Development of electronic toll collection of vehicles on the highways using RFID

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Electronic Toll Collection System is a new technology for collecting toll in a faster and more efficient way. It is a great alternative to long waiting at manual toll plazas. In order to overcome the wastage of time and fuel at same time we have come up with a concept of RFID based automated toll collection system using Arduino. RFID stands for Radio Frequency Identification; these cards are unique identities provided to every vehicle by Registration Office at each city. Whenever a vehicle with such Unique ID reaches the toll plaza, the RFID card reader attached on the toll plaza gate reads the card and transfer the unique ID to Arduino ATmega 328. Accordingly the processor works and deducts a fixed money from prepaid card. If the card's ID is valid the controller will command the servo motor to start and open the gate, letting the vehicle to pass. If the card is not valid it will prompt to move the vehicle to manual toll collection lane. A load cell is also used in this project to measure the weight of vehicles so that no over loaded vehicle can pass through the Toll.

Keywords: ATCS, RFID, Arduino, Load Cell.

I. INTRODUCTION

Our life is changing very fast and the role of automation in our day to day life is increasing at a very fast rate. This is the motive behind our project i.e. "Automation". Day by day the number of vehicles passing over the road is increasing due to which the road condition is decaying rapidly. The government sponsors the price of road construction and road maintenance. The government has some source of money to build and maintain these roads & this source is the Toll Station.

At the onset, the goal of our project group was to design an Automatic tolling system for collecting toll. After studying various techniques like weight-based systems, bar coding etc. we chose Radio frequency identification, which is an emerging technology applied for tracking and communication. RFID (Radio frequency Identification) is an area of automatic identification that has quickly been gaining momentum in recent years and has now being seen as a radical means of enhancing data handling processes, complimentary in many ways to other data capture technologies such as bar coding.

In today's era of technology, where machines are being extensively used in all the fields we are trying to emulate concept, which will be of great use in public transport systems. Today a person has to travel long distances into vastly unknown territories for job, business, or even for tourism. As the vehicles are increasing and roads are falling short, nowadays we see frequently traffic jams or long queues at the toll stations waiting for paying the toll. Paying the toll every-time through cash or checking the pass takes a lot of time. And today Time is more precious than money. Therefore our project is aimed at reducing time consumed for manual transactions and human effort.

II. OBJECTIVE OF THE PROJECT

Here we are going to see some points regarding to purpose behind choosing this topic & what is the requirement of this type of the project in our day to day life.

- Avoid the fuel loss
- Saving of time in collecting toll
- Avoid financial loss
- To monitor the traffic

III. HARDWARE REQUIREMENTS

- RFID Module
- Arduino board
- IR Sensor
- Servo Motor
- LED Light
- Relay
- Jumper Wire
- Vero Board
- Registor

IV. SOFTWARE REQUIREMENTS

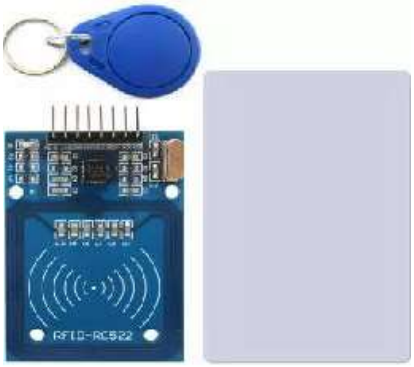
- Arduino board open source software

V. HARDWARE DESCRIPTION

- **RFID module -** The MFRC522 is highly integrated reader or written IC for contactless communication at with IOS/IEC 14443A/MIFARE cards and transponders without additional active circuitry. RFID means radio-frequency identification. RFID uses electromagnetic fields to transfer data over short distances. RFID is useful to identify people, to make transactions, etc

