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A Comprehensive Review Report on Wireless Power Transmission

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Abstract—*In present time, each individual requires a remote framework, yet at the same time for control transmission of low power gadgets we are utilizing the wired gadget consistent power supply is one of the significant issues with the reason for utilization of remote innovation. Be that as it may, in remote sensor systems (WSN) control frameworks, the battery has an extremely constrained life expectancy and has not been changed by some other persistent power framework up until this point. Envisioning a future in which remote power exchange is conceivable: we can charge PDAs, residential robots, MP3 players, smart phones other compact hardware that are never connected to, so we show the idea of energy transmission without utilizing wires i.e. transmitting power as microwave to get expanded effectiveness and diminish cost, transmission and appropriation misfortunes. Common WPT is a point to-point control transmission. For the WPT, we would be advised to focus energy to recipient. It was demonstrated that the power transmission productivity can approach near 100%.*

Keywords*: Wireless sensor network, Nikola Tesla Experiment, Microwave power transmission (MPT), Wireless power transmission (WPT), Power Satellites.*

1. INTRODUCTION

Wireless power Transfer (WPT) is the transmission of electrical power from a power source to an expending gadget without utilizing discrete synthetic conveyors. Scientists have built up a few strategies for moving power over long separation without wires. Some exist just as speculations or models yet others are now being used. This Publications gives the strategies used to remote power transmission. It is a nonexclusive term that alludes to various diverse power transmission advancements that utilization time-differing electromagnetic fields. Remote transmission is valuable to control electrical gadgets on the off chance that where interconnecting wires are badly designed, dangerous, or are impractical. For instance the life of WSN is its hub which comprise of a few gadget controllers, memory, sensors, actuators, handsets and battery and battery. The handset can work in four states, i.e 1) Transmit 2) Receive 3) Idle and 4) Sleep. The real vitality issue of a transmitter of a hub is its accepting out of gear state, as in this state it is continually being prepared to get, expending awesome measure of energy. In any case, the player has a short lifetime and in addition in a few improvements inferable from both for all intents and purposes and monetarily infeasible or may include huge opposes to human life. That is the reason vitality gathering for WSN in substitution of battery is the main and one of a kind arrangement. In remote power exchange, a transmitter gadget source, for example, the mains control line, transmits control by electromagnetic fields over an interceding space to at least one recipient gadgets, where it is changed over back to electric power and used. In correspondence the objective is the transmission of data, so the measure of energy achieving the collector is insignificant as long as it is sufficient that flag to clamor proportion is sufficiently high that the data can be gotten coherently. In remote correspondence advances, for the most part, just minor measures of energy achieve the recipient. By differentiate, in remote power, the measure of energy got is the critical thing, so the productivity (part of transmitted power that is gotten) is the more huge parameter.

1.1 Field Regions

Electric and attractive fields are made by charge particles in issue, for example, electrons. A stationary charge makes an electrostatic field in the space around it. A consistent current of charge (coordinate current, DC) makes a static attractive field around it. The above fields contain energy, however can't convey power since they are static. However time-differing fields can convey power. Quickening electric charge, for example, are found in a substituting current (AC) of electrons in a wire, make time-changing electric and attractive fields in the space around them. These fields can apply swaying power on the electrons in a getting "recieving wire", making them move forward and backward. These speak to exchanging current whichcan be utilized to power a heap. The swaying electric and attractive fields encompassing moving electric charges in a reception apparatus gadget can be isolated into two locales, contingent upon remove. Drange from the antenna[7]. Diverse advances are utilized for transmitting power: Near-field or non-radiative district This implies the region inside about wavelength (λ) of the antenna.

