CHARGING STATION SYSTEM FOR E-AUTOMOTIVES WITH IOT MONITORING

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Abstract:

The Internet of Things (IoT) technology has immense potential for application in improvement and development of Smart Grid. The rising number of distributed generations, aging of present grid infrastructure and appeal for the transformation of networks has spare the interest in smart grid. The need for energy storage system primarily the electrical energy storage systems is growing as the prospects for their usage is becoming more compelling. Dynamic electrical energy storage system viz., Electric Vehicles (EVs) are relatively standard due to their excellent electrical properties and flexibility but the possibility of damage to their batteries is there in case of overcharging or deep discharging and their mass penetration profoundly impacts the grid. To circumvent the possibility of damage, EVs' batteries need a precise state of charge estimation to increase their lifespan and to protect the equipment they power. Based on ease of implementation and less overall complexity, this project proposes a real-time EV Charging Monitoring System (EVCMS) using coulomb counting method for SoC estimation and information is being shared with internet of things technology. The proposed EVCMS is implemented on hardware platform using appropriate sensing technology, central processor, interfacing devices and the Node MCU environment. An optimization model aimed at maximizing the trade revenue for EV's aggregator is presented aimed at enabling the smart charging.

I. INTRODUCTION

As per reports of National Renewable Energy Laboratory (NREL), mass production of EVs has limited adverse effect on the electricity generation need. For example, in USA, for EVs constituting the 50% of the total vehicles in use by year 2050 will entail only 8% increment in electricity generation and an increment of 4% in generation capacity meanwhile also considerably reducing the emissions from conventional vehicles and lowering the fuel usage in transportation sector.

Other effect of mass adoption of EVs on power grid are-

- Increase in the working temperature of transformers due to the extra load of charging EVs. This reduces the operating life, thereby incurring additional expenditure.
- The energy storage system ought to store electricity from the minimum carbon producing sources, e.g., nuclear energy and renewable energy. However, coinciding the demand and supply load curves is a big challenge.
- Shortage in electric power supply, if the accumulated EV charging profile constitutes the peak demand period.

However, charging of EVs at off peak hours augments the load curve for electric utilities. So, the usage of large no of EVs must be accurately optimized for various charging setups and technologies.

Demand Response is additional advantage to the grid by disrupting the EVs charging demand at peak hours. In parked condition, EVs generate or store electricity which can be fed back to grid using appropriate connections- this is known as vehicle-to-grid power or V2G power. The batteries of EVs plugged into charging infrastructure can act as distributed energy storage systems for the electrical grid. The electrical energy delivered backed to the grid must be priced such that the additional cost incurred must be recovered back as the battery's lifecycle is reduced due to frequent charging-discharging. The distributed storage providesadvantages such as making the grid more steady, secure and resilient by regulating frequency and the spinning reserve as backup power in the distribution system. Large scale integration of intermittent sources of energy e.g., wind and solar sources into the grid is facilitated by V2G system. For the world-wide shift to the emerging green and sustainable energy economy, V2G is an important enabler.