Specification

- Module Name: MFRC522
- Working current: 13-26mA/DC 3.3 V
- Standby current: 10-13mA/DC 3.3 V
- Sleeping current: <80uA
- Peak current: <30mA
- Working frequency: 13.56MHz
- Card reading distance: 0-60mm
- Protocol: SPI
- Data Communication speed: Maximum 10Mbit/s
- Dimension: 40mmX60mm
- Working temperature: 20-80 degree
- Max SPI speed: 10Mbit/S



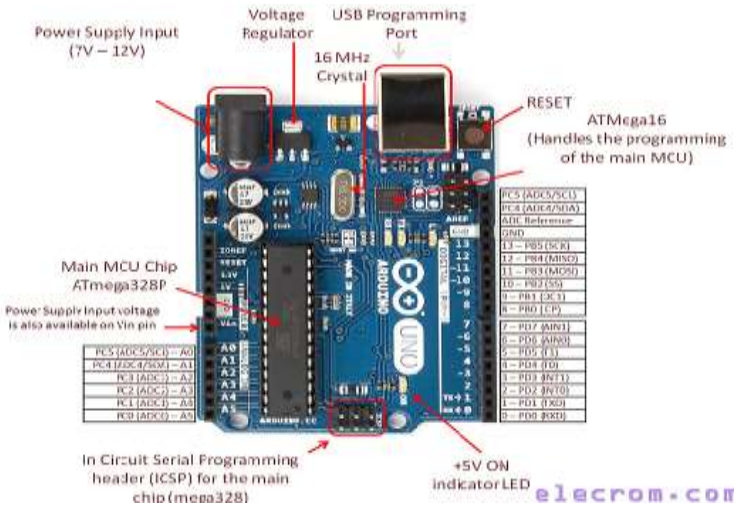
Advantages of RFID

- RFID functions through both natural and man-made metallic materials.
- RFID allows flexible tag placement and can be embedded into an object. It reads changes or adds information to a tag at any user read point.
- RFID stored information can be protected with a range of security options.
- RFID tags can be rewritten repeatedly or used for permanent data retention.
- RFID provides an extra level of information in some cases as RFID tags can be programmed more than once.
- The ability to read multiple items simultaneously, to read and write information etc, and a whole new layer to AIDC (AUTO IDENTIFICATION AND DATA CAPTURE).
- The tag does not need to be in line of sight with the receiver to be read (compare to a barcode and its optical scanner)
- RFID tags can store a lot of information, and follow instructions
- Has the ability to pinpoint location

Application of RFID

- Customized RFID solutions are now available for all applications.
- Prisoners in certain ways are tagged to prevent violent behavior and possibly their escape.
- Petrol stations across America use tracking systems as payment systems for fuel.
- At airport tagged baggage can be easily located even if they are at few meters away from the wrong conveyer belt.
- In Mumbai Marathon for the first time RFID tags were used in a marathon in Asia to track each competitor and how fast they were running.

- **Arduino UNO**



The Arduino Uno is a microcontroller board based on the ATmega328. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs), a 16 MHz resonator, a USB connection, a power jack, an in-circuit system programming (ICSP) header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

Specification

1	Microcontroller	ATmega328P
2	Operating voltage	5V
3	Input Voltage(recomended)	7-12V
4	Input Voltage(limit)	6-20V
5	Digital I/O Pins	14(of which 6 provide PWM output)
6	PWM Digital I/O Pins	6
7	Analog Input Pins	6
8	DC current per I/O Pin	20mA
9	DC current for 3.3V Pin	50mA
10	Flash Memory	32KB(ATmega 328P) of which 0.5 KB used by Bootloader
11	SRAM	2KB
12	EEPROM	1KB
13	Clock Speed	16MHz
14	LED_BUILTIN	13
15	Length	68.6mm
16	Width	53.4mm
17	Weight	25g

➢ IR sensor Module

An infrared sensor is an electronic device that emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. This type of sensor measures only infrared radiation in the range of 700 nm to 1400 nm.

