Section A-Research paper
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Design & Implement Near Field Energy Harvesting and Wireless Power Transmission System using Resonant Inductive Coupling Method

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Abstract
In this paper, the design & implement near field energy harvesting and wireless power transmission system using resonant inductive coupling method is presented along with the simulation results. The idea of wirelessly supplying power to a load is one that is both daunting and challenging to implement. The invention of wireless system powering has opened the doors to a new universe. WPT (Wireless Power Technology) with Resonant Inductive Coupling, which belongs to the NFWPT category, transmits power to the receiver coil by way of a magnetic field utilizing a transmitter coil. An effective method of transferring power across short distances, resonant inductive coupling is finding use in cellphones and the medical field. This paper presents the overview of the theory behind resonant Inductive coupling and gives the circuit design of the different stages of the system. The experimental results were discussed along with the comparison of efficiency versus distance.

Key Words WPT (Wireless Power Technology), Energy Harvesting, NFWPT, FFWPT, Resonant Inductive Coupling.

1. Introduction

NFWPT (Near Field Wireless Power Technology) and FFWPT (Far Field Wireless Power Technology) are two subfields of wireless power transfer (Hassan & Elzawawi, 2015). NFWPT is additionally categorized as electromagnetic induction since it depends on the coupling of the magnetic fields between the two coils, which explains why it has a limited range. NFWPT's field (range) shrinks rapidly. It includes inductive power transfer (IPT), resonant inductive power transfer (RIPT), capacitive power transfer (CPT), resonant capacitive coupling, and magneto-dynamic coupling. FFWPT is additionally categorized as electromagnetic radiation. Long range applications benefit from it the most [1].

It is, however, comparatively less efficient because of the power losses. Since the 1960s, wireless power transfer has been in use. The smartphone industry is one of the more well-known sectors utilizing this type of wireless technology. Near field communication (NFC) and wireless battery charging technologies are being included into an increasing number of smartphones and wearable technology products. The mechanics of wireless power transfer are examined in this article, which also provides a basic design for a wireless power transmission to charge two Arduino boards and a demonstration of effective device communication. Also given is research on the limits of NFC. The electromagnetics of wireless transmission, design, construction, results of a system where data exchange occurs between three Arduinos, restrictions, and the conclusion are covered in the following sections [2].

2. Literature Review

Radio signals with frequency ranges between 300 GHz and as low as 3 kHz are utilised as a conduit to carry energy in the form of electromagnetic radiation in RF energy harvesting. One of the wireless energy transfer strategies is RF energy transfer and harvesting. Magnetic resonance coupling and inductive coupling are the additional methods. Magnetic coupling, which transfers electrical energy between two coils adjusted to resonate at the same frequency, is the foundation of inductive coupling [1]. Between two coils, a magnetic field carries the electric current. Evanescent-wave coupling is used in magnetic resonance coupling [2] to produce and transmit electrical energy between two resonators [3].

A capacitance is added to an induction coil to create the resonator. The two methods mentioned above both use near-field wireless transmission and have high power densities and conversion efficiencies. The coupling coefficient, which is influenced by the separation between two coils or resonators, determines the power transmission efficiency. Power transmission distance is limited because the power intensity attenuates by the cube of the reciprocal of the distance [3], [4], or 60 dB per decade of the distance. Furthermore, calibration and alignment of coils and resonators at transmitters and receivers are necessary for both inductive coupling and resonance coupling. They are not appropriate for remote and mobile replenishment/charging. The authors in [5], [6] have given more detailed introduction of wireless energy transfer techniques [4].

3. Principle of Wireless Transmission & Mathematical Modelling

Among the parts of a passive circuit are resistors, capacitors, and inductors. Each of these parts has an impedance, which means that when a voltage is put across their terminals, they resist the flow of current. There are imaginary and real components to impedance. In a perfect world, resistors would only have real impedances, whereas capacitors and inductors would only have imaginary impedances. Capacitors and inductors have frequency-dependent impedances. In this section, frequency is denoted by the symbol ω. The impedance Z_L of an inductor with inductance L is described by equation 1 below [5].

$$Z_L = j\,\omega\,L \quad \ldots. (1)$$

Keep in mind that an inductor's impedance will rise with frequency. Comparable to the impedance of a capacitor is this. Equation 2 provides the impedance Z_C of a capacitor with capacitance C. Yet again, this component's impedance is frequency dependent [6].

$$Z_c = \frac{1}{j\,\omega\,C} = \frac{-j}{\omega\,C} \quad \ldots.. (2)$$

Note that the impedance now reduces at higher frequencies when capacitors are used. When combining capacitors and inductors, they will produce a resonant frequency, ω_0, based on the inductance and capacitance of the components. Recall that the resonant frequency of a circuit is the frequency at which the imaginary parts of the circuit impedance are equal to zero. Selecting the right inductance and capacitance values for a specific circuit architecture will result in a specific resonant frequency or tuned resonant frequency. It's crucial to remember that Equations 1 and 2 presuppose ideal components. Parasitic resistances, capacitances, and inductances, which are present in real-world components because they are not ideal, will somewhat alter the given equations and cause an error in the voltage across the inductor. The polarity of this electromotive force (EMF) opposes the change in current. Equation below defines the EMF across an inductor with inductance L and time-changing current dI / dt.

$$\varepsilon = L\,\frac{di}{dt} \quad \ldots\ldots (3)$$

An associated parameter may now be explained using the understanding of how energy is stored in an inductor. The quantity of magnetic field flowing across a given area is known as the magnetic flux Φ. It is now able to explain how power is transferred between the two inductors as shown in the figure 1 below.

