Range anxiety-free electric vehicles: an integrated approach using v2v charging and solar power

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Abstract: *The integration of electric vehicles (EVs) into the grid has become an important topic because of the widespread usage of EVs. The possible increase in demand due to EVs has become a concern. However, recent studies have shown that EVs maybe beneficial in terms of grid reliability and flexibility by using charging models such as vehicle-to-grid(V2G) energy transfer, vehicle-to-home(V2H) energy transfer and vehicle-to-vehicle(V2V) energy transfer. The widespread adoption of electric vehicles (EVs) grapples with a significant challenge known as 'range anxiety', which is the fear of depleting the battery charge before reaching the destination. This project proposes an inventive strategy to mitigate range anxiety by integrating Vehicle-to-Vehicle(V2V) charging as a fundamental component of the EV ecosystem. Moreover, it can charge the car any-time, anywhere, like a power bank. The V2V charging mechanism harnesses the energy-sharing capabilities of EVs, facilitating power exchange between vehicles on the road. This technology can effectively solve the problem of the limited number of plug-in stations. It underscores the potential of V2V charging, in tandem with solar panels, as a promising stride towards a more sustainable and range-anxiety free future for electric vehicle users. The primary target of this project is to provide valuable insights for the advancement of electric vehicle technology.*

Keywords: *Embedded System; Electromagnetic Induction; Arduino IDE*

I. INTRODUCTION

Transportation is an important aspect of our lives, just like food and water. It affects daily lives, but it must be controlled by intelligent systems; one day in the future it will be completely controlled by things, not people. V2V communication is typically developed as part of Intelligent Transport Systems (ITS). The implementation of this technology is more environmentally beneficial than the use of fossil fuels, which contribute to the greenhouse effect. This alternative technology is developing rapidly and will soon become the current transportation system. The electric car can be further upgraded to become a self-driving vehicle. One of the challenges of electric vehicles is the energy management system, which involves charging and discharging the car. V2V can be particularly useful because charging can happen anywhere without having to travel to a specific charging station; currently there are not as many charging facilities for electric cars as there are for traditional fossil fuel charging stations (gas stations). The V2V system can be further enhanced by using a wireless charging system in which the source car charges the other vehicle without using a physical wire. Because it does not require stopping or standing still, this wireless charging solution is more promising and efficient. In this study, the concept of wireless charging of a real-time inter-vehicle charging system is discussed. Wireless technology allows a vehicle such as a bus or an automated vehicle to continue driving. This study is a continuation of previous research that underlies the wireless system. It discusses the concept of an automatic vehicle.

II. CONTENT

Embedded systems:

As its name suggests, Embedded means something that is attached to another thing. An embedded system can be thought of as a computer hardware system having software embedded in it. An embedded system can be an independent system or it can be a part of a large system. An embedded system is a microcontroller or microprocessor based system which is designed to perform a specific task. For example, a fire alarm is an embedded system; it will sense only smoke. Embedded Systems are easily Customizable, have low power consumption, cost is low and they enhance performance.
Components of Embedded Systems:

- It has hardware.
- It has application software.
- It has Real Time Operating system (RTOS) that supervises the application software and provide mechanism to let the processor run a process as per scheduling by following a plan to control the latencies. RTOS defines the way the system works. It sets the rules during the execution of application program. A small scale embedded system may not have RTOS. So embedded system can be defined as a Microcontroller based, software driven, reliable, real-time control system.

Basic structure of an Embedded system:

- Sensor − It measures the physical quantity and converts it to an electrical signal which can be read by an observer or by any electronic instrument like an A2D converter. A sensor stores the measured quantity to the memory.
- A-D Converter − An analog-to-digital converter converts the analog signal sent by the sensor into a digital signal.
- Processor & ASICs − Processors process the data to measure the output and store it to the memory.
- D-A Converter − A digital-to-analog converter converts the digital data fed by the processor to analog data.
- Actuator − An actuator compares the output given by the D-A Converter to the actual (expected) output stored in it and stores the approved output.

