Design Of Electronic Toll Collection (Etc) System On Arm- 7 Using Rfid Techonology

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Abstract*—RFID is used for reading the physical tags on single products, cases, pallets, or re-usable containers which emit radio signals to be picked up by reader devices. The complete RFID picture combines the technology of the tags and readers with access to global standardized databases. This project is to make the payment automation in toll gate using RFID technology. Here the process is worked out by using Arm7 based LPC2129 microcontroller along with GSM modem. Whenever the vehicle enters the toll gate, the vehicle is detected automatically through the RFID card present with owner. To read the information from RFID card, RFID reader is available at toll gate. Here we have to design one circuit with the help of RFID reader, GSM module, LCD, L293D, DC motor and external memory. Here DC motor is used as a toll gate. Whenever user is placing RFID card nearer to RFID reader it will read the information from the card and give it to microcontroller. Now microcontroller read the card number and it will check whether card is valid or not. If that card is valid some amount is reduced from user account and one message is transmitted to the user with the help of GSM module. The message contains how much amount is reduced from the user account. The resultant amount is stored in the external memory.

Keywords—RFID, LPC2129, GSM SIM-300.

I. INTRODUCTION

Electronic toll collection (ETC) is a technology enabling the electronic collection of toll payments.It has been studied by researchers and applied in various highways, bridges, and tunnels requiring such a process. This system is capable of determining if the car is registered or not, and then informing the authorities of toll payment violations,debits, and participating accounts [2]. The most obvious advantage of this technology is the opportunity to eliminate congestion in tollbooths, especially during festive seasons when traffic tends to be heavier than normal. It is also a method by which to curb complaints from motorists regarding the inconveniences involved in manually making payments at the tollbooths. Other than this obvious advantage, applying ETC could also benefit the toll operators.

The benefits for the motorists include:

- Fewer or shorter queues at toll plazas by increasing toll booth service turnaround rates;
- Faster and more efficient service (no exchanging toll fees by hand);
- The ability to make payments by keeping a balance on the card itself or by loading a registered credit card; and
- The use of postpaid toll statements (no need to request for receipts).

Other general advantages for the motorists include fuel savings and reduced mobile emissions by reducing or eliminating deceleration, waiting time, and acceleration.

Meanwhile, for the toll operators, the benefits include:

- Lowered toll collection costs;
- Better audit control by centralized user accounts; and
- Expanded capacity without building more infrastructures.

Thus, the ETC system is a win-win situation for both the motorists and toll operators, which is why it is now being extensively used throughout the world.

An ETC system commonly utilizes radio frequency identification (RFID) technology. RFID is a generic term used to identify technologies utilizing radio waves to automatically identify people or objects [3].In general, RFID is used for tracking, tracing, and identifying objects. A complete RFID system consists of a transponder (tag), reader/writer, antenna, and computer host. The transponder, better known as the tag, is a microchip combined with an antenna system in a compact package. The microchip contains memory and logic circuits to receive and send data back to the reader [5]. These tags are classified as either active or passive tags. Active tags have internal batteries that allow a longer reading range, while passive tags are powered by the signal from its reader and thus have shorter reading range [6]. Tags could also be classified based on the content and format of information. The classifications range from Class 0 to Class 5. These classes have been determined by the Electronic Product Code (EPC) Global Standard.

A reader contains an antenna to transmit and receive data from the tag. The reader also contains a decoder and an RF module. It could be mounted or built as a portable handheld device. The computer host acts as an interface to an IT platform for exchanging information between the RFID system and the end-user. This host system then converts the information obtained from the RFID system into useful information for the end-user as depicted in fig 1.

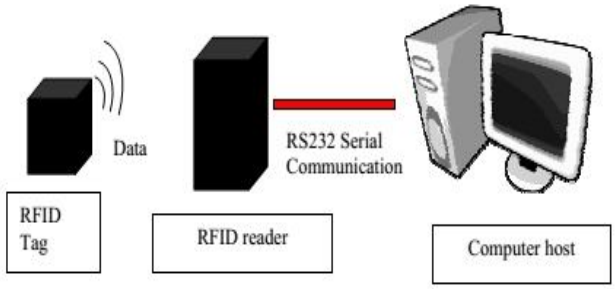


Fig 1:Complete RFID System

II.RELATED WORK

The ETC system is currently being used throughout the world. Other countries that have applied the ETC system are Canada, Poland, the Philippines, Japan and Singapore, among many others.

