SIDDAGANGA INSTITUTE OF TECHNOLOGY
TUMAKURU – 572103

(An Autonomous Institute under Visvesvaraya Technological University, Belagavi)

TECHNICAL SEMINAR REPORT
On

"IoT BASED SMART BATTERY STATION USING WIRELESS POWER TRANSFER TECHNOLOGY"

Submitted in partial fulfillment of the requirement for the award of

BACHELOR OF ENGINEERING

In

ELECTRONICS AND INSTRUMENTATION ENGINEERING

Submitted by:

SNEHA
1SI19EI041

DEPARTMENT OF ELECTRONICS AND INSTRUMENTATION ENGINEERING

2022-23

CONTENTS

List of Figures
Acknowledgement
Abstract

Chapter	Title	Page No.
1.	**Introduction**	**06**
2.	**Literature Survey**	**08**
3.	**Wireless Power Transfer**	**10**
	3.1 WPT By Mutual Inductance	**12**
4.	**Mathematical Model of IPT Circuit**	**14**
	4.1. Circuit Diagram Assembly	**17**
5.	**Results**	**20**
6.	**Conclusion**	**23**
7.	**References**	**24**

LIST OF FIGURES

Fig1.1	A Collection of smart Devices	**08**
Fig1.2	IoT Protocols	**08**
Fig3.1	General Classification of power transfer in terms of mobility, distance, and means of powering.	**11**
Fig3.2	Overview of a topology for wireless power transfer	**12**
Fig3.1.1	An illustration of Inductive over transfer	**13**
Fig4.1	An equivalent circuit model for series-series inductive power transfer	**15**
Fig4.1.1	Block diagram of input power supply	**17**
Fig4.1.2	Circuit diagram of Tx side	**18**
Fig4.1.3	Circuit diagram of Rx side	**19**
Fig5.1	Tx side of the assembly	**20**
Fig5.2	Rx side of the assembly	**21**
Fig5.3	Finished Prototype	**21**
Fig5.4	Monitoring of data using Thing speak Module	**22**

ACKNOWLEDGEMENT

I am delighted to express my sincere gratitude and pranaam to His Holiness Dr. **SREE SREE SHIVAKUMARA SWAMIJIGALU**, Founder President and **SREE SREE SIDDALINGA SWAMIGALU**, President, Sree Siddaganga Education Society, Sree Siddaganga Mutt for all their blessings bestowed upon me, which has been a constant and immense blessing during my course of study.

I dually respect and thank our respected Director **Dr.M.M. Channabasappa**, for his sincere dedication, perseverance for creating a continuous platform towards the society and betterment of the nation in the field of education, as the future of every nation lies in the hands of education.

I express my gratitude and will remain indebted to **Dr. Shivakumariah**, C.E.O and **Dr. S. V. Dinesh**, Principal, SIT, Tumakuru, for fostering an excellent academic environment in this institution and also providing excellent campus facilities, which made our endeavor possible. I am grateful **to Dr.H M Kalpana**, Professor and Head, Department of E&IE, SIT for continuous support and encouragement. Her suggestions and advice have been valuable.

I am too content to express my gratitude to our Technical Seminar Coordinator **Dr. Panwala Fenil Chethankumar**, Assistant Professor, Department of E&IE, SIT, Tumakuru, who has inspired all the students, and has been unflattering zeal and a constant support, to strive for those great achievements, and an inspiration during the course with his irreplaceable enlightenment. Not to forget all the Faculty and Supporting staff of E&IE Department, for their succour and concurrence in completing and in carrying Technical Seminar. Last, but not the least a sincere gratitude to my Parents and Friends for their patience, love, support and encouragement throughout this journey.

SNEHA
1SI19EI041

ABSTRACT

IoT technology has been playing an increasingly important role in the development of modern technology. The idea of smart devices, which are able to regulate and maintain themselves as well as respond to external stimuli has led to the new paradigm in appliance manufacturing, of which the household appliance and the electrical industries are the most affected. Also, on a side note, there have been many strides in wireless power transfer technology, some of which are great improvements in efficiency and reduction in size, which bring the technology closer to household applications. This project effectively aims to utilize the conjunction of the two aforementioned technologies to create a prototype of a smart appliance, a battery charging station powered wirelessly and integrated with IoT technology, which enable the user to continuously monitor the critical parameters of the battery, such as charge level, input and output current, etc. The logged data can also be accessed from anywhere, such as a smartphone or a PC, due to its easy availability as it is uploaded to the cloud. Thus, this project synthesizes a new generation of electronic devices.

CHAPTER 1

INTRODUCTION

Smart devices are the new generation of devices whose primary characteristic is that they are capable of networking among themselves and with outside agents such as PCs, Smartphones, etc., utilizing an array of wireless communication protocols like Bluetooth, Zigbee, NFC, Wi-Fi, LiFi, 3G, etc. The word smart may also refer to a device that exhibits certain computing properties, like artificial intelligence, though not always. Smart devices can be designed to support a number of environments, a range of various computing properties, and be used in three major areas: physical world, human-centered environments, and distributed computing environments. Usually, smart devices consist of a hardware layer (including a radio transmitting signals), a network layer (through which devices communicate with each other), and an application layer (through which end users receive commands). Smartphones, tablets, phablets, smartwatches, smart glasses, and other personal electronics are some of the most commonly used smart devices.

