International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com

Vol.7., Issue.2, 2019
Mar-Apr

RESEARCH ARTICLE

ISSN: 2321-7758

WIRELESS POWER TRANSFER FOR ELECTRIC VEHICLE APPLICATIONS USING STATIC AND DYNAMIC WITH SAFETY

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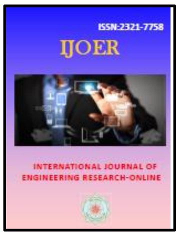
https://doi.org/10.33329/ijoer.72.1



ABSTRACT

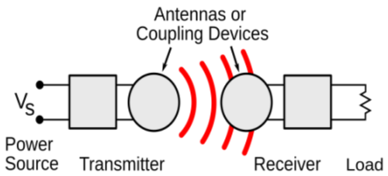
Charging time and power transfer efficiency are the main challenges of wireless power transfer for electric vehicles. It is proposed in this paper to resolve both issues using the transformer induction concept as well as adaptive robotic technology. A high efficiency WPT system for electric vehicle charging that carries a receiving coil. A prototype is built and tested to verify the feasibility of the proposed design with unity power factor can be achieved over an air gap of 8cm and maximum sliding distance of 10 cm under various power conditions and output voltage is produce upto 15V approximately. It uses solar energy to produce electric voltage. The popular renewable sources of energy, solar energy source is individually modeled and then combined together to represent a distributed generation system in the Simulink model.

Keywords: Inductive coupling, Transmitter, Receiver, Solar Panel, Battery.

1. INTRODUCTION

WPT technology has numerous inherent advantages over conventional means of power transfer, thus has received much attention in the past decade and has been proposed to apply to a wide range of applications, ranging from low power biomedical implants electrical vehicle charger to railway vehicles with efficiency up to 95% or higher in some prototype systems. Magnetic WPT systems rely on magnetic field coupling to transfer electric power between two or more magnetically coupled coils across relatively large air gap. In this paper, a wireless charging system for lightweight electric vehicle is designed, built and tested. Wireless power transfer (WPT), wireless energy transmission, or electromagnetic power transfer is the transmission of electrical energy from a power source to an electrical load, such as an electrical power grid or a consuming device, without the use of discrete human-made conductors. Wireless power is a generic term that refers to a number of different power transmission technologies that use time-varying electric, magnetic, or electromagnetic fields. In wireless power transfer, a wireless transmitter connected to a power source conveys the field energy across an intervening space to one or more receivers, where it is converted back to an electrical current and then used.

Wireless transmission is useful to power electrical devices in cases where interconnecting wires are inconvenient, hazardous, or are not possible. Wireless power techniques mainly fall into two categories, non-radiative and radiative.In near field or non-radiative techniques, power is transferred by magnetic fields using inductive coupling between coils of wire, or by electric fields using capacitive coupling between metal electrodes. Inductive coupling is the most widely used wireless technology; its applications include electric toothbrush chargers, RFID tags, smartcards, and chargers for implantable medical devices like artificial cardiac pacemakers, and inductive powering or charging of electric vehicles like trains or buses. A current focus is to develop wireless systems to charge mobile and handheld computing devices such as cellphones, digital music players and portable computers without being tethered to a wall plug. In far-field or radiative techniques, also called power beaming, power is transferred by beams of electromagnetic radiation, like microwaves or laser beams. These techniques can transport energy longer distances but must be aimed at the receiver. Proposed applications for this type are solar power satellites, and wireless powered drone aircraft.



1.1 Block Diagram of a Wireless Power System

"Wireless power transfer" is a collective term that refers to a number of different technologies for transmitting energy by means of electromagnetic fields. The technologies, listed in the table below, differ in the distance over which they can transfer power efficiently, whether the transmitter must be aimed (directed) at the receiver, and in the type of electromagnetic energy they use: time varying electric fields, magnetic fields, radio waves, microwaves, or infrared or visible light waves.

In general a wireless power system 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. The word "antenna" is used loosely here; it 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 λ = c/f of the waves which carry the energy across the gap, where c is the velocity of light. Electric and magnetic fields are created by charged particles in matter such as electrons. A stationary charge creates an electrostatic field in the space around it. A steady current of charges (direct current, DC) creates a static magnetic field around it. The above fields contain energy, but cannot carry power because they are static. However time-varying fields can carry power.