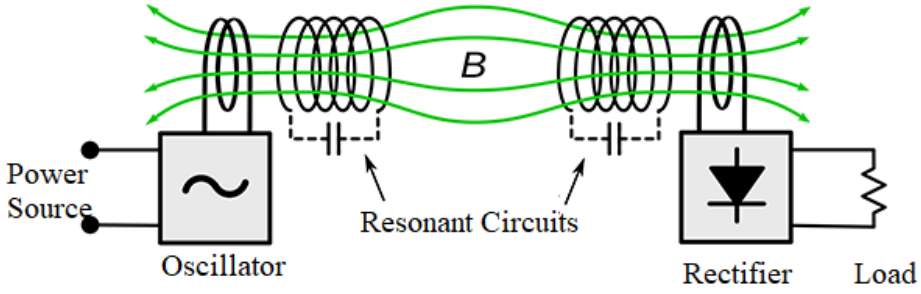


Figure 1: Basic resonant inductive coupling wireless power transfer system.

4. Power Transmitting & Receiving Module: Design & Implementation - Power Transmission Module

The first module designed for the wireless power transmission system is the Transmit module. This module takes power from AC mains and produces a magnetic field. The Transmit module block is shown below in Figure 2 [7].

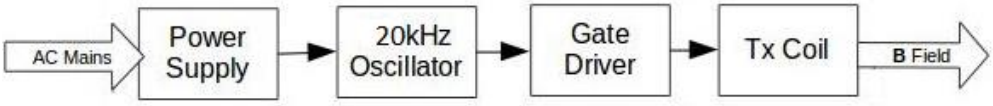


Figure 2: Transmission Module.

The module input to this block is AC mains. This input is fed into the power supply, which provides 12V to the designed circuitry. An oscillator circuit creates a square wave of frequency approx. 20 kHz, will drive the gate of a Darlington transistor which is used to get the sufficient current which pulses current through an inductor, denoted as the Tx coil in Figure 4.2. This inductor is aligned with a second and third matched inductor. As the matching coefficient M gets closer to 1, the two matched inductors should operate as an air-core 1:1 transformer. This translates into the receiving coil absorbing all the magnetic field's energy, producing a voltage and current that are exactly mirrored between the transmission and receiving coils. M does not represent the ideal value of 1, hence there are transmission losses. The output of the Transmit module can be characterized as energy that must be received by the Receive module and converted into a functional electrical signal [8].

5. Power Transmitting & Receiving Module: Design & Implementation - Oscillator & Driver Circuit Design

Astable Multivibrators are free running oscillators which oscillate between two states continually producing two square wave output waveforms. Astable Multivibrator are the most used type of relaxation oscillator because not only are they simple, reliable and ease of construction they also produce a constant square wave output waveform [9].

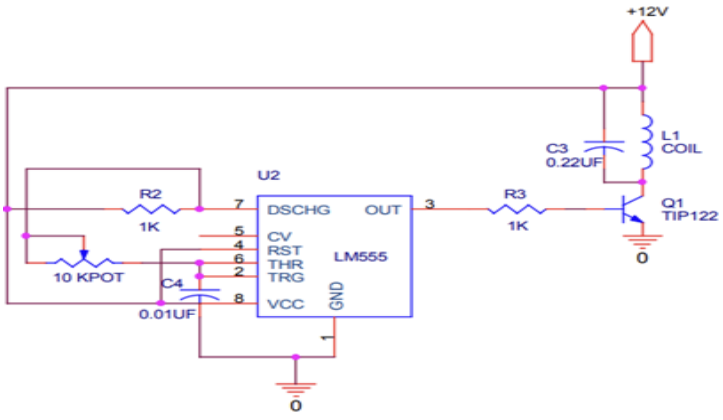


Figure 3: Oscillator and driver circuit

In the design as shown in figure 3 above a variable resistor of 10k ohm pot is used which allows a variation of generated frequency. The output of the above circuit is a square wave which resonates at a frequency approx. 20 kHz. The frequency *f* is given by [10],

$$f = \frac{1.44}{(R_1 + 2 \times R_2) * C_1} \quad \ldots\ldots (4)$$

The oscillator was constructed and produced the desired sinusoidal signal. However, the oscillator was incapable of driving the Tx coil, as the output impedance of the oscillator is less than the impedance of the inductor. The inductor has a nominal inductance of 34µH. To drive the Tx coil L_1, a transistor TIP122 was used to pulse current through the inductor as shown above in the driver circuit. Along with the Concept of WPT, a communication between the nodes 1 & 2 with master node is presented in this work. The master node consists of an Arduino board as controller, Zigbee transceiver module and a LED display to show the values of temperature and light intensity values received from node1 and node 2. The Schematic of master node is given in figure 4 [11].

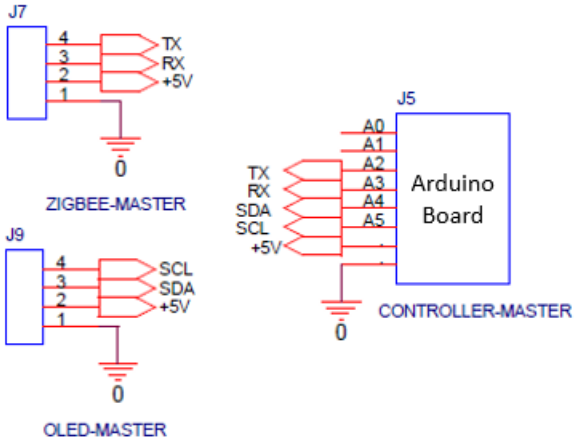


Figure 4: Schematic of Master Node

6. Power Transmitting & Receiving Module: Design & Implementation - Power Receiving Module

The overall purpose of the Receive module is to take the energy sent from the Transmit module and transform it into a current to charge the battery. The Receive module is shown below in Figure 5 [12].

