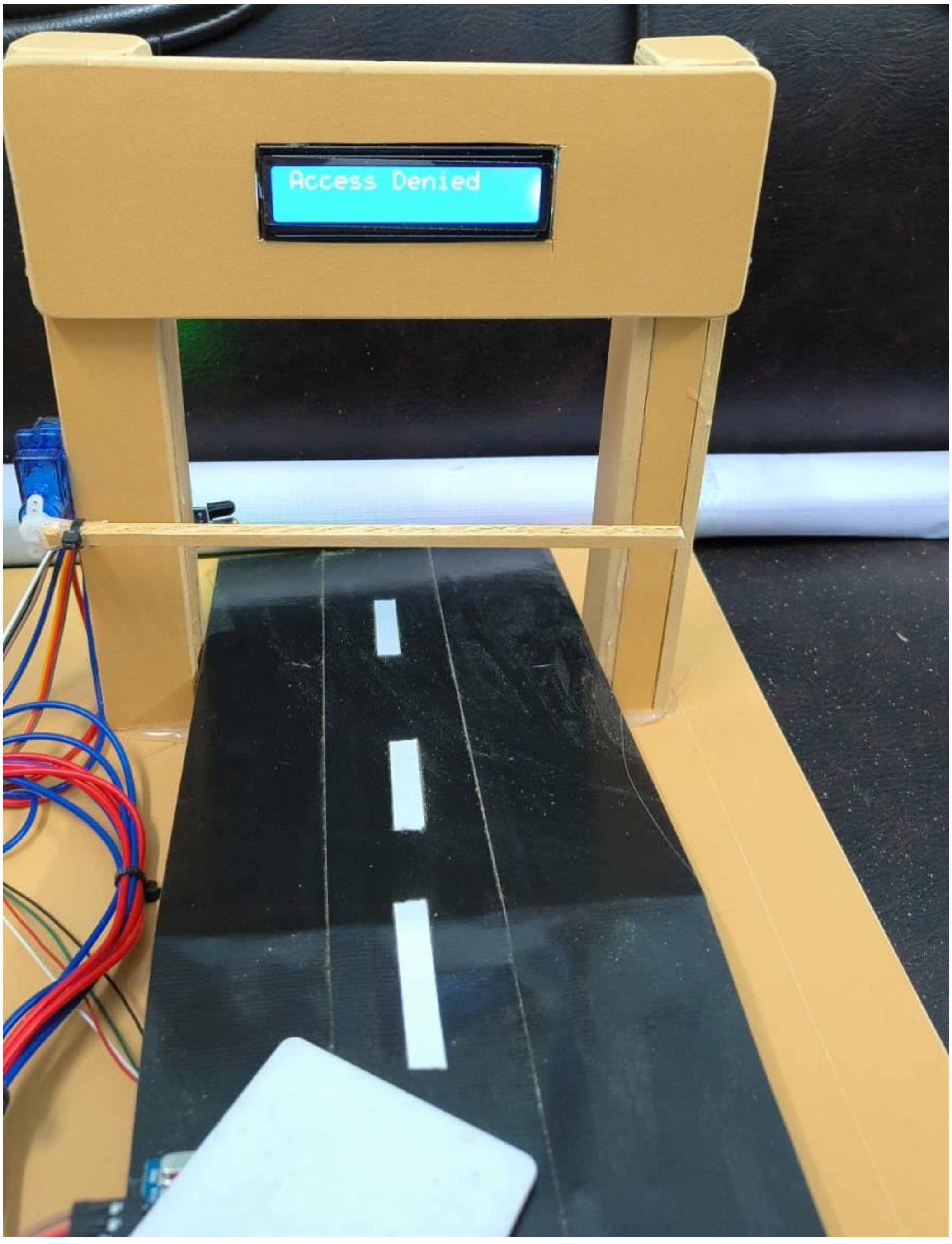
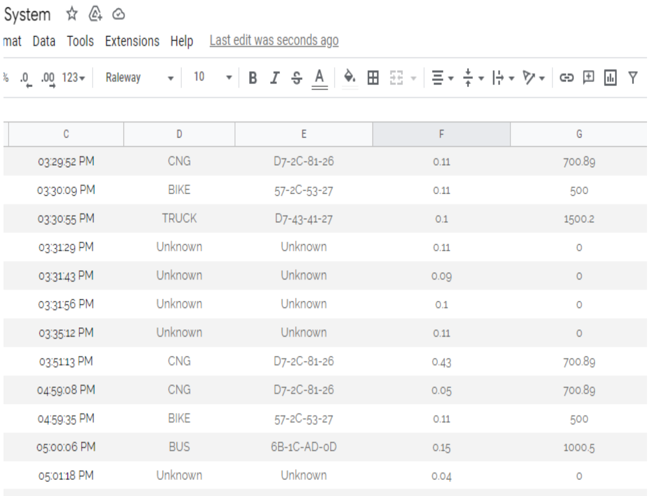