IoT refers to the Internet of Things, which are a series of interrelated computing devices, mechanical or virtual computers, artifacts, animals and individuals with unique identifiers (UIDs) and the ability to transfer information over a network without the need for human-to-human or human-to computer communication. IoT devices can be either used as standalone devices or can be added as upgrades to already existing devices. The modularity of IoT provides a lot of advantages and can be utilized effectively to bolster the capabilities of already existing devices, making it a powerful tool in the arsenal. Coupled with cloud storage platforms, IoT devices can be used to monitor and log data from remote devices such as sensors, factory instruments, etc.

Fig 1.1. A Collection of smart Devices

Fig1.2. IoT Protocols

The aim of the project is to fabricate a prototype of a smart device, by a combination of three major technologies: IoT, Smart Devices and Wireless Power Transfer. By a combination of the above three technologies, taking their benefits, an electrical device capable of continuous data logging and monitoring can be achieved. By improving on the design on a conventional battery charger, a prototype which can lead to further developments is achieved, and if feasible, used commercially. This project documents the integration of IoT technology with electrical devices, it's feasibility and results, thus adding the scope to improve already existing designs of electric devices, as upgrades.

CHAPTER 2

LITERATURE SURVEY

[1] Kim, J., Kim, J., Kong, S., Kim, H., Suh, I.-S., Suh, N. P., … Ahn, S. (2013). Coil Design and Shielding Methods for a Magnetic Resonant Wireless Power Transfer System. Proceedings of the IEEE, 101(6), 1332–1342.doi:10.1109/jproc.2013.2247551.

The basic principles of wireless power transfer using magnetic field resonance and describe techniques for the design of a resonant magnetic coil, the formation of a magnetic field distribution, and electromagnetic field (EMF) noise suppression methods. The experimental results of wireless power transfer systems in consumer electronics applications are discussed in terms of issues related to their efficiency and EMF noise. Furthermore, we present a passive shielding method and a magnetic field cancellation method using a reactive resonant current loop and the utilization of these methods in an online electric vehicle (OLEV) system, in which an OLEV green transportation bus system absorbs wireless power from power cables underneath the road surface with only a minimal battery capacity.

[2] D. Ravi Kishore and T. Vijay Muni, ―Efficient energy management control strategy by model predictive control for standalone dc micro grids‖, AIP Conference Proceedings 1992, 030012 (2018); doi: 10.1063/1.5047963.

Energy Management Strategy that dynamically optimizes the operation of stand-alone dc microgrids, consisting of wind, photovoltaic (PV) and battery branches, and coordinately manage all energy flows in order to achieve four control objectives i.e. regulating dc bus voltage level of microgrids; proportional power sharing between generators as a local droop control realization; charging batteries as close to IU regime as possible; and tracking MPPs of wind and PV branches during their normal operations. Non-linear model predictive control (NMPC) strategies are inherently multivariable and handle constraints and delays. The EMS is developed as an NMPC strategy to extract the optimal control signals, which are duty cycles of three DC-DC converters and pitch angle of a wind turbine. The variable load demands are also shared accurately between generators in proportion to their ratings. Moreover, the DC bus voltage is regulated within a predefined range, as a design parameter.

[3] Kumar, M.K. Datta, D.V. T Vijay Muni., Performance enhancement of asynchronous machine with super Capacitor, International Journal of Engineering and Advanced Technology, 8(4), pp. 1208- 1210.

The supercapacitor which solves the high current starting problem of three phase induction machine when it is subjected to load condition. Super capacitor is a energy storage device, it will stores the energy in it at the time of normal condition, and at the time of load condition it will supplies the energy which is stored in it to the three phase induction machine. The three-phase induction machine and DC motor are coupled by using a mechanical shaft. Super capacitor is place across the DC motor and a controller also used in this system.

[4] Samanta, S., & Rathore, A. K. (2016). Wireless power transfer technology using full-bridge currentfed topology for medium power applications. IET Power Electronics, 9(9), 1903– 1913.doi:10.1049/iet-pel.2015.0775.

This paper studies, explores and analyses a wireless power transfer (WPT) system using current-fed power electronics topology for electric vehicles and battery charging applications. The main contribution is analysis, design, and implementation of a current-fed technology for WPT application. The required resonance in both the transmitter and receiver coils is parallel (L)(C) and series (LC) type, respectively. Stiff DC current at the input of the inverter limits the inverter switch current stress. Also, the inductor in DClink provides natural short-circuit protection during inverter fault. It is quite important in such application. Resonant converter facilitates soft-switching at turn-off of the transmitter side switches. Also, soft-commutation of rectifier diodes reduces reverse recovery loss. Mathematical analysis is verified by simulation results using PSIM 9.3. A 420 W proof-of-concept lab hardware prototype is developed and the experimental results are demonstrated to validate the mathematical analysis and simulation results. The maximum efficiency of DC–DC WPT stage obtained from the proof-of-concept lab-prototype is close to 90% with a coefficient of coupling 18%. It is suitable for solar-to-vehicle and single-phase residential slow charging

.

