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Design and Implementation of Addis Ababa-Adama Highway Automated Payment System

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Abstract— *Light Emitting Diodes (LEDs) offer the advantages of long Road pricing or the condition in which fees are paid for using a road is called toll collection or tooling at large. Now a day there are different methods and technologies that are used to control the road payment, toll tax payment in the world. But none of these technologies are yet applied in our country specifically, at Addis Ababa to Adama Express Highway road, which is a new road of its type. The proposed system can be used in order to eliminate corruption, traffic jam and to reduce wastage of time which the problem of the current system.*

The aim of my project is to design a system which uses an online data server for the payment. The driver needs to pay some amount of money at the road authority office before attempting to use the road which implies that the system is prepaid. The driver is given a secret code which will be asked by the system and his/her account activated online. As a car approaches the entry of the express way the system measure the weight of the car by use of load sensor and calculates amount to be paid then display on LCD if the weight is within the permissible range; the driver is then asked to input the secret code and the payment is done accordingly if the correct input is entered and the balance of the driver can afford the amount needed by using the database system. Then the system opens the road for the car and close it after it has crossed the gate. The system also send SMS to the driver amount of his/her current balance, amount of needed discounted money and the remaining balance after the payment is done, so that the driver may charge the balance for the next time, if the balance is low. Otherwise, if the weight is out of the permissible range the system displays warning message and it doesn't open the road blocker.

Keywords*— Highway, Payment, Road, Car, System*

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I. Introduction

A. ***Background***

Tolling as a method of financing the transportation system is becoming more common in countries that have toll roads. Neither the traveling public nor State Departments of transportation want vehicles to stop or slow down to pay to use a toll facility. To this end, several technologies, collectively called Electronic Toll Collection (ETC), have been developed recently, allowing drivers to move in and out of toll systems without delay. Open Road Tolling (ORT), with all-electronic toll collection, is now the preferred practice, being more efficient, environmentally friendly, and safer than manual toll collection.

Charging for road use is by no means a new concept. Toll roads can be traced back to at least Roman times, when travelers paid a fee for using a road/track maintained and in many cases protected by the authorities of the day. Across the world today toll roads make up a significant proportion of the road networks. Tolling is essentially the recovery of a fee from users of a facility to cover the capital of building, operation, and maintenance costs of the road .A variety of electronic technologies in the 1970s and in the mid- to late 1980s were developed and tested with the aim of speeding up the collection of tolls. Subsequently, microwave tags and radio frequency identification (RFID) devices were developed, so that queuing at manual tollbooths could be reduced or completely eradicated, allowing drivers to pass through toll plaza facilities without stopping, their transactions being made automatically using appropriate road charging equipment across the roadside-to-vehicle communications link.

The first commercial use of e-tolling technology was in 1987 when the Ålesund Tunnel in Norway was equipped with a simple identification (ID) tag using microwave technology. Similar tag-based schemes were introduced in the United States, Southern Europe, and Japan over the past few years to introduce electronic toll charging that were used for revenue raising, and had the ability to influence travel demand and reduce peak- or traffic congestion.

Numerous advanced technologies, such as global satellite navigation, automated number plate recognition, and dedicated short range communication (DSRC) are being used in ETC system implemented in different developed countries[1]-[6]. However, the third world developing countries are still deprived of these

technologies due to high cost and technological complexity. Recent research on ETC system is mainly concerned with combining the information and communication technology with transport infrastructure [3].

The two currently preferred charging technologies are microwave in vehicle tags communicating with roadside antennas, and satellite-based location systems that locate the position of the vehicle on an onboard digital map (the vehicle is then appropriately charged, based upon or distance based charging. Mobile wireless networks, RFID, mobile phone technology, or camera based automatic number plate recognition (ANPR) solutions may also offer options that are appropriate to support future nationwide road pricing solutions.

B. Statement of the Problem

The existing manual toll collection or payment system in the new Addis ababa Adama express high way is not suitable for providing standard quality of service due to a constraint in time and traffic congestion. There is also a need for additional human resource which can be avoided by using automated systems and last but not least the existing manual system is highly exposed to corruption.