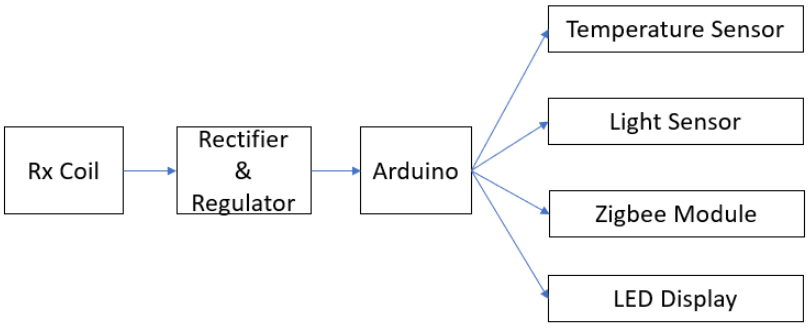


Figure 5: Receiver Module

The module input for the Receive block is the module output of the Transmit block. The energy output of the Tx coil, which is a magnetic field, is seen by the Rx coil. This magnetic field induces a current through the Rx coil, which can be measured as a voltage across the inductor using Equation 3. The voltage across the Rx coil is rectified in order to power a battery charging circuit. The fully charged battery acts as the module output for the Receive block [13].

7. Power Transmitting & Receiving Module: Design & Implementation - Power Receiver Design

The goal of the Receive module is to take the current induced by the Rx coil and produce a power supply for the next circuitry. First, the AC signal from the Receive coil is rectified and regulated. Inductor L_2 from Figure 5 represents the R_x coil shown in the Receive block diagram. The EMF induced across the Rx coil is approximately equal to the voltage measured across the Tx coil, as defined in Equation 3. The current through the Rx coil L2 is dependent on the mutual inductance coupling coefficient. For the signal to be capable of powering the Arduino board, the signal needs to be rectified. A bridge rectifier is used for the purpose and a voltage regulator LM7805 is used to get a constant voltage of 5V as shown in below figure 6 [14].

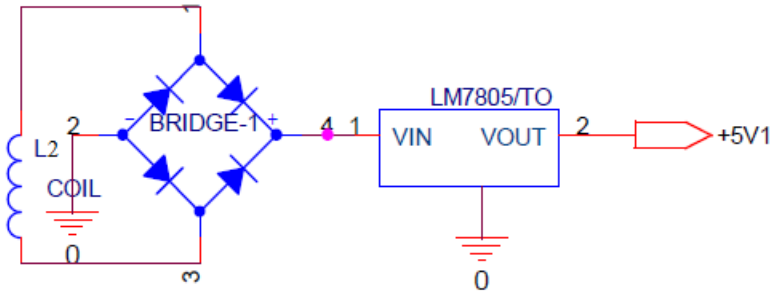


Figure 6: Rectification and regulation at node1

The same circuitry is used at node2 as well to get the regulated voltage as shown in figure 7. Here a receiving coil L3 is used where the EMF is induced across it [15].

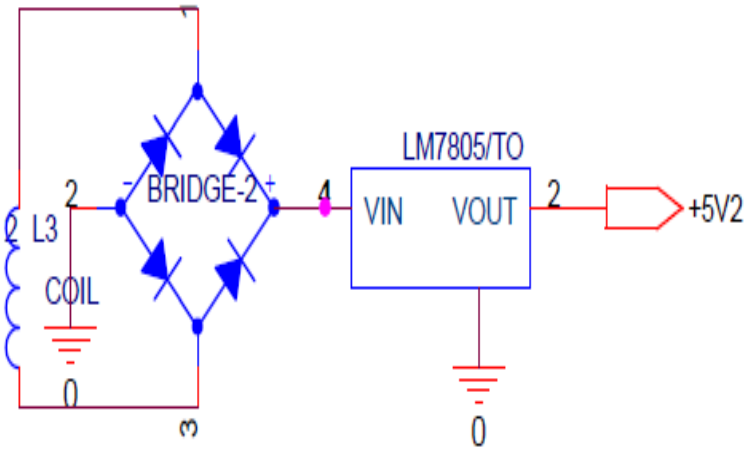


Figure 7: Rectification and regulation at node2

As presented above, a voltage of 5V is generated from the WPT technique, this voltage will be supplied to an Arduino board as a power source with which the controller will be operated to perform various functions. The Arduino controller is connected to many devices, Temperature sensor, Light sensor, Zigbee module and a LED display which gives the details of schematic of node1 as shown in figure 8. Arduino receives the signal from Temperature and Light sensors and the values will be displayed on the LED display. Zigbee module is connected to the controller which acts as a transceiver, receives the signal from Node 1 Arduino and transmits to the Mater node Arduino.

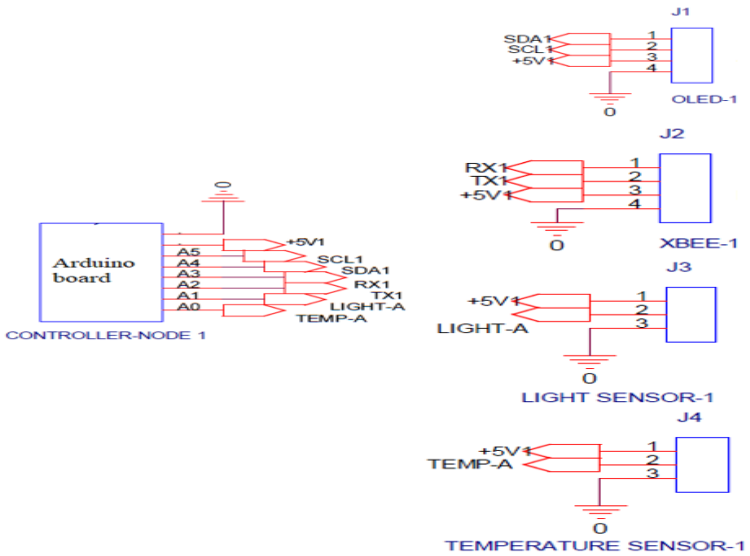


Figure 8: Node 1 Schematic

Like the above schematic, Node 2 is also set up to have the devices connected to node 2 Arduino as shown in below figure 9.