Electromagnetic induction

Electromagnetic Induction is a process where a conductor placed in a changing magnetic field (or a conductor moving through a stationary magnetic field) causes the production of a voltage across the conductor. This process of electromagnetic induction, in turn, causes an electrical current-it is said to induce the current. Faraday explained electromagnetic induction using a concept he called lines of force. Coils of wire in the base station (the charging plate) create a magnetic field as the current passes through. This field can induce an electrical current in an adjacent coil of wire without actually touching it. Inductive charging uses an electromagnetic field to transfer energy between two objects. This is usually done with a charging station. Energy is sent through an inductive coupling to an electrical device, which can then use that energy to charge batteries or run the device.

Wireless Charging Techniques**:**

- Magnetic Inductive Coupling
- Magnetic Resonance Coupling
- Microwave Radiation

Three major techniques for wireless charging are magnetic inductive coupling, magnetic resonance coupling, and microwave radiation. The magnetic inductive and magnetic resonance coupling work on near field, where the generated electromagnetic field dominates the region close to the transmitter or scattering object. The near-field power is attenuated according to the cube of the reciprocal of the distance. Alternatively, the microwave radiation works on far field at a greater distance.

III. METHODOLOGY

Existing system:

In the existing systems of EV charging grid to vehicle charging is present. Mostly plug-in EV chargers are implemented. Wireless chargers are not yet implemented commercially since plug-in chargers are simple to design and more affordable. To charge an Electric vehicle require a charging system where one can plug in their EV to charge. Each vehicle has a different type of charging connector which needs to be plugged into the charging module as well as the vehicle to start with charging. Depending upon the Level of charging system it will take time to charge the vehicle. Some fast charging capable charging stations are able to charge the vehicle in a stipulated time. But Traditional charging systems take up to 8 hours to charge the vehicle 100%. This can vary

depending upon the capacity of battery and type of battery. This method of charging is time consuming as well as still there are very less numbers of charging stations in India.

Proposed sytem:

Due to limited availability of charging stations, charging of EVs will be a major problem. In case of emergency charging requirements, the availability of grid connected charges is very limited and in case of charge down situations vehicles are unable to move from that spot to the charging stations. For that purpose a wireless charger is proposed which serves dual purpose.

1. Can charge from grid connected power supply
2. Can get wirelessly charged from another vehicle
3. Can wirelessly charge to another vehicle

In this project, vehicle 1 is powered with solar panel. Energy generated from the panel is stored in battery. Stored battery energy is used to run the vehicle -1 and also to charge the another vehicle if needed. Vehicle to Vehicle charging is done through wireless power transfer.

Block diagrams:

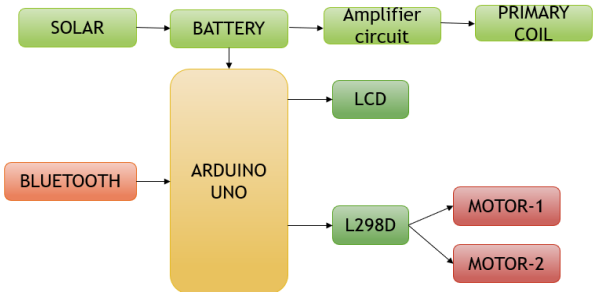

Fig 1: Block diagram for vehicle-1

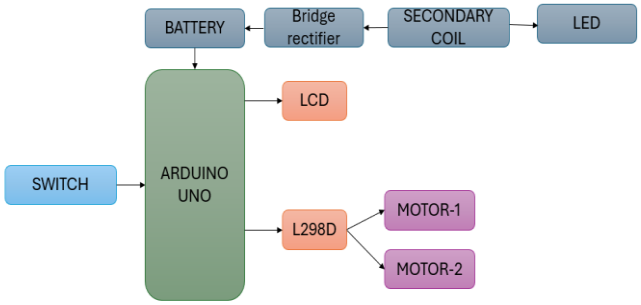

Fig 1: Block diagram for vehicle-2

IV. DESCRIPTION

The working of each component in this project is explained in this section. Let's talk about them one by one:

Hardware Description:

(1) Arduino Uno:

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

Fig 3: Arduino Uno R3 Front

(2) LCD:

A liquid crystal display (LCD) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. One of the most common devices attached to a controller is an LCD display. Some of the most common LCDs connected to the controllers are 16x1, 16x2 and 20x2 displays. This means 16 characters per line by 1 line 16 characters per line by 2 lines and 20 characters per line by 2 lines, respectively.