C. Objectives

The general objective is to design and implement an automated toll collection system to the new Addis abab Adama express highway.

II. Related Works

The ETC system is currently being used throughout the world. In the United States alone, various states have implemented an ETC system called E-Z Pass. Some of the other countries that have applied the ETC system are Canada, Poland, the Philippines, Japan and Singapore, among many others.

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 .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 Recognition (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.

Poland

The ETC system used in Poland has been proposed by the Motor Transport Institute along with the University of Technology in Warsaw and Dublin. This system is called the National Automatic Toll Collection System (NATCS), and consists of the National Automatic Toll Collection Center (NATCC), control gates, and on-board units (OBU). The NATCS uses a combination of mobile telecommunication technology (GSM) with satellite-based Global Positioning System (GPS). Using GPS technology, the OBUs determine the kilometers that have been driven, calculate the toll fees and rates, and then transmit the information to the NATCS computer center. Each vehicle will be charged from the highway entrance up until the end of the highway. In order to identify the plate numbers of trucks, the system has control gates equipped with digital short range communication (DSRC) detection equipment and high resolution cameras. Due to the technical specifications, this system incurs a high cost for motorists.

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 Tran score technology. Here, electronic transponders are placed in front of a vehicle's rearview 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.

South Africa

In South Africa many of the National routes have sections that are toll roads. In cities such as Cape Town and Durban the freeways are free of charge. However, with the introduction of electronic tolling (e-tolls) as part of the Gauteng Freeway Improvement Project, tolls were introduced on the upgraded the urban freeways that are National Roads in the province of Gauteng, which includes Johannesburg and Pretoria. These Gauteng tolls met resistance in the media and from parts of the population.

Ethiopia

In Ethiopia there is one toll road named Addis Ababa-Adama express way. It began service recently in 2014.The road connects the capital of Ethiopia Addis Ababa and the Adama town which is found in Oromia region. The road is along one of the main road in the country which runs from Djibouti to Ethiopia .The Addis Ababa-Adama expressway, is built at a cost of more than 10.3 billion Birr (US$530 million).It is 84 kilometer long and it reduced average travel time between the two places from the current three hours to 45 minutes. Vehicles will be charged for using the expressway and the revenue will be used for its maintenance.

III. Methodology And System Design

Time is a key constraint that may challenge a researcher during the project development time. In this study, the Systems Development Life Cycle Model, known as iterative enhancement Method is used as it is the best model to address constraints and activities involved in this project.

In this study, the Systems Development Life Cycle Model, known as iterative enhancement model will because it is the one which can address the constraints and activities involved in this project. In iterative enhancement model, each phase must be completed sequentially in its entirety before the immediate next phase can begin. A review is done after each phase to analyze whether the project is running as per the required standards, specifications and timelines. The output of each phase can be an input to the immediate next phase if it is confirmed that the project is running as per the specification during the review of each phase in this model. Otherwise it goes back to one of the previous cycles that can best used to raise the specification to the expected level. This model is well suited for this project because it allows additional features that were not in the requirements from the beginning to be included for further performance of the system. The Figure below shows the system development life cycle model.

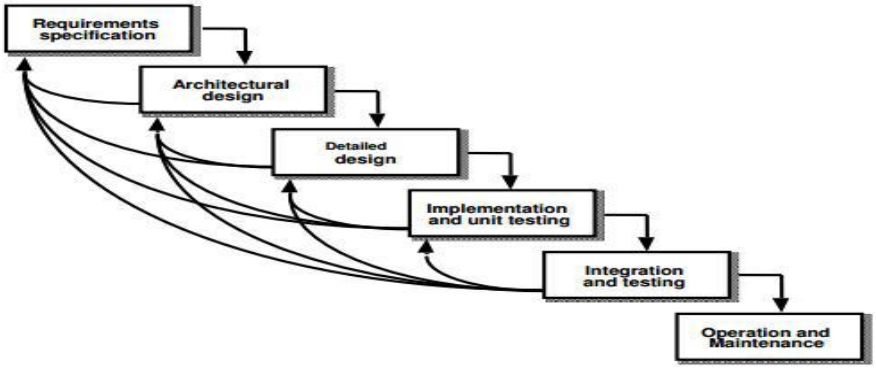

Fig. 1 Iterative Enhancement development life cycle model

The advantage of iterative enhancement development is that it helps an inclusion of new features that were not specified at the beginning to be added at any time during the software development phase. This is a good thing about this model because it is difficult to specify all the requirement of the system at the beginning .The other advantage of this model is that in case something is wrong it goes back to the phase that can help to fix the problem rather than starting the project from the beginning which is the case in most other software development methods.

