Design and Implementation of Low Cost Automatic Toll Collection System using RFID

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Abstract

Manual toll systems in India are found everywhere at present. This paper focuses on an Electronic Toll Collection (ETC) system using radio frequency identification (RFID) technology. The main goal is to accomplish the contact less toll payment. In this thesis we will discuss RFID based Smart Toll Collection System as a solution to solve the traffic problems and also to maintain transparency of the toll collection system. The aim of the project is to design a system, which automatically identifies an approaching vehicle with the help of the RFID tag. A vehicle will hold an RFID tag with a unique identification number which is placed on the windshield of the vehicle. This number will be assigned by RTO or traffic governing authority. In accordance with this number we will store, all basic information as well as the amount he has paid in advance for the TOLL collection. Thus the reader reads the information in the tag and the transaction takes place through a centralized data base and the aftermath details of the transaction is intimated to the user's mobile through GSM technology.

Keyword- Electronic Toll Collection (ETC), Radio Frequency Identification (RFID), GSM Technology

I. INTRODUCTION

In recent days people used to travel from one place to another. Most of the travellers wish to choose roadways because of cost effective and sophistication. Hence our government has made many bridges, fly over's and bypass roads along with toll plaza's. Most of these toll plazas are operated manually. Hence people may cross N number of tolls which are operated manually. The average waiting time in a manually operated toll plaza is more than 10 minutes. While passing 6 such tolls the total waiting time of a vehicle is 60 minutes (equal to 1 hour). This costs a lot of fuel and time wastage. It proves that the present system requires an improvement for its efficient service. Here we suggest an automatic Electronic Toll Collection system which will not stop the vehicle in tolls. This drastically controls the time and fuel wastage also reduces the pollution a little. This automatic ETC system uses RFID technology. The RFID tags placed in the vehicle has an UIN number which is used to achieve the cashless payment. The weight sensor (load cell) plays a vital role in determining the type of the vehicle. The arduino ATmega 328 has been programmed to calculate the toll tax according to the vehicle type without any human involvement thus makes it a more reliable system.

II. RELATED WORKS

In [1], the automation of toll plaza has been done based on image processing. ANPR (Automatic Number Plate Recognition) system has been employed which uses a camera to capture the number plate of the vehicle and deducts the toll by matching it with the owner database.
Similarly [18] also uses ANPR technology to detect the vehicle in toll plaza and collect the cash manually.

In [2], the system is based on infrared sensors. In this, the user has to get the IR transmitter from the main toll office. The transmitter will be charged by the store office and the data of the user will be stored in the microcontroller. When the car arrives at the toll plaza the user will have to mount the transmitter on the car and press a button to turn it on. It must be in the line of sight of the receiver. The receiver will confirm the data from the transmitter with the database and the amount of toll will get deducted. It uses a stepper motor for gate control.

In [3] also the system is based on the RFID technology. The controller used is PIC 18F4550 and has been connected with the system using USB. The RFID receiver senses the tag coming in its range and the amount gets deducted from the account of the owner after all the related information is checked from the database. The IR senses the vehicle motion for controlling the opening and closing of the gate. A stepper motor is used to control the gate.

The other related papers use RFID technology only the creation of database is different. Authors have put the SMS sending application using GSM Modem in future scopes which we have implemented in our project.

III. PROPOSED SYSTEM ARCHITECTURE

RADIO-FREQUENCY IDENTIFICATION: Radio-frequency identification (RFID) is method for Automatic Identification and Data Capture. It uses electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically-stored information. Generally the tags are classified as active tags and passive tags. The active tag consists of own battery and transmitter. The merit of active tag is its operating range is more than a passive tag. But its manufacturing and maintenance cost is high and also the lifetime is only for about 5-7 years. Hence passive RFID tags are widely used by this automobile world. Passive tag does not require battery for its operation. Instead it draws the power from the radio waves of the reader. It usually lasts for more than 10 years and cost is also affordable. This makes the popularity of passive tags in many applications. Unlike a barcode, the tag needs not to be line of sight with the reader. RFID systems consist of three components: an RFID tag or smart label, an RFID reader, and an antenna.

A. RFID Tag

An RFID tag consists of transponder, rectifier circuit, controller, memory. The transponder receives the radio wave coming from the reader and sends the feedback signal back to the reader. Passive types do not have the own supply and they rely on the radio waves that are coming from the reader. Thus they receive the energy from the reader by the principle of electromagnetic coupling. Using the rectifier circuit, the energy stored in the capacitor and this energy is used for the controller and memory.

B. RFID Reader

RF signal generator generates radio wave which is transmitted using the transmitting antenna. The receiver antenna is used to receive the feedback signal coming from the tag. The RFID reader also have receiver signal detector for this process. They pass the information which has been send by the RFID tag to the microcontroller present in the reader. The RFID reader can also be connected with the PC. In our project we have used EM18 reader (Fig1.1). This reader module connects directly to any microcontroller UART. This works with any 125KHZ RFID tags. It can read the tags about a distance of 10 cm. This active reader is fixed in every toll plaza and it reads the tags whenever it comes in the range. Thus the read information is sent to the controller serially.