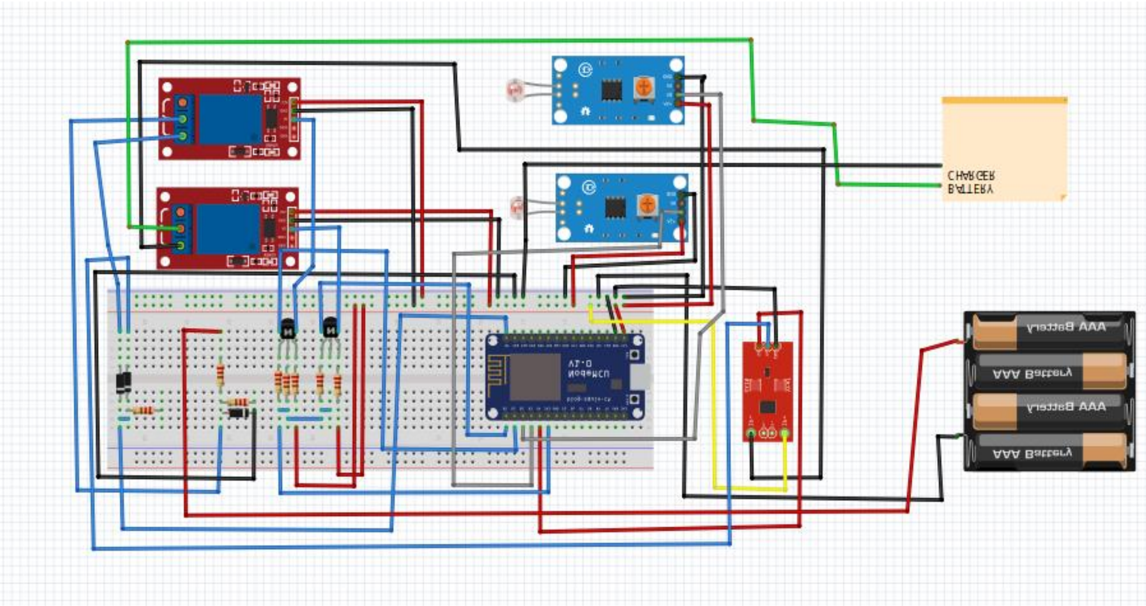
II. SYSTEM SPECIFICATIONS

2.1RESEARCH METHODOLOGY

EV Charging Battery Monitoring System (EVCMS) is a smart system whose function is to monitor the vigor of a battery pack. BMS computes the battery's capacity, depreciation of battery while the charging/discharging and correct productivity of the battery and provides this information in real time to users. This mitigates the sense of incorrect safety of periodic battery assessment as it is vigilant to emerging issues before hand the occurrence of a possible malfunction. As every cell is observed separately, so any damage can be checked and appropriate warnings against the values pre-set by consumers and protective measures can be employed, safeguarding the other cells against cumulative damage thereby extending battery life. EVCMS logs history data of all measured parameters for further analysis and future reference.

2.2 Future Scope

- The scope is huge for opening up charging stations.it will do two things-drive up electric vehicle less, and put places on the map.
- The best bit is whoever can use solar energy to generate all thin power will also garner brownie points. main is the long-term goal of tesla is to feed most of its 800 charging stations with a solar panel and battery system.
- however, in June 2017 a few of them were actually connected to this system. most of them are still directly connected to the grid.
- In future the usage of electric vehicles increases as charging stations also increases.
- Installation of more charging stations takes place as usage of electric vehicles.



Circuit Diagram of Implementation

III. DESIGN AND ARCHITECTURE OF COMPONENTS

3.1 NODE MCU

Development boards, such as Arduino and Raspberry Pi, are common choices when prototyping new IoT devices. Those development boards are essentially mini-computers that can connect to and be programmed by a standard PC or Mac. After it has been programmed, the development boards can then connect to and control sensors in the field. Because the "I" in IoT stands for internet, the development boards need a way to connect to the internet. In the field, the best way to connect to the internet is by using wireless networks. However, Arduino and Raspberry Pi do not have built-in support for wireless networks. Developers will have to add a Wi-Fi or cellular module to the board and write code to access the wireless module.

In this article, I will introduce an open source IoT development board called Node MCU. One of its most unique features is that it has built-in support for Wi-Fi connectivity, and hence makes IoT application development much easier.

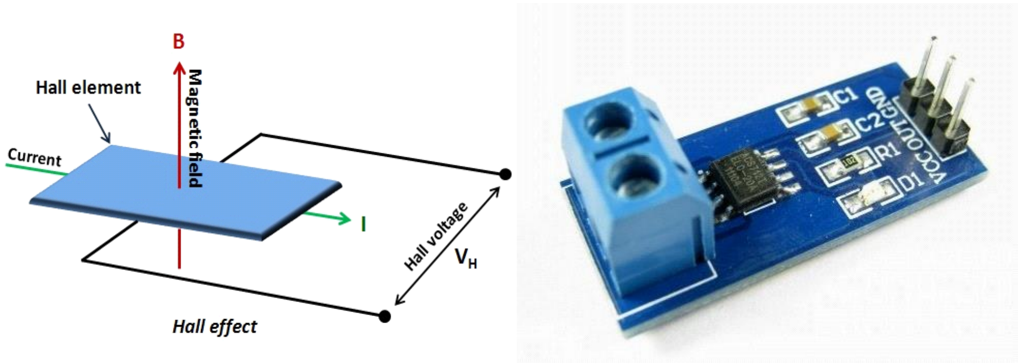
3.2 Hardware Used

1.Current Sensor (ACS712)
2.Voltage Converter
3. LDR Module
4.Relay
5. Node MCU
6. multiplexer
7. Amplifier

3.2.1 Current Sensor (ACS712)

ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, commercial, and communications systems. The device package allows for easy implementation by the customer. Typical applications include motor control, load detection and management, switch mode power supplies, and over current fault protection. The device is not intended for automotive applications.

The device consists of a precise, low-offset, linear Hall circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction. Path generates a magnetic field which the Hall IC converts into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer.



