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Charging and Regeneration of Hybrid Vehicles Using Wireless Power

P.S.V.Anudeep[1], K.Vijaya Kumar[2], B.N.S.Anudeep[3], S.Ravindra Reddy[4] and K.Sampath Siva Kumar[5]

[1]*Student, EEE Department, Pragati Engineering College, Surampalem, India.*
[2]*Student, EEE Department, Pragati Engineering College, Surampalem, India.*
[3]*Student, EEE Department, Pragati Engineering College, Surampalem, India.*
[4]*Student, EEE Department, Pragati Engineering College, Surampalem, India.*
[5]*Student, EEE Department, Pragati Engineering College, Surampalem, India.*

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ABSTRACT

Wireless power transfer (WPT) using 'Inductive power transfer' is the technology which could set human free from the annoying wires. WPT technology is developing rapidly in recent years. At kilowatts power level, the transfer distance increases from several millimeters to several hundred millimeters with a grid to load efficiency above 90%. The advances make the WPT very attractive to the electric vehicle (EV) charging applications in both stationary and dynamic charging scenarios. This paper reviewed the technologies in the WPT area applicable to EV wireless charging. By introducing WPT in EVs, the obstacles of charging time, range, and cost can be easily mitigated. Battery technology is no longer relevant in the mass market penetration of EVs. Electric vehicles are creating more and more of their own electricity from daylight, wind and other sources including regeneration. Regeneration converts wasted heat and movement in the vehicle into electricity, as with a turbine in the exhaust. More elegantly, regeneration prevents wasted heat and movement in the first place as with regenerative suspension giving a better ride and longer range and flywheels replacing burning brake disks. Shock absorbers can create electricity that controls them to give a smoother ride. Yes, it does make sense. Indeed it is the future.

Keywords: Oscillator, Resonance circuits, Rectifier, Microcontroller, WPT and EV.

1. INTRODUCTION

In olden days gasoline engine technology vehicles have now become one of the major contributors of greenhouse gases. Plug-in Electric Vehicles (PEVs) have been proposed to achieve environmental friendly transportation. Even though the PEV usage is currently increasing, a technology breakthrough would be required to overcome battery related drawbacks. Although battery technology is evolving, drawbacks inherited with batteries such as; cost, size, weight, slower charging characteristic and low energy density would still be dominating constrains for development of EVs. Furthermore, PEVs have not been accepted as preferred choice by many consumers due to charging related issues. To address battery related limitations, the concept of dynamic Wireless Power Transfer (WPT)[3] enabled EVs have been proposed in which EV is being charged while it is in motion. WPT enabled infrastructure has to be employed to achieve dynamic EV charging concept. The weight of the battery pack can be reduced as the required energy storage is lower if the vehicle can be powered wirelessly [4] while driving. Stationary WPT charging where EV is charged wirelessly. When it is stopped it is simpler than dynamic WPT in terms of design complexity. However, stationary WPT does not increase vehicle range compared to wired-PEVs. WPT is the transmission of electrical power from the power source to an electrical load without the use of physical connectors.

"Wireless power transfer"[1] is a collective term that refers to a number of different technologies for transmitting energy by means of electromagnetic fields. In general a WTP consists of a "transmitter" connected to a source of power such as a mains power line, which converts the power to a time-varying electromagnetic field, and one or more "receiver" devices which receive the power and convert it back to DC or AC electric current which is used by an electrical load. At the transmitter the input power is converted to an oscillating electromagnetic field by some type of "antenna" device. Antenna may be a coil of wire which generates a magnetic field, a metal plate which generates an electric field, an antenna which radiates radio waves, or a laser which generates light. A similar antenna or coupling device at the receiver converts the oscillating fields to an electric current. An important parameter that determines the type of waves is the frequency f in hertz of the oscillations. The frequency determines the wavelength $\lambda = c/f$ of the waves which carry the energy across the gap, where c is the velocity of light.

2. PROPOSED SYSTEM

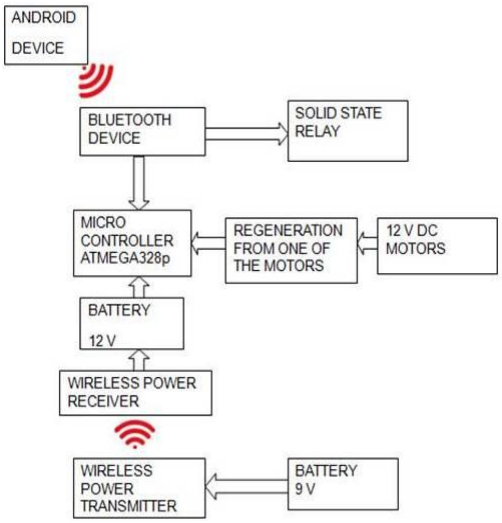

Fig 2.1 Block Diagram of Hybrid Vehicle Using Wireless

2.1 Power Transfer and Regeneration

The circuit is built around a Bluetooth device, transmitter and receiver (tesla coils), microcontroller and relay. First, we connect the Bluetooth of our Android device with Bluetooth device for arduino. Then after pairing, we give the commands to the microcontroller through the Bluetooth. The Microcontroller is given supply from a battery of 12V with the help of a voltage regulator it receives the signal from the Bluetooth device. Then it processes & send signal to the specific relays that have to operate. It also provides supply to the devices like Bluetooth. For each command in the Bluetooth specific relays operate and make the respective motors to move in that specific direction.