D. Data Gathering Techniques

In order to gather the needed data and information, the following techniques are used:

Observation: I observed that how the Addis Ababa Adama express highway works currently. This starts from the process of how the cashier identifies the car type which is the basis of the payment system, the cashier then prepares a receipt for those who have paid, and then opens the road for the corresponding derivers.

Document Analysis: A systematic examination of Addis Ababa Adama express highway payment system was conducted to identify the needs and challenges of the proposed system. The focus of the analysis should be a critical examination, rather than a mere description, of the documents. Five steps were considered in planning the document analysis. These are 1) Describe the context; 2) Identify stakeholder needs and develop central questions; 3) Determine the purpose of the document analysis; 4) Determine how you will use the results; and 5) Develop document analysis criteria.

E. Block Diagram of Digital Learning Display System

The figure below is the engineering block diagram of my project that I have designed at the primary stage of my project. So, the diagram consist of LED, stepper motor, Load cell, amplifier, inverter, LCD display keypad and Database. The flow starts from LED first which is either red or green, if it is green the front stepper motor will rotate 90 degree anticlockwise in order to open the front door, otherwise, if it is red the stepper motor won't start. After the car passing front door the load cell then weighs the vehicle accurately & transmits the analog signal through the differential amplifier. The controller then compares the signal with the value of permissible weight and if it is possible it will compare it with the respective toll and displays on LCD, otherwise it will display the error on LCD. So the driver is asked to type the secret code so desired amount will be deducted from his account which is stored inside the database and then the remaining amount of money is displayed or sms to the driver from the system, this done if the secret code is valid, if not error displayed on LCD. Since I are using PIC16F877A, which have internal analog to digital converter, I didn't use any signal conditioning unit, which converts the analog signal coming from the amplifier to digital will converted to 0-5 v which is suitable for controller.

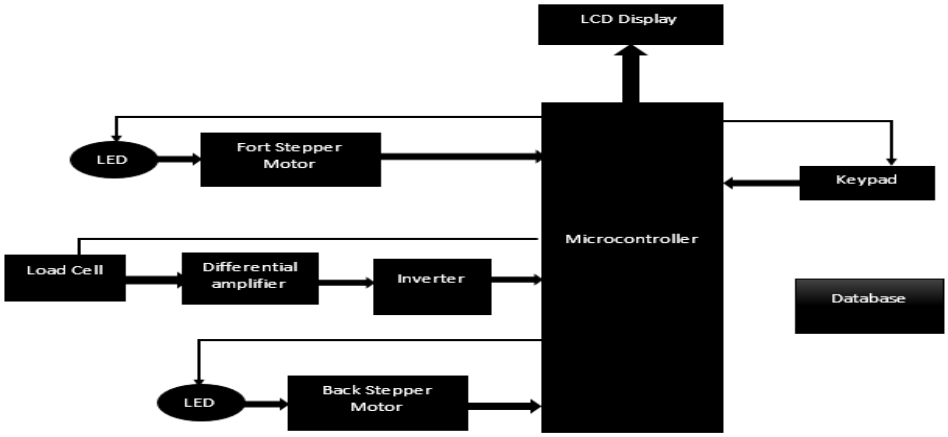

Fig. 2 Block diagram of the system

The payment mechanism for my system used here is a pre-paid system. The user needs to be registered at an authorized office for the payment. Then he/she is given a secret code that has to be inserted when asked by the system. The balance is then activated for the user from which the payment amount is deducted later. Here a database is used to store the user information and his/her balance. Later when the secret code is asked by the system and if the user enters his/her code the payment the desired amount will be deducted from the balance in the database and the remaining amount is displayed on the LCD. If the balance is lower than the amount to be paid, the user can transfer money to that account by the use of mobile banking to continue with the process.