A. ***Canada***

The ETC system used in Canada is known as the Canada 407 Express toll route (ETR). It is one of the most sophisticated toll roads in the world [7]. The Canada 407 ETR is a closed-access toll road, which means that there are gantries placed at the entrance and exit points of each toll. In this system, cameras are equipped with Optical Character Recogntion (OCR).

The OCR cameras are used to photograph license plate numbers of vehicles that do not have transponders. The toll bill will then be sent directly to the registered address of the vehicle owners. Other than that, two laser beam scanners are placed above the roadway to detect the types of
vehicles passing through the gantries. Nevertheless, this toll road bears a very high infrastructure cost, and the users are the ones who help recover the cost
through increments in their toll bills [8].

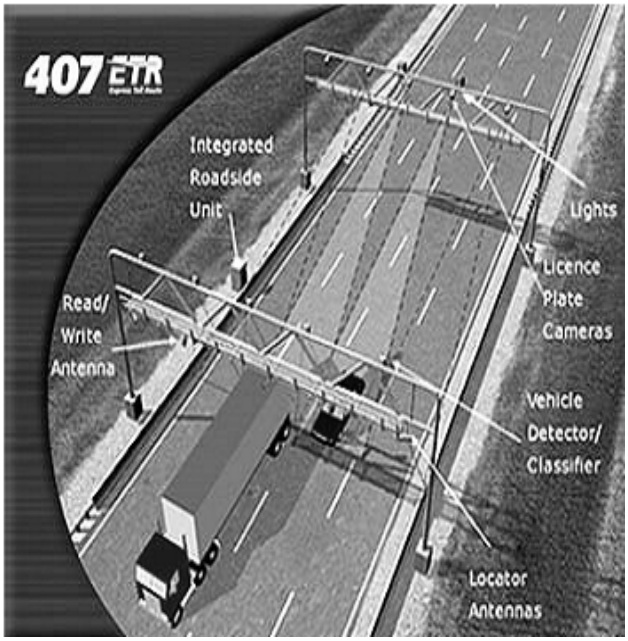


Fig 2: Canada's 407 ETR for ETC [7]

B. ***Philippines***

The ETC system used in the Philippines has been implemented at the South Luzon Expressway (SLEX) since August 2000. The ETC is referred to as the E-PASS system, which uses Transcore technology. Here, electronic transponders are placed in front of a vehicle's rear view mirror. Each
time a vehicle enters the toll booth, the tag is read by the receiver, automatically identifying the account and debiting the toll fee amount from the corresponding account. Once the amount has been debited, the control gate will lift and the vehicle is allowed to pass through [10].

III .PROPOSED METHOD

The Smart RFID Tag allows a motorist to travel non-stop through the toll plaza. It is an electronic device the size of a computer mouse which is installed on front side of the vehicle. It is has the capability of interacting with RFID reader placed at the toll gates. Which means that all you have to do is to slow down to 20 Km/hr (you don't have to stop) near the toll gates, the sensor? At the gates interact with your Smart RFID Tag, the transaction is recorded and the toll deducted, you hear a confirmation beep inside your car and you're off.

All of this takes less than a second and is extremely convenient to commuters and the best way to do away with waiting periods at the toll gates. Smart tag works like a debit card, it has no expiry and you can use it till you keep re-charging the amount in your account. Designated lanes for Smart Tag holders have been created to ensure a seamless drive through. Any person may apply for a smart tag device who travels on the NH-8. This could include

Motorists, Local residents and local commercial traffic. All you need is a copy of the registration Certificate of your vehicle and you can register for the Smart RFID Tag at the following locations as per your convenience: Rules for vehicle with Smart Tag:

• Tag users are required to proceed only after observing green traffic signal.
• Tag users are required to maintain approx. 2 car length distances while crossing toll gate.
• Speed of the vehicle should not be more than 15 km while crossing the toll gate.
• Tag is not an authority to move freely without following traffic rules. Being electronic item
• Each vehicle will be required to have its own Smart-Tag. If anyone tries to tamper the device, a tamper switch which is monitored by the system and will result in hot-listing of the account.
• If there is any problem in the Smart-tag, the consumer should visit the POS and get the Smart-tag checked. It will be replaced if it has not been tampered with.
• Speed limits in a nonstop Smart Tag lane must be not more than 15 Km/h for the safety of commuters.
• In case the customer changes his/her vehicle or changes the existing fleet, change in particulars need to be filled in, which would then be available at all plazas to avoid any inconvenience.
• If the Smart-tag is lost or stolen, the customer should report it to the Point of Sale in writing.