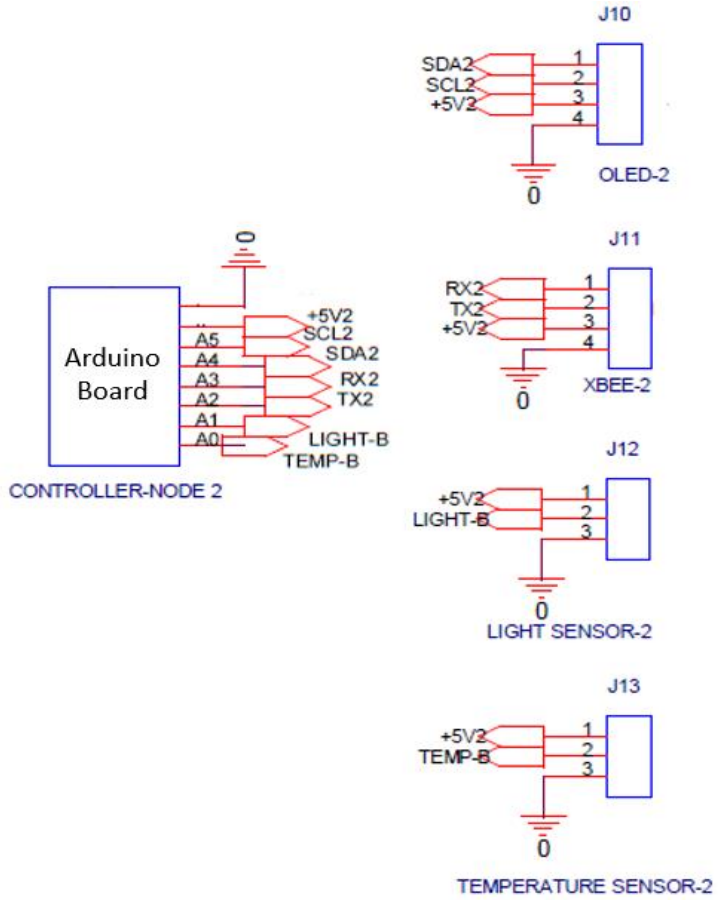


Figure 9: Node 2 Schematic

8. Hardware Implementation

The inductively resonant Wireless Power transfer system design presented in this chapter is demonstrated with the hardware setup. The signal of frequency approx.20kHz is generated using an Astable multivibrator and a driver circuit consists of a transistor TIP122 to pulse current through the inductor coil i.e., Tx coil L_1. At the receiving side there are two Rx coils L_2 and L_3 which drives the next circuitry. The EMF induced across the Rx coil produces an AC voltage which will be converted as DC is done by Bridge rectifier and regulated to a constant value 5V by a regulator LM7805. This voltage drives the Arduino and the sensor network formed around the Arduino controller. The sensory information / values produced by Temperature and Light sensors will be received by the controller and the zigbee module will receive and transmit to the master Arduino controller/ master node. The complete hardware setup is shown in below figure 10.