[5] Zhang, Z., Pang, H., Georgiadis, A., & Cecati, C. (2018). Wireless Power Transfer - An Overview. IEEE Transactions on Industrial

Due to limitations of low power density, high cost and heavy weight etc., the development and application of battery-powered devices is facing with unprecedented technical challenges. As a novel pattern of energization, the wireless power transfer (WPT) offers a band new way to the energy acquisition for electric-driven devices, thus alleviating the over-dependence on the battery. This paper presents an overview of WPT techniques with emphasis on working mechanisms, technical challenges, metamaterials, and classical applications. Focusing on WPT systems, this paper elaborates on current major research topics and discusses about future development trends. This novel energy transmission mechanism shows significant meanings on the pervasive application of renewable energies in our daily life.

[6] Kurs, A., Karalis, A., Moffatt, R., Joannopoulos, J. D., Fisher, P., &Soljacic, M. (2007). Wireless Power Transfer via Strongly Coupled Magnetic Resonances. Science, 317(5834), 83– 86.doi:10.1126/science.1143254

Using self-resonant coils in a strongly coupled regime, we experimentally demonstrated efficient nonradiative power transfer over distances up to 8 times the radius of the coils. We will be able to transfer 60 watts with approximately 40% efficiency over distances in excess of 2 meters. We present a quantitative model describing the power transfer, which matches the experimental results to within 5%.

CHAPTER 3

WIRELESS POWER TRANSFER

Wireless power transmission (WPT), wireless power transmission (WET) or electromagnetic power transmission is the transfer of electrical energy without wires as a physical connection. Wireless power methods fell primarily into two groups, close field and far-field. For near-field or non-radiative methods, energy is transmitted over short distances through magnetic fields by means of inductive couplings between wire coils or electrical fields by means of capacitive couplings between metal electrodes. In far-field and radiative methods, also known as energy beaming, power is distributed through electromagnetic radiation signals, such as microwaves and laser beams. Such techniques can transport energy longer distances, but they must be guided at the receiver.

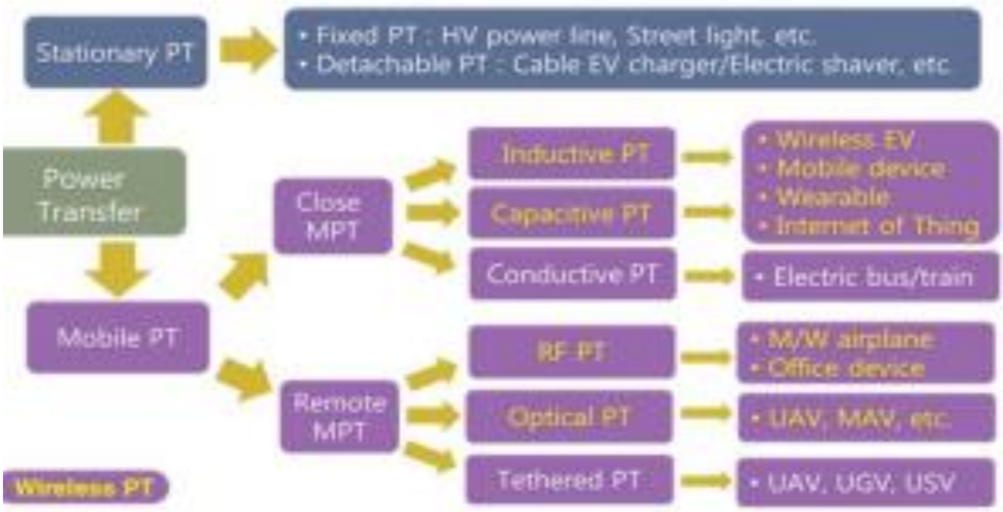

Fig 3.1. General Classification of power transfer in terms of mobility, distance, and means of powering.

Remote power is one of the new expressions portraying this century. The need for wi-fi power transmission (WPT) is developing quickly in the time of mobility. The query inspirations and its relative noteworthiness are related to constant applications. Convenience is the key inspiration for wi-fi control move as the quantity of versatile units is immensely expanding and wired chargers will limitation their convey ability. Electric autos and cell robots broad spreading is clung to the accessibility of remote battery chargers since versatility is their dominating concern.

