International Journal of Research Publication and Reviews, Vol 3, no 6, pp 1855-1859, June 2022

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

A Real-Time Controlled Active Matching Circuit Utilizing Genetic Algorithms for Wireless Power Transfer to Biomedical Implants

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ABSTRACT

A Genetic algorithm based optimal design strategy for wireless magnetic-resonant charger of deep brain stimulation devices is presented. In recent days , medical progress has been evolved with an increased interest in most popular instruments for sensor systems and controlling systems the specific functions of the brain. These medical instruments considerably decrease morbidity and improve the standard of life for certain patients. Sensor systems are always quite advanced but it is providing power to these devices is still with a major challenge. The quick answer to this issue is using wireless power transmission (WPT) technologies for a sudden range of biomedical implants. WPT is an secure method and appropriate as new energy supply for recharging biosensors systems and electrical implanted methods as well as for data communication in these specific applications. It is proposed that a differential evolution algorithm discrete variables (turn numbers of coils) and constrains (induced current and voltage in the load loop) is used to design the wireless power transfer system. The variables which normally include the sizes of the load coil, receiver coil, transmitter coil, source coil and capacitance are analyzed in the optimization study. Analytical formula are being embedded with in a numerical optimization to speed up the due to convergence of the searching process. The designed receiver can be able to receive with its enough power to recharge a 3.7 V circular button-type nickel-metal hybrid rechargeable battery which can be implanted into the patients' skull. The performance of an designed system has been successfully verified experimentally.

INTRODUCTION

Medical Implants like Deep brain stimulation is a neurosurgical procedure which involves implanting a device with three parts: a neurostimulator (similar in size to a pacemaker) that is placed under the skin of the upper chest, a lead (the stimulating electrode), and insulated wire that connects the neurostimulator to the lead that runs under the skin. [1]. The lead is placed by the surgeon in a specific location in the brain that, when activated, provides symptom relief to the patient. For patients suffering from Parkinson's disease (PD), this is typically in the subthalamic nucleus (STN). Once the system is in place, the neurostimulator is turned on and adjusted until motor symptoms disappear. The patient is awake to help the surgeon guide the positioning of the electrode into the target area. A cather-based urodynamic, used to diagnose urinary incontinence, because it is considered as an unreliable because it can be difficult to exactly reproduce symptomatic leakage in a clinical setting some urologists instead diagnose and treat incontinence based solely on patient reporting of symptoms. The long-term physiological confirmation of patient complaints in an ambulatory environment cannot presently be achieved, but would be lead to more precise diagnoses and in the treatments with higher success rates.

LITERATURESURVEY

A Xinyi Song School of Electrical Engineering Naval University of Engineering Wuhan, China Research and Design of Coupling Structure of Inductive Wireless Power Transmission DC Side Parallel System IEEE 2021 the 4th International Conference on Energy, Electrical and Power Engineering

Wireless power transmission technology has the characteristics of flexibility, safety, and reliability, and has become an inevitable trend in the development of modern power transmission technology.[2]The system coupling parameters and compensation network are theoretically analyzed using mutual inductance theory and circuit principles, and Combined with Maxwell simulation, design the structural parameters and electrical parameters of the parallel coupler. Afterwards, through multiple sets of comparative experiments, the changes of the coupling coil parameters under the influence of the horizontal offset between the coupling coils and the change of the parallel coupler spacing are tested, and the performance of the coupling structure is studied and analyzed.

EXISTING METHOD

Wireless power transmission (WPT) is a critical technology that provides an alternative for wireless power and communication with implantable medical devices (IMDs). This article provides a study concentrating on popular WPT techniques for IMDs including inductive coupling, microwave, ultrasound, and hybrid wireless power transmission (HWPT) systems. Moreover, an overview of the major works is analyzed with a comparison of the symmetric and asymmetric design elements, operating frequency, distance, efficiency, and harvested power. In general, with respect to the operating frequency, it is concluded that the ultrasound-based and inductive-based WPTs have a low operating frequency of less than 50 MHz, whereas the microwave-based WPT works at a higher frequency.

Moreover, it can be seen that most of the implanted receiver's dimension is less than30 mm for all the WPT-based methods. Furthermore, the HWPT system has a larger receiver size compared to the other methods used. In terms of efficiency, the maximum power transfer efficiency is conducted via inductive-based WPT at 95%, compared to the achievable frequencies of 78%, 50%, and17% for microwave-based, ultrasound-based, and hybrid WPT, respectively. In general, the inductive coupling tactic is mostly employed for transmission of energy to neuro-stimulators, and the ultrasonic method is used for deep-seated implants.