F. Hardware design

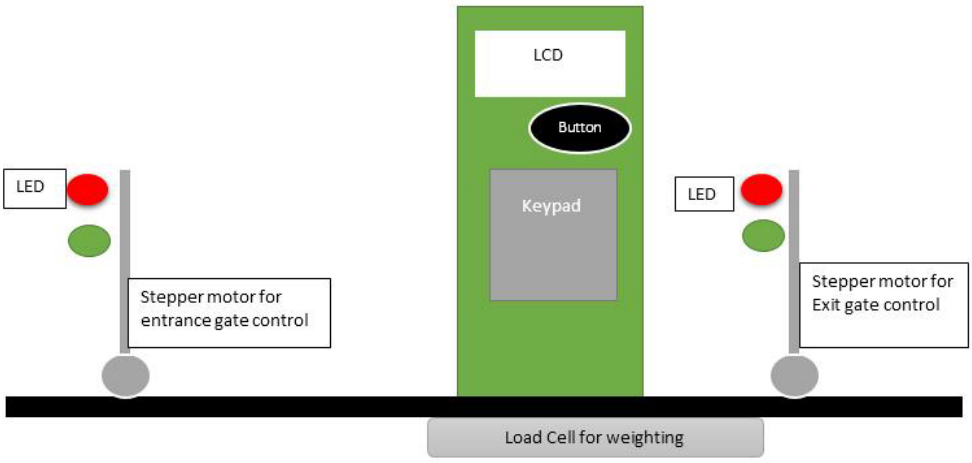

Fig. 3 Hardware design layout

IV. Result And Discussion

G. Circuit diagram of the system

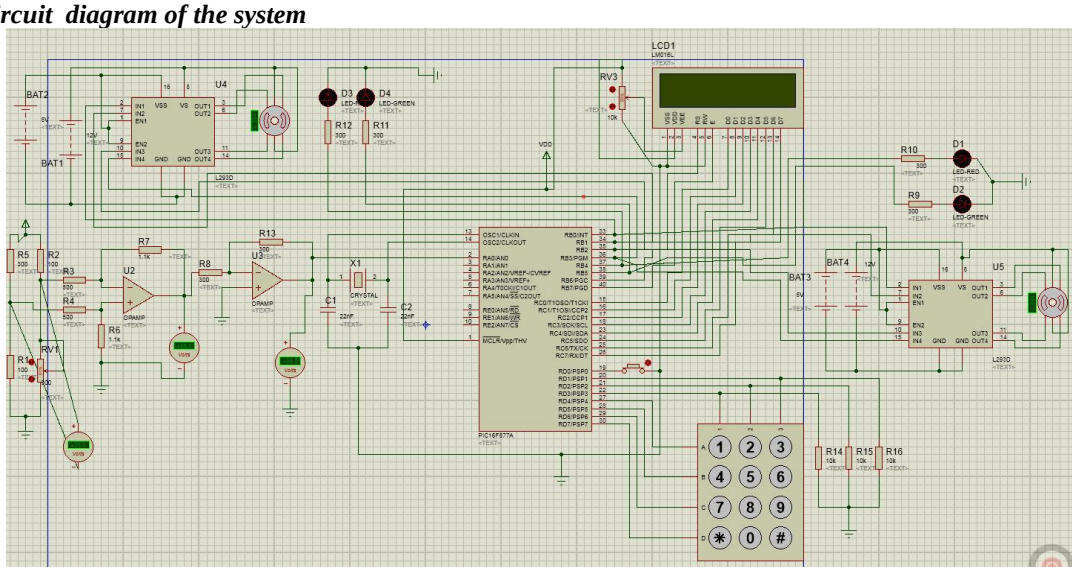

Fig. 4 Full circuit diagram of the system

H. Usecase diagram of the system

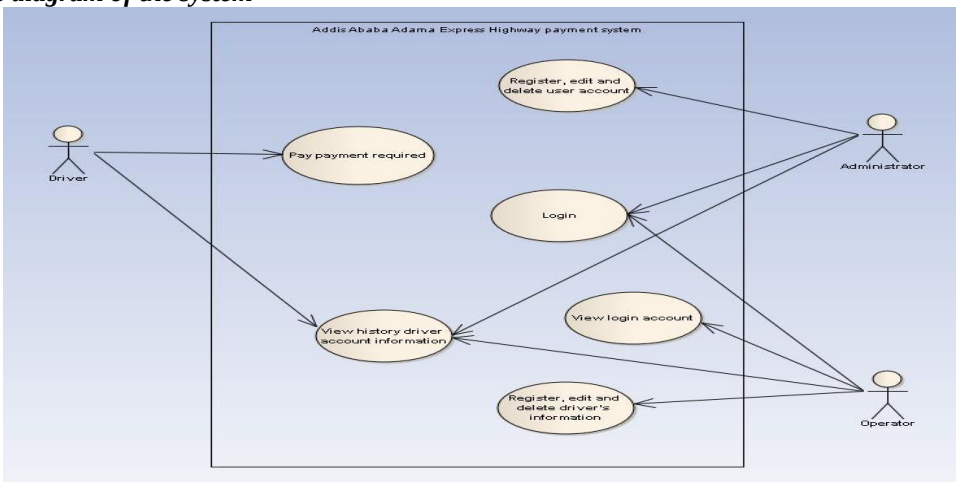

Fig. 5 Usecase diagram

Database part which is serves as an input for all the other part of the system is shown by the following figures.

System Login: An authorized officers must login, in order to access the software part of the system by typing assigned user name, password.

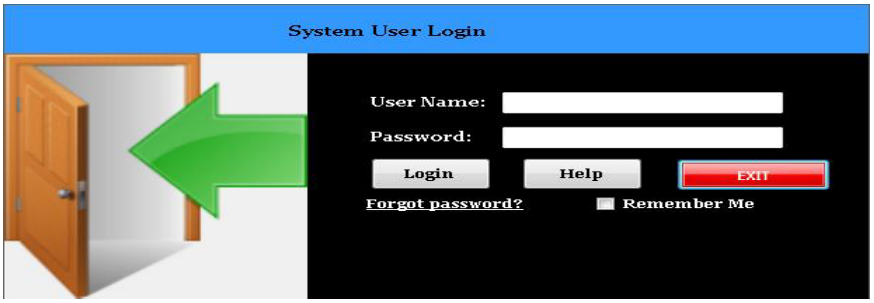