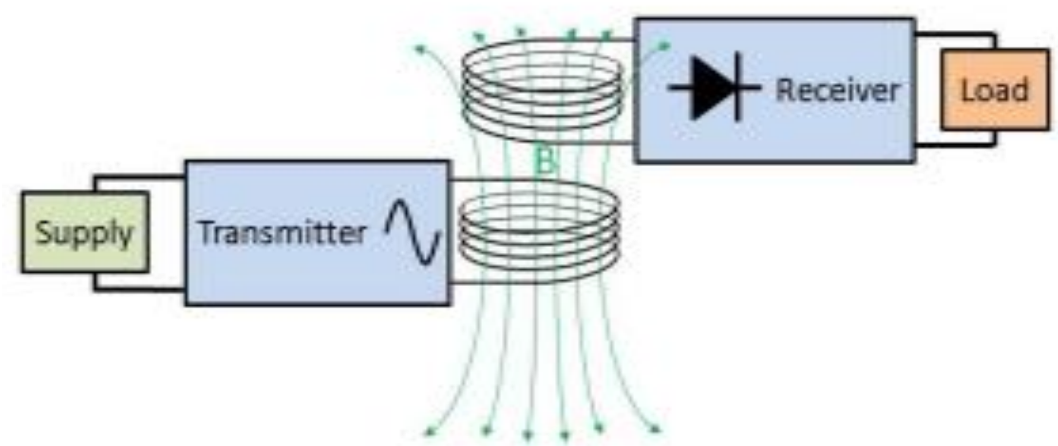

Fig3.2. Overview of a topology for wireless power transfer

3.1. WPT BY MUTUAL INDUCTANCE

Through inductive coupling (electromagnetic induction and inductive energy transfer) the power is passed to the magnetic field between the wire coils. The transmitter and the receiver coils create a transformer together. The alternating current (AC) through the transmitter coil produces an oscillating magnetic field according to the law of Ampere. The magnetic field travels through the transmitting wire, where the opposing EMF (voltage) is caused by Faraday's principle of induction, which induces an alternating current in the transmitter.

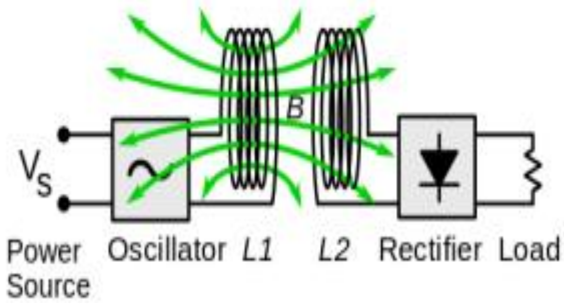

Fig3.1.1. An illustration of Inductive Power Transfer

The transmitted power increments with recurrence and the M inductance between the curls, which depends on their design and the size between them. An extensively utilized parameter to assess the degree of coupling is the coupling coefficient, given by the condition $k=M/\sqrt{(L_1 L_2)}$, the spot M is the shared inductance and L1 and L2 are the inductances of the curls individually. This dimensionless component is equivalent to the amount of the attractive motion through the transmitter curl L1 that movements by means of the beneficiary loop L2 when the L2 is open circuited. The more noteworthy the division between the loops, the more noteworthy the attractive field of the main loop, the littler the second, and the decline the k, and the bigger the yield of the connection, the closer to zero at gigantic partitions.

The effectivity of the hyperlink and the quality transmitted are generally relative to k^2. Customary inductive coupling can exclusively increase unreasonable generally speaking execution if the loops are exceptionally near one another, typically neighboring. In most normal inductive frameworks, resounding inductive coupling (depicted underneath) is utilized to grow effectivity by method for the utilization of thunderous circuits**.** Thunderous inductive coupling is a sort of inductive coupling where attractive fields switch control between two resounding circuits, one in the transmitter and one in the receiver.

The advantages of the utilization of thunderous coupling to make greater transmitting separation have exclusively as of late been discussed. Every full circuit comprises of a wire curl associated with a capacitor or a self-thunderous loop or distinctive internal capacitance resonator. Both of them are intended to answer at the indistinguishable resounding recurrence. The reverberation between the loops will apparently grow the holding and the exchange of power. Resonant building is now normally done into regular inductive remote quality frameworks. One of the probabilities visualized for this development is the remote power appropriation locale. A loop in the divider or roof of a space could allow wi-fi vitality to lights or cell phones some place in the live with perfect yield.