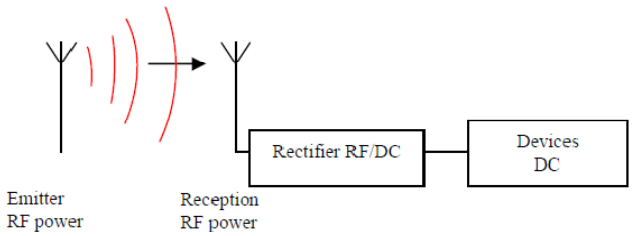

Figure 1.1: Schematic view of the WPT system

In this region the oscillating electric and attractive fields are discrete and power can be exchanged by means of electric fields by capacitive coupling (electrostatic acceptance) between metal terminals, or by means of attractive fields by inductive coupling(electromagnetic enlistment) between loops of wire[5][6]. The scope of these fields is short, and relies upon the size and state of the "receiving wire" gadgets, which are typically loops of wire. The fields, and hence the power transmitted decline exponentially with separate, so if the separation between the two "reception apparatuses" Drange is considerably bigger than the measurement of the "recieving wire" Dant next to no power will be received. Therefore, these procedures can't be utilized for long separation power transmission. Reverberation, for example, thunderous inductive coupling, can expand the coupling, can build the coupling between the radio wires enormously, permitting proficient transmission at fairly more prominent separation, despite the fact that the fields still reduction, in spite of the fact that the fields still diminishing exponentially. Hence the scope of close fields gadgets is routinely isolated into two classes: Short range-up to around one radio wire breadth: Drange ≤ Dant. This is the range over which conventional non-thunderous capacitive or inductive coupling can exchange molecule measures of power. Mid-run up to 10 times the reception apparatus width: extend ≤ 10 Dant. This is run over which standard non-resounding capacitive or inductive coupling can exchange reasonable measure of power. Far-field or radiative district: Beyond around 1 wavelength(λ) of receiving wire, the electric and attractive fields opposite to each other and spread as an electromagnetic wave; illustration are radio waves, microwave, or light waves. This piece of the energy is radiative, which means it leaves the reception apparatus regardless of whether there is a collector ingests it. The segment of energy which does not strike the getting radio wire is dispersed and lost to the framework. The measure of power produced as electromagnetic waves by a receiving wire relies upon the proportion of the radio wire's size Dant to the wavelength of waves λ, which is controlled by the recurrence f where the recurrence: λ=c/f. At low frequencies f where the radio wire is substantially littler than the measure of the waves, Dant << λ, next to no power is emanated. Along these lines the close field gadgets above, which utilize bring down frequencies, emanate none of their energy as electromagnetic radiation. Radio wires about an indistinguishable size from the wavelength Dant ≈ λ, for example, monopole or dipole receiving wires emanate power effectively, yet the electromagnetic waves are transmitted every which way. so if the accepting receiving wire is far away, just a little measure of the radiation will hit it. Therefore, these can be utilized for shorter range wasteful power transmission however not for short range transmission but rather for long range transmission. In any case, not at all like fields, electromagnetic radiation can be engaged by reflection or refraction into bars. By utilizing a high pick up receiving wire or optical framework which amasses the radiation into a restricted pillar went for the collector, it can be utilized for long range power transmission. From the Rayleigh foundation, to deliver the important to center a lot of the energy on a far off beneficiary, a receiving wire must be significantly bigger than the wavelength of the wave utilized Dant >> λ = c/f. Functional pillar power gadgets require wavelength in the centimeter locale or beneath in the relating to frequencies over 1GHz, in the microwave run.

1.2 Classification of WPT

1.2.1 Non- radiative (Near –field techniques)

In close field or non-radiative procedures, power is exchanged over short separation by attractive fields utilizing inductive coupling between loops of wire or in a couple of gadgets by electric fields utilizing capacitive coupling between terminal [5][8]. A present concentration is to create wireless frameworks to charge versatile and handheld figuring gadgets, for example, PDAs, advanced music players and compact PCs without being fastened to a divider plug. Use of this compose are electric toothbrush chargers, RFID labels, smartcards and chargers for implantable restorative gadgets like counterfeit heart pacemaker, and inductive powering or charging of electric vehicles like prepares or transports. Fig .1.2 demonstrates the grouping of WPT.

1.2.2 Radiative (Far-field techniques) :

In radiative or Far-field systems, additionally called power radiating, power is transmitted by light emissions radiation, similar to microwaves or laser pillars. These procedures can transport energy longer separations yet should be gone for the recipient. Proposed application for this compose is sunlight based power satellites, and wireless powered automaton flying machine.