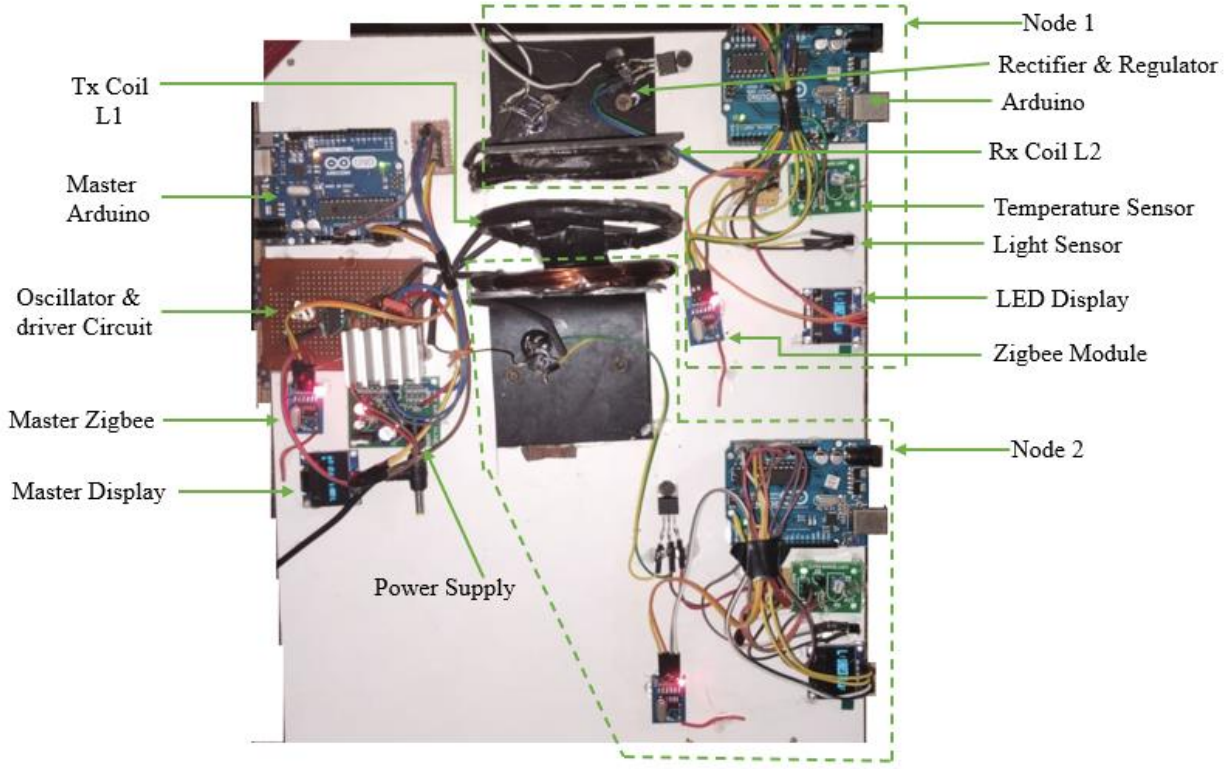


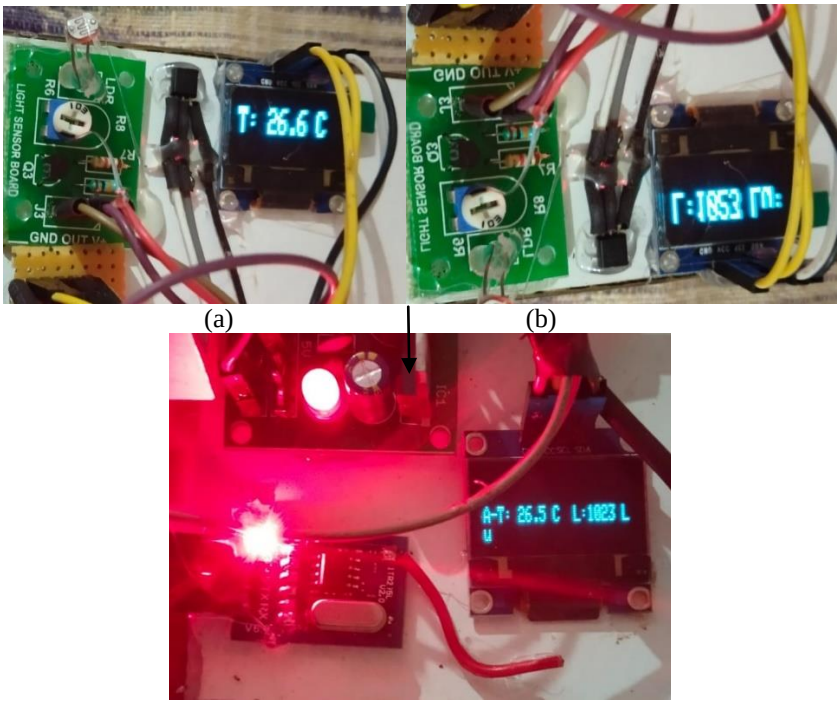
Figure 10: Hardware Setup

The hardware construction involved taking measurements at various points in the analog circuitry to determine whether the system would be successful, then performing overall testing. This resulted in multiple iterations of the circuitry, including tuning of component values and circuit layout. It was discovered, through experimentation, that the signal through the inductor did not produce a strong enough magnetic field, which led to a small current induced through the Rx coil. These results led to the inclusion of the gate driver circuit to pulse high amounts of current through the inductor. There was also an issue with the number of turns of both transmitter and inductor coil which were carefully matched later to produce the required output. The distance between the Tx and Rx coils were affecting on the amount of output produced. A reasonable distance was maintained to get the sufficient output to drive the next circuitry.

9. Results and Discussions

As expected from the design, the magnetic field is induced to both the receiving coils from a single transmitting coil. A regulated output of 5V produced from WPT is given as a power supply to the Arduinos, that means there is no external power supply to the Arduino. A star kind of network is formed as Node 1 and Node 2 where Arduino

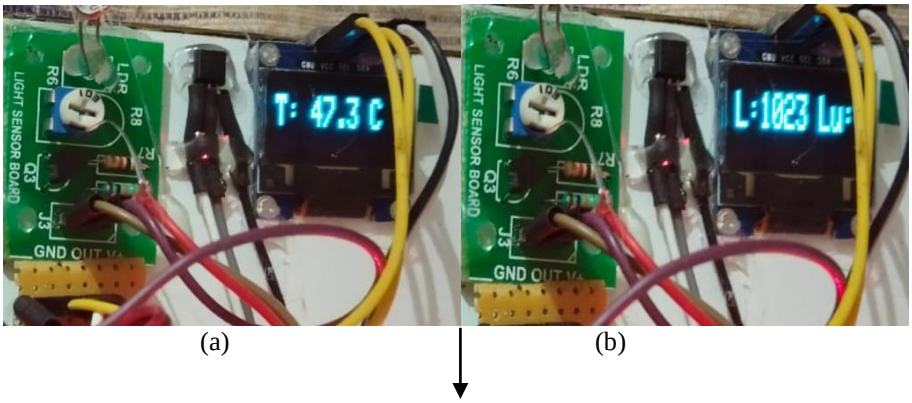
controller board as the master node and Temperature sensor, Light Sensor, Zigbee and Display as the slave nodes. All these slave nodes are powered from Arduino board of node1 and node 2. The sensory data by Temperature and Light sensors were sent to the Arduino on real time basis. The LED displays were also used to display the real time values of Temperature in degrees and Light as intensity (Lu) at both the nodes. These real time data is transmitted to the master node Arduino through the Zigbee modules, and the values were also displayed at Master LED display to show up the real time data transfer and communication.



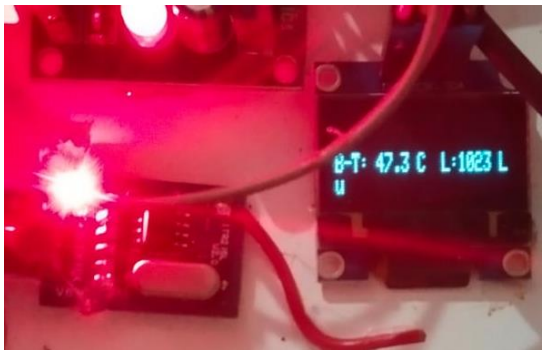
(a) (b)

(c)

Figure 11: The data exchange between Node1 and master node. (a) Node1 Temperature (b) Node1 Light Intensity (c) Node1 data at Master node



(a) (b)



(c)

Figure 12: The data exchange between Node2 and master node. (a) Node2 Temperature (b) Node2 Light Intensity (c) Node2 data at Master node

The master node displays the received data from the node1 or node 2 which ever sends it immediately. The reason behind it is there is no request command used in coding to prioritize the condition for LED display. This real time data can also be imported to a computer to analyze the delay in the data transfer and to plot any graphs if required. In case of NFWPT the distance between the Tx and Rx coil is an important factor. The below plot figure 13 shows how the energy efficiency is dependent on the distance. It can be observed that the efficiency decreases to 0.5% beyond 4cm.