The Electric Vehicle battery is charged wirelessly [12] by using Tesla coil [1]. Here when the Tesla coil in the charging station is energized using the supply, it produces flux. This flux gets cut by another Tesla coil arranged in the vehicle. This induces voltage in the secondary Tesla coil in the vehicle. Whenever the load is connected to the secondary tesla coil current flows through it. The wireless power [1] fed to the battery of the vehicle.

A wheel is attached with a DC Motor so that it can rotate with the wheel when vehicle is moving. Then DC motor acts as a dynamo and generated electricity. This regenerated energy is given back to the battery and the battery gets charged while moving. This increases the time taken for the discharge of battery.

3. HARDWARE IMPLEMENTATION.

This paper is designed to State-of-art WPT technology for future transportation. This feat is achieved with Arduino board. Arduino is a single board microcontroller, intended to make the application of interactive objects or environments more accessible. The hardware consists of an open source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. Pre-programmed into the on-board microcontroller chip is a boot-loader that allows uploading programs into the microcontroller memory without needing a chip /device programmer. Serial 0 (RX) and 1 (TX) is used to receive (RX) and transmit (TX) TTL serial data. On the Arduino Diecimila, these pins are connected to the corresponding pins of the FTDI USB-to-TTL Serial chip. On the Arduino BT, they are connected to the corresponding pins of the WT11 Bluetooth module. On the Arduino Mini and LilyPad Arduino, they are intended for use with an external TTL serial module. In addition to the specific functions listed below, the digital pins on an Arduino board can be used for general purpose input and output via the pinMode(), digitalRead() and digital Write() commands. Each pin has an internal pull-up resistor which can be turned on and off using digital Write(). When the pin is configured as an input, the maximum current per pin is 40 mA [12]. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. SPI 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK) pins support SPI communication.

On the Diecimila and LilyPad, there is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off. In addition to the specific functions listed below, the analog input pins support 10-bit analog-to-digital conversion using the analogRead() function. Most of the analog inputs can also be used as digital pins: analog input 0 as digital pin 14 through analog input 5 as digital pin 19. Analog inputs 6 and 7 -present on the Mini and BT cannot be used as digital pins. I2C: 4 and 5. Support I2C communication using the Wire library. Reset brings the line LOW to reset the microcontroller.

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External power can come either from an AC-to-DC adapter or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and Vin pin headers of the POWER connector.

The arduino board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The input voltage to the Arduino board when it's using an external power source as opposed to 5 volts from the USB connection or other regulated power source. You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA. Ground pins provide the ground terminal. The power pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack 7 - 12V, the USB connector 5V, or the VIN pin of the board 7-12V. Supplying voltage via the 5V or 3.3V pins bypasses the regulator. This pin on the Arduino board provides the voltage reference with which the microcontroller operates.

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL 5V serial communication, which is available on digital pins 0 for RX and 1 for TX. An ATmega8U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '8U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an *.inf file is required.. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to serial chip and USB connection to the computer but not for serial communication on pins 0 and 1. A Software Serial library allows for serial communication on any of the Uno's digital pins.

The ATmega328 micro controller has 32 KB with 0.5 KB used for the boot loader. It also has 2 KB of SRAM and 1 KB of EEPROM which can be read and written with the EEPROM library.

The ATmega48A/PA/88A/PA/168A/PA/328/P is a low-power CMOS 8-bit microcontroller based on the AVR

enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega48A/PA/88A/PA/168A/PA/328/P achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

Here the specifications of ATmega, The high-performance Atmel 8-bit AVR RISC-based microcontroller combines 32 KB ISP flash memory with read-while-write capabilities, 1 KB EEPROM, 2 KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter programmable watchdog timer with internal oscillator, and five software selectable0 power saving modes. The device operates between 1.8-5.5 volts.

Here some advantage of Arduino over other systems. Arduino boards are relatively inexpensive compared to other microcontroller platforms. The Arduino software runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows. The Arduino programming environment is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs if you want to.

The Arduino is based on Atmel's ATMEGA8 and ATMEGA168 microcontrollers. The plans for the modules are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money. Bluetooth is a popular method of wirelessly transferring [8] data between two devices such as your phone and your head phones, your media player and a speaker. Here we connect the Bluetooth of our Android device with Bluetooth device for arduino, after pairing we give commands to the ATmega328 through the Bluetooth.

ATmega328 is given supply from a battery of 12V with the help of a voltage regulator. A Voltage regulator is a device which converts varying input voltage into a constant regulated output voltage.