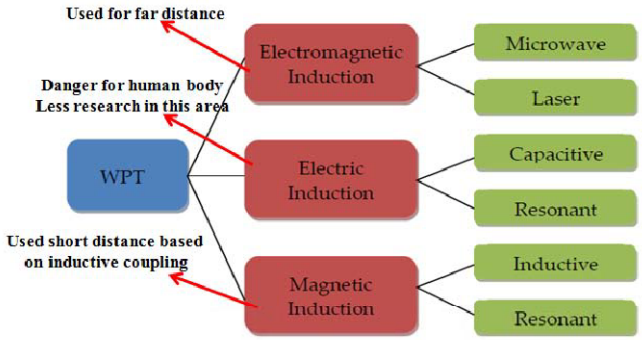

Figure 1.2: Classification of wireless power transmission.

2. LITERATURE REVIEW:

2.1 History

In 1826 Andre-Marie Ampere built up ampere's circuital law demonstrating that electric current delivers an attractive field. Michael Faraday built up Faraday's law of enlistment in 1831, portraying the electromagnetic power instigated in a conductor by a period differing attractive flux. In 1862 James Clerk Maxwell incorporated these and different perceptions, trials and conditions of power, attraction and optics into a steady hypothesis, inferring Maxwell's conditions. This arrangement of fractional differential conditions frames the reason for present day electromagnetic including the wireless transmission of electrical energy.

2.1.1 Tesla's Experiment:

Tesla exhibiting wireless power transmission in an address at Columbia College, New York, in 1891.The two metal sheets are associated with his Tesla loop oscillator, which applies a high recurrence swaying voltage. The swaying electric fields between the sheets ionizes the low weight gas in the two long Geissler tubes he is holding, making them shine by fluorescence, like neon lights. Examination in full inductive exchange by Tesla at Colorado Springs 1899.The curl is in reverberation with Tesla's amplifying transmitter adjacent, powering the light at base. Innovator Nikola Tesla played out the main tests in wireless power transmission in wireless power transmission at the turn of the twentieth century, and may have

accomplished more to promote the thought than some other person. In the period 1891 to 1904 he tried different things with transmitting power by inductive and capacitive coupling utilizing sparkle energized radio recurrence full transformer, now Called Tesla curls, which created high AC voltages. With these he could transmit power for short separations without wires. In exhibits before the American Institute of Electrical Engineers and the 1893 Columbian Exposition in Chicago he lit lights from over a phase. He discovered he could expand the separation by utilizing an accepting LC circuit tuned to reverberation with the transmitter's LC circuit, utilizing thunderous inductive coupling. At his Colorado springs research center amid 1899-1900, by utilizing voltages of the request of 10 megavolts produced by a huge loop. He could light three radiant lights at a separation of an around one hundred feet. The resounding inductive coupling which Tesla spearheaded is presently a well-known innovation utilized all through gadgets and is right now being broadly connected to short-go wireless power systems[1][2].

2.2 Wireless Power Transmission System:

W.C. Brown, the pioneer in wireless power transmission innovation, has planned, built up a unit and exhibited to indicate how power can be exchanged through free space by microwave. The idea of wireless power transmission framework is clarified with useful piece chart appeared in Fig.2.1 In the transmission side, the microwave power source produces microwave power and the yield power is controlled by electronic control circuits. The waveguide ferrite circulator which shields microwave source from reflected power is associated with the microwave power source through the persuade waveguide connector. The tuner coordinates the impedance between the transmitting reception apparatus and the microwave source. The lessened signs will be then isolated in light of the heading of flag engendering by Directional Couplers by Directional Coupler. The transmitting radio wire emanates the power consistently through free space to the rectenna. In the recieving side, a rectenna gets the transmitted power and changes over the microwave power into DC power.

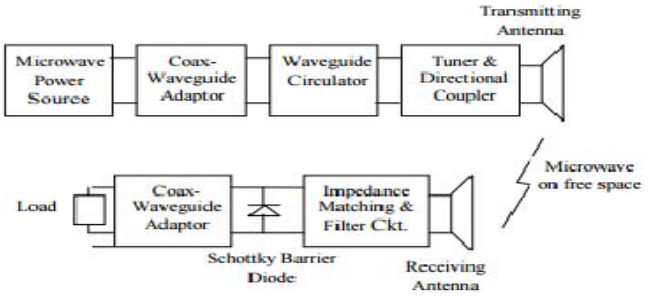

Figure 3.1: Functional Block Diagram of Wireless Power Transmission System.