ARCHITECTURE

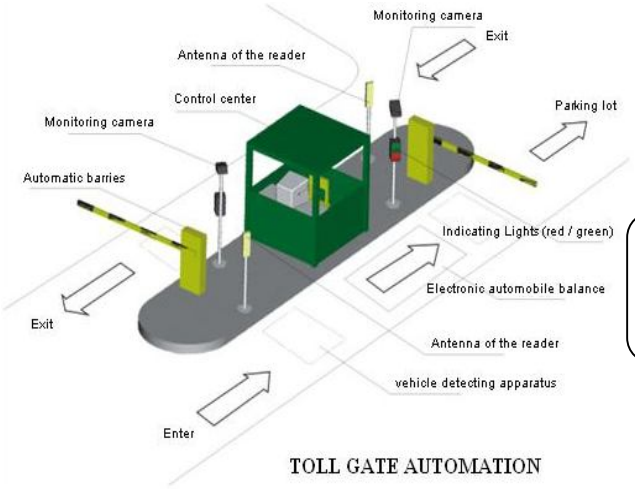


Fig 3. Flow of operation

Base Module:

The Base Module is installed at the entry points of Highway near the barriers of Toll Plazas.

The function of the base module is to register the vehicles in its range, allow them to pass if the vehicles are valid and trigger the alarms in case of invalid vehicles and should not lift the gate.

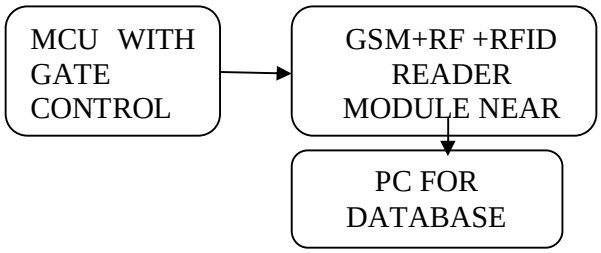


Fig 4. Base Module

The base station computer is programmed to continuously send an interrogation over its range. In case of any response to the interrogation message, if the base computer receives any vehicle data, it compares the data with the pre-saved data in its database. If the vehicle is allowed to pass, the base sends an authentication message to the vehicle module. The purpose of the authentication message is to counter erroneous transmission of data identify the thieves. Another feature that is installed in the base station is to accept chat requests once a vehicle in range has been registered. This can be used to inform the base station personnel if help is needed or for any sort of feedback. The base station can also send short messages in the chat area to the vehicle. This is useful for sending out broadcasts or other road related warnings. Users will also be able to access data related to vehicles in range, such as registration number, engine number, and owner's name. These features will enable to combat theft and unauthorized use of the vehicle modules. The usage of the user interface is designed to be simple yet functional.

Vehicle Module:

The vehicle module is installed in the vehicle. When the vehicle enters in the range of base, it receives the interrogation message and it replies it with its stored data.

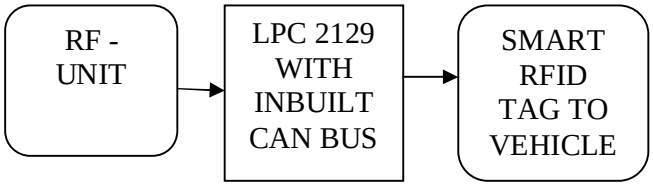


Fig 5 .Vehicle module

The vehicle module uses LPC 2129 RISC machine having inbuilt CAN bus so that any erroneous operation in vehicle can be communicated, transferred and resolved immediately [6]. The microcontroller contains the data of the vehicle in which it is installed. The vehicle data consists of registration number, chassis number, engine number, or owner's name etc. MAX-232 IC converts voltage levels to and from +5V and +9V. It is placed between microcontroller and RF modem.