Fig. 6 Login page of the System user interface

Home page: this page is the main page of the software which have different option like, registering user account or drivers, editing user account or driver information, deleting user account or driver's information, viewing driver history.

Fig. 7 Home page of the system

Registering driver: here the authorized officers can register driver with required information.

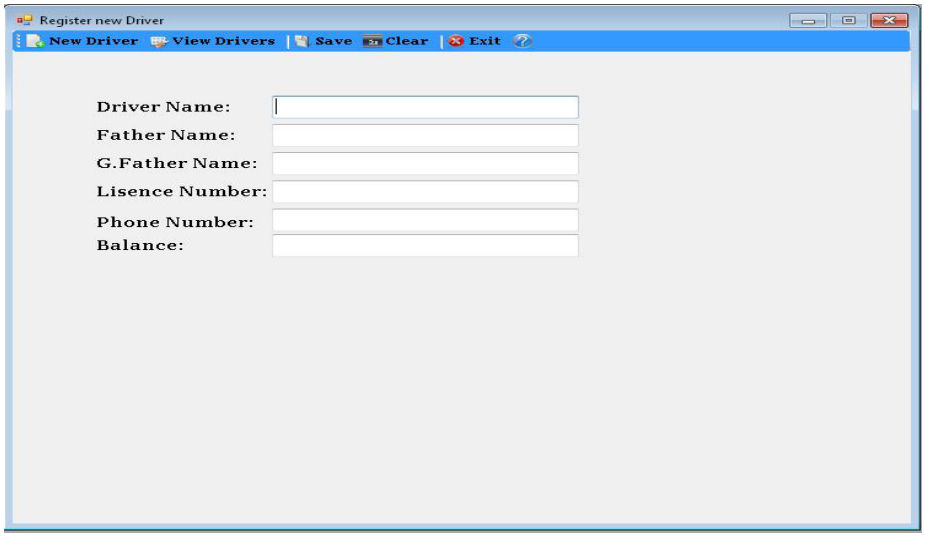

Fig. 8 Driver registration page

Create new user account: this page is used to create new user accounts in order to access system account, this page is accessible only for system administrator.