ACS 712 Sensors

The terminals of the conductive path are electrically isolated from the signal leads. This allows the ACS712 to be used in applications requiring electrical isolation without the use of opto-isolators or other costly isolation techniques.

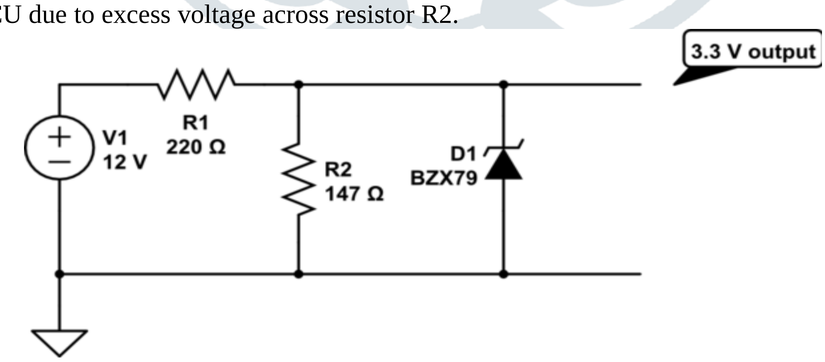
Features and Benefits

- Low-noise analog signal path
- Device bandwidth is set via the new FILTER pin
- 5µs output rise time in response to step input current
- 80 kHz bandwidth
- Total output error 1.5% at TA = 25°C
- Small footprint, low-profile SOIC8 package
- 1.2mΩ internal conductor resistance
- 2.1kVRMS minimum isolation voltage from pins 1-4 to pins 5-8
- 5.0 V, single supply operation
- 66 to 185 mV/A output sensitivity
- Output voltage proportional to AC or DC currents
- Factory-trimmed for accuracy
- Extremely stable output offset voltage
- Nearly zero magnetic hysteresis
- Ratio metric output from supply voltage

The ACS712 device comes in three variants, providing current range of±5A (ACS712-05B), ±20A (ACS712-20B), and ±30A (ACS712-30A). The ACS712-05B can measure current up to ±5A and provides output sensitivity of 185mV/A (at +5V power supply), which means for every 1A increase in the current through the conduction terminals in positive direction, the output voltage also rises by 185 mV. The sensitivities of 20A and 30A versions are 100 mV/A and 66 mV/A, respectively.

3.2.2 Voltage Converter

Voltage converter is designed by using two potentiometer that are R1=220 Ohm and R2=147 Ohm respectively. A Zener diode of 3.3 V is connected across R2 used to maintain the voltage up to 3.3V when battery is fully charged and also maintain the current up to 10mA. Excess voltage can be by passed to ground through Zener diode. Zener diode provide the protection to Node `MCU due to excess voltage across resistor R2.



Voltage converter Circuit

It senses the voltage level of the battery. when the battery level is indicated in between the 3.3v that could be easily measured by the NODE MCU. The output from the voltage converter will be taken as, if the battery is full then the output will be 3.3v if not less than 3.3v

3.2.3 LDR Module

LDR sensor module is used to detect the intensity of light. It is associated with both analog output pin and digital output pin labeled as AO and DO respectively on the board. When there is light, the resistance of LDR will become low according to the intensity of light and greater the intensity of light, the lower the resistance of LDR. The sensor has a potentiometer knob that can be adjusted to change the sensitivity of LDR towards light.

LDR Module

Specifications

- Operating Voltage: 3.3V to 5V DC
- Operating Current: 15ma
- Output Digital - 0V to 5V, Adjustable trigger level from preset
- Output Analog - 0V to 5V based on light falling on the LDR
- LEDs indicating output and power
- PCB Size: 3.2cm x 1.4cm
- LM393 based design

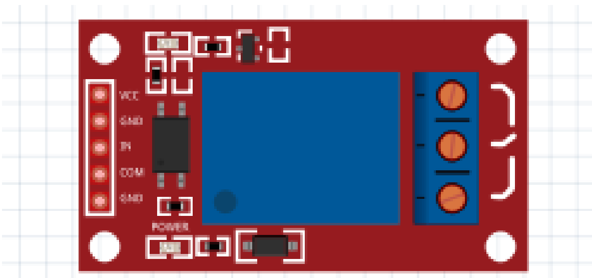
3.2.4 Direction for Using LDR Module

- Photosensitive resistor module most sensitive to environmental light intensity is generally used to detect the ambient brightness and light intensity.
- Module light conditions or light intensity reach the set threshold, DO port output high, when the external ambient light intensity exceeds a set threshold, the module D0 output low;
- Digital output D0 directly connected to the MCU, and detect high or low TTL, thereby detecting ambient light intensity changes;
- Digital output module DO can directly drive the relay module, which can be composed of a photoelectric switch.
- Analog output module AO and AD modules can be connected through the AD converter, you can get a more accurate light intensity value.