Pin Configuration

Pin Name	Description
VCC	Power Supply Input
GND	Power Supply Ground
OUT	Active High Output

Features

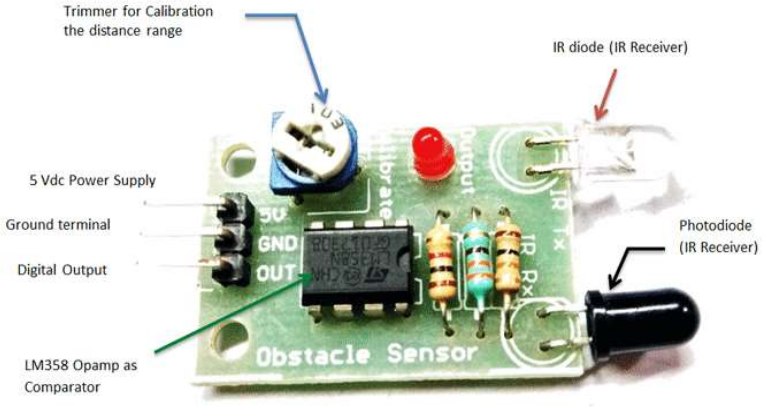
- ❖ 5VDC Operating voltage
- ❖ I/O pins are 5V and 3.3V compliant
- ❖ Range: Up to 20cm
- ❖ Adjustable Sensing range
- ❖ Built-in Ambient Light Sensor
- ❖ 20mA supply current
- ❖ Mounting hole

Brief about IR Sensor Module

The IR sensor module consists mainly of the IR Transmitter and Receiver, Opamp, Variable Resistor (Trimmer pot), output LED.

IR LED Transmitter

IR LED emits light, in the range of Infrared frequency. IR light is invisible to us as its wavelength (700nm – 1mm) is much higher than the visible light range. IR LEDs have light emitting angle of approx. 20-60 degree and range of approx. few centimeters to several feets, it depends upon the type of IR transmitter and the manufacturer. Some transmitters have the range in kilometers. IR LED white or transparent in colour, so it can give out amount of maximum light.



Photodiode Receiver

Photodiode acts as the IR receiver as its conducts when light falls on it. Photodiode is a semiconductor which has a P-N junction, operated in Reverse Bias, means it start conducting the current in reverse direction when Light falls on it, and the amount of current flow is proportional to the amount of Light. This property makes it useful for IR detection. Photodiode looks like a LED, with a black colour coating on its outer side, Black colour absorbs the highest amount of light.

LM358 Opamp

LM358 is an Operational Amplifier (Op-Amp) is used as voltage comparator in the IR sensor. the comparator will compare the threshold voltage set using the preset (pin2) and the photodiode's series resistor voltage (pin3).

Photodiode's series resistor voltage drop > Threshold voltage = Opamp output is High

Photodiode's series resistor voltage drop < Threshold voltage = Opamp output is Low

When Opamp's output is **high** the LED at the Opamp output terminal **turns ON** (Indicating the detection of Object).

Variable Resistor

The variable resistor used here is a preset. It is used to calibrate the distance range at which object should be detected.

- **Servo Motor**

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a close-loop control system. Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing.

The servomotor is a closed loop servomechanism that uses position feedback in order to control its rotational speed and position. The control signal is the input either analog or digital which represents the final position command for the shaft. A type of encoder serves as a sensor providing speed and position feedback. In most cases only the position is reported. The final position is reported to the controller and this is compared to the initial position input and then if there is a discrepancy the motor is moved in order to get the correct position.