Microcontroller operates at +5V whereas RF modem communicates through serial port at +9V. So there is a need to convert the signal levels going through RF modem to microcontroller and vice versa.

A. *CAN: Creating Your Own Network*

CAN is extensively used in automotive but it has found applications everywhere. Modern CAN transceivers provide a stable and reliable CAN physical environment without the need for expensive coaxial cables. Many think CAN is just for automotive, but this is not true. CAN has become the standard for vehicle networks, but it has been adopted in most other fields.

All we need to do in practice is to configure the controller by writing to its registers, write data to the controller and the controller then does all the housekeeping work to get your message on the bus.

The controller will read any frames it sees on the bus and hold them in a small FIFO memory. It will notify the host processor that this data is available which is then reads it from the controller.

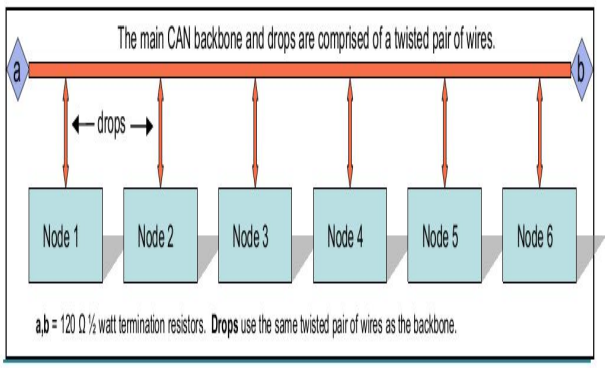


Fig 6. CAN Topology

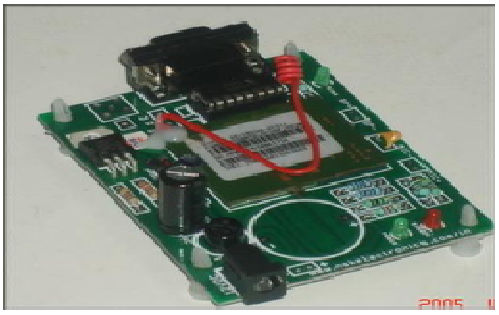
The controller also contains a hardware filter mechanism that can be programmed to ignore those CAN frames you do not want passed to the processor. Modern bus transceiver chips have made the physical CAN bus much less “finicky” and easier to construct and maintain.

A CAN network consists of at least two nodes connected together with a twisted pair of wires as shown below. A ground wire can be included with the twisted pair or separately as part of the chassis. One twist per inch (or more) will suffice and the integrity of the ground is not important for normal operation as described above.

The maximum length of the network is dependent on the frequency, number of nodes and propagation speed of the wire. CAN is a broadcast system. Any node can “broadcast” a message using a CAN frame on a bus that is in idle mode. Multiple controllers tend to start their messages at the same time. Every node will see this message. A “message” can be considered the same as a CAN frame until you need to use more than one frame to send a long message.

B. *Global System Mobile Communications (GSM):*

This is a plug and play GSM Modem with a simple to interface serial interface. Use it to send SMS, make and receive calls, and do other GSM operations by controlling it through simple AT commands from micro controllers and computers. It uses the highly popular SIM300 module for all its operations.



It comes with a standard RS232 interface which can be used to easily interface the modem to micro controllers and computers. The modem consists of all the required external circuitry required to start experimenting with the SIM300 module like the power regulation, external antenna, SIM Holder, etc.

Features

- Uses the extremely popular SIM300 GSM module
- Provides the industry standard serial RS232 interface for easy connection to computers and other devices
- Provides serial TTL interface for easy and direct interface to microcontrollers
- Power, RING and Network LEDs for easy debugging
- Onboard 3V Lithium Battery holder with appropriate circuitry for providing backup for the modules’ internal RTC
- Can be used for GSM based Voice communications, Data/Fax, SMS,GPRS and TCP/IP stack
- Can be controlled through standard AT commands
- Comes with an onboard wire antenna for better reception.
- Board provides an option for adding an external antenna through an SMA connector

- The SIM300 allows an adjustable serial baud rate from 1200 to 115200 bps (9600 default)
- Modem a low power consumption of 0.25 A during normal operations and around 1 A during transmission
- Operating Voltage: 7 – 15V AC or DC (board has onboard rectifier

C. RF ID Reader with Serial Output

This is a low frequency (125 KHz) **RFID Reader with Serial Output** with a range of 8-12cm. It is a compact unit with built in antenna and can be directly connected to the PC using RS232 protocol.This unit is a kind of play and plug device with a reading range of 8 to 10 cm and can be availed in the following specifications.