3.2.5 Relays

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers

An electromagnetic relay uses electromagnet to control "on" or "off" status of the operating circuit. When placing voltage to both ends of a coil, the coil will be flowed with current and generate electromagnetic effect. The electromagnet will attract armature to the iron core against tension of spring, so as to pull the movable contact of the armature to the stationary contact (normally open contact, or NO). When cutting off power, attraction of the electromagnet will disappear and the armature will restore its position under tension of the spring to release the movable contract from the stationary contact (normally closed contract or NC). The pulling and releasing are used to control opening and closing of the circuit. Normally open and closed contacts respectively refer to the stationary contract is in the state of "on" when the coil is cut off from power and the stationery contract is in the state of "off" when the coil is connected to power.



Relay Module

3.2.6 Node MCU

• Voltage:3.3V.

• Wi-Fi Direct (P2P), soft-AP.

• Current consumption: 10uA~170mA.

• Flash memory attachable: 16MB max (512K normal).

• Integrated TCP/IP protocol stack.

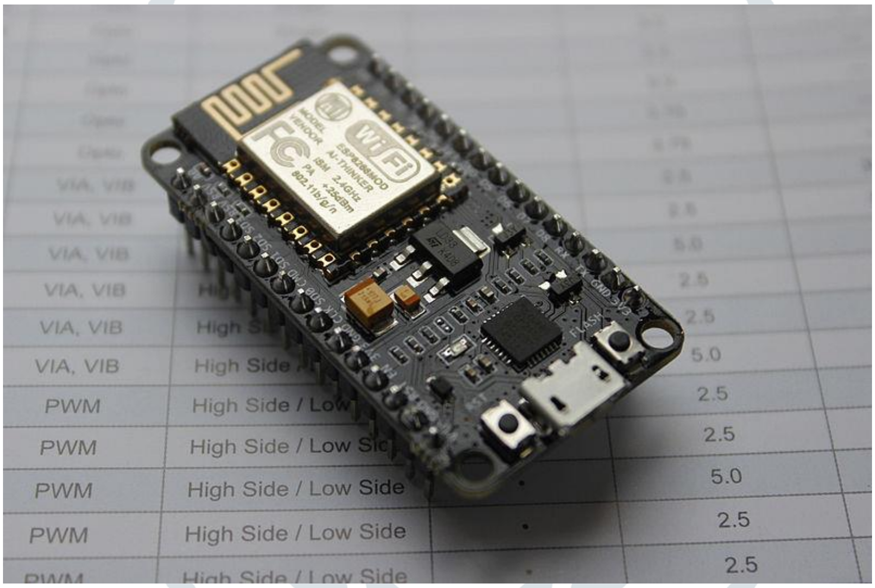
• Processor: Ten silica L106 32-bit.

• Processor speed: 80~160MHz.

• RAM: 32K + 80K.

• GPIOs: 17 (multiplexed with other functions).

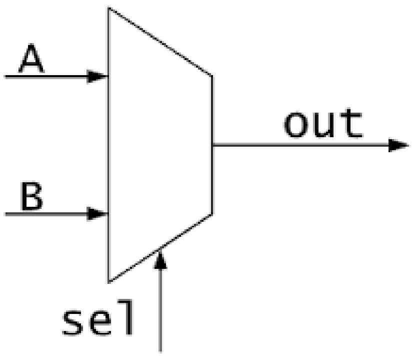
• Analog to Digital: 1 input with 1024 step resolution.



Node MCU

3.2.7 Multiplexer

- Multiplexing is the generic term used to describe the operation of sending one or more analogue or digital signals over a common transmission line at different times or speeds and as such, the device we use to do just that is called a **Multiplexer**.

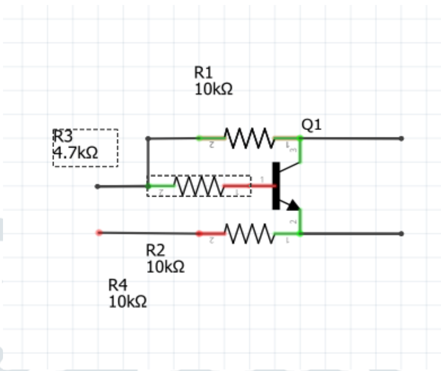


Multiplexer

- The multiplexer, shortened to "MUX" or "MPX", is a combinational logic circuit designed to switch one of several input lines through to a single common output line by the application of a control signal. Multiplexers operate like very fast acting multiple position rotary switches connecting or controlling multiple input lines called "channels" one at a time to the output.