Wire Configuration

Wire Number	Wire Colour	Description
1	Brown	Ground wire connected to the ground of the system
2	Red	Power of the motor typically +5V is used
3	Orange	PWM signal is given in through this wire to drive the motor

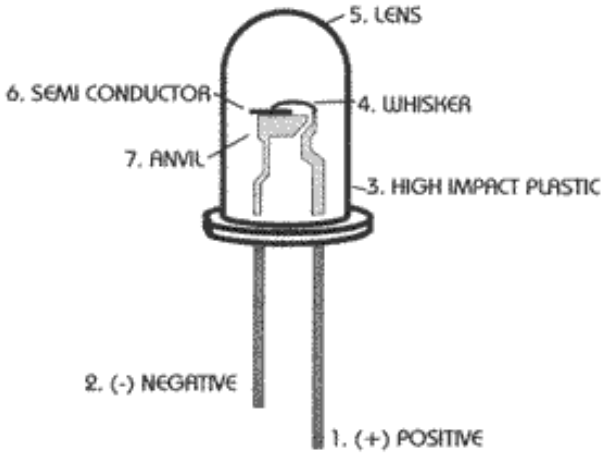
Features

- Operating Voltage is +5V typically
- Torque 2.5Kg/cm
- Operating speed is $0.1s/60^0$
- Gear type: Plastic
- Rotation: 0^0 to 180^0
- Weight of motor: 9gm
- Package includes gear horns and screws.

➢ LED light

Light emitting diodes are made from a very thin layer of fairly heavily doped semiconductor material and depending on the semiconductor material used and the amount of doping, when forward biased an LED will emit a coloured light at a particular spectral wavelength.

When the diode is forward biased, electrons from the semiconductors conduction band recombine with holes from the valence band releasing sufficient energy to produce photons which emit a monochromatic (single color) of light. Because of this thin layer a reasonable number of these photons can leave the junction and radiate away producing a color light output. In our project we uses Red, Yellow and green LED.

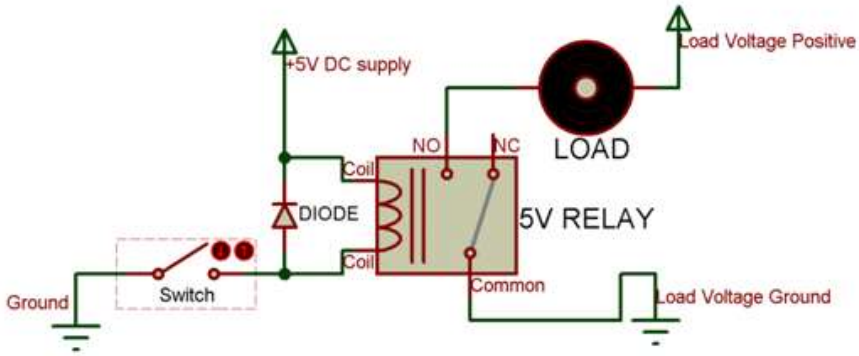


WAVELENGTH RANGE (NM)	COLOUR	V_F @ 20MA	MATERIAL
< 400	Ultraviolet	3.1 - 4.4	Aluminium nitride (AlN) Aluminium gallium nitride (AlGaN) Aluminium gallium indium nitride (AlGaInN)
400 - 450	Violet	2.8 - 4.0	Indium gallium nitride (InGaN)
450 - 500	Blue	2.5 - 3.7	Indium gallium nitride (InGaN) Silicon carbide (SiC)
500 - 570	Green	1.9 - 4.0	Gallium phosphide (GaP) Aluminium gallium indium phosphide (AlGaInP) Aluminium gallium phosphide (AlGaP)
570 - 590	Yellow	2.1 - 2.2	Gallium arsenide phosphide (GaAsP) Aluminium gallium indium phosphide (AlGaInP) Gallium phosphide (GaP)
590 - 610	Orange / amber	2.0 - 2.1	Gallium arsenide phosphide (GaAsP) Aluminium gallium indium phosphide (AlGaUInP) Gallium phosphide (GaP)
610 - 760	Red	1.6 - 2.0	Aluminium gallium arsenide (AlGaAs) Gallium arsenide phosphide (GaAsP) Aluminium gallium indium phosphide (AlGaInP) Gallium phosphide (GaP)
> 760	Infrared	< 1.9	Gallium arsenide (GaAs) Aluminium gallium arsenide (AlGaAs)

➢ Relay

Relays are most commonly used switching device in electronics. Let us learn how to use one in our circuits based on the requirement of our project.