ATmega328 receives the signal from the Bluetooth device. Then it processes the signal and send signal to the specific relays that have to operate. ATmega328 also provides supply to the devices like Bluetooth. Relays are simple switches which are operated both electrically and mechanically. The main operation of a relay comes in places where only a low-power signal can be used to control a circuit. The relays are connected to the transistors and resistors of 1kilo ohm. They are used for switching purposes and the resistors are used to limit the current through the electronic devices. The relays then operate the required motors to move the vehicle in forward, backward, left and right directions. The Electric Vehicle battery is charged wirelessly [11] by using Tesla coil. The Tesla coil is an electrical resonant transformer circuit designed by inventor Nikola Tesla around 1891 as a power supply for his "System of Electric Lighting". It is used to produce high-voltage, low-current, high frequency alternating-current electricity. To produce the largest output voltage, the primary and secondary tuned circuits are adjusted to resonance with each other. The resonant frequencies of the primary and secondary circuits are determined by the inductance and capacitance in each circuit. Generally the secondary is not adjustable, so the primary circuit is tuned, usually by a moveable tap on the primary coil L1, until it resonates at the same frequency as the secondary. Here when the Tesla coil (wireless transmitter)in the charging station is energized using the supply, it produces flux. This flux gets cut by another Tesla coil arranged in the vehicle. This induces voltage in the secondary Tesla coil (wireless receiver) in the vehicle. Whenever load is connected to the Tesla coil, it becomes closed circuit and the current passes through the load. This wireless power [1] is fed to the battery of the Electric Vehicle.

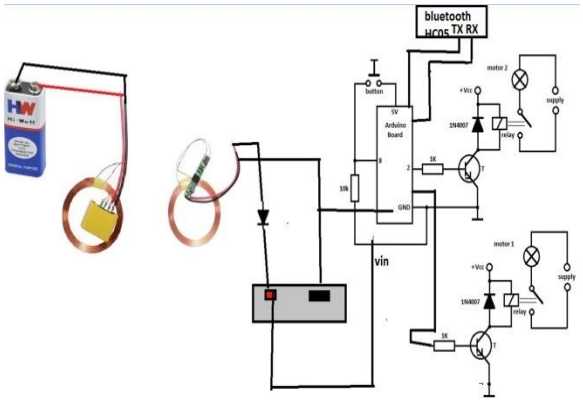

Fig. 3.1 Schematic Diagram

A wheel is attached with a DC Motor so that it can rotate with the wheel when vehicle is moving. Here while moving of the vehicle dc motor acts as a dynamo and generates electricity. This regenerated energy is fed to the battery. The battery gets while moving it helps to increase the discharging time of the battery.

4. RESULT

The following table 4.1 shows the movement of Hybrid Electric Vehicle.

Command in Android Phone given through Bluetooth	Movement of Hybrid Vehicle
1	Forward Direction
2	Backward Direction
3	Right side
4	Left side

When the command is given to the microcontroller, it sends

signal to the relays so that they operate to allow the vehicle to move in the desired direction. Here, first the Bluetooth device is paired with the Bluetooth in Android Phone through SPP Pro app. As shown in table 4.1 the movement of hybrid electric vehicle of their respective commands in the android phone.

When the Tesla coil in the vehicle reaches the Tesla coil in the charging station, an EMF is induced in the Tesla coil and it is given to the battery of the vehicle and the battery charges. The induced voltage in the Tesla coil increases with the increase of no. of turns of the sending coil and receiver coil. This helps the battery of the vehicle to charge quickly. The electricity is regenerated from one of the wheels of the vehicle while moving. This is connected to the battery in series to the voltage induced from Tesla coil [6] so that battery discharging Period can be decreased.

The following Table 4.2 Shows the test data for current as distance increases

Distance	Receiver Voltage - Fixed Regulated DC	Receiver Current
1mm	5V	600mA
2mm	5V	450mA
3mm	5V	360mA
4mm	5V	310mA
5mm	5V	240mA
6mm	5V	210mA
7mm	5V	162mA
8mm	5V	150mA
9mm	5V	132mA
10mm	5V	120mA
11mm	5V	110mA
12mm	5V	70mA
13mm	5V	54mA
14mm	5V	41mA
15mm	5V	28mA
16mm	5V	19mA
17mm	5V	17mA
18mm	5V	10mA

The transmitter coil and the receiving coil distance suitable is from 1mm to 20 mm. Increase the number of turns of the receiver coil to increase the transmission [7] distance when low current is suitable in your application. As distance increase, current capacity of receiver will drop.

5. CONCLUSION

This paper proposes the hybrid vehicle using wireless power charging and regeneration. In this we can run the vehicle on electricity instead of using conventional fuels to conserve the non-renewable resources. It reduces the usage of wires and the time taken for charging. In addition to the wireless charging regeneration of electricity from the wheels of the vehicle is also implemented. A DC motor attached to a wheel acts as dynamo and charges the battery while moving. This reduces the time of discharging of battery and enables the battery to last for long time. So vehicle can travel for more time without running out of fuel frequently.

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