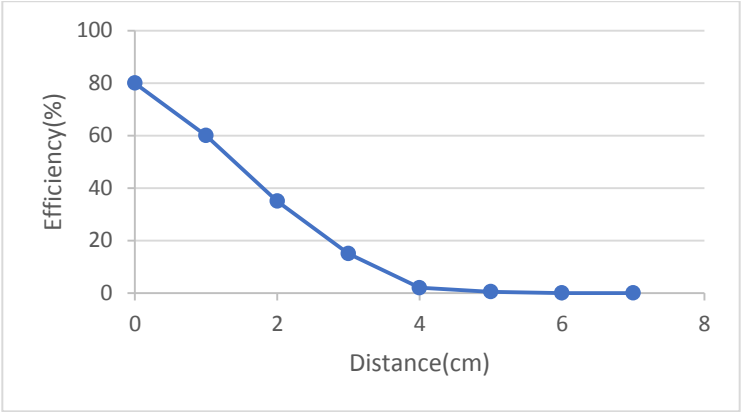


Figure 13: Plot of Efficiency vs Distance

10. Conclusions & scope for future works

Near Field wireless power transmission is an effective way of powering many devices including mobile phones while far field wireless power transfer techniques were failed to do it because of higher voltage requirements. The NFWPT using inductive resonant coils were designed, implemented and hardware demonstrated in this work. The data transfer between the nodes and master node is also demonstrated by using a network model. Along with all the advantages of NFWPT it is also very important to consider distance as the limitation of this technology. Even though there is lot of research going on to design FFWPT and implement in real time the amount of power harvested is still a challenge.

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He has got a teaching (academic), research & administrative experience of more than 34+ years in various engineering colleges all over the country (Karnataka, Gujarat, Maharashtra) and spent his entire career after graduation in the field of academics, research & administration only. He has worked in the levels of Lecturer-Asst. Prof (>18+ yrs), PG Coordinator, Prof-i/c HOD-Prof. & Head (>7+ yrs), Director-Research, i/c Principal & as Full time Principal (9 yrs approx) in various institutions where he has worked so far across the country. Currently, he is working as Professor & Head of the Dept. of Electronics & Communication Engg of the renowned 44 year-old Dayananda Sagar Group's 'Dayananda Sagar College of Engineering' in Bengaluru, Karnataka, India since more than 6+ years, which is an autonomous institution affiliated to VTU. He has also worked as a Project Assistant and as a Research Engineer in the Systems and Control Engineering of IIT Bombay and worked on vibration control of space launch vehicles in IITB during his research tenure for a period of nearly one year, a funded project from ISRO under the guidance of his supervisor.

He has published more than **1000+** papers in various National, International Journals and Conferences in India & abroad (with 100+ Scopus Q-Series SCI WOS IEEE Springer, Wiely, Elsevier, etc…) and published more than a dozen textbooks (20 nos) with editions, notable among them being ('Introduction to Robotics' - 1st edition, 'Fast Track to Robotics' - 4th Edn., 'Fundamentals of Robotics' in 2 volumes, Vol-1 and Vol-2 along with a CD which contains about 200 C / C++ programs for performing various simulations on robotics – 5th edition, 'Examination Security System - Design & Development of Examination Mechanism Using Electronic Box' from Germany costing around 49 Euros, 'Microcontroller & Applications Theory', 'Basic Electronics', 'Computer Communication Networks', 'Optical Communication & Networking', 'Emerging Trends in Engg. & Tech.', 'Recent Advnaces in Engg. & Tech.', 'Recent Developments in Computing, Electronics and Mechanical Sciences', 'Contemporary Research in Electronics, Computing and Mechanical Sciences', 'Recent Developments in Engg. & Tech.', 'Signals & Systems', Playing Smart – Artificial Intelligence, Deep learning and it's techniques, Computer Vision and Techniques, Image Processing and Machine Vision, Digital Signal Processing, Computational Intelligence, Electronic Devices & Circuits for Computer Engineers, Basic Electrical & Electronics Engineering & still many books are under the pipeline in press.

He has also published a number of 'book chapters' in various edited books from renowned publishers (30+ nos). He has also published a research monograph in the International level from the Springer-Verlag publishers (Europe) based on his Ph.D. thesis topic titled, "Modeling, Control & Implementation of Smart Structures", Vol. 350, LNCIS, costing €114.39 Euros.

He is a member of 30 professional societies across the world. Some of them are …. a member of IEEE for the past 22 years (currently Sr. Member of IEEE), Sr. member of IIIEM, SPIE student member (USA) and IOP (USA) student member for 4 years, life member of ISSS-IISc (India), life member of additive manufacturing society of India (LMAMSI), life member of the ISTE (India), life member of ISOI (India), life member of SSI (India), life member of the CSI (India), Life member of IMAPS, Sr. Member of IACST (Singapore) and life member cum fellow of the IETE (India), AMSI, Life member of IAENG, Life member of Inspira Research Association, Chartered Engineer from IE (I) and a Fellow of the Institution of Engineers (FIE), Member of ACDOS - Automatic Control & Dynamic Optimization Society, Member of ACCS-Advanced Computing & Communications Society. He was also an EC & GC member of the IETE (Bangalore) for 2 years.

He has given (delivered) a number of guest lectures / invited talks / expert talks and seminars in many institutions across the length & breadth of the country (>50 times) and participated (attended) in more than 200 CEP / DEP courses, seminars, workshops, symposiums (with certificates), besides conducting >300+ courses, i.e., workshops, FDP's conference, symposiums, SDP's in the institutions where he worked. He was awarded with the "Best research scholar award in engineering discipline" for the academic year 2006-07 for the entire institute from the Research Scholars Forum (RSF) from Indian Institute of Technology Bombay IITB. This award was presented in recognition of the significant contribution to the research (amongst all the researchers in all disciplines) in IIT Bombay, where he published 30 research papers (all of them were free & referreed ; 1-monograph from springer, 14 Journals-all refereed & free journals-abroad, 15 conferences). He is also a Sr. Typing (First Class with Distinction) specialist from the commerce institutes association of karnataka and a United Nations certified candidate along with 82nd position in the tenth standard merit list all over Karnataka. He is also an Hindi-Rastrabhasha (DBHPS) holder.