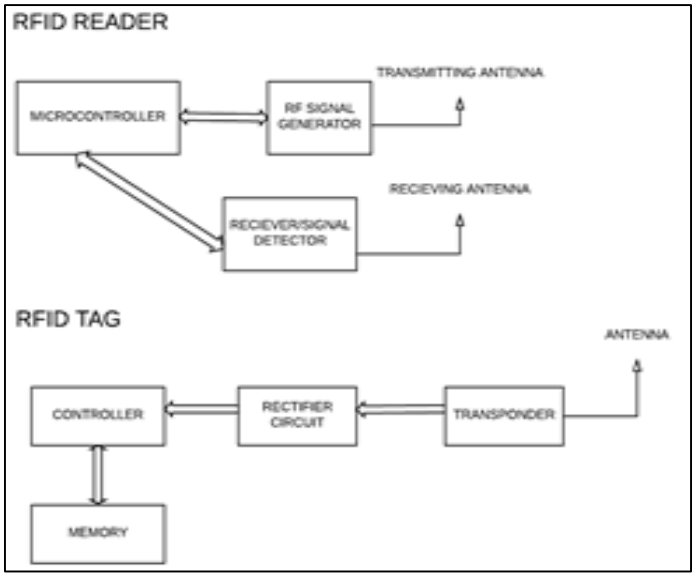


Fig: Components of RFID tag and reader

Fig 1.1

C. Load Cell

Load cell is a transducer which transforms the force into electrical output. This electrical output is directly proportional to the force being applied. We have used the strain gauge load cell. Strain gauge load cells work on the principle that the strain gauge deforms

when the material of the load cells deforms appropriate0.ly. Deformation of the strain gauge changes its electrical resistance, by an amount that is equal to the force applied. The change in resistance produces an electrical value change. Our load cell typically use four strain gauges arranged in a Wheatstone bridge. This circuit is highly sensitive and produces output signal in millivolts and hence requires an amplification before it can be used. We have used HX711 (Fig1.2) amplifier. It is a 24 bit ADC used for load cell amplification in weight measurement. This makes the fine measurement of the load cell to be detected accurately. According to the statistics the average weight of a car is about 2722 kg and average weight of light duty vehicle is 4500 kg while over those are termed as heavy duty vehicles. In our prototype we have used 10 kg load cell (Fig 1.3) hence we termed any load above 0.5kg below 2kg as car while above that as heavy duty vehicle.

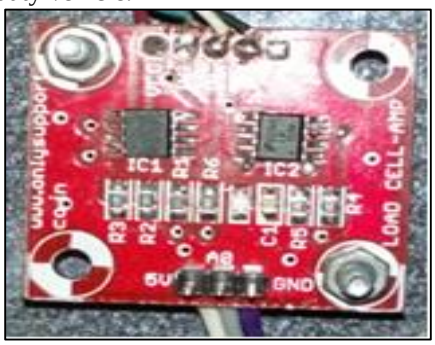


Fig 1.2

Fig 1.3

Fig 1.4

D. Arduino

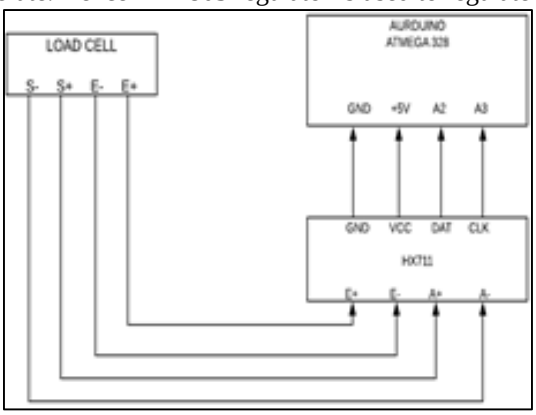
Arduino mega328 is implemented as a microcontroller. It is a 8 bit AVR RISC based microcontroller consists of 32KB flash memory , 1KB EEPROM , 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, SPI serial port, 6-channel 10-bit A/D converters. The device operates between 1.8-5.5 volts. We have used this because it has programmable UART's for both RFID and GSM module. The arduino has been programmed using embedded C for all actions like reading the information from the EM18 reader, calculating the toll amount according the load from load cell, displaying the LCD, sending message through GSM module.

E. GSM Module

We have used GSM SIM 900A module (Fig 1.4) with dual band 900/1800 MHZ. It has a built in port for SIM card holding and built in network status LED. It has configurable baud rate and low power consumption. It can be operated at 5V-12V DC supply.