Accelerating electric charges, such as are found in an alternating current (AC) of electrons in a wire, create time-varying electric and magnetic fields in the space around them. These fields can exert oscillating forces on the electrons in a receiving "antenna", causing them to move back and forth. These represent alternating current which can be used to power a load. The oscillating electric and magnetic fields surrounding moving electric charges in an antenna device can be divided into two regions, depending on distance Drange from the antenna. The boundary between the regions is somewhat vaguely defined. The fields have different characteristics in these regions, and different technologies are used for transferring power

This means the area within about 1 wavelength (λ) of the antenna. In this region the oscillating electric and magnetic fields are separate and power can be transferred via electric fields by capacitive coupling (electrostatic induction) between metal electrodes, or via magnetic fields by inductive coupling (electromagnetic induction) between coils of wire. These fields are not radiative, meaning the energy stays within a short distance of the transmitter. If there is no receiving device or absorbing material within their limited range to "couple" to, no power leaves the transmitter. The range of these fields is short, and depends on the size and shape of the "antenna" devices, which are usually coils of wire. The fields, and thus the power transmitted, decrease exponentially with distance, so if the distance between the two "antennas" Drange is much larger than the diameter of the "antennas" Dant very little power will be received. Therefore, these techniques cannot be used for long range power transmission. Resonance, such as resonant inductive coupling, can increase the coupling between the antennas greatly, allowing efficient transmission at somewhat greater distances, although the fields still decrease exponentially. Therefore the range of near-field devices is conventionally divided into two categories: Short range: Up to about one antenna diameter: Drange ≤ Dant. This is the range over which ordinary non resonant capacitive or inductive coupling can transfer practical amounts of power. Mid-range : Up to 10 times the antenna diameter: Drange ≤ 10 Dant. This is the range over which resonant capacitive or inductive coupling can transfer practical amounts of power.

Beyond about 1 wavelength (λ) of the antenna, the electric and magnetic fields are perpendicular to each other and propagate as an electromagnetic wave; examples are radio waves, microwaves, or light waves. This part of the energy is radiative, meaning it leaves the antenna whether or not there is a receiver to absorb it. The portion of energy which does not strike the receiving antenna is dissipated and lost to the system. The amount of power emitted as electromagnetic waves by an antenna depends on the ratio of the antenna's size Dant to the wavelength of the waves λ, which is determined by the frequency: λ = c/f.

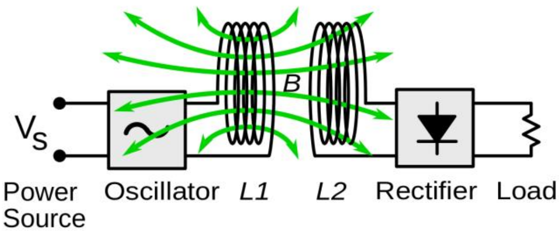
At low frequencies f where the antenna is much smaller than the size of the waves, Dant << λ, very little power is radiated. Therefore the near-field devices above, which use lower frequencies, radiate almost none of their energy as electromagnetic radiation. Antennas about the same size as the wavelength Dant ≈ λ such as monopole or dipole antennas, radiate power efficiently, but the electromagnetic waves are radiated in all directions (Omni directionally`), so if the receiving antenna is far away, only a small amount of the radiation will hit it. Therefore, these can be used for short range, inefficient power transmission but not for long range transmission. However, unlike fields, electromagnetic radiation can be focused by reflection or refraction into beams. By using a high-gain antenna or optical system which concentrates the radiation into a narrow beam aimed at the receiver, it can be used for long range power transmission.

As a result, inductive and capacitive coupling can only be used for short-range power transfer, within a few times the diameter of the antenna device D_{ant}. Unlike in a radiative system where the maximum radiation occurs when the dipole antennas are oriented transverse to the direction of propagation, with dipole fields the maximum coupling occurs when the dipoles are oriented longitudinally.

1.1. Inductive Coupling

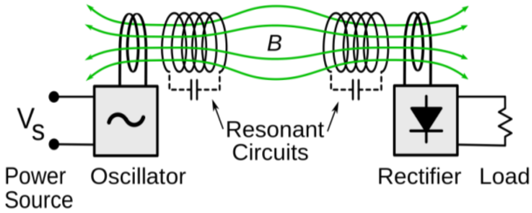
In inductive coupling (electromagnetic induction or inductive power transfer, IPT), power is transferred between coils of wire by a magnetic field. The transmitter and receiver coils together form a transformer. An alternating current (AC) through the transmitter coil (L1) creates an oscillating magnetic field (B) by Ampere's law. The magnetic field passes through the receiving coil (L2), where it induces an alternating EMF (voltage) by Faraday's law of induction, which creates an AC current in the receiver.