Also, he was conferred with the best paper awards (20 times) in a number of national & international conferences. He was also conferred with the prestigious Rajiv Gandhi Education Excellence Award, Global Education Achiever of India award, Rashtriya Vidya Gaurav Gold Medal Award & International educational excellence award (in recognition of sterling merit excellence performance and outstanding contribution for the progress of the nation & world-wide) from New Delhi in the year 2013, Global Outreach Research Award Recipients-2019 for his life time

achievements in research (life time achievement award-2020) from ESNA & Global Outreach Foundation, all the previously mentioned awards was awarded w.r.t. his achievements in the field of education, overall life time performance, academics, administration & research.

He was also instrumental in getting a no. of Research centres (along with M.Tech. programmes & new UG programmes in the engineering colleges where he has worked so far as the administrative head, i.e., as principal. He was also responsible for getting AICTE grants under MODROB scheme for the development of the Robotics & Mechatronics Labs in one of the colleges where he worked. Apart from which, he has brought a number of grant-in-aid for the conduction of various events like workshops, conferences, seminars, projects, events, etc., wherever he has worked [from VTU, DST, IETE, CSI, IEEE, IE(I), DRDO, ISRO, VGST, KSCST, Vodafone, Uninor, etc.] from different sources. In the current college where is working as Prof. & Head, 70+ research scholars were pursuing Ph.D. in ECE Dept. VTU R & D centre and 22 of them have already completed.

He has visited Singapore, USSR-Russia, United States of America and Australia for the presentation of his research papers in the various reputed international conferences abroad. His biography was published in the 23rd edition of Marquis's Who's Who in the World in the 2006 issue. He has also guided more than 100+ projects (B.E. / B.Tech. / M.E. / M.Tech.) in various engineering colleges where he has worked, apart from guiding a couple of research scholars who are doing Ph.D. in various universities under his guidance (9 Ph.D's have already come out from VTU & 6 more are pursuing). Majority of the B.E. & M.Tech. works what he has guided were converted into research papers. Many of his guided projects, interviews, achievements, the events what he had conducted so far till date have appeared in various state & national level newspapers and magazines (more than 300 times). He has also reviewed many research papers for the various national & international journals & conferences in India & abroad (more than 200 times). He has more than 100+ scopus indexed, web of science, IEEE, Elsivier papers along with more than 25,000+ citations in the google scholar portal with more than 50 in h-index & more than 500 in i-10 index. He was also associated with NBA, NIRF works & ISO works in the DSCE w.r.t. his department and a number of other types of survey activities from reputed organizations.

He has also organized a number of state & national level sports tournaments like yogasana, chess, cricket, volleyball, etc. where he had worked as a employee. He is also an (50+) editorial board / advisory board / reviewer member and is on the panel of many of the national & international Journals as editor, reviewer, committee member etc... He has also served on the advisory / steering / organizing committee member of a number of national & international conferences in the country & abroad. He has given many keynote / invited talks / plenary lecturers in various national & international conferences and chaired many sessions, was judge, special invitee, guest of honor & was chief guest on various occasions.

He has also conducted / organized / convened / coordinated more than 300+ courses / Workshops / Training Programmes / Hands on workshops / Symposiums / STTP's / FDP's / Technical paper fests, Student level competitions, etc., in various engineering colleges where he worked so far. Till date he has given more than 1 dozen webinars on hot topics to various organizations in the world. He has also taken many administrative initiatives in the college where he has worked as HOD, Principal, PG Coordinator, Research Director & also where he is currently working as Prof. & Head in ECE Dept of DSCE, besides conducting all the semester university exams successfully as chief superintendent, deputy chief superintendent, squad member, BOE & BOS Chairman, etc. Some of the special administrative achievements as Faculty, HOD, Principal & Head of the Institution are ….

He improved the results of the various branches in Atria Inst. of Tech. / BTL Inst. of Tech. / HKBK College of Engg. / Dr. Ambedkar Inst. of Tech. / Nandi Inst. of Tech. & Mgmt. Sciences, where he was working as the principal. He gave more importance to the development of the in-house projects for the final year students & initiated the Project Open-Day, where all the final year students used to exhibit their project works on a single platform. He has also motivated many of the faculties to take up take up consultancy works & did it efficiently, so that the college got some good income (revenue generation scheme), besides sending large no. of students towards the internships (1000+) in various industries. He made the faculties to take up research (Ph.D) work or do M.Tech. by compelling them constantly to purse for higher studies as a part of the career enhancement project.

As an administrative head, he made the faculties to publish paper in either national / international journals & conferences at least one or two in an academic year. He started the student chapters (professional societies) in all the branches such as IETE, IEEE, ISTE, IEI, CSI, SAE, ISOI & also conducted a number of events under their banners, which were very much useful to the students & staff members. He brought in power decentralization by developing the habit of making coordinator-ships for various works, getting the work done by monitoring and following it up successively. He was also involved in TEQIP-2 & 3 process in Dr. AIT along with the development

of many of the autonomy and world bank works & brought crores of rupees as TEQIP grants while he was the Principal in Dr. AIT.

He was also a BOS member & BOE member in the some of the university panels. He conducted a number of exams from the public sectors & private sectors such as GATE exams, CET / COMED-K, KPSC, TCS, Police Exams, Inst. of Civil Engineer exams & conducted a number of state & national level examinations like Defense, PG entrance exams, Medical, KPTL in the college where he had worked as administrative head, so that the college could get some revenue (under the banner of revenue generation scheme). He started the weekly monitoring of the staff & students by making the proctoring or the mentoring process very strong. He developed the counseling of student data booklets & that of the faculty work-diary, besides the monthly newsletter & the research bulletin (samshodhana saara) in all the places where he has worked.