CHAPTER 4

MATHEMATICAL MODEL OF IPT CIRCUIT

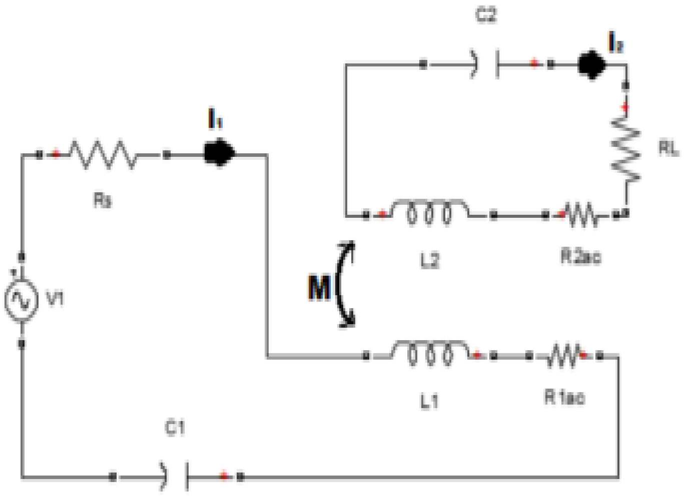

Fig4.1. An equivalent circuit model for series-series Inductive power transfer

The above fig4.1 describes the mathematical model of the wireless power transfer system using the inductive coupling approach. Fig3.1.1 displays the simpler corresponding circuit design of the wireless power transmission system with two resonant coils in sequence. Load energy is enhanced by increasing the frequency and inductance of each other or by increasing the strength of the source present. The loop equations of the above circuit are:

$$V1 = Z_1 I_1 - j\,\omega\, M\, I_2 \qquad (1)$$

$$|I_2| = \frac{\omega\, M\, I_1}{Z_2} \qquad (2)$$

Then, there's the distribution voltage. The moving currents in the primary and secondary coils are the corresponding impedances of the transmitting and receiving loops, respectively. M is the reciprocal coupling between the two coils which relies on the factor of coupling between the coils and the self-inductance depends on the coupling and the inductances L1 and L2.

$$M = k\sqrt{L_1 L_2} \qquad (3)$$

The corresponding impedances Z1 and Z2 can be generalized and approximated at the resonance frequency.

$$\mathbf{Z_1 = R_s + R_{1ac}} \tag{4}$$

$$\mathbf{Z_2 = R_l + R_{2ac}} \tag{5}$$

Where R1ac and R2ac are the series resistances of the primary and secondary coils, respectively. and are the source and load resistances, respectively. The resonant frequency ω is defined as

$$\omega = \frac{1}{\sqrt{l_1 c_1}} = \frac{1}{\sqrt{l_2 c_2}} \tag{6}$$

The load power can be calculated using

$$P_l = \frac{\omega^2 M^2 \quad I_1^2 R_l}{(R^2 + R_{2ac})^2} \tag{7}$$

The power transfer efficiency is given by

$$\eta = \frac{\omega^2 M^2 R_l}{(\omega^2 M^2)(R_l + R_{2ac}) + (R_s + R_{1ac})(R_1 + R_{2ac})^2} \tag{8}$$

From equations (7) and (8), the load power increases by increasing the frequency or inductance of each other or by increasing the magnitude of the source current. From formula (8), output improves by reducing parasitic resistance, rising frequency and increasing inductance. The power bonding theory describes how electrical energy is moved from one system to another. When the contact between the couplers is induced by the magnetic field of one of the couplers, the coupling is defined as a magnetic coupling. The more stream the receiver reaches; the stronger the coils are combined. The degree of coupling is represented by the parameters of coupling. From formula (3), it is obvious that the coefficient of coupling k depends on the medium between the two coupled coils and their parameters, such as the number of twists, the cross-section region and the width of the coils.

Major Benefits of Wireless Power Transfer :

- It allows multiple batteries to be charged simultaneously which is done by adjusting the geometry of the coil as well as by providing broad loading surface areas, such as table tops or charging benches.
- Wireless power transfer allows for greater spatial independence between the power source and the device to be charged. The two do not have to be exactly matched for the transfer of power.
- The technology is safe and used in remote controls, mobile headset alarms, portable thermostats, smoke detectors, smartphone devices, notebooks, etc.

Disadvantages of Wireless Power Transfer :

- Relatively low efficiency as compared to conventional power transmission systems, but new advances have been steadily improving the transfer efficiency.
- Requires a bit of setup before functional.
- They are usually operated at a very high frequency, thus making them unfavorable for some cases.

4.1 CIRCUIT DIAGRAM ASSEMBLY

The design of the power supplies of the Tx and the Rx side are explored, as well as the assembly and the working of the prototype. On the Tx side, the supply is first stepped down to 24V using a transformer and rectified using a full bridge rectifier to a voltage of 36V, which is further reduced to a voltage of 15V and 5V via a regulator to supply the ATMEGA328P microcontroller. The coils are fed with the 38V unregulated line which is inverted using a fast-switching switch, based on a class E configuration.