The induced alternating current may either drive the load directly, or be rectified to direct current (DC) by a rectifier in the receiver, which drives the load. A few systems, such as electric toothbrush charging stands, work at 50/60 Hz so AC mains current is applied directly to the transmitter coil, but in most systems an electronic oscillator generates a higher frequency AC current which drives the coil, because transmission efficiency improves with frequency.



1.2 Inductive wireless power system

Resonant inductive coupling (electrodynamic coupling strongly coupled magnetic resonance) is a form of inductive coupling in which power is transferred by magnetic fields (B, green) between two resonant circuits (tuned circuits), one in the transmitter and one in the receiver (see diagram, right). Each resonant circuit consists of a coil of wire connected to a capacitor, or a self-resonant coil or other resonator with internal capacitance. The two are tuned to resonate at the same resonant frequency. The resonance between the coils can greatly increase coupling and power transfer, analogously to the way a vibrating tuning fork can induce sympathetic vibration in a distant fork tuned to the same pitch.



1.3 Resonant inductive wireless power system

1.2. Capacitive Coupling

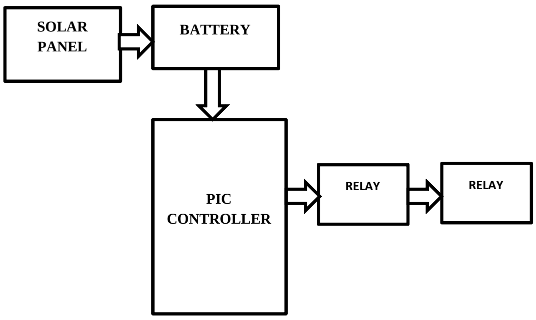
In capacitive coupling (electrostatic induction), the conjugate of inductive coupling, energy is transmitted by electric fields between electrodes such as metal plates. The transmitter and receiver electrodes form a capacitor, with the intervening space as the dielectric. An alternating voltage generated by the transmitter is applied to the transmitting plate, and the oscillating electric field induces an alternating potential on the receiver plate by electrostatic induction, which causes an alternating current to flow in the load circuit. The amount of power transferred increases with the frequency the square of the voltage, and the capacitance between the plates, which is proportional to the area of the smaller plate and (for short distances) inversely proportional to the separation.

1.2. Magneto dynamic coupling

In this method, power is transmitted between two rotating armatures, one in the transmitter and one in the receiver, which rotate synchronously, coupled together by a magnetic field generated by permanent magnets on the armatures. The transmitter armature is turned either by or as the rotor of an electric motor, and its magnetic field exerts torque on the receiver armature, turning it. The magnetic field acts like a mechanical coupling between the armatures.

1.3. Existing System

- Solar based mobile were designed. As advance wireless charger particularly for small load system was implemented recently. Furthermore, a prototype of the whole system, consisting of a commercial panel, the thermal and electrical circuits and an innovative wireless remote data acquisition system has been setup. The latter, based on an open-source electronic



3.1 Block diagram of

Existing System

DISADVANTAGES

- High complexity switching process.
- High power losses

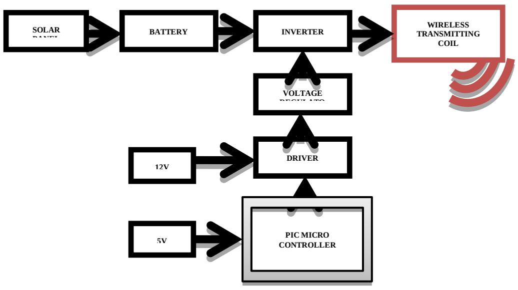
2. PROPOSED SYSTEM

In this proposed system, we implement ARDUINO microcontroller based wireless power charging methodology in electric vehicles. This system consists of ARDUINO microcontroller, inductive coils, vehicle prototype module.