The impedance matching circuit and filter is provided to setting the output impedance of a signal source equal to the rectifying circuit. The rectifying circuit consists of schottky barrier diodes converts the received microwave power into DC power [3].

2.3 Energy Harvesting

With regards to wireless power, energy harvesting, likewise called power harvesting or energy searching, is changing natural energy to electric power, to power little self-governing wireless electronic gadgets. Surrounding energy dissemination may originate from electrical power, essentially to power little independent wireless electronic gadgets. Surrounding energy may originate from radio waves with runaway electrical or attractive field or motor energy as speed, light, warm energy. In spite of the fact that the change limit is for the most part low and power assembled is frequently tiny (process watts or smaller scale sections), yet little miniaturized scale power, for example, remote sensors might be adequate to run or energize wireless gadgets, which are by and large required in numerous regions. This new innovation is being produced to wipe out the requirement for substitution of batteries or charging of such wireless gear, with the goal that they can work completely self-sufficiently.

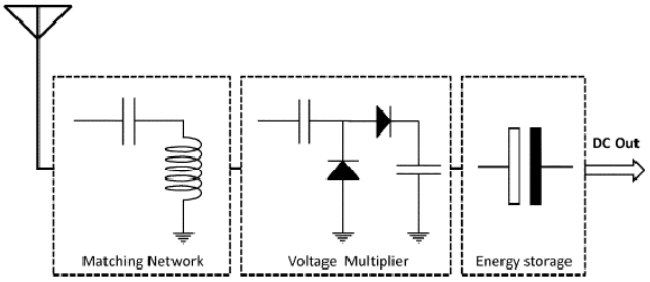

Figure 3.2: Energy Harvesting Circuit

3. ADVANTAGES, DISADVANTAGES & BIOLOGICAL IMPACTS OF WPT AND ISSUWA IN WPT:

Advantages

- Eliminating the need for a power cord or battery replacement, making the equipment more convenient and thus more desirable for buyers.
- Light failure due to short circuit and fault on the cable will never be present in the transmission.
- Reduced e-waste by reducing the requirement of electric wires.
- Wireless charging offers no corrosion as the electronics are all enclosed, away from water or oxygen in the atmosphere [2].

Disadvantages

- The capital cost of implementing WPT particles is very high.
- WPT may be the reason for interference with current communication systems.
- Less efficiency compared to traditional charging.

3.1 Biological Impacts:

General beliefs are fear of the effect of microwave radiation. But studies have shown that the level of microwave radiation will not exceed the dose received when opening the microwave oven door, which means that it is slightly more.

3.2 Issues in WPT

One of the real issue in power system is the misfortunes happens amid the transmission and dispersion of electrical power. As the request builds step by step, the power age increments and the power misfortune is likewise expanded. The real measure of power misfortune happens amid transmission and dissemination. The level of loss of power amid the transmission and appropriation is

approximated as 26% [4]. The fundamental purpose behind power misfortune amid transmission and dispersion is the protection of wires utilized for matrix. The effectiveness of power transmission can be enhanced to certain level by utilizing high quality composite over head conductors and underground links that utilization high temperature super conductor. Be that as it may, the transmission is as yet wasteful. As indicated by World Resources Institution (WRI), India's power matrix has the most astounding transmission and dissemination misfortunes on the planet an incredible 27% . Numbers distributed by different Indian government organizations put that number at 30%,40% and more noteworthy than 40%. This is ascribed to specialized misfortunes (lattice's wasteful aspects) and burglary [4]. The above talked about issue can be fathomed by pick an elective alternative for power transmission which could give considerably higher effectiveness, low transmission cost and stay away from power burglary. Microwave Power Transmission is one of the promising advances and might be the honorable option for proficient power transmission.

4. YEAR WISE ASSESSMENT OF RESEARCH PUBLICATIONS ON WIRELESS POWER TRANSMISSION:

Table 4.1: Number of research Publications published till date.