All the laboratory manuals were developed in-house, printed & given to the students (both in the hard as well as in the soft copy). All the laboratory experiments were videographed individually & given to the students and put on the departmental portal also. The notes of the different subjects were put in the moodle server of the departmental portal so that the students could use it for their study purposes. He used to conduct the academic & governing council meetings regularly along with the HOD's meetings & staff meetings time to time. He had looked after the NBA process (6 times) in Fr. CRCE, Atria IT, HKBKCE, BTLITM, Dr. AIT & in DSCE and got NBA in all the colleges mentioned previously. He has also looked after the NBA NAAC process in DSCE and was the NAAC coordinator for couple of criterias. He conducted the prestigious 7th IETE ICONRFW & the 28th Karnataka State CSI Student Convention in HKBKCE when working as a Principal. He introduced the scheme of best lecturer award / best HOD award / best non-teaching award / service awards concept / Principal cup / Departmental cup, etc. in the colleges where he worked as administrative head in few colleges for the various staff members. He also conducted a number of national & international conferences in the colleges where he worked such as the NCECON-14, NCECON-19, SIETCON-17 & 18, ICRTEMP-20.

He created a record placement of more than 3000 students in Atria Inst. of Tech. / HKBKCE / BTLIT / Dr. AIT / NITMS / DSCE with the help of the college placement department & with the help of placement coordinators of the department and institution when he was worked as the Principal & currently where he is working as the Head of the Department. He helped the management to fill up many of the student admissions in the first year of UG (B.E.) & in PG (M.Tech.) course by doing extensive marketing from different angles and sources. He created a number of hobby-clubs, start-up, e-club, EDC cells, Innovation & Incubation centres, centre of excellences in the institute for the staffs & students to work towards development of prototypes, models, and projects. He started the faculty seminar series in the institute so that every faculty gives a lecture of 45 mins with 15 mins discussion at least once in a month in many colleges. Many of the subjects were treated with project-based learning concepts in the autonomous colleges. He introduced many new subjects in the autonomous colleges such as 5G Communications, AI, ML, DL, AI & Robotics, etc. to enrich the curriculum with current technology subjects.

He introduced the concept of coaching class/tutorial classes for weak students & remedial class concept for failed students, slow learners, which yielded successful results apart from the training of top 10 students for getting ranks. He made students to get university ranks in BTL & HKBKCE in the UG & in PG streams when he was working as Principal. He started the On-line courses, Certificate oriented courses of 1/2/3 months & 6 months for various types of people, especially on weekends when he was the Principal. He made students to participate in competitions outside the college & win a number of prizes, brought laurels to the institution (brought awards, prizes & certificates from the students more than 50 times). He helped the students to get some financial assistance using sponsors for conducting the cultural events & other activities such as the workshops, FDPs & Conferences. He was on the panel of Local Inspection Committee (LIC) member of inspecting various engineering colleges of VTU a number of times & he is also a registered & recognized research supervisor in the Visvesvaraya Technological University & went as expert panel member for conduction of research interviews in couple of universities, faculty selection panel member for appointment purposes, etc…

He brought a project grant of nearly Rs. 4 crores till date in the various organizations where he has worked so far with help of faculties under various funded projects scheme such as DST, ISRO, KSCST, VTU, IEI, DRDO, TEQIP, VGST, AICTE, MHRD, etc…. along with a number of research proposals being submitted to various organizations. He developed the Innovation & Entrepreneurship Development Cell in HKBKCE & did a number of programs under its belt. He was responsible for some of the UG students of HKBKCE to make them establish a start-up company in the college itself by name 'pentaP systems Inc'. He also developed a number of hobby clubs in the departments such as the 'e¬-club' robotics club, nano-club, micro-club, which was used to conduct a large number of activities w.r.t. technical & non-technical problems. He made 20 MOU's with reputed firms & sectors

with the college and utilized all the advantages of the signed MOUs with the companies, used the MOU banner to get projects, conduct seminars, conferences, workshops & FDPs in the various colleges where he worked & currently working.

He streamlined many of the process in the office level & that of the departmental level by developing new & newer formats for the smooth conduction of various processes along with excellent documentation. He underwent the one-week NUS-Leadership training programme in Singapore @ National University of Singapore-NUS, sponsored by TEQIP-II SPFU MHRD GOK DTE & Govt. of India in the year Sept. 2015 when he was the Principal of the Govt. Aided Dr. Ambedkar Inst. of Tech in Bangalore. He developed the culture of making up of small / mini hobby projects by the students along with the development of a number of alternate assessment tools, i.e., the AATs. He developed the systematic documentation of entire departments & that of the college as HOD & Principal. He also on many occasions made the students to work upon the project-based learning, i.e., whatever is taught in the theory, the same is carried out in practicals in few subjects. He conducted a no. of AATs such as Surprise Test, Seminar, Quiz, Role Play, Group Discussion, Case Study, E-Course Certification, Mini Projects, Developing Products, Building, Models, Paper Presentation, Poster Publication, Programming Contest, General Science & Technical Quiz, Hackathons, Demonstrations, Analysis, Optimization & comparison of theoretical concepts using modern tools.

He has got 160+ Patents from the Govt. of India & the Australian Govt, out of which few of them were granted & the rest published with the remaining in the process of getting granted, filed & published. He also has got very good experience in the autonomous curriculum of the VTU course in the context of make up exams, fast track exams, supplementary exam and also got good ideas about BOS/BOE/COE, CIE, SEE, Curriculum Design, etc… as he has worked for more than 6 years in the autonomous colleges. Under industry-institute interaction, he conducted a number of industry-oriented courses like CADD course, ANSYS course, PCB Designing course, Quadcopter course, IOT Course, Oracle course, Infosys campus connect courses (18 batches rolled out in HKBKCE), Software testing, etc.

His special areas of interest are - Control systems, DSP, AI, ML, DL, Swarm Intelligence, Research Methodology, Cognitve Sciences, IP, PE, Robotics, Signals & systems, Smart Intelligent Structures, Basic Electrical Engg., Basic Electronics, Network Analysis, Vibration control, Communication Theory, Instrumentation, IoT, Power Electronics, WSNs, Circuits & Networks, Matlab, etc...