Specifications:

- Voltage: 5 vdc
- Current: <50ma
- Operating Frequency: 125 kHz
- Read Distance: 8 to 10 cm
- Size: 32 mm (length), 32 mm (width), 8 mm (height)
- Serial Output

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This RFID card come with a range of about 12-15 cm and delivers the processed data very quickly and in a easy readable format. Our range matches with the prevailing requirements of the market and are installed with modern features

D.RF transmitters and receivers

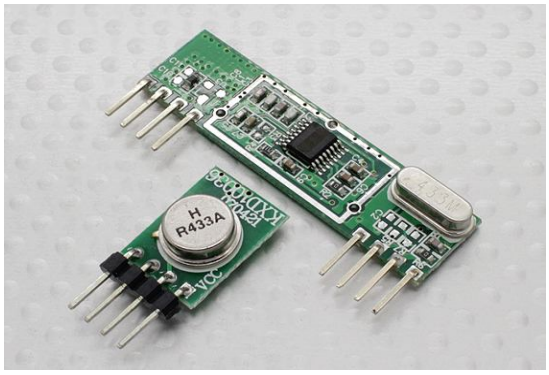
RF Link Transmitter - 434MHz

Description: These wireless transmitters work with our 434MHz receivers. They can easily fit into a breadboard and work well with microcontrollers to create a very simple wireless data link. Since these are only transmitters, they will only work communicating data one-way, you would need two pairs (of different frequencies) to act as a transmitter/receiver pair.

Note: Both the transmitter and receiver work at common frequencies and don't have IDs. Therefore, a method of filtering this noise and pairing transmitter and receiver will be necessary.

Features:

- 434 MHz
- 500ft range (given perfect conditions)
- 4800bps data rate
- 5V supply voltage



RF Link Receiver - 4800bps (434MHz)

Description: These wireless receivers work with our 434MHz transmitters.

E. LPC2129 Chip Features

The LPC2119/LPC2129 is based on a 16/32 bit ARM7TDMI-S“CPU with real-time emulation and embedded trace support, together with 128/256 kilobytes (kB) of embedded high speed flash memory. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at maximum clock rate. For critical code size applications, the alternative 16-bit Thumb Mode reduces code by more than 30 % with minimal performance penalty.

- In-System Programming (ISP) and In-Application Programming (IAP) via on-chip boot-loader software.
- On-chip Embedded-ICE-RT, Embedded Trace Macrocell debugger

- Two interconnected CAN interfaces with advanced acceptance filters.
- Four channel 10-bit A/D converter with conversion time as low as 2.44 ms.
- Multiple serial interfaces including two UARTs (16C550),
- Fast I2C (400 Kbits/s) and two SPIs
- Phase-Locked Loop with settling time of 100 ms.
- Vectored Interrupt Controller with configurable priorities and vector addresses.
- Two 32-bit timers (with four capture and four compare channels), PWM unit (six outputs), Real Time clock and Watchdog.

IV.RESULTS AND DISCUSSION

OPERATION FLOW:

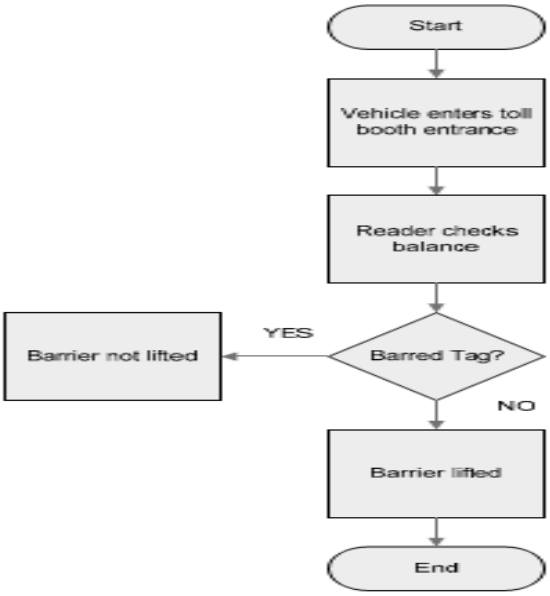


Fig 7 Toll Gate Entrance Flow Chart (Prepaid and Postpaid)

