EFFECTIVE AND EFFICIENT ELECTRIC VEHICLE CHARGING SYSTEM FOR SRI LANKA

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***Abstract*— Recently the Sri Lankan parliament discussed the issue of the introduction of Electric Vehicle Charging System. In Sri Lanka, day-to-day air pollution is being increased and there is no way to reduce the vehicle usage. Due to the releasement of harmful substances (carbon dioxide and toxic) from vehicle fluids into the environment, Sri Lanka has planned to implement an electric charging stations island wide. In Sri Lanka, most of the vehicles are based on the gasoline fuel system and few are on electrical systems, but there is still no adequate electric vehicle charging system in the country.**

Profitable and efficient electric charging systems are needed to be met the electric vehicle charging requirements in Sri Lanka. The objective of this document is to monitor the charging system through modern technologies and also the energy backup power system for areas where charging stations are not available in Sri Lanka at a lowest cost.

Development approaches are data collection to evaluate the model, the proper way to interconnect electronic components, practical limitation, electronic system tasks, functional system research, derivation of system requirements, test circuit test to verify needs system practices, and sample system design.

This article presents the following aspects:

• Evaluation of an introduction of the new electric vehicle charging system and its background.

• Explanation of literature review: theoretical approach, methods and resources used.

• Explanation of objectives: activities carried out for the research methodology. Achievements and methods adopted to meet these objectives.

• Explanation of the design and implementation of the cost-effective charging system to build successfully.

• final design and complete test of the system

Keywords— Electric Vehicles in Sri Lanka; Green Sffect Electric Vehicle Charging System; Low Cost Charging System;

I. INTRODUCTION

The electric vehicle usage has dramatically been increased for recent years in Sri Lanka. Sri Lankans are showing increasing interest to modify fuel vehicles to Electrical Vehicles (EVs).

Following facts are the reasons to maneuver from gasoline to EVs.

- Nature atmospheric phenomenon is low contrast to fuel vehicles.
- When driving excess distance, the value is low in EVs.
- Up-keep charges in EV vehicles are less contrast to the fuel vehicles.
- Required energy is obtained within the country in EVs.
- Hoping to increase the battery life to extend the space range and reduce the charging time
- When starting a journey, care should be taken regarding the space to be travelled because there could also be no electric charging stations in between departing and arriving points. So there's a risk within the journey.
- People aren't encouraged to use electric vehicles thanks to improper general knowledge.
- No way of reducing pollution thanks to usage of gasoline vehicles.

A. Research objectives

The predicted model objective is to implement an efficient charge calculating system for EVs to beat above mentioned problems. Following objectives are considered to be achieved by proposing an appropriate charge calculating system for EVs.

- System should be designed to compute the fee using time taken for charging and therefore the ampere value because the fee calculating guideline.
- System should be designed to look at the ampere rate and therefore the fee for the entire charging of the battery.
- To design a system which will be needed to send information about the charging location where customer can easily identify the situation.
- To design a backup power grid which will be needed to give power where the charging stations not available.
- To design a system which will be needed to send an alert message to customer indicating charge completion and therefore the cost.

B. Research questions

how to change domestic power environment as charging station in Sri Lanka?

- how to get notification of the nearest charging points?
- how to give backup power to the charging station?
- how to display charging details in low cost?
- how to get notification of full charge?
- how to calculate cost for charging?
- how to test the product?

II. OVERVIEW

A. Charging an electric car per kilometer and the current situation in Sri Lanka

People will be interested to go for electric vehicles since maintenance cost is less compared to gasoline vehicles, compared to regular vehicles. Electric vehicles' impact on

nature is very less. Shifting from fuel vehicle to electric vehicle is taken as a main consideration in the country. To fulfill these requirements, electric charging stations are needed all over the country. Implementing the unit in the vehicle with solar & GPS module. As a result, user can calculate the distance to the next closest charging station and solar energy can be used to run the vehicle when battery power runs off [1].

Using the battery electrical power, the vehicle runs first 50 to 100 kilometers in one charging during long distance running. This feature offers a better position for electrical vehicles from just being a "second vehicle", Electric Vehicle charging consumes much electric power from the grid [2].

Each full charge needs 12 kw hrs. For a Nissan Leaf, which amounts to 240 units per month, will be added to electricity bill [3]. On average, each 11 miles needs full charge for normal electric cars [4].

B. Electric charge and cost analysis for measuring charge

To measure the Watts usage value of an appliance, after plugging the monitor to the outlet of the appliance and the appliance can be connected to the monitor. This will display the wattage value of the device. Then to calculate the cost, usage watt value should be multiplied by the charges per kilowatt-hour. Some monitoring devices allow to inputs utility charges per kilowatt-hour and provide usage cost. Most of the devices allow to inputs, the rate in US dollar currency, these meters are little expensive and cannot be customized according to our requirements [5].