PROPOSED SYSTEM

A Genetic algorithm based optimal design strategy for wireless magnetic-resonant charger of deep brain stimulation devices is presented. It is proposed that a differential evolution algorithm discrete variables (turn numbers of coils) and constrains (induced current and voltage in the load loop) is used to design the wireless power transfer system. In embedded system the analytical formulas are the numerical optimization to speed up the convergence of the searching process. The receiver designed can be allow to receive enough power to recharge a 3.7Vcircular button-type on nickel-metal hybrid rechargeable battery which can implanted into the patients' skull**.**

A. Rectifier

In the Wireless Power Transmitter unit, An AC to DC conversion unit and a Resonator is present.

B. Resonator

It transmits the electrical energy into electromagnetic wave through a LC tuned coil.

C. Tx/Rx Coils

The system consists of transmitter and receivers both that contain circular magnetic loops critically tuned to the same frequency.

D. HF Rectifier

The power received from the transmitter coil is picked up by multiple receiving coils.

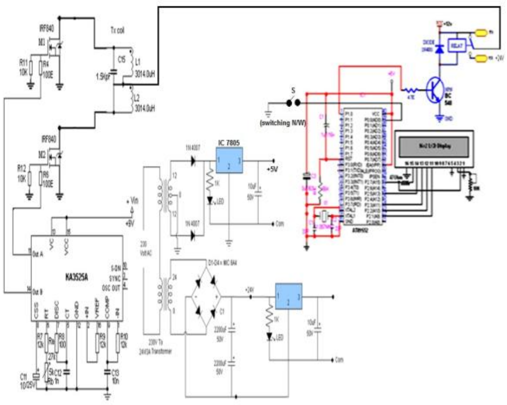
A HF rectifier at the receiver converts the HF AC into a pure DC output which is utilized by the loads.

The current flows in the path from point through D1, up through RL, through D3, through the secondary of transformer back to point B, this path is indicated by an solid arrows.

E. Transmitter unit:

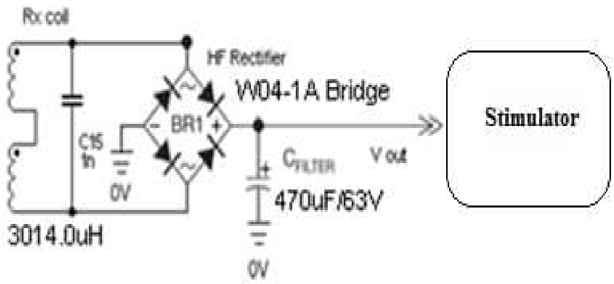
In the transmitter section two step down transformer is used (12-0-12/1A & 500mA). The transformer is reduced the primary voltage AC 230V into AC 12V. Its output is given to regulated power supply. The regulated power supply is used to convert the AC voltage to DC regulating voltage 9V as well as 5V. The input of the regulating unit is taken from bridge rectifier output 24V DC.

This DC voltage is given to the resonator. The resonator is oscillating the high frequency components by using MOSFET and LC tank circuit. The transmitter coil is induced electrical energy at desired resonant frequency.



The IC KA3525 is a PWM (Pulse Width Modulation) generator which is used to triggering the MOSFET. Based on time/width of the pulse defines the MOSFET switching response. The AT89S52 microcontroller is used to control the radiating power through relay when it receives the signal from switching network. The 2X16 LCD display unit is used to shows the information about the system status.

F. R**eceiver unit:**



The receiving coil is received the electrical energy from the transmitting coil. When the resonance frequency is identically the transmitting coil transmits the energy, otherwise not transmitting the energy from the transmitter. In receiver section, the transmitting frequency is observed by the coil and it converts the resonant frequency into voltage form. This voltage can be rectified and charged to stimulator device.[6]

G.I C voltage regulators

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage.

The regulator scan be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts to tens of watts.

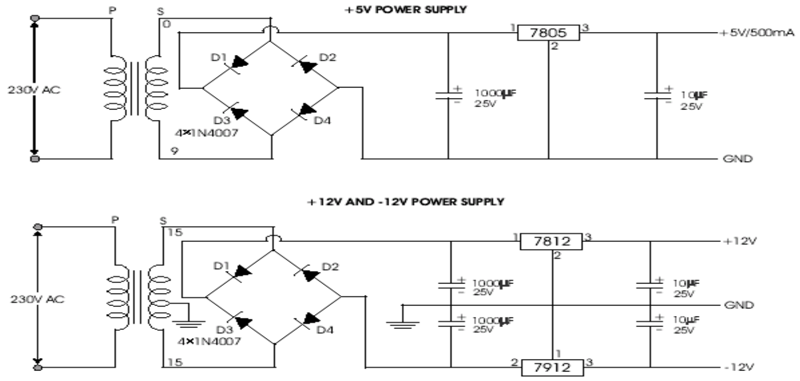


Fig. Circuit Diagram of Power Supply

A fixed three-terminal voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated dc output voltage, Vo, from a second terminal, with the third terminal connected to ground.