S. No	Year Module	No. of Publications/Work done(in IET &IEEE journals)
1.	1960-1970	1
2.	1970-1980	0
3.	1980-1990	1
4.	1990-2000	173
5.	2000-2010	1001
6.	2010-Present	6093

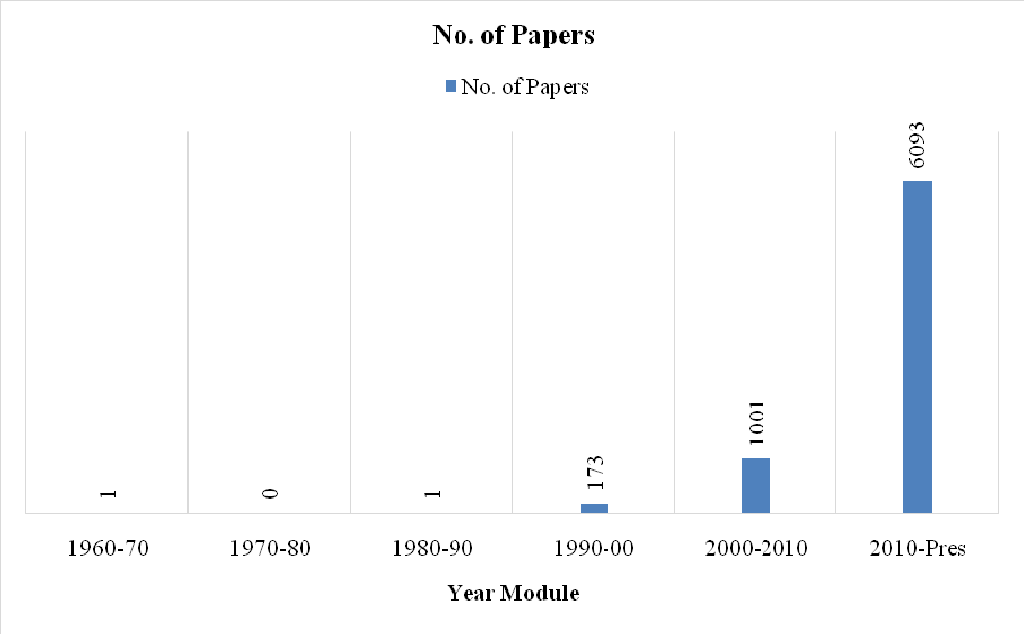

Table 4.2 Details of a few ImportantResearch Publications:

S. no.	Title	Author	Focused Area	Publication Date
1.	**FREE-SPACE TRANSMISSION**	**W. C. Brown Raytheon Company**	Microwave energy can be generated at power levels for some applications of wireless power transfer.	October, 1964
2.	**WIRELESS TRANSMISSION OF POWER AND INFORMATION THROUGH ONE HIGH-FREQUENCY RESONANT AC LINK INVERTER FOR ROBOT MANIPULATOR APPLICATIONS**	A. Kawamura K. Ishioka J. Hirai	A prototype of a wireless transmission system of power and information (WTPI system) was built [7].	May,1996
3.	**POWER CONTROL AND CAPACITY ANALYSIS FOR A PACKETIZED INDOOR MULTIMEDIA DS-CDMA NETWORK**	S. Manji	This Publications proposes a packetized indoor wireless system using direct-sequence code-division multiple-access (DS-CDMA) protocol [9].	May,2000