Hall Effect Current sensor can be used to measure the current usage of an appliance. It is commonly used to calculate the amp value. The current flow generates a magnetic field around the loop and it is proportional to the magnitude of the current flowing in the conductor. Current is set to flow through the terminal pins and ground and supply 5V is connected to the corresponding external pins. Microcontroller ADC unit receives signals from sensor out pin. For standard applications sensor can be interfaced without using an op amp since the sensing value is large enough to detect by the sensor [6].

Electricity usage is charged in hourly basis. In Sri Lanka The end-user electricity tariffs are defined by Ceylon Electricity board [7].

C. Embedded System & Charge Calculating Meters

There are cost calculating meters which use the general purpose microprocessor as the computing engine of the billing system. The advantages of microprocessor Charge calculating meters are high performance, easy to interface to other intelligent peripherals and systems. Most of the new Micro Processor based Electric Charge Calculating Meters are designed based on "Raspberry Pi Mini Computer Systems" and are very expensive compared to "Micro Controller based systems". The disadvantages of microprocessor charge calculating meters are poor temperature performance, higher susceptible from electrical and electromagnetic interference, higher cost and higher power requirements. When comes to "general purpose microprocessor" in cost calculating meter is not economical as the microprocessor. As well as it has many capabilities with higher cost, but which are not needed for electric charge calculating system [8-10].

Micro Controller Based Electric Charge Calculating Meters use dedicated processor in microcontroller for billing system. the advantages of microcontroller cost calculating meters are cheaper, good resolution, Less power consumption, effective performance for current cost meter. Most of the Micro Controller based Electric Usage Charge Calculating Meters are designed using Arduino System Boards and those meters are not customizable and less expensive compared to PIC Microcontroller based custom design circuits. In contrast to that, the disadvantages of microcontroller cost calculating meters are no alerting mechanism is used for customers about the job completion, mainly depending on hydro-electric power source, and easy location finding system is not included [8-10].

D. Location Tracking Technology for Tracking Charge Stations

Android device manager is a new google service which allows to locate the android devices. once you configure the A.D.M app and register with a google account, the device can be tracked easily by using the app or android website. Any devices can be tracked physically by integrating the device with an android device [11].

Open GPS module has the capability to provide latitude, longitude and direction of travel geographical information about a particular object. When this information is extracted and sent it to the web, people can track the location of the object by using application like Google map. To search the location in google map data should be in decimal degree format, but GPS receive coordination from satellite in degree minute format. microcontroller can be programmed to convert the degree minute to decimal degree format. This location is sent to the web server for Google map identification. These modules are very cheap, but needs some configuration to make it as a user friendly location tracker [12,13].

E. Backup Power source

Wind energy is a renewable energy which keeps the environment clean. wind power plant mainly use turbines to produce the electricity. This energy system cannot be used as a medium scale backup system due to high cost and special spacious arrangement [14].

Solar energy system is a renewable energy system which can be used until the sun runs out. Sun energy is inverted to electric energy using photovoltaic cells. These cells are mainly made of silicon semiconductor doping with p type atoms [15]. solar panel can be used as a backup source because Sri Lanka gets an adequate solar energy.

F. GSM Technology for Alert Message

There are ample choices of mobile phone network operator services available in Sri Lanka. User can obtain a GSM/GPRS connection from available series of packages to offer. The GSM net chain services are rapidly growing in the country. Few mobile net chain operators (Dialog, Airtel, Etisalat, Mobitel) provides GSM-900/1800 and 3G-2100 frequency services in Sri Lanka [16,17].

GSM is the widely accepted benchmark for portable phones in the Earth. Microcontroller interfacing with a GSM modem is done using an intermediate MAX-232 IC circuit. Most of the newly designed modems come with built in Max232 IC circuit and can be connected to Microcontroller directly using TTL-TX and TTL-RX pin is used instead of using DB serial connecter. Max-232 IC circuit converts serial signals to TTL compatible signals. GSM modem also needs a separate SIM card as in mobile phones to connect to GSM network. Sending SMS from

GSM modem is done using series of AT commands generated by a microcontroller or input through a PC serial interface [18].

G. Display and Input Device

Additional to the character display TFT support graphics, animation and touch input, these are expensive compared to alpha numeric display unit & suitable for hotel management system [19]. Liquid Crystal Display units used in the embedded systems are alpha numeric display units. Main advantage of using this unit in a microcontroller circuit is less expensive and low power consumption. Serial and parallel are two varieties among this LCD types where parallel is cheaper compared to the serial unit [20]. According to the market analysis, the function of the audio conversion device is to convert audio format to a readable digital format and these devices are little more expensive compared to standard input devices. These devices are not much compatible with Microcontrollers and interfacing with microcontroller is a tuff task. keypad is fully compatible with Microcontrollers and are much cheaper compared to other input devices.