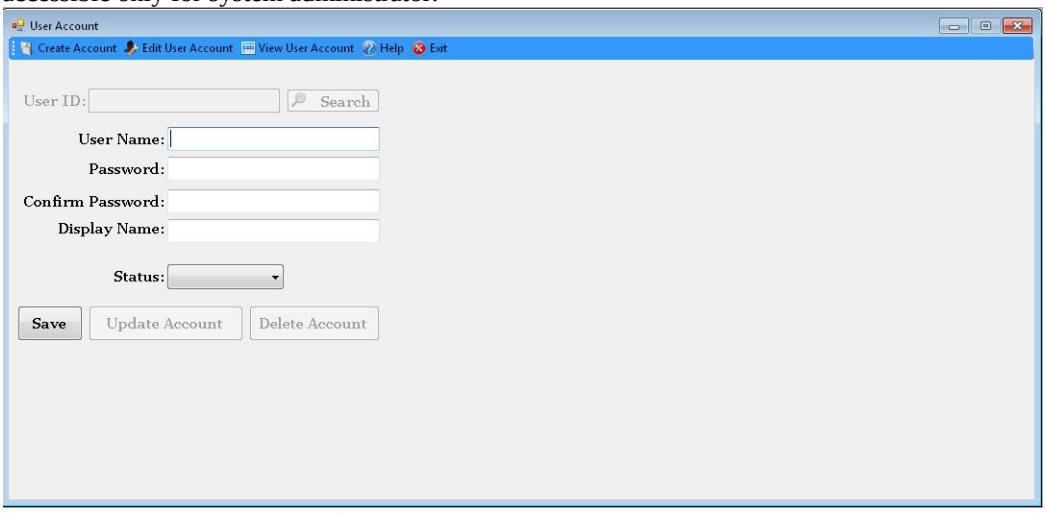

Fig. 9 Create new user account page

I. Output of simulation result

The default state: The green LED is switched on and road blocker will be open by default when a car is not passing across the road. This is the state the system occupies before a car comes and after a car is passed.

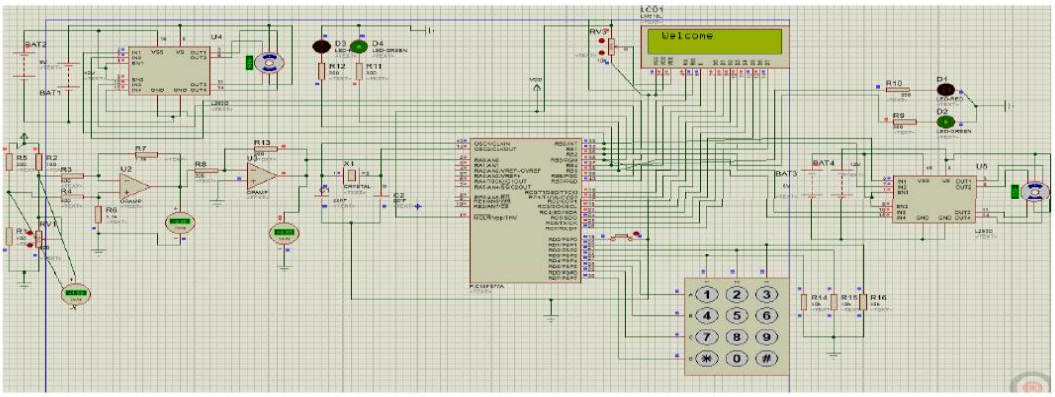

Fig. 10 Output of system default state

Measuring vehicle weight and calculating payment: this is accomplished by the use of the load sensor, then the weight and the amount to be paid is displayed on the LCD. I assume the following things for simulation purpose: 1V input from the load cell is approximately 313.81 Ton and payment calculation is done by using 0.25 cent/Ton.