The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts.

- For ICs, micro controller, LCD--------------------- 5 volts
- For alarm circuit, op-amp, relay circuits----------12 volts

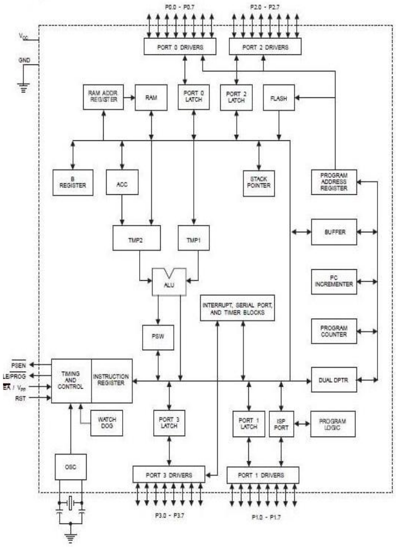
H. Microcontroller

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which six can be used as PWM outputs), six analog inputs, a 16 MHz crystal oscillator, 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 an AC-to-DC adapter or battery to get started. The Arduino Uno differs from all preceding boards because it does not use the FTDIUSB-to-serial driver chip. Instead, it features the ATmega8U2 programmedasaUSB-to-serialconverter.Revision2 of the Arduino Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier toput into DFU mode.

"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Unoboardandversion1.0ofArduinoSoftware (IDE) were the reference versions of Arduino, now evolved to newer releases. [5]The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 4K bytes of In-System Programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry- Standard 80C51 instruction set and pin-out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with In-System Programmable Flash on a monolithic chip, the Atmel AT89S51 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

The AT89S51 provides the following standard features: 4K bytes of Flash, 128 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, two 16-bit timer/counters, a five vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S51 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next external interrupt or hardware rese



The Arduino Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 microcontroller chip programmed as a USB-to-serial converter.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Arduino Uno and version 1.0 will be the reference versions of Arduno, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform.

PROGRAMMING

The Arduino Uno can be programmed with the (Arduino Software (IDE)). Select "Arduino/Genuino Uno from the Tools > Board menu (according to the microcontroller on your board). For details, see the reference and tutorials. The ATmega328 on the Arduino Uno comes pre-programmed with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files). You can also bypass the boot loader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header using Arduino ISP or similar; see these instructions for details

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The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available in the Arduino repository.[4] The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by:On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then rising the 8U2.On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode. You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU boot loader)\

RESULT

In this effort, the feasibility of a real-time active matching circuit for biomedical WPT applications is discussed. First, open helical type coils which have a self-resonance frequency of 13.56 MHz were designed utilizing an EM simulator and characterized through measurements. Based on the measured S-parameters of the coils, a variable matching circuit unit was designed utilizing the genetic-algorithm. Also, the prototype of low cost real-time automatic matching circuit was designed and analyzed to quantitatively reveal the limitation of the real-time automatic matching system. Finally, the real-time matching system was implemented and verified through the measurement. Eventually, the proposed real-time automatic matching circuit system achieved the maximum of 3.2 dB transfer coefficient improvement in the range of 10 to 16 cmcoil separation distance automatically in about 64 ms. Additional operation verification tests conducted for mis aligne dcoil topologies and for non-symmetrical Tx-Rx WPT systems featured similar improvement results with the preliminary well aligned same-size Tx and Rx configurations. These very promising preliminary results suggest the wide potential applicability of the proposed real-time automatic matching system to a variety of WPT applications especially when there is strong coupling between Tx and Rx coil causing the frequency split, for example charging of skin implanted devices, electrical vehicles and unmanned aerial vehicles (UAV). Possibly, the system can be applied to the powering of deep tissue implanted

CONCLUSION

Wireless power transfer thus allows a convenient, easy to use battery charging of and powering other electrical or electronic devices. No hassle with cables and plugs, just place the device on a pad and that’s it. Such a system even has the potential to become a standard charging solution. By only adjusting the coupling coefficient between coils in transmitter can improve the system performance. The significant finding is that the technique shows the effectiveness with multiple receiving coils, which is very useful in practice, as well. It enables the industry to practically implement the high efficient wireless charging system for mobile consumer electronics devices in future.

From an efficiency point of view, wireless resonant power transfer is feasible for general power applications only if transmitter and receiver coils are in close proximity to each other. Resonant power transfer in a larger space is not feasible due to the very low efficiency. A Resonant inductive power pad to charge battery operated devices along with powering some electronic devices is presented, which allows arbitrary positioning and local detection.

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