Before we proceed with the circuit to drive the relay we have to consider two important parameter of the relay. Once is the Trigger Voltage, this is the voltage required to turn on the relay that is to change the contact from Common->NC to Common->NO. Our relay here has 5V trigger voltage, but you can also find relays of values 3V, 6V and even 12V so select one based on the available voltage in your project. The other parameter is your Load Voltage & Current, this is the amount of voltage or current that the NC,NO or Common terminal of the relay could withstand, in our case for DC it is maximum of 30V and 10A. Make sure the load you are using falls into this range.

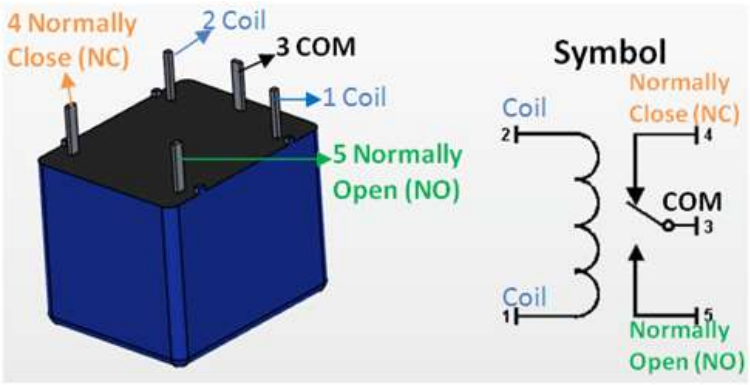


The above circuit shows a bare-minimum concept for a relay to operate. Since the relay has 5V trigger voltage we have used a +5V DC supply to one end of the coil and the other end to ground through a switch. This switch can be anything from a small transistor to a microcontroller or a microprocessor which can perform switching operating. You can also notice a diode connected across the coil of the relay, this diode is called the Fly back Diode. The purpose of the diode is to protect the switch from high voltage spike that can produced by the relay coil. As shown one end of the load can be connected to the Common pin and the other end is either connected to NO or NC. If connected to NO the load remains disconnected before trigger and if connected to NC the load remains connected before trigger.

Features of 5-Pin 5V Relay

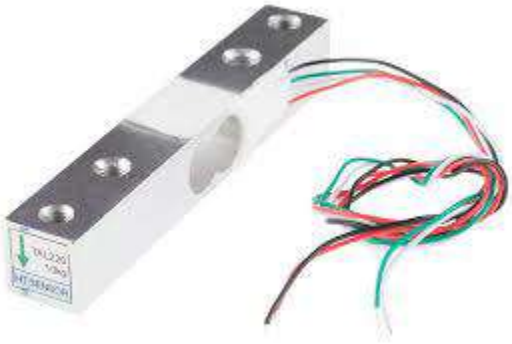
- Trigger Voltage (Voltage across coil) : 5V DC
- Trigger Current (Nominal current) : 70mA
- Maximum AC load current: 10A @ 250/125V AC
- Maximum DC load current: 10A @ 30/28V DC
- Compact 5-pin configuration with plastic moulding
- Operating time: 10msec Release time: 5msec
- Maximum switching: 300 operating/minute (mechanically)