III. METHODOLOGY

Different technologies can be used when designing an electric vehicle charge calculating system. When designing such a system, consideration should be taken regarding the accuracy, environment and the cost. These vary from each other when comes to performance outcomes.

A. Conceptual Designs

- Microprocessor based electric charge system.
- Arduino microcontroller based electric charge system.
- Microcontroller based electric charge system.

Microprocessor based electric charge system is based on ARM Cortex A7 microprocessor and the system is introduced as a mini computer unit. Main board used here is an open source "Raspberry Pi" board to perform the energy monitoring, ADC sampling and power calculations, the biggest disadvantage of the system is the higher cost. "Raspberry Pi" board is a mini computer and runs on Dabian Linux. Power consumption and heat dissipation is little higher compared to micro controller based systems. Many compatibility issues are there when interfacing Modem and GPS module.

Arduino Microcontroller based electric charge system is an AT mega microcontroller based system board and introduced as Arduino Uno. INA 219 current sensor is used to calculate the ampere rate and Atmega microcontroller is used for computing and calibrating the power usage cost.

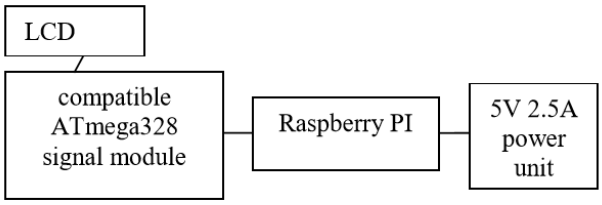

Fig 1: Block diagram for Micro Processor Based Electric Charge System

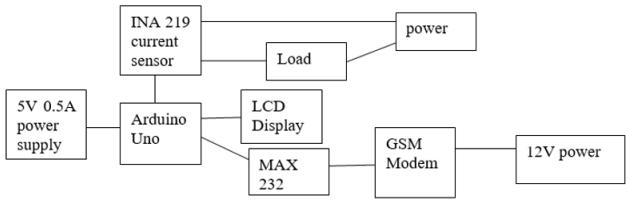

Fig 2: Block diagram for Arduino Based Electric Charge System

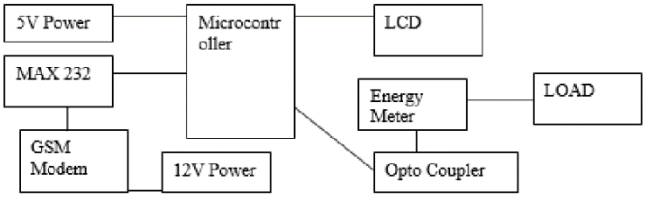

Fig 3: Block diagram for Microcontroller Based Electric Charge System

GSM modem is interfaced to send alert messages to the customer and GPS module can be interfaced to send location information to the web server. Due to the system board architecture, customizing the circuitry for our requirement is little complicated. Since we need to buy the entire system board, the cost is little high.

Energy meter & a GSM Modem are interfaced with a microcontroller unit in Microcontroller based electric charge system. Energy meter pulses are read by microcontroller and written programme will calculate the energy consumption and the cost. Cost will be sent to the GSM based mobile phone and will be displayed on the LCD screen. GPS module can be interfaced with the sent location information of the web server. "OptoCoupler" is used to isolate the energy meter from microcontroller circuit. system cost will increase due to high cost of the energy system.

B. Optimum Design

- The design which was selected as the optimum design (Figure-4) is based on PIC Microcontroller. This system uses several components to achieve the required goal. The GSM modem is used to send the final calculated output to the customer's mobile, GPS unit is used to get the location information from the satellite, LCD unit is used to display the output processed by the microcontroller, and the current measured by the current sensor. Keypad is used to input the mobile number. The PIC microcontroller is used to calculate the time taken for the job to complete and will gather data from all components to get the required output.

The methodology of the design is to calculate the cost for current usage and send an sms alert to the customer when the job is completed and send information about the location of the meter to the web server.

System Requirements:

- The cost of production should be low.
- System should be able to reset the system to process the new billing information.
- It must be able to show ampere value, time & the cost.