Solar panel system is implemented to transfer the power to the primary coil. Solar panel is connected to the battery directly. Then it can driven into the rectifier circuit through an inverter. In inverter circuit is connected by ARDUINO micro controller to switching the power supply. The switched power is fed into the inverter through driver circuit. The coil has high capacity of inductance which can able to transfer the power with high frequency. It is named as the high frequency coil. Those power input are connected to the high frequency primary coil which is laid under the road segment.

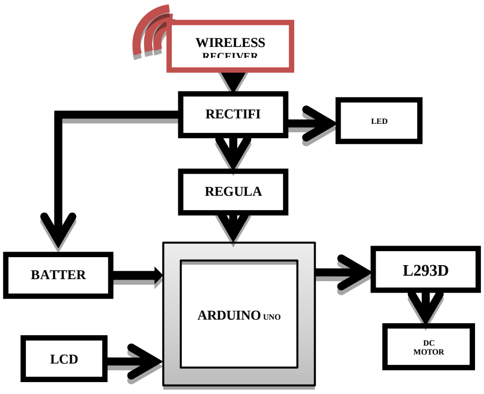
The vehicle has receiving coil segment. The receiver section consisting of the receiver coil, rectifier and regulator.When the vehicle move along the primary coil, receiver coil in vehicle receives the power from the primary coil by the electromagnetic induction technique. That received power is driven to the regulator through rectifying circuit. Then the power is stored in the battery. The battery power is given to the controller and the motor driver circuit. Motor driver is used for control the motor of vehicle.

The vehicle can charge automatically when it cross over the primary coil connected to the battery. By this, we can able reduce the pollution of air and demand in petroleum products.



2.1 Block diagram of Transmitter

In this system, transmitter block consisting of battery, inverter, rectifier, and High frequency wireless transmitting coil. The power supply is given from the solar panel. A solar panel power is stored in battery then delivers its power to the inverter circuit. The power is rectified by the rectifier circuit and rectified power is transferred to high frequency transmission coil. In transmitter circuit PIC microcontroller has been connected with the inverter circuit to switch the transmission power. The transmission power efficiency has been increased by switching the power. Then the switching power is transferred to the inverter circuit through the driver circuit.



2.2 Block diagram of Receiver

The receiver block has receiving coil which receives the power from the transmitter coil. Then the power is fed into the rectifier circuit and drive to the regulator circuit and battery. The regulated power is given to the controller to drive the motor of the vehicle. LED indicated the charging status and LCD shows the information about power transfer and charging. Motor drier is used to controls the 12V motor by the controller. Also it can control the rotation of each motor.

2.2 ARDUINO UNO

ARDUINO is an open-source computer hardware and software company, project and user community that designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control objects in the physical world. The project is based on microcontroller board designs, manufactured by several vendors, using various microcontrollers. These systems provide sets of digital and analog I/O pins that can be interfaced to various expansion boards ("shields") and other circuits. The boards feature serial communications interfaces, including USB on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on the Processing project, which includes support for the C and C++ programming languages. The first Arduino was introduced in 2005, aiming to provide an inexpensive and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators.

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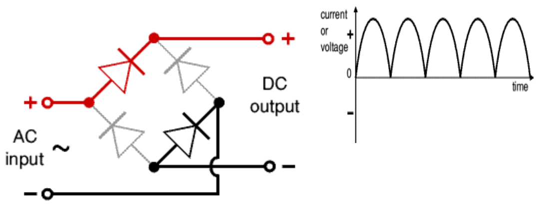
Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

2.3 POWER SUPPLY CIRCUIT

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others.

Power supplies for electronic devices can be broadly divided into linear and switching power supplies. The linear supply is a relatively simple design that becomes increasingly bulky and heavy for high current devices; voltage regulation in a linear supply can result in low efficiency. A switched-mode supply of the same rating as a linear supply will be smaller, is usually more efficient, but will be more complex.

A bridge rectifier can be made using four individual diodes, but it is also available in special packages containing the four diodes required. It is called a full-wave rectifier because it uses the entire AC wave (both positive and negative sections). 1.4V is used up in the bridge rectifier because each diode uses 0.7V when conducting and there are always two diodes conducting, as shown in the diagram below. Bridge rectifiers are rated by the maximum current they can pass and the maximum reverse voltage they can withstand (this must be at least three times the supply RMS voltage so the rectifier can withstand the peak voltages). Please see the DIODES page for more details, including pictures of ridge rectifiers.