Relay Pin Configuration



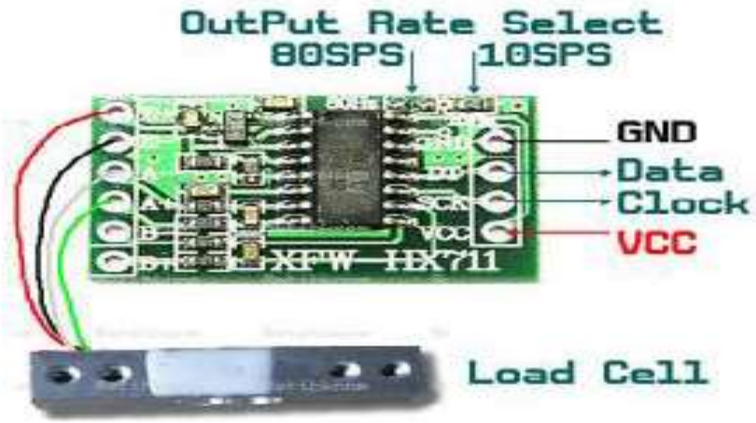
Pin Number	Pin Name	Description
1	Coil End 1	Used to trigger(On/Off) the Relay, Normally one end is connected to 5V and the other end to ground
2	Coil End 2	Used to trigger(On/Off) the Relay, Normally one end is connected to 5V and the other end to ground
3	Common (COM)	Common is connected to one End of the Load that is to be controlled
4	Normally Close (NC)	The other end of the load is either connected to NO or NC. If connected to NC the load remains connected before trigger
5	Normally Open (NO)	The other end of the load is either connected to NO or NC. If connected to NO the load remains disconnected before trigger

- **Load Cell**



A **load cell** is a transducer which converts force into a measurable electrical output. Although there are many varieties of load cells, strain gage based load cells are the most commonly used.
Except for certain laboratories where precision mechanical balances are still used, strain gage load cells dominate the weighing industry. Pneumatic load cells are sometimes used where intrinsic safety and hygiene are desired, and hydraulic load cells are considered in remote locations, as they do not require a power supply. Strain gage load cells offer accuracies from within 0.03% to 0.25% full scale and are suitable for almost all industrial applications.

- **Load cell module (HX711)**

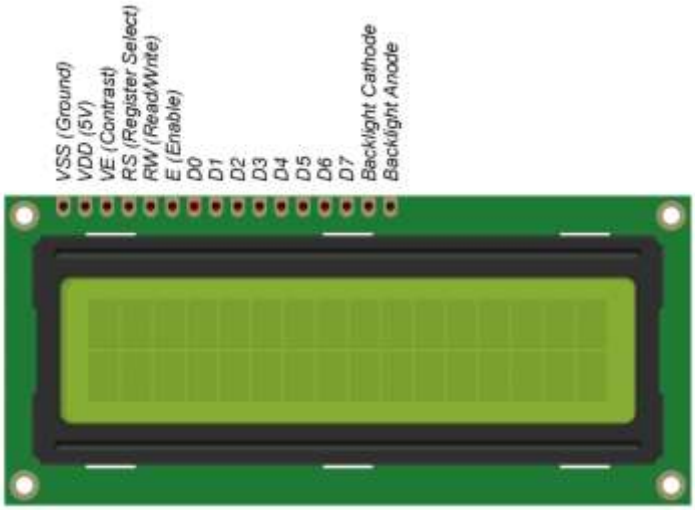


This Load Cell Amplifier is a small breakout board for the HX711 IC that allows you to easily read load cells to measure weight. By connecting the amplifier to your microcontroller you will be able to read the changes in the resistance of the load cell and with some calibration you'll be able to get very accurate weight measurements. This can be handy for creating your own industrial scale, process control, or simple presence detection.
The HX711 uses a two wire interface (Clock and Data) for communication. Any microcontroller's GPIO pins should work and numerous libraries have been written making it easy to read data from the HX711.
Load cells use a four wire wheatstone bridge to connect to the HX711. These are commonly coloured Red, Black, White, Green. Each color corresponds to the conventional color coding of load cells:
Red (Excitation+ or VCC)
Black (Excitation- or GND)
White (Amplifier+, Signal+, or Output+)
Green (A-, S-, or O-)

Features:

- Operation Voltage: 2.7V-5V
- Operation Current: < 1.5mA
- Selectable 10SPS or 80SPS output data rate
- Simultaneous 50 and 60Hz supply rejection

- **16*2 LCD Display**



LCD modules are very commonly used in most embedded projects, the reason being its cheap price, availability and programmer friendly. Most of us would have come across these displays in our day to day life, either at PCO"s or calculators. The appearance and the pinouts have already been visualized above now let us get a bit technical.
16×2 LCD is named so because; it has 16 Columns and 2 Rows. There are a lot of combinations available like, 8×1, 8×2, 10×2, 16×1, etc. but the most used one is the 16×2 LCD.