- It should be able to provide information about the location to the web server.
- It should be able to send an alerting message to customer mobile.
- User should be able to input his mobile number to get the job completion message

Proposed Optimum design consist of several sub systems as follows

- Charge Calculating sub system: It uses a current sensor to detect the current and built in timer module in PIC Microcontroller to calculate the time and with the help of a C programming language to calculate the cost.
- Display & Keypad Sub System: It is used to display the ampere rate, time, cost and the fully charged indicating message when the battery is fully charged. Keypad is used to input the mobile number of the user.
- GSM/GPRS Technology System & GPS Location Sub Systems: This unit is used to send an SMS alert to customer and GPS received information to the web server to indicate the location. GPS module is used to get location information from satellites.
- Backup solar power sub system: This is used to power the charging circuit when the main power source is failed to power the system.

IV. CALCULATIONS

A. Microcontroller

From PIC16f877A data sheet, maximum current into Vdd pin is 250mA and the maximum current out of Vss pin is 300mA. For safety reason current in to Vdd derated by 40%, then Idd=150mA. Protect from voltage spikes 0.5V is reduced at Vdd pin using protection resister.

$$r = v/i = 0.5/0.15 = 3.3\Omega \quad (1)$$

decoupling 0.1µF capacitor is used to minimize the effect of rapid changing in power demand by devices in the circuit. Current sensor: supply voltage (5Volt) is taken as a reference voltage.

B. Current sensor

supply voltage (5Volt) is taken as a reference voltage.

$$\text{Outcome} = (\text{Vrelate+} - \text{Vrelate-})/(1024-1) \quad (2)$$
$$= 5/1023 = 4.887\text{mV}$$

10-digit counter increment is proportional to 4. 887mV.When counter value increase to the maximum value (1023), then the applied voltage will be approximately 5V at sensor pin. Sensitivity(185v/A), Vcc (5.0V) and ADC Vref = Vcc, relationship between input voltage & ADC count is,

$$\text{Count} = \frac{1023 \times V_{in}}{V_{cc}} \quad (3)$$

$$\text{But, } V_{in} = (V_{cc}/2) + (0.185 \times I) \quad (4)$$

$$\text{Count} = \frac{1023}{V_{cc}} \left(\frac{V_{cc}}{2} + 0.185 \times I\right) \quad (5)$$

$$I = 0.0264(\text{count}-512) \quad (6)$$

For example: if count value is 600 then the ampere value will be 2.32A. When the value is 5A the voltage at sensor pin will be 3.425V. When the maximum measurable current value is 5A, the voltage value at ADC1 unit will be 3.425V. When the amp value is 5A counter value will be 701.Below result shows derived equation is accurately measuring the amp value of the current. Here the related voltage is taken as a supply voltage so supply voltage fluctuation won't influence the outcome.

$$I = 0.0264(701-512) = 5A \quad (7)$$

V. RESULTS AND DISCUSSION

Till the battery is charged fully display unit repeatedly display the required information such as time, amp value, and the fee. Fully charged message will be displayed as the battery get fully charged and the pay bill message will display the cost and an alert message will be sent to the user's mobile phone to indicate that the charging is completed.

Solar unit is used as a backup power to the station in the case of main power interrupted. Program can be written to calculate the cost for every hour, 30 min, or any required value thus if disconnected before battery being fully charged still cost can be paid for the current used up to that time. As the charging starts current will start to flow at a rate of five amperes. When the battery is getting charged value of the current flowing to the battery will be reduced slowly. Battery condition also can determine by examining the rate of change in amp value. When it takes long time to reduce the amp value than usual then we can suspect battery having a leakage. LED indicator is used to identify the current conduction and the battery status.

There are three Device Configuration methods used for configured the system such as Interrupt, Timer Interrupt and USART Configurations.

There are three testing methods used for test the system. such as Black box (defect testing), White box and Integration testing.

VI. CONCLUSION

This device is marketable because it can be able to use for multiple purpose applications and electric fueling system which is about to be introduced in the country. This device will be useful when used in the user's vehicle with the GPS module and the solar unit. GPS module will track the current location of the vehicle and web server provides location information about the station and thus easily calculates the distant to the charging station. Solar unit can be used to power the vehicle when battery power interrupted.

As a result, the key target of this paper is to introduce a cost effective and reliable electric charging System.

A. Limitation

Since it is taking much more time to charge the vehicle compare to gasoline fuel station, few meters are needed for one station to avoid congestion.

B. Further testing and evaluation

Can design a single unit to charge 5A, 20A or 30A batteries, Improvement can be done to automatically disconnect the charging system when it is reached to full charge by introducing a relay system, system can be modified to input the cost and charge accordingly to the cost and disconnect the charging circuit automatically when it reached the cost, Instead of sending longitude and latitude value to the server, values can be stored in SD card as a file and a script can be written to indicate directly the location in the Google map.

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