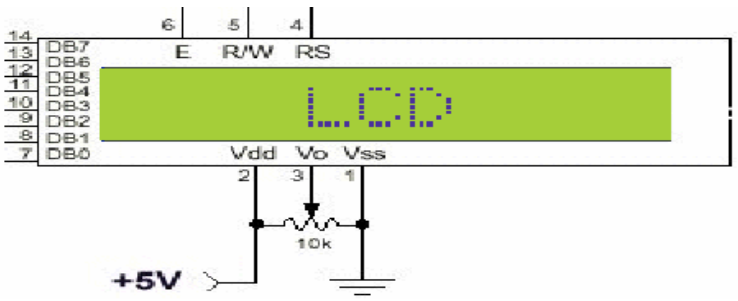

Fig 4: pin diagram of 1x16 lines lcd

(3) DC motor:

A Direct Current (DC) motor is a rotating electrical device that converts direct current, of electrical energy, into mechanical energy.

DC gear Motor:

A gear motor is an all-in-one combination of a motor and gearbox. The addition of a gear head to a motor reduces the speed while increasing the torque output. In order to select the most suitable gear motor for application user must first compute the load, speed and torque requirements for the application. Most of the DC motors can be complimented with one of the unique gearheads, providing us with a highly efficient gear motor solution.

Fig 5: DC gear motor

(4) L298N Motor driver module:

L298N Motor Driver Module is a high power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control.

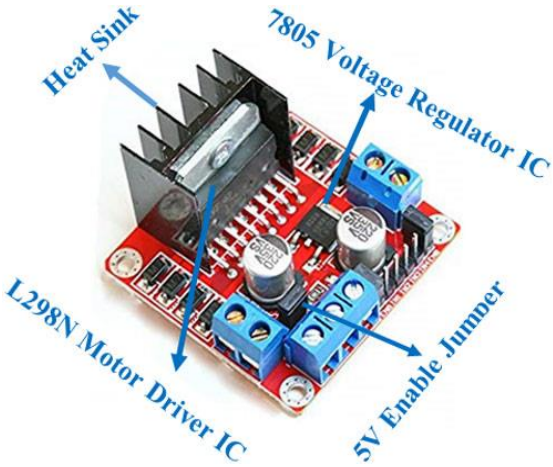

Fig 6: L298N Motor Driver Module

(5) Bluetooth Module HC-05:

HC-05 is a Bluetooth module which is designed for wireless comunication. This module can be used in a master or slave configuration. It is used for many applications like wireless headset, game controllers, wireless mouse, wireless keyboard and many more consumer applications. It has range up to <100m which depends upon transmitter and receiver, atmosphere, geographic & urban conditions. It is IEEE 802.15.1 standardized protocol, through which one can build wireless Personal Area Network (PAN). It uses frequency-hopping spread spectrum (FHSS) radio technology to send data over air. It uses serial communication to communicate with devices. It communicates with microcontroller using serial port (USART).

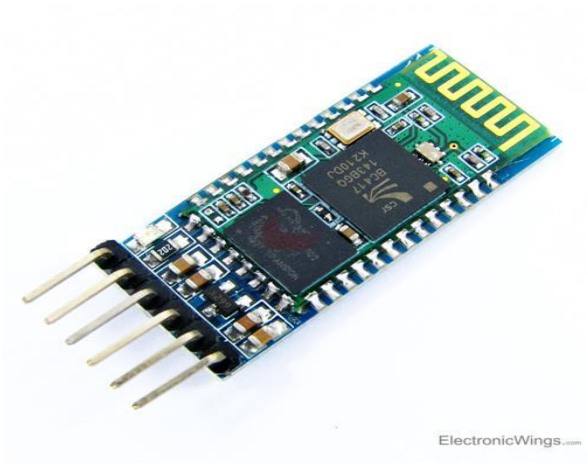

Fig 7: HC-05 Bluetooth Module

(6) IRFZ44N n-channel power mosfet:

The IRFZ44N is a N-channel MOSFET with a high drain current of 49A and low Rds value of 17.5 mΩ. It also has a low threshold voltage of 4V at which the MOSFET will start conducting. Hence it is commonly used with microcontrollers to drive with 5V. However a driver circuit is needed if the MOSFET has to be switched in completely. The IRFZ44N is known for its high drain current and fast switching speed. The IRFZ44N is a versatile and reliable power MOSFET that's well-suited for a wide range of high-power switching applications.