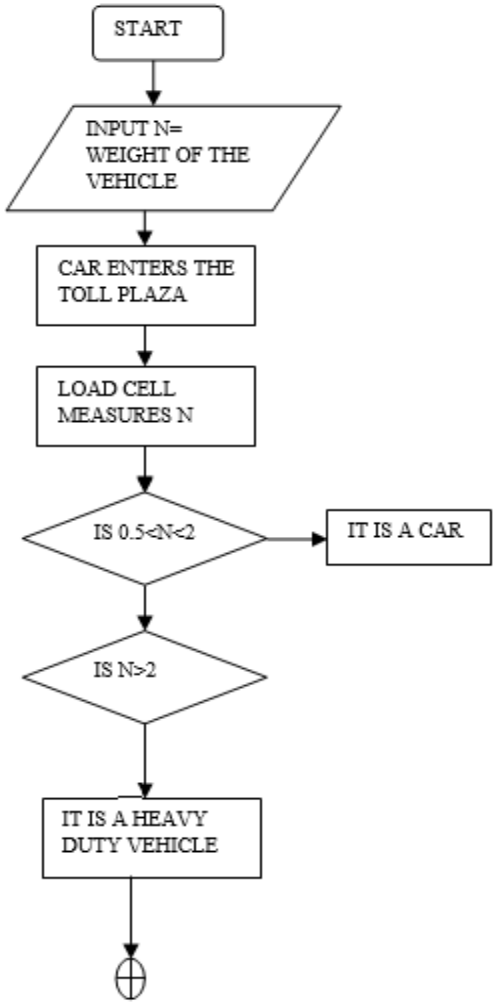
F. Power Supply Unit

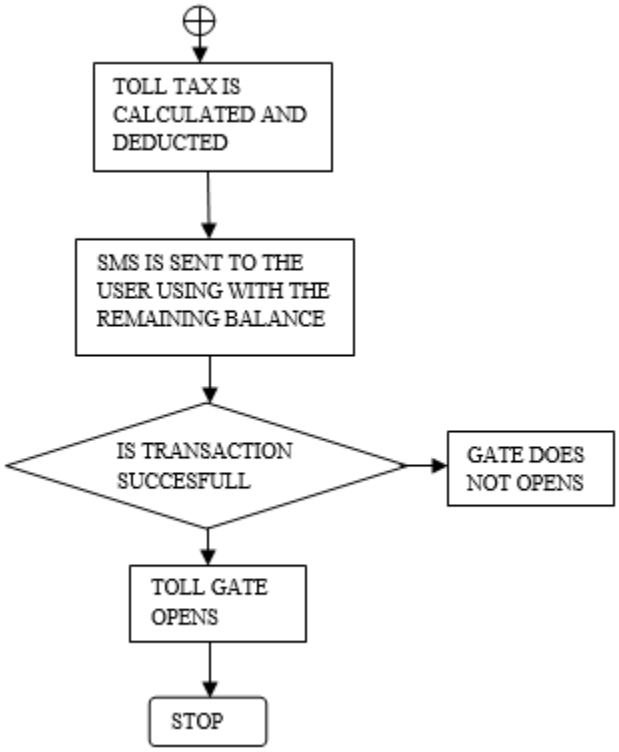
All the components require DC power supply hence the 230V AC domestic power is converted into DC by using rectifiers. Initially the 230V AC is stepped down to 12V AC by the transformer. This is further converted in 12V DC with the help of bridge rectifier. The arduino requires only 5V DC to operate. Hence LM7805 regulator is used to regulate the 12V DC into 5V.



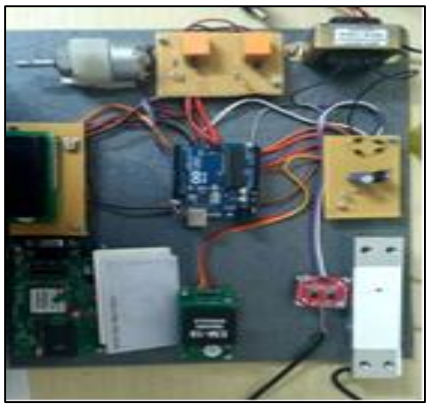
Circuit Diagram of Load Cell, Arduino, Hx-711 Amplifier Connection

IV. FLOWCHART OF PROPOSED ARCHITECTURE





V. AUTOMATIC ELECTRONIC TOLL SYSTEM



VI. CONCLUSION

We can reduce the prevalent problem of skipping the payment of toll at toll plazas because of automatic deduction and enhance the security of the vehicle due to GSM interfacing. The long queues at the toll plaza and need for human intervention is reduced greatly. This system will ensure a smoother and safer journey for the passenger.

VII. FUTURE SCOPES

We can improve the security of the toll with the help of surveillance systems to detect the thefted and illegal vehicle very efficiently and more reliable.

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