3.2.8 Amplifier

An amplifier, electronic amplifier or (informally) amp is an electronic device that can increase the power of a signal (a time-varying voltage or current). It is a two-port electronic circuit that uses electric power from a power supply to increase the amplitude of a signal applied to its input terminals, producing a proportionally greater amplitude signal at its output. Amplifier is used for the triggering the relays for switching.



Amplifier

IV. RESULTS AND DISCUSSION

4.1 Initial output

The output will be displayed in serial monitor after NODE MCU connected to the blynk cloud. At first voltage level of the battery is displayed in the serial monitor.

```
voltage: 1.25
need to charge
voltage: 1.26
need to charge
voltage: 1.26
need to charge
voltage: 1.24
need to charge
```

Initial output at serial monitor

4.2 Start

When the START LDR is activated the charging station gets activated and battery gets charging.

```
voltage: 1.24
need to charge
56cost: 0.00
voltage: 1.26
need to charge
6CHARGING
432.00
821.00
```

Start command

4.3 Stop

When the STOP LDR is activated the charging process will be stop and diplay the cost charged for the time of usage.

```
12028.57
12417.57
12796.57
910cost: 7.50
voltage: 1.26
need to charge
voltage: 1.29
need to charge
[439369] Connecting to blynk-cloud.com:80
```

Stop command

4.4 Reset

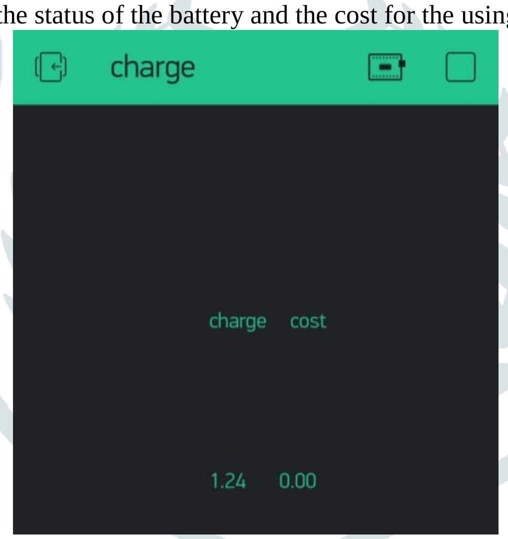
To reset the whole values and readings RESET LDR is used. By resetting the next user can use the charging station system with the new readings and cost fare for usage

```
voltage: 1.27
need to charge
voltage: 1.27
need to charge
reset
timep: 159
cost: 3.00
```

Reset command

4.5 Output in Blynk app

In the Blynk app the values shown are the status of the battery and the cost for the using.



Output shown in blynk

4.6 Commercial results

While electric vehicle markets are in early development and adopters are just beginning to establish regular charging schedules, the projects delivered valuable data that utilities continue to analyze. Evaluation of charging station usage and behavior provides key insight that can inform utility decisions as plug-in electric vehicle adoption rises. The utilities identified several common technical and market needs that must be met before electric vehicle charging stations can be adopted more widely:

- Improve significantly the reliability of communications and ease of integration between smart meters and charging stations.
- Achieve better coordination with equipment vendors to ensure that performance specifications are understood and properly implemented.
- Reduce the costs for equipment and maintenance for public charging stations.
- Make Level 2 chargers available to residential customers in a convenient and cost-effective manner.

Develop pricing strategies for public stations that encourage consumers to use them, don't exacerbate peak demands, and enable profitable business models for ownership and operation.

4.7 Conclusion

Internet of Things (IoT) refers to the networked interconnection of everyday objects. IoT has a major role in the rapid development of smart grid. The implementation of Smart Grid devices in the utility grid will influence vast modification in grid management and usage of electric power in upcoming years. The integration of distributed generation necessitates the deployment of energy storage system. Due to better electrical characteristics, the dynamic energy storage system i.e., Electric Vehicles (EVs) is a good prospect although the probability of damage to battery pack in case of overcharging or deep discharging situations is there and uncontrolled charging can severely impact the grid functioning. To mitigate the danger of damage, an accurate real-time capacity determination of a battery pack is desired to increase their lifespan and to protect the equipment they power. A less complex and easy to implement algorithm i.e., coulomb counting technique is implemented in this paper and the estimated SoC along with measured parameters are made available in real time to the user on a remote basis in form of messaging communication. Further an optimization model for maximizing the trade revenue for aggregate of EVs is presented aimed at facilitating smart charging to reduce the impact of increased penetration of EVs on grid.

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