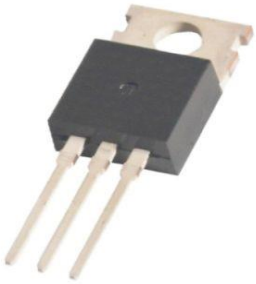

Fig 8: IRFZ44N N-Channel Power MOSFET

(7) Solar panel RL-SP04:

The RL-SP04 is likely a small to medium-sized solar panel designed for various low-power applications. It's probably intended for projects that require a portable or easily integrated solar power source. It could be a monocrystalline, polycrystalline, or thin-film panel. Likely designed for portability, so it's probably relatively compact and lightweight. The power output is likely in the range of a few watts to tens of watts, suitable for charging small batteries or powering low-power devices. It likely consists of solar cells encapsulated in a protective material (e.g., tempered glass, plastic).

A solar cell is a semiconductor device that can convert solar radiation into electricity. Its ability to convert sunlight into electricity without an intermediate conversion makes it unique to harness the available solar energy into useful electricity. That is why they are called Solar Photovoltaic cells.

Fig 9: RL-SP04 solar panel

SOFTWARE DESCRIPTION:

Arduino software (IDE):

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The Arduino Software (IDE) uses the concept of a sketchbook: a standard place to store programs (or sketches). The sketches in the sketchbook can be opened from the File > Sketchbook menu or from the Open button on the toolbar. The first time while running the Arduino software, it will automatically create a directory for the sketchbook. One can view or change the location of the sketchbook location from with the Preferences dialog.

Versions of the Arduino Software (IDE) prior to 1.0 saved sketches with the extension .pde. It is possible to open these files with version 1.0, user will be prompted to save the sketch with the .ino extension on save.

1. Verify : Checks your code for errors compiling it. It will report memory usage for code and variables in the console area.
2. Upload : Compiles your code and uploads it to the configured board. See uploading below for details.
3. New : Creates a new sketch.
4. Open : Presents a menu of all the sketches in your sketchbook. Clicking one will open it within the current window overwriting its content.
5. Save : Saves your sketch.

Arduino IDE setup:

Step 1: Arduino IDE Initial Setup

Download Arduino Integrated Design Environment (IDE) here (Most recent version: 1.6.5):

https://www.arduino.cc/en/Main/Software.

Step 2: Board Setup Procedure

Users have to tell the Arduino IDE what board they are uploading to. Select the Tools pulldown menu and go to Board. This list is populated by default with the currently available Arduino Boards that are developed by Arduino. If they are using an Uno or an Uno-Compatible Clone (ex. Funduino, SainSmart, IEIK, etc.), select Arduino Uno. If they are using another board/clone, select that board.

Step 3: IDE COM Port Setup

If downloaded the Arduino IDE before plugging in Arduino board, when plugged in the board, the USB drivers should have installed automatically. The most recent Arduino IDE should recognize connected boards and label them with which COM port they are using. Select the Tools pulldown menu and then Port. Here it should list all open COM ports. Select the Arduino board that you have connected to the PC.

If the setup was successful, in the bottom right of the Arduino IDE, you should see the board type and COM number of the board you plan to program. The Arduino Uno occupies the next available COM port; it will not always be COM3. At this point, your board should be set up for programming, and you can begin writing and uploading code.

Step 4: Testing Your Settings: Uploading Blink

One common procedure to test whether the board you are using is properly set up is to upload the "Blink" sketch. This sketch is included with all Arduino IDE releases and can be accessed by the File pull-down menu and going to Examples, 01.Basics, and then select Blink. Standard Arduino Boards include a surface-mounted LED labeled "L" or "LED" next to the "RX" and "TX" LEDs, that is connected to digital pin 13. This sketch will blink the LED at a regular interval, and is an easy way to confirm if your board is set up properly and you were successful in uploading code. Open the "Blink" sketch and press the "Upload" button in the upper-left corner to upload "Blink" to the board.