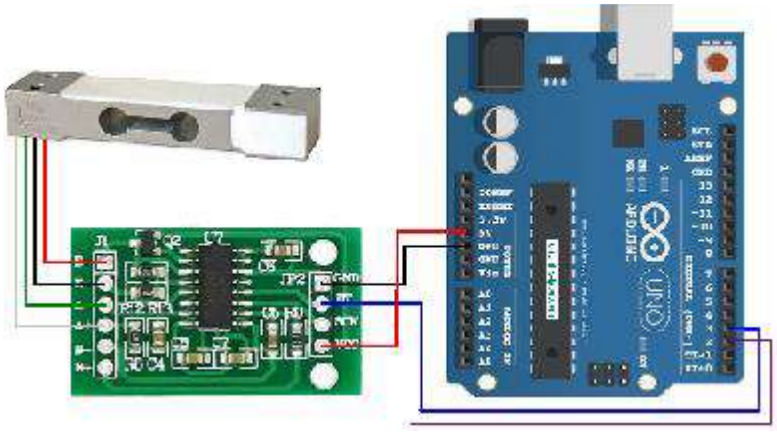
Features

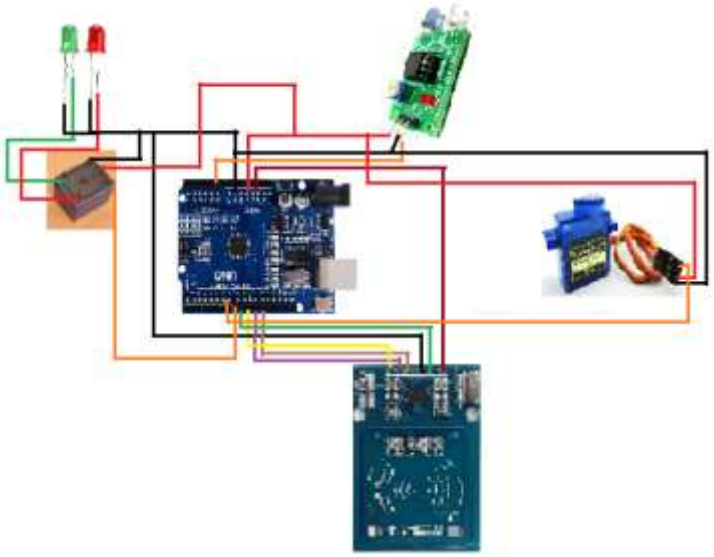
- Operating Voltage is 4.7V to 5.3V
- Current consumption is 1mA without backlight
- Alphanumeric LCD display module, meaning can display alphabets and numbers
- Consists of two rows and each row can print 16 characters.
- Each character is build by a 5×8 pixel box
- Can work on both 8-bit and 4-bit mode
- It can also display any custom generated characters
- Available in Green and Blue Backlight

VI. WORKING OF THE PROJECT

For manufacturing of the automatic toll collection , first of all Arduino UNO(ATMEGA 328) is programmed and compiled. Then it is connected with the circuit which is primarily implanted on a vero board. The circuit consists of IR sensors, Relay, and a servo motor connected gradually. When the IR sensor senses the arrival of the car, it triggers the relays with the help of the programme. Thus the gate either opens at the time of arrival or closes at the time of departure of the car.
For the manufacturing of the automatic toll collection, RFID module is needed. The RFID Module is firstly programmed and compiled accordingly. Then it is connected to the other circuit which is Arduino UNO (ATMEGA 328). The IR sensor senses the car and the relay will cut and then the green LED glows. After that the RFID Module will sense the RFID tag which is connected in the car and the toll will be paid through automation , then the barrier gate will automatically open through the help of servo motor with the help of Arduino.
Finally these three circuits are being implanted and shouldered on the vero board and placed inside the model. The circuit should be placed in such a manner so that the wire doesn't gets messed up in it.