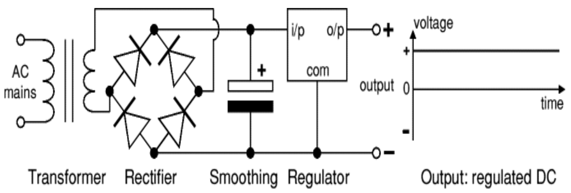


2.3 Bridge rectifier

Alternate pairs of diodes conduct, changing over the connections so the alternating directions of AC are converted to the one direction of DC.

Voltage regulator ICs are available with fixed (typically 5, 12 and 15V) or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current ('overload protection') and overheating ('thermal protection').

The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and current. Many of the fixed voltage regulator ICs has 3 leads and look like power transistors, such as the 7805 +5V 1A regulator shown on the right. They include a hole for attaching a heat sink if necessary.



2.4 Block diagram of Regulator

The regulated DC output is very smooth with no ripple. It is suitable for all electronic circuits.

2.4 LIQUID CRYSTAL DISPLAY

A liquid crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements. An LCD is a small low cost display. It is easy to interface with a micro-controller because of an embedded controller (the black blob on the back of the board). This controller is standard across many displays (HD 44780) which means many micro-controllers (including the Arduino) have libraries that make displaying messages as easy as a single line of code.

2.5 LCD display unit

LCDs are used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, and signage. They are common in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephones, and have replaced cathode ray tube (CRT) displays in most applications. They are available in a wider range of screen sizes than CRT and plasma displays, and since they do not use phosphors, they do not suffer image burn-in. LCDs are, however, susceptible to image persistence.

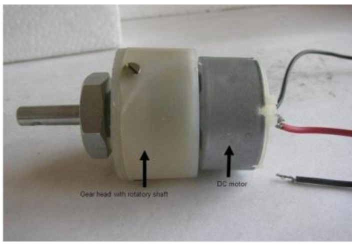
2.5 Software Development

A program for Arduino may be written in any programming language for a compiler that produces binary machine code for the target processor. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio. The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the programming language Java. It originated from the IDE for the languages Processing and Wiring. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus. A program written with the IDE for Arduino is called a sketch. Sketches are saved on the development computer as text files with the file extension .ino. Arduino Software (IDE) pre-1.0 saved sketches with the extension .pde. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution.

The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware. A minimal Arduino C/C++ sketch, as seen by the Arduino IDE programmer, consist of only two functions: This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch. **loop:** After setup has been called, function loop is executed repeatedly in the main program. It controls the board until the board is powered off or is reset. Most Arduino boards contain a light-emitting diode (LED) and a load resistor connected between pin 13 and ground, which is a convenient feature for many tests and program functions

2.5 DC MOTOR

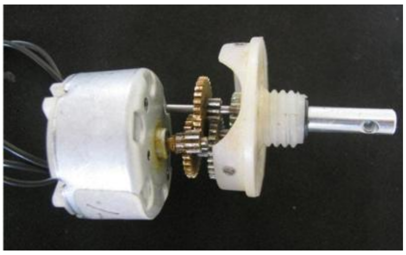
Geared DC motors can be defined as an extension of DC motor which already had its Insight details demystified here. A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM .The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reduction. This Insight will explore all the minor and major details that make the gear head and hence the working of geared DC motor.



2.6 DC Motor

The outer body of the gear head is made of high density plastic but it is quite easy to open as only screws are used to attach the outer and the inner structure. The major reason behind this could be to lubricate gear head from time to time. The plastic body has a threading through which nut can be easily mounted and vice versa from the gear head

The DC motor works over a fair range of voltage. The higher the input voltage more is the RPM (rotations per minute) of the motor. For example, if the motor works in the range of 6-12V, it will have the least RPM at 6V and maximum at 12 V.



2.7 Gear arrangement of DC Motor

The working of the gears is very interesting to know. It can be explained by the principle of conservation of angular momentum. The gear having smaller radius will cover more RPM than the one with larger radius. However, the larger gear will give more torque to the smaller gear than vice versa. The comparison of angular velocity between input gear (the one that transfers energy) to output gear gives the gear ratio. When multiple gears are connected together, conservation of energy is also followed. The direction in which the other gear rotates is always the opposite of the gear adjacent to it.