Figure 4.4: When Car does not get permission to go



System

mat Data Tools Extensions Help Last edit was seconds ago

C	D	E	F	G
03:29:52 PM	CNG	D7-2C-81-26	0.11	700.89
03:30:09 PM	BIKE	57-2C-53-27	0.11	500
03:30:55 PM	TRUCK	D7-43-41-27	0.1	1500.2
03:31:29 PM	Unknown	Unknown	0.11	0
03:31:43 PM	Unknown	Unknown	0.09	0
03:31:56 PM	Unknown	Unknown	0.1	0
03:35:12 PM	Unknown	Unknown	0.11	0
03:51:13 PM	CNG	D7-2C-81-26	0.43	700.89
04:59:08 PM	CNG	D7-2C-81-26	0.05	700.89
04:59:35 PM	BIKE	57-2C-53-27	0.11	500
05:00:06 PM	BUS	6B-1C-AD-0D	0.15	1000.5
05:01:18 PM	Unknown	Unknown	0.04	0

Figure 4.5: All Data Save in the Google sheet

4.2.2 Discussions

For our project, we will implement a smart toll management system. Every car has a tag attached to it. Scanning the tag will show what type of car it is, and the toll will be determined accordingly. If it is overweight, the car cannot go.

Information about their transactions will be added to a central database. The use of internet transactions eliminates the need to carry cash. Human error is therefore reduced at the toll booths. The system is more transparent due to the cashless transactions.

4.3 Cost Analysis

Table 4.1: Cost analysis of the project.

Serial No.	Components Name	Price
01	Arduino uno	880/=
02	ESP32	1100/=
03	LCD 16*2	330/=
04	GSM	950/=
05	RFID Module & Tag	450/=
06	IR Sensor	50/=
07	Servo Motor	220/=
08	Power Supply	300/=
09	Others	1187/=
10	HX 711 and Load Cell	1200/=
	Total=	**8087 Taka**

4.4 Advantages of the project

The benefits of a Smart Toll Management System include:

- When there is more than one toll booth on the route, it decreases stoppage time and decreases travel time.
- Eventually, as the toll plaza slows down, harmful vehicular emissions are reduced on a larger scale. As a consequence, nearby areas are also less polluted.
- Several vehicles can be accommodated in less time at the toll booth since the capacity of the lanes is increased about three times.
- Having an electronic toll management system reduces accidents since there is minimal congestion at toll booths with this system.
- The benefit of stopping idling and accelerating for one day may not seem like much, but over time, the difference in fuel consumption becomes noticeable. The long queues at the toll plazas can be avoided, resulting in substantial fuel savings.
- With technology such as FasTAGs, payments are done automatically with the electronic wallet linked, and the person does not have to worry about carrying cash. It is even possible for the user to make payments in a variety of ways.
- Congestion no longer exists, as vehicles no longer need to stop for long at toll booths because the toll payment is carried out electronically and quickly. Toll payment queues for vehicles have been greatly reduced.
- It is now easier to save and retrieve details like the number of vehicles in a day or information on any individual vehicle. Data is not saved manually; everything is done online.

4.5 Applications

- Parking centers at shopping malls can be adapted for the project.
- Projects such as this can be implemented in city parking lots.
- This device can be used in a police emergency.
- Parking garage systems can be integrated with the project.

CHAPTER 5

Conclusion and Future Scopes

5.1 Conclusion

The Smart Toll Management System can be beneficial for Bangladesh and other developing countries. Time can be saved, fuel consumption is reduced, and traffic flows smoothly. A major benefit is that the government won't lose any revenue through toll collection. Furthermore, a weight sensor will always help the bridge avoid any unwanted mishaps such as bridge collapses. People will also be pleased with the free toll system. When the passenger has paid the toll, the GSM module will send a text message. The passenger will know how much he has paid and no extra charges will be made. It is also necessary to deal with RFID tags and register all vehicles so that no unregistered cars can be used in any unethical way.

For our project, we will implement a smart toll management system. Every car has a tag attached to it. Scanning the tag will show what type of car it is, and the toll will be determined accordingly. If it is overweight, the car cannot go. Information about their transactions will be added to a central database. The use of internet transactions eliminates the need to carry cash. Human error is therefore reduced at the toll booths. The system is more transparent due to the cashless transactions. It provides high security, ease of use, and low costs as proposed. The design reduces the noise and pollution from all toll stations, and an anti-theft solution has been implemented.

5.2 Future Scopes

Using facial recognition technology in conjunction with the Electronic Toll Collection system would allow toll authorities to identify drivers. Implementing a real-time tracking system would improve traffic management and monitoring for the toll authorities. Putting in place an automatic payment system would enable drivers to pay using their credit cards or mobile phones and eliminate the need for manual payment. Introducing dynamic pricing would allow toll authorities to change the toll costs following the volume of traffic. It would be possible for toll authorities to collect tolls from buses and trucks without the requirement of manual labor by developing an automated toll collection system. By implementing a real-time data analytics system, toll authorities would be able to learn more about traffic patterns and pinpoint areas for improvement.

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