4.	**MAGNETIC COUPLING ANALYSIS IN WIRELESS TRANSFER ENERGY**	Dragos Niculae Mihai Iordache Lucia Dumitriu	Focus is to highlight some aspects regarding wireless power transfer and the necessary conditions of this process [8].	May,2011
5.	**WIRELESS POWER TRANSFER SYSTEM FOR CAPSULE ENDOSCOPY BASED ON STRONGLY COUPLED MAGNETIC RESONANCE THEORY**	Xuelin Fang Hao Liu Guiyang Li	Capsule endoscopy is a new technique. The wireless power transfer system consists of four coils, an excitation source and a load [10].	Aug,2011
6.	**PROPOSAL OF SWITCHED-MODE MATCHING CIRCUIT IN POWER SUPPLY FOR WIRELESS POWER TRANSFER USING MAGNETIC RESONANCE COUPLING**	Keisuke Kusaka Jun-ichi Itoh	This Publications discusses on the matching circuit in the power supply for wireless power transfer using a magnetic resonance coupling (MRC). For Industry Science Medical (ISM) bands such as 13.56 MHz [11].	Feb,2012
7.	**GRID SIDE REGULATION OF WIRELESS POWER CHARGING OF PLUG-IN ELECTRIC VEHICLES**	Clifford P. White Omer C. Onar John M. Miller	Conductive charger regulation of vehicle regenerative energy storage system (RESS) in coordination with the vehicles battery management system (BMS) [12].	Sept,2012
8.	**WIRELESS POWER TRANSFER: AN APPLICATION TO CELL PHONE BATTERY RECHARGING**	Md. Atiqur Rahaman Khan Abir Ahmed Md. Rafiqul Islam	A simple prototype wireless power transfer (WPT) system has been practically implemented to explore the possibility of cell phone battery recharging [13].	Dec,2012
9.	**VAMPIRE: A MAGNETICALLY SELF-POWERED SENSOR NODE CAPABLE OF WIRELESS TRANSMISSION**	Jinyeong Moon John Donnal Jim Paris	Power electronic topology for providing a vibration monitor with in-situ magnetic energy harvesting [14].	Mar,2013
10.	**AN OVERVIEW OF TECHNICAL CHALLENGES AND ADVANCES OF INDUCTIVE WIRELESS POWER TRANSMISSION**	Tobias Dräger Peterspies Iker Mayordomo	Actual technical challenge addressed in the field of inductive magnetic coupling at low-frequency (LF) and high-frequency (HF) bands for wireless power transfer [15].	Apr,2013
11.	**LOAD MONITORING AND OUTPUT POWER CONTROL OF A WIRELESS POWER TRANSFER SYSTEM WITHOUT ANY WIRELESS COMMUNICATION FEEDBACK**	Jian Yin Deyan Lin Chi Kwan Lee	In this project, a new method is proposed to determine the load impedance and load power without using any direct output feedback [16].	Sept,2013
12.	**REVIEW OF WIRELESS CHARGING TECHNOLOGIES FOR ELECTRIC VEHICLES**	T. W. Ching Y. S. Wong	This Publications aims to review current wireless power transfer (WPT) technologies on electric vehicle charging [17].	Dec,2013
13.	**MULTILAYER CERAMIC COIL FOR WIRELESS POWER TRANSFER SYSTEM BY PHOTO RESIST FILM PROCESS**	T. Nishi M. Kaneko M. Takato	A multilayer ceramic coil for a wireless power transfer system that fabricated by a photo resist film process [18].	April,2014