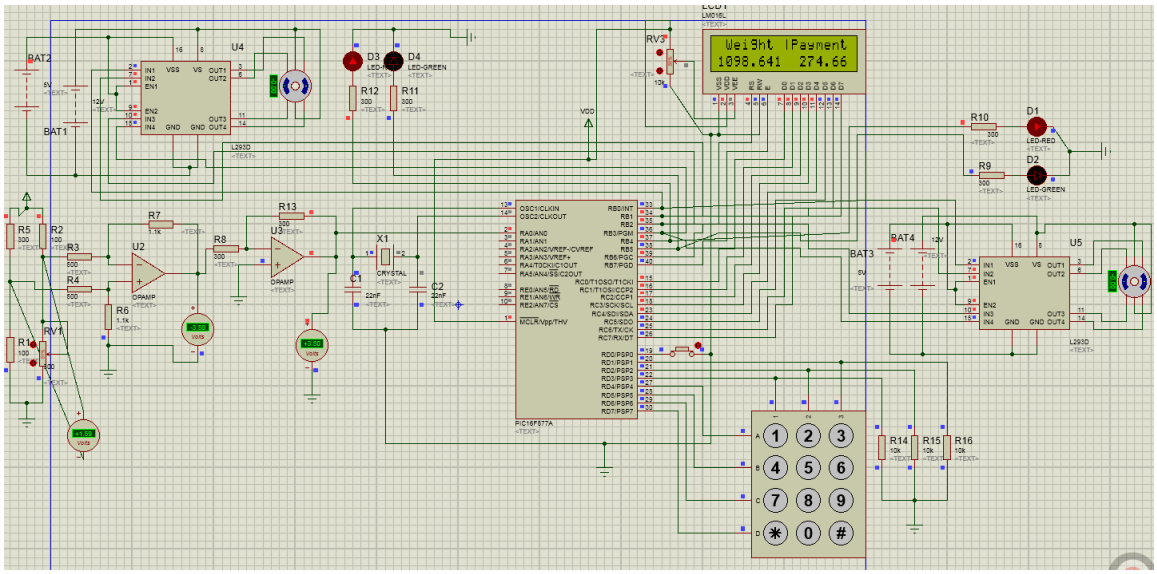

Fig. 11 output during weight measurement

V. Conclusions

By doing automation of toll payment system I can have the best solution over the revenue loss that would occur in case human power is required at the toll payment station for whom a salary will be paid. Beyond that this automated system also avoids malfunctioning such as corruption that may occur under the current system. The proposed system also increases efficiency of the overall system and provides comfort for the users. The time that would be needed at payment station especially at the peak hours will be reduced to minimum. It also reduces traffic jam. In my project I have introduced an automated system that uses a database to store the payment information and PIC microcontroller on which other system component like load cell which is introduced for weighing the vehicles so as to serve as an input for payment calculation, keypad to take an input from the user, LCD to display the payment amount and the remaining balance, stepper motor which is in charge of the opening and closure of the road are the key system components.

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References

[1]. R. Zhengang and G. Yingbo, "Design of electronic toll collectionsystem in Expressway Based on RFID," in Proc. ESIAT'09 , 2009, p.779.

[2]. Z. Xiao, Z. Guan, and Z. Zheng, "The research and the developmentof the highway's Electronic toll collection system," in Proc.WKDD'08 , 2008, p. 359.

[3]. R. Turnock and J. Kohli, "High occupancy vehicle status signalingusing electronic toll collection infrastructure," U.S. Patent20100085213, Apr. 8, 2010.

[4]. A. Demisch, H. Iseki, and B.D. Taylor, "Examining the linkages between electronic roadway tolling technologies and road pricing policy goals," Univ. of California, Berkeley, UCB-ITS-PRR-2009-31,Jul. 2009.

[5]. Goh, M., "Congestion management and electronic pricing in Singapore ," Journ. Transport Geog. , vol. 10, no. 1, pp. 29-38, 2002.

[6]. M. Sarfraz, M. J. Ahmed, and S. A. Ghazi, "Saudi Arabian license plate recognition system," in Proc. GMAC'03 , 2003.

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