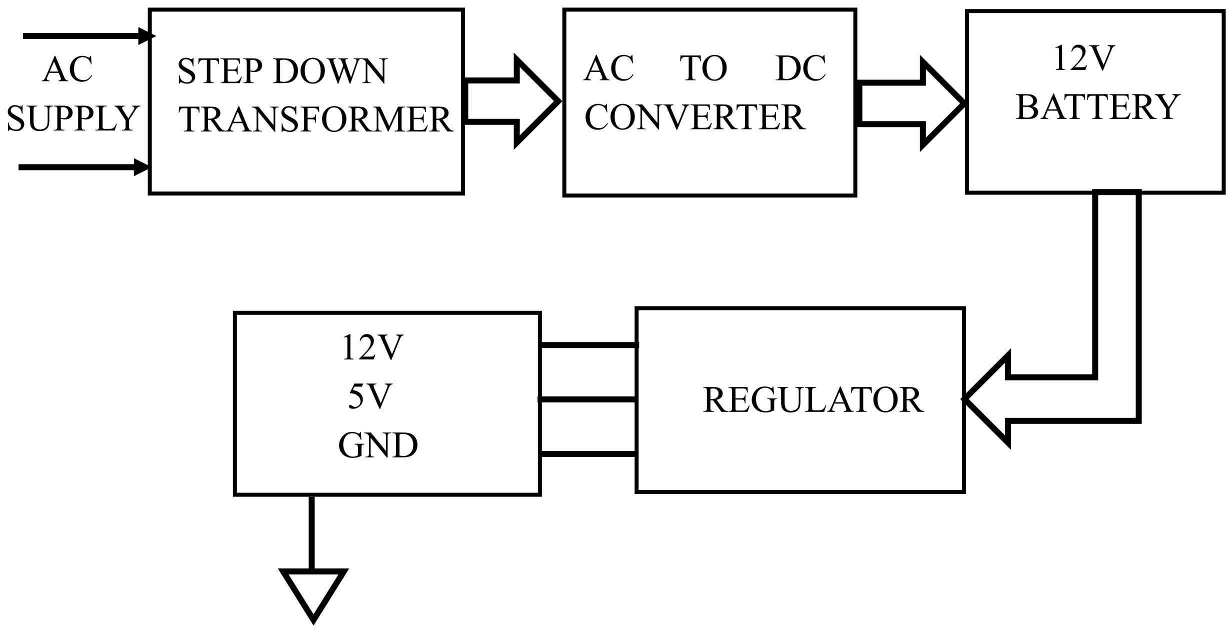

Fig4.1.1. Block diagram of the input power supply

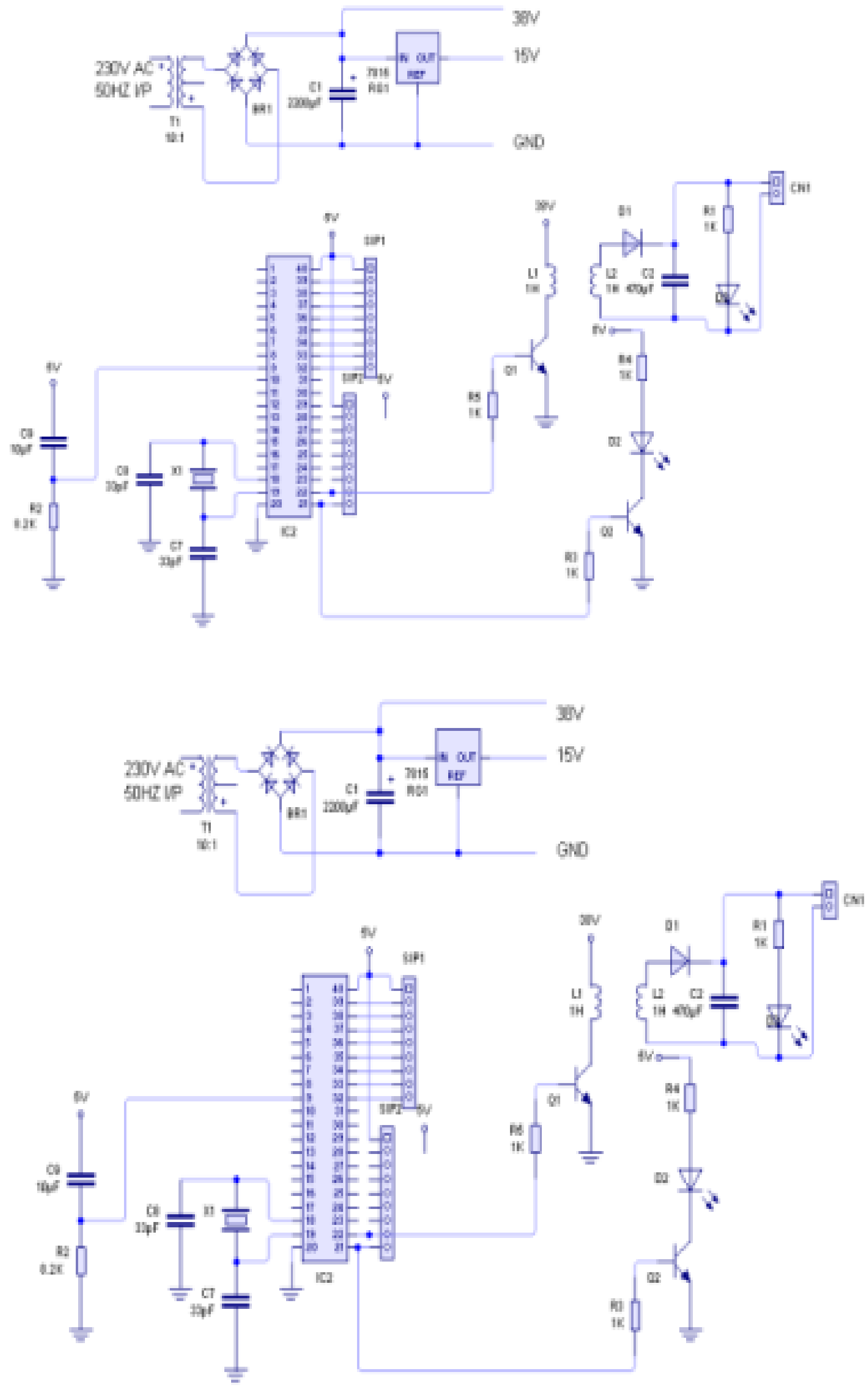

Fig.4.1.2. The Circuit diagram of Tx side.

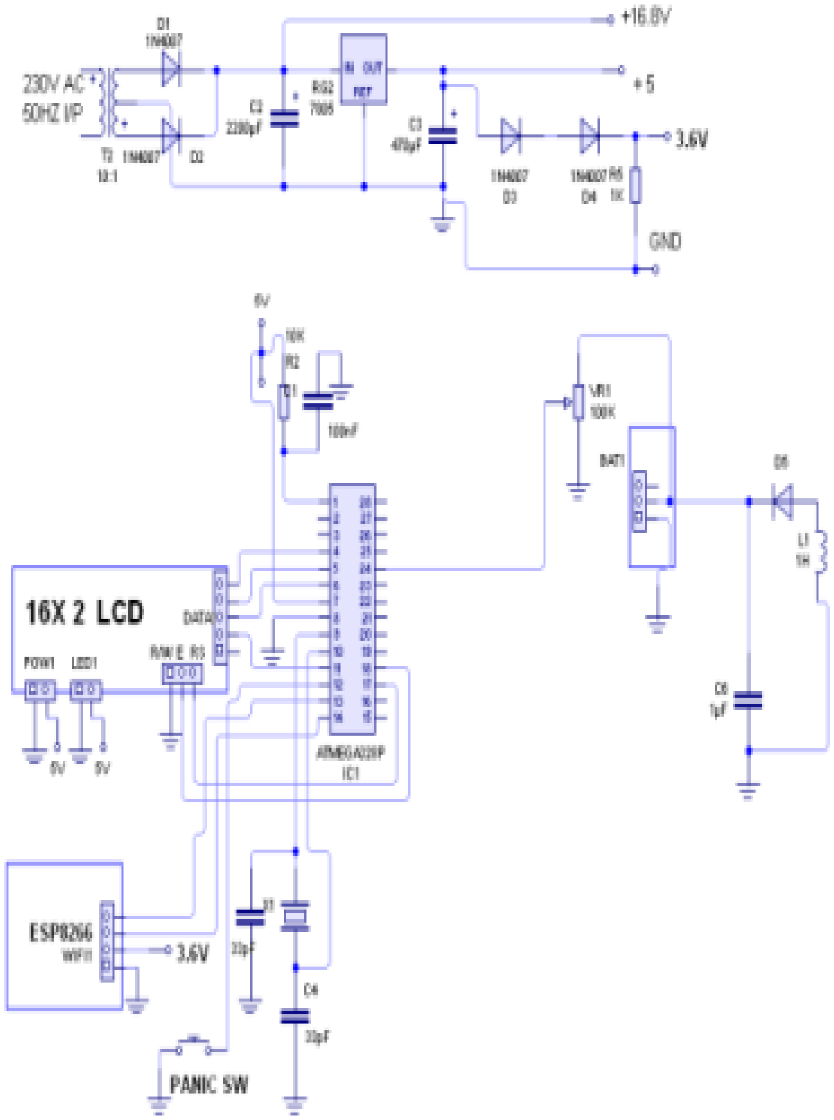

Fig.4.1.3. The Circuit diagram of Rx side.

CHAPTER 5

RESULTS

The Tx side of the project after assembled is shown below:

Fig.5.1. Tx side of final assembly.

As we can observe in the above image, the Tx side of the project consists of a Class-E configured switch connected to an Aluminium heat sink, as the switching losses are high and the temperature of operation is increased. The efficiency of the entire process is about ~50-65%, which is not very high but since this is a prototype setup the energy losses can be ignored. Another problem we have faced during assembly is the design of power supply for the project (completed power supply design is provided in the Tx circuit diagram above) as it was hard to design a constant 5V power supply from 36V DC.