Customer accounts may be postpaid, where toll transactions are periodically billed to the customer, or prepaid, where the customer funds a balance in the account which is then depleted as toll transactions occur. Figures 7,8and 9 below illustrate the flow of the proposed system.

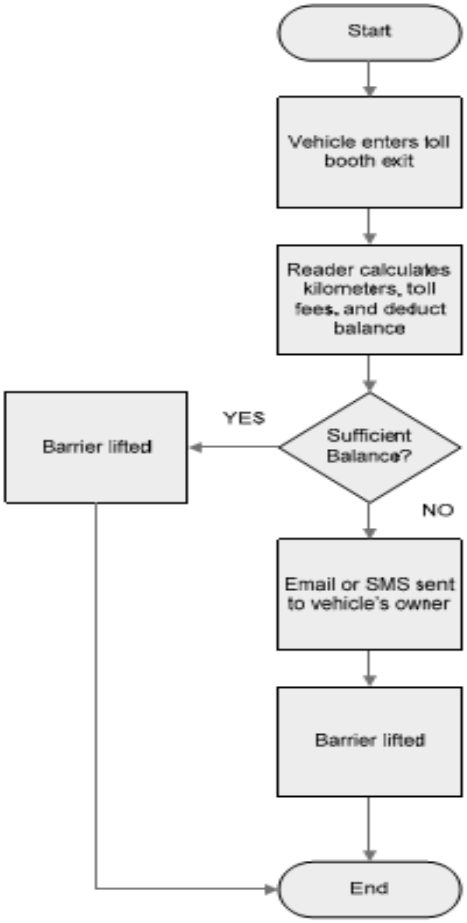


Fig 8 Toll Gate Exit Flow Chart (Prepaid)

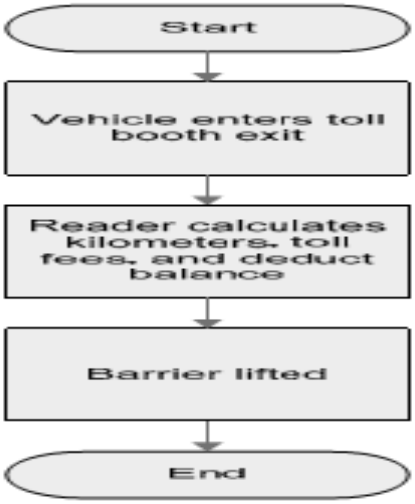


Fig 9 Toll Gate Exit Flow Chart (Postpaid)

Taxing Schemes:

In order to get the taxing done at ease, two parameters are introduced.

First, a prepaid system or tag which will provide a certain balance calculation and the amount resultant will be read and hereby processed. In prepaid module, the vehicle will be provided with Tags which will be recharged initially and also can be done at regular intervals which when processed from the toll gate will be read by the tag reader and hereby after the balance deduction; the gate will authorize to pass the vehicle.

Secondly, a postpaid system will also be interfaced along with the module comprising the tag which will allow the drivers/passers to go for e-billing in case the balance in the prepaid module goes without balance; the driver will be alarmed to acknowledge the permission of getting e-billing done.

Vehicle authorized
Amount deducted 100

Fig 10.Database at Tollgate PC.

V. CONCLUSION

The project is aimed at various types of ETC systems applied in some countries. The proposed ETC system discussed in this work applies passive RFID technology. By doing so, increased efficiency will be guaranteed since RFID is known as a highly stable technology. With the elimination of human interaction in the entire toll collection process, we can create a better ETC system to be implemented. It can also significantly improve the efficiency of toll stations and the traffic abilities of the toll road.

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VII.BIODATA

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