In any DC motor, RPM and torque are inversely proportional. Hence the gear having more torque will provide a lesser RPM and converse. In a geared DC motor, the concept of pulse width modulation is applied.

In a geared DC motor, the gear connecting the motor and the gear head is quite small, hence it transfers more speed to the larger teeth part of the gear head and makes it rotate. The larger part of the gear further turns the smaller duplex part. The small duplex part receives the torque but not the speed from its predecessor which it transfers to larger part of other gear and so on. The third gear's duplex part has more teeth than others and hence it transfers more torque to the gear that is connected to the shaft.

3. RECTIFIER

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification. Physically, rectifiers take a number of forms, including vacuum tube diodes, mercury-arc valves, copper and selenium oxide rectifiers, semiconductor diodes, silicon-controlled rectifiers and other silicon-based semiconductor switches. Historically, even synchronous electromechanical switches and motors have been used. Early radio receivers, called crystal radios, used a "cat's whisker" of fine wire pressing on a crystal of galena (lead sulfide) to serve as a point-contact rectifier or "crystal detector". Rectifiers have many uses, but are often found serving as components of DC power supplies and high-voltage direct current power transmission systems. Rectification may serve in roles other than to generate direct current for use as a source of power. As noted, detectors of radio signals serve as rectifiers. In gas heating systems flame rectification is used to detect presence of a flame. Because of the alternating nature of the input AC sine wave, the process of rectification alone produces a DC current that, though unidirectional, consists of pulses of current. Many applications of rectifiers, such as power supplies for radio, television and computer equipment, require a steady constant DC current (as would be produced

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by a battery). In these applications the output of the rectifier is smoothed by an electronic filter (usually a capacitor) to produce a steady current. More complex circuitry that performs the opposite function, converting DC to AC, is called an inverter.

4. INVERTER

A power inverter, or inverter, is an electronic device or circuitry that changes direct current (DC) to alternating current (AC). The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source. A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process. A typical power inverter device or circuit requires a relatively stable DC power source capable of supplying enough current for the intended power demands of the system. The input voltage depends on the design and purpose of the inverter. Examples include: 12 VDC, for smaller consumer and commercial inverters that typically run from a rechargeable 12 V lead acid battery or automotive electrical outlet. 24, 36 and 48 VDC, which are common standards for home energy systems. 200 to 400 VDC, when power is from photovoltaic solar panels. 300 to 450 VDC, when power is from electric vehicle battery packs in vehicle-to-grid systems. Hundreds of thousands of volts, where the inverter is part of a high-voltage direct current power transmission system.

The two dominant commercialized waveform types of inverters as of 2007 are modified sine wave and sine wave. There are two basic designs for producing household plug-in voltage from a lower-voltage DC source, the first of which uses a switching boost converter to produce a higher-voltage DC and then converts to AC. The second method converts DC to AC at battery level and uses a line-frequency transformer to create the output voltage. The AC output frequency of a power inverter device is usually the same as standard power line frequency, 50 or 60 hertz If the output of the device or circuit is to be further conditioned (for example stepped up) then the frequency may be much higher for good transformer efficiency.

The AC output voltage of a power inverter is often regulated to be the same as the grid line voltage, typically 120 or 240 VAC at the distribution level, even when there are changes in the load that the inverter is driving. This allows the inverter to power numerous devices designed for standard line power. Some inverters also allow selectable or continuously variable output voltages. A power inverter will often have an overall power rating expressed in watts or kilowatts. This describes the power that will be available to the device the inverter is driving and, indirectly, the power that will be needed from the DC source. Smaller popular consumer and commercial devices designed to mimic line power typically range from 150 to 3000 watts. Not all inverter applications are solely or primarily concerned with power delivery; in some cases the frequency and or waveform properties are used by the follow-on circuit or device.

5. BATTERY

An electric battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices such as flashlights, smart phones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The terminal marked negative is the source of electrons that when connected to an external circuit will flow and deliver energy to an external device. When a battery is connected to an external circuit, electrolytes are able to move as ions within, allowing the chemical reactions to be completed at the separate terminals and so deliver energy to the external circuit.

It is the movement of those ions within the battery which allows current to flow out of the battery to perform work. Historically the term "battery" specifically referred to a device composed of multiple cells, however the usage has evolved to additionally include devices composed of a single cell. Primary (single-use or "disposable") batteries are used once and discarded; the electrode materials are irreversibly changed during discharge. Common examples are the alkaline battery used for flashlights and a multitude of portable electronic devices. Secondary (rechargeable) batteries can be discharged and recharged multiple times using mains power from a wall socket; the original composition of the electrodes can be restored by reverse current.