VII. BLOCK DIAGRAM





VIII. ADVANTAGES

- Human effort and time is reduced.
- The technology used does not require line of sight.
- Requires no Toll Plazas and investment on the infrastructure of building huge toll plaza can be saved.
- At presently available manual toll plazas there are high chances of cheatings to be conducted. But in case of computerized toll station, the cheating is completely eliminated because the control is over the main server and there is no human interface in the collection of the charges at the toll plazas.
- Without the interruption in the flow of traffic, this system can efficiently work 24 hours a day.
- Helps to trace the illegal vehicles.
- Since most of the working is software based hence hardware cost is saved.
- Also due to most of the working being software base, the chances of the system failure is less.

IX. LIMITATIONS

- We have to invest in dedicated computers which run 24X7 for each lane for fast service.
- We have to make provision for UPS for uninterrupted service.
- If RFID tag is destroyed the information in it is lost & we will have to make separate back-ups for every tag.
- So basically investment cost is only the main limitation factor.

X. CONCLUSSION

Times are changing and even this Manual Technique for Taxation at toll station has to change and seeing a change in mind set of every individual this technology would also be taken whole heartedly. And we would see that paying Toll at the Toll station won‟t be that time consuming and much accurate and preferred across every nook and corner of the globe wherever there would be a toll station. And as described above about the merits of this Toll station we don‟t think that its not that far enough when we would see this technology being used in India and in terms benefiting the whole society as well as the company whose is involved in Toll taxation.

RFID is a powerful technology, and it is likely to see world-wide deployment within the coming years. Continuous technological advancements of RFID have resulted in reduced cost of installation and maintenance of devices across different market segments. Comparing advantages and limitations of our system we can conclude that our system is beneficial for daily travellers and Toll station authorities to lessen the burden.

And finally, while RFID may seem to be a fairly simple and innocuous technology on the surface, a wide range of issues and choices need to be explored and resolved for its successful, wide-scale deployment. We are seeing great promise and signs that the RFID and future upcoming sensor network technologies will help to change the way we think about our manufacturing processes and the interactions with the people and customers.

On the concluding node we can say that we have successfully implemented one of the phase of our project but still have some improvements and advancements to be done.

XI. SCOPE FOR FUTURE DEVELOPMENT

As of in future we are planning of making this system more accurate. Also we will be probably implementing the facility of post charging the users account. Also we will be looking to send user a sms about his transaction details. Apart from these all the major modification that we are planning is to directly link the users‟ toll account with his bank account. Hence the toll tax will be directly deduced from the user‟s bank account instead of his toll account. Also in future we are looking to add a feature that will allow the government cars to pass through without collecting their tax.

In our present concept we are only using the RFID system for vehicle detection. So we can extend the scope of this concept in other way for centralize data recording. For that purpose we can use the IR courting at the entry gate which is followed by the Camera which will be continuously capturing the images of the vehicles entering into the toll plaza. And the third step the RFID is collecting the vehicle number. Now when the vehicle passes through the IR courting it tresses the outline of the vehicle, in the next step the camera will take the image of the vehicle & followed by the RFID to record the data related to the vehicle. The load cell weighs the vehicle & classifies it into two categories as light & heavy vehicle respectively. The whole data collected together & sent to the centralize server which will store it for stipulated time. This application will help in detecting the vehicles in the crime cases like terrorism & smuggling of goods & it will also reduce the load on check posts.

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