Step 5: Press the Upload button to upload the program to the board

Step 6: Confirm that your board is working as expected by observing LED

IV.RESULTS

In this working model, the integration of Vehicle-to-Vehicle(V2V) charging and solar technology in electric vehicles(EVs) has demonstrated significant potential in enhancing the efficiency, sustainability, and practicality. We developed two robotic vehicles, one with a solar panel on top, and the other with visible electronic components including batteries and an LCD display. The vehicle with the solar panel likely showed the ability to charge its batteries using solar energy. The transfer of power from the solar-charged vehicle to the other vehicle is done wirelessly using transformer coils. The vehicle receiving the charge likely experienced an extension in its operational range. The LCD on the second vehicle displays charge sharing status.

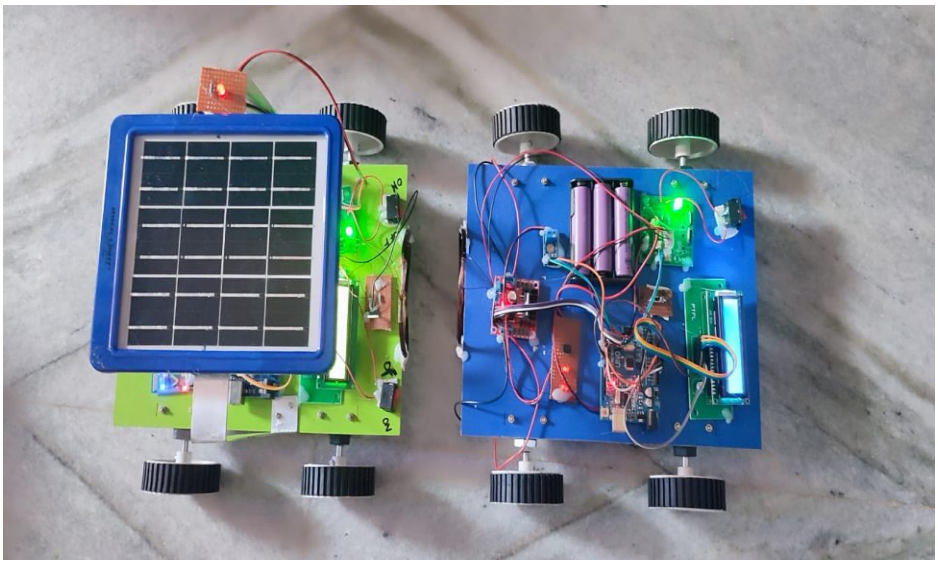

Fig 10: Vehicle to Vehicle charging in EVs

V.CONCLUSION

This project model presents a compelling case for the implementation of V2V wireless charging as a practical solution to the limitations of current EV charging infrastructure. The ability of EVs to function as both energy consumers and suppliers, coupled with the flexibility of wireless charging, offers a significant advancement in sustainable transportation. The proposed system effectively addresses range anxiety and enhances charging accessibility, paving the way for wider EV adoption. This article provides valuable insights into the integration of Vehicle-to-Vehicle (V2V) charging and solar technology in electric vehicles, with a specific emphasis on mitigating range anxiety and promoting sustainable electric mobility. The key findings underscore the transformative impact of these technologies on the modern transportation landscape. V2V charging reveals its promise as a solution to extend the driving range of electric vehicles. In practical scenarios, V2V charging systems significantly alleviate range anxiety, instilling greater confidence in EV users for both urban and long-distance travel. The convenience of quick and efficient charging from nearby vehicles positions V2V charging as a practical alternative to traditional methods. The effective integration of solar panels into electric vehicles demonstrates the tangible benefits of harnessing solar energy. The generated solar power not only supplements the vehicle's energy requirements but also contributes to reducing the environmental impact of electric mobility. Solar integration holds the potential to extend driving range and enhance energy independence. Crucially, V2V charging and solar integration directly address range anxiety among electric vehicle users by providing a safety net for energy availability and extending the driving range.

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