Examples include the lead-acid batteries used in vehicles and lithium-ion batteries used for portable electronics such as laptops and smart phones. Batteries come in many shapes and sizes, from miniature cells used to power hearing aids and wristwatches to small, thin cells used in smart phones, to large lead acid batteries used in cars and trucks, and at the largest extreme, huge battery banks the size of rooms that provide standby or emergency power for telephone exchanges and computer data centers.

5.1. RESONANT INDUCTIVE COUPLING

Resonant inductive coupling or Magnetic phase synchronous coupling is the phenomenon that the coupling is enhanced when the secondary side of the loosely coupled coil resonates. The most basic resonant inductive coupling consists of one drive coil on the primary side and one resonance circuit on the secondary side. In this case, when the resonant state on the secondary side is observed from the primary side, two resonances as a pair are observed. One of them is called the antiresonant frequency (parallel resonant frequency), and the other is called the resonant frequency (series resonant frequency). The short-circuit inductance and resonant capacitor of the secondary coil are combined into a resonant circuit. When the primary coil is driven with a resonance frequency (serial resonance frequency), the phases of the magnetic fields of the primary coil and the secondary coil are synchronized. In this state, the amount of mutual flux increases. As a result, the maximum voltage is generated in the secondary coil.

Resonant transformers are widely used in radio circuits as bandpass filters, and in switching power supplies. Resonant inductive coupling is also being used in wireless power systems. Here the LC circuit is in different devices; a transmitter coil in one device transmits electric power across an intervening space to a resonant receiver coil in another device. This technology is being developed for powering and charging portable devices such as cellphones and tablet computers at a distance, without being tethered to an outlet. The Wi-Tricity type magnetic resonance is that the primary side resonant is added to the basic resonant inductive coupling system in order to increase the power transmission intensity of the resonance.

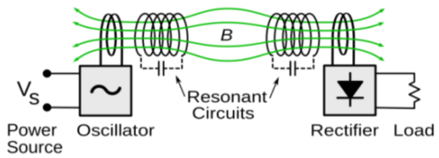
Thus, the Wi-Tricity type magnetic resonance is characterized in that the resonant coils on the primary side and the resonant coils on the secondary side are paired. Resonant transfer works by making a coil ring with an oscillating current. This generates an oscillating magnetic field. Because the coil is highly resonant, any energy placed in the coil dies away relatively slowly over very many cycles; but if a second coil is brought near it, the coil can pick up most of the energy before it is lost, even if it is some distance away. The fields used are predominantly non-radiative, near fields (sometimes called evanescent waves), as all hardware is kept well within the 1/4 wavelength distance they radiate little energy from the transmitter to infinity.

5.2. Energy transfer and efficiency

The Wi-Tricity type magnetic resonance is characterized in that the resonant coils on the primary side and the resonant coils on the secondary side are paired. The primary resonator increases the primary driving coil current and increases the generated magnetic flux on the primary side. This is equivalent to driving the primary coil at high voltage. In the case of the type on the left figure, the general principle is that if a given oscillating amount of energy (for example a pulse or a series of pulses) is placed into a primary coil which is capacitively loaded, the coil will 'ring', and form an oscillating magnetic field. The energy will transfer back and forth between the magnetic field in the inductor and the electric field across the capacitor at the resonant frequency. Solar panel refers to a panel designed to absorb the sun's rays as a source of energy for generating electricity or heating. A photovoltaic (PV) module is a packaged, connect assembly of typically 6×10 photovoltaic solar cells. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that

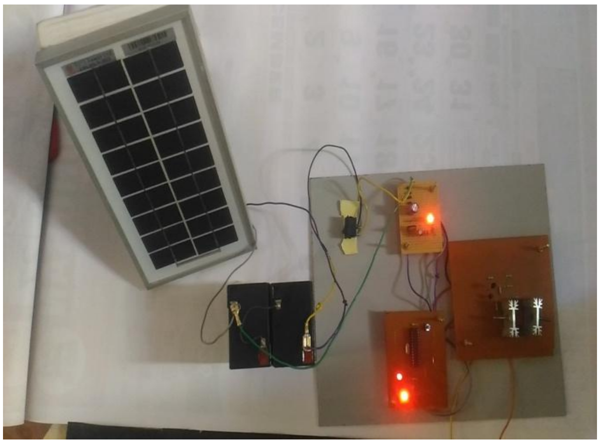
International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com
Vol.7., Issue.2, 2019
Mar-Apr

generates and supplies solar electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 365 watts. The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module.