14.	**INVESTIGATION OF DUAL-BAND COIL MODULE FOR NEAR-FIELD WIRELESS POWER TRANSFER SYSTEMS**	Ming-Lung Kung Ken-Huang Lin	A dual-band coil module for near-field resonant wireless power transfer (WPT). It provides additional channel either for more power transfer or higher data transmission [19].	May,2014
15.	**RADIO ALIGNMENT FOR INDUCTIVE CHARGING OF ELECTRIC VEHICLES**	Wei Ni Iain B. Collings Xin Wang	A high-precision wireless ranging and misalignment estimation scheme [20].	Feb,2015
16.	**WIRELESS POWER TRANSFER FOR MOBILE DEVICES WITH CONSIDERATION OF GROUND EFFECT**	Chang Won Jung Seok Hyon Kang Van Thuan Nguyen	In this study, a wireless power transfer (WPT) system including three coils and working at 6.78 MHz is investigated [21].	May,2015
17.	**MAX–MIN FAIR WIRELESS ENERGY TRANSFER FOR MULTIPLE-INPUT MULTIPLE-OUTPUT WIRETAP CHANNELS**	Wei Wu Xueqi Zhang Shaohang Wang	The Publications aim to maximise the minimum harvested energy among the multiple multi-antenna energy receivers [22].	April,2016
18.	**DESIGN OF MULTI-FREQUENCY COIL FOR CAPACITOR-LESS WIRELESS POWER TRANSFER USING HIGH ORDER SELF-RESONANCE OF OPEN END COIL**	Takehiro Imura Yoichi Hori Koichi Furusato	Available frequency for wireless power transfer (WPT) is limited by the industrial, scientific, and medical (ISM) radio bands in MHz band [23].	May,2016
19.	**A LOW SAMPLING FREQUENCY SWITCHED CAPACITOR LOW-PASS FILTER FOR WIRELESS RECEIVERS**	Krzysztof Siwiec Lukasz Wiechowski Jakub Kopanski	This Publications presents a low-pass filter with variable gain for use in direct conversion wireless receivers [24].	June,2016
20.	**INVESTIGATION OF RECEIVING POT CORE EFFECT ON MAGNETIC FLUX DENSITY IN INDUCTIVE COUPLING-BASED WIRELESS POWER TRANSFER**	Mohammad Haerinia Ebrahim S. Afjei	An inductive-based wireless power transfer system for low power applications at short distances [25].	June,2016
21.	**WIRELESS POWER TRANSFER SYSTEM BASED ON HIGH-INDEX DIELECTRIC RESONATORS** **WIRELESS POWER TRANSFER SYSTEM BASED ON HIGH-INDEX DIELECTRIC RESONATORS**	P. V. Kapitanova M. Song P. A. Belov	Demonstrated two magnetic resonant wireless power transfer (WPT) systems based on dielectric spherical and disk resonators implemented with ceramics [26].	July,2016
22.	**A LOOSELY COUPLED CAPACITIVE POWER TRANSFER SYSTEM WITH LC COMPENSATION CIRCUIT TOPOLOGY**	Hua Zhang Fei Lu Heath Hofmann	A double-sided LC compensated capacitive power transfer (CPT) system, which is the dual of the conventional series-series (SS) compensated inductive power transfer (IPT) system [27].	Sept,2016
23.	**EDUCATION FOR THE COLLEGE STUDENT THROUGH STUDY OF WIRELESS POWER TRANSMISSION (WPT)**	Tamami Maruyama	Studies of wireless power transmission (WPT) draws attention from college student of National Institute of Technology (NIT) for this research area [28].	Mar,2017

24.	**MAXIMUM POWER AND EFFICIENCY TRANSMISSION USING PARALLEL ENERGY STORAGE LOAD FOR WIRELESS POWER TRANSFER SYSTEMS**	Zhongping Yang Fei Lin Yuyu Geng	A control strategy is proposed to not only meet the requirements of the system energy output, but also maintain the high efficiency of the system [29].	May,2017
25.	**COMPARISON OF TWO STRUCTURAL MAGNETIC COILS FOR WIRELESS POWER TRANSFER**	Gong Li Jiao Li Xin Heng Li Yang	Comparison of two structural coils (solenoid and planar spiral coil) for wireless power transfer (WPT) system [30].	Aug,2017

5. APPLICATION OF WPT

- Moving targets such as fuel free airplanes, fuel free electric vehicles, moving robots and fuel free rackets.
- Automatic wireless charging for mobile robots, cordless tools and instrument which eliminates complex mechanisms, and labour intensive manual recharging and battery replacement.
- Another application of WPT are solar power satellites, energy to remote areas, broadcast energy globally.
- WPT are used for Ubiquitous power source, RF power Adaptive Rectifying Circuits (PARC).

6. FUTURE SCOPE

Witricity is building a close field remote charging mechanical assembly for buyer gadgets with the assistance of the Haier gathering, a Chinese hardware maker. Witricity showed this innovation by remote powering a 32 inch TV at a separation of six feet. Delphi Automotives is working with Witricity to build up a remote charging system for electric autos. The noteworthy innovation will empower to car producer to coordinate remote surging into the outline of crossover and electric vehicles. There is another standard convention for charging cell phone started by the Wireless Power Consortium [6].

7. CONCLUSION

The idea of wireless power transmission gives more noteworthy potential to electrical power transmission with irrelevant misfortune. Over the long haul, it can diminish the reliance of our general public on the battery, which is at present substantial and costly. As the wireless innovation is getting to be mainstream, the interest for batteries is likewise diminishing. Long separation power transmission power can be sent from the source to the collector without wires, to decrease the cost. Batteries should be energized or in the long run supplanted, so the wireless power transmission will prove to be useful in every one of the territories.

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