The Rx side of the project after assembled is shown below:

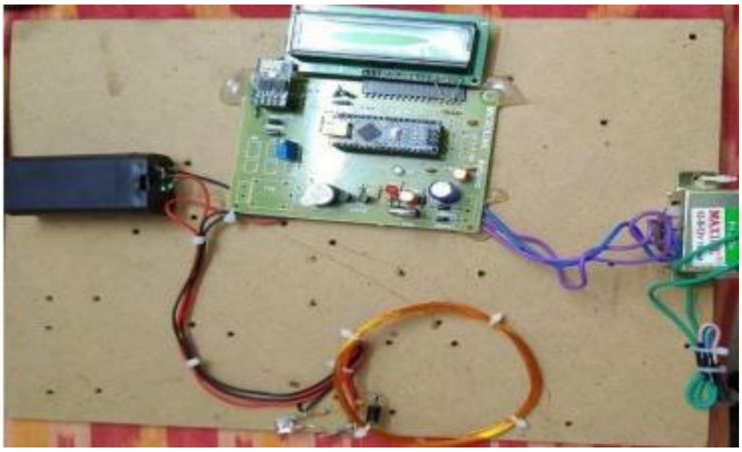

Fig.5.2. Rx side of the assembly.

On the Rx side, the 12V transformer powers the electronics board which contains the Arduino Nano and the ESP 8266, along with an LCD to indicate the battery Rate of Charge (RoC). The problems faced during the assembly of the Rx side is the orientation of the coils along with the power supply for ESP8266 as it takes 3.6V as an input.

The Finished Prototype is Shown below:

Fig5.3. The Finished Prototype

The above prototype is compact and small, requires only a few components to charge the battery and upload the data to the cloud via the ESP8266 Module. The battery charge status can be monitored anytime from the cloud. Here is the data, as seen on an android phone:

Fig.5.4. Monitoring of Data using Thing speak Module

As we can see in the above image, the battery charging data can be accessed from anywhere via the thing speak network. This provides us with the advantage that the working of the charger and the charging status can be monitored in real time, and the controller can be programmed to send out alerts to the user in case of completion of charge.

CHAPTER 6

CONCLUSION

The prototype provides the framework for an IoT integrated smart electronic device, a device which will pave the way for future approaches to smart electronic devices that can be integrated into networks, thus enabling better monitoring and control. The use of Wireless Power Transfer to transfer the power in a compact circuit also shows that by some improvements in the WPT tech, the devices of the future might me more compact and secure and operate at a higher efficiency. WPT provides isolation to the circuit and protects the transmission and receiving sides from disturbances in the other side, and WPT can be used for applications like dynamic battery charging and mass charging stations which will prove to be a boon for the implementation of Electrical Vehicle technology in the future.

REFERENCES

1. Kurs, A., Karalis, A., Moffatt, R., Joannopoulos, J. D., Fisher, P., &Soljacic, M. (2007). Wireless Power Transfer via Strongly Coupled Magnetic Resonances. Science, 317(5834), 83–86.doi:10.1126/science.1143254
2. Zhang, Z., Pang, H., Georgiadis, A., &Cecati, C. (2018). Wireless Power Transfer - An Overview. IEEE Transactions on Industrial Electronics, 1– 1. doi:10.1109/tie.2018.2835378
3. Kumar, N., Sundaram, K. M., &Anusuya. (2017). IoT Based Smart Charger. Proceedings of the International Conference on Big Data and Internet of Thing - BDIOT2017.doi:10.1145/3175684.3175685
4. Kim, J., Kim, J., Kong, S., Kim, H., Suh, I.-S., Suh, N. P., … Ahn, S. (2013). Coil Design and Shielding Methods for a Magnetic Resonant Wireless Power Transfer System. Proceedings of the IEEE, 101(6), 13321342.doi:10.1109/jproc.2013.2247551.
5. D. Ravi Kishore and T. Vijay Muni, ―Efficient energy management control strategy by model predictive control for standalone dc micro grids‖, AIP Conference Proceedings 1992, 030012 (2018); doi: 10.1063/1.5047963.
6. Samanta, S., & Rathore, A. K. (2016). Wireless power transfer technology using full-bridge currentfed topology for medium power applications. IET Power Electronics, 9(9), 1903– 1913.doi:10.1049/iet-pel.2015.0775
7. Ramakrishna, B., Srikanth, T., Chaitanya, M.N., Muni, T.V., ―Comparative analysis of perturb and observe method and current based method‖, International Journal of Innovative Technology and Exploring Engineering 8(6), pp. 1012-1016.
8. Swapna Sai, P., Rajasekhar, G.G., T Vijay Muni, Sai Chand, M., ―Power quality and custom power improvement using UPQC‖, International Journal of Engineering and Technology(UAE) 7(2), pp. 41-43.
9. Kumar, M.K. Datta, D.V. T Vijay Muni., Performance enhancement of asynchronous machine with super Capacitor, International Journal of Engineering and Advanced Technology, 8(4), pp. 1208- 1210.
10. Sowmya, S., Sai Sri Vasthava, V.K., T Vijay Muni, ―Active filter control strategies for renewable power generation systems using ANN controller, International Journal of Innovative Technology and Exploring Engineering 8(5), pp. 690-696.