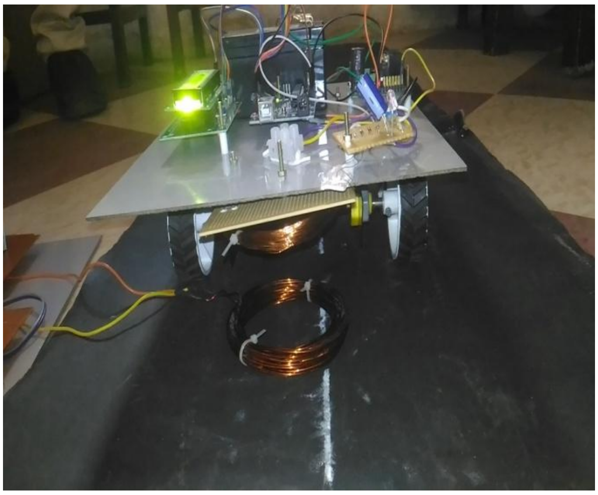


5.1 Resonant inductive wireless power system

6. HARDWARE IMPLEMENTATION



6.1 Transmitter with Solar Panel and Battery



6.2 Receiver with inductive coil in Electric Vehicle

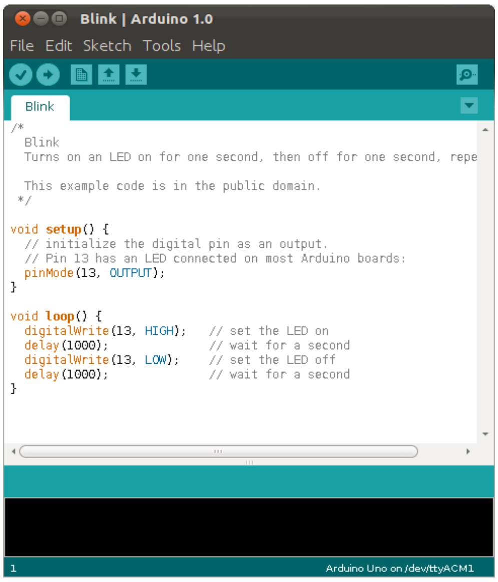
There are a few commercially available solar modules that exceed 22% efficiency and reportedly also exceeding 24%. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes an array of photovoltaic modules, an inverter, a battery pack for storage, interconnection wiring, and optionally a solar tracking mechanism. The most common application of solar panels is solar water heating systems. The price of solar power has continued to fall so that in many countries it is cheaper than ordinary fossil fuel electricity from the grid.

Rugged 3W 12Vdc photovoltaic solar panel. Sealed to withstand hail, snow and wind. Multi crystalline silicon solar cells in a heavy-duty anodized aluminum frame. High-transparency, low-iron tempered glass. 188 x 195 x 17mm. Junction box with screw or solder terminals.

6.3 Solar Panel

Arduino is an open source, computer hardware and software company, project, and user community that designs and manufactures microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world. The project's products are distributed as open-source hardware and software, which are licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), permitting the manufacture of Arduino boards and software distribution by anyone.

Arduino boards are available commercially in preassembled form, or as do-it-yourself kits. Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers.



6.2 Coding of Arduino uno

The Wiring platform consisted of a printed circuit board (PCB) with an ATmega168 microcontroller, an IDE based on Processing and library functions to easily program the microcontroller. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler toolchains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project. The Arduino project started in 2005 as a program for students at the Interaction Design Institute Ivrea in Ivrea, Italy, aiming to provide a low-cost and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

7. CONCLUSION

A high efficiency wireless power transfer system for electric vehicle charging application is proposed. System configuration and design considerations were analysed and discussed in details. The popular renewable sources of energy, solar energy source is individually modeled and then combined together to represent a distributed generation system in the Simulink model. A prototype was designed, built and tested with solar panel to verify the circuit performance of the developed WPT charging system.

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