A

Seminar report

On

Wireless Electricity

Submitted in partial fulfillment of the requirement for the award of degree
Of ECE

Preface

I have made this report file on the topic **Wireless Electricity**; I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to ..... who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

Acknowledgement

I would like to thank respected Mr. Aditya Kumar and Mr Ashish Kumar for giving me such a wonderful opportunity to expand
my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

Secondly, I would like to thank my parents who patiently helped me as i went through my work and helped to modify and eliminate some of the irrelevant or un-necessary stuffs.

Thirdly, I would like to thank my friends who helped me to make my work more organized and well-stacked till the end.

Next, I would thank Microsoft for developing such a wonderful tool like MS Word. It helped my work a lot to remain error-free.

Last but clearly not the least, I would thank The Almighty for giving me strength to complete my report on time.

CHAPTER 1

INTRODUCTION

Now day‘s electricity has become a cup of life. A moment without electricity makes your thinking go dry. The major source of conventional form of electricity is through wires. The continuous research and development has brought forward a major breakthrough, which provides electricity without the medium of wires. This wonder baby is called WiTricity. There are certain small but very useful discoveries made in history, which changed the world for ever, Newton‘s gravitational law, Watt‘s steam engine, Thomson‘s bulb and many more. But a renaissance occurred with the invention of Electromagnetic Waves by Maxwell. Sir Jadish Chandra Bose successfully generated electromagnetic waves having wavelength in the range of 5mm to 25 mm.

It is known that electromagnetic energy is associated with the propagation of electromagnetic waves. Theoretically, we can use all electromagnetic waves for a wireless power transmission (WPT). The difference between the WPT and communication systems is only efficiency. Maxwell’s Equations indicate that the electromagnetic field and its power diffuse to all directions. Though we transmit energy in a communication system, the transmitted energy is diffused to all directions. Though the received power is enough for a transmission of information, the efficiency from the transmitter to receiver is quiet low. Therefore, we do not call it the WPT system.

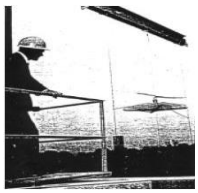
Typical WPT is a point to point power transmission. For the WPT, we had better concentrate power to

receiver. It was proved that the power transmission efficiency can approach close to 100%. We can more concentrate the transmitted microwave power to the receiver aperture areas with taper method of the

CHAPTER 2

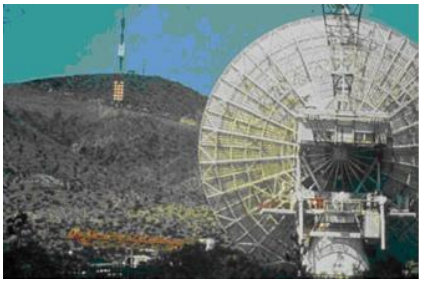
1. HISTORY OF WIRELESS POWER TRANSMISSION

In 1864, James C. Maxwell predicted the existence of radio waves by means of mathematical model. In 1884, John H. Poynting realized that the Poynting vector would play an important role in quantifying the electromagnetic energy. In 1888, bolstered by Maxwell's theory, Heinrich Hertz succeeded in showing experimental evidence of radio waves by his spark gap radio transmitter. The prediction and evidence of the radio wave in the end of 19th century was start of the wireless power transmission.



CHAPTER 2, FIG 2.1: MPT DEMONSTRATION WITH HELICOPTER BY W.C.BROWN

.With the rectenna, he succeeded in MPT experiments to wired helicopter in 1964 and to free flied helicopter in1968 (Fig. 1). In 1970s; he tried to increase DC RF transmission RF DC total efficiency with 2.45 GHz microwave. In 1970, overall DC total efficiency was only 26.5 % at 39WDC in Marshall Space Flight Center.



CHAPTER 2, FIG 2.2: FIRST GROUND TO GROUND MPT EXPERIMENT IN 1975 AT THE VENIUS SITE OF JPL GOLDSTONE FACILITY

In parallel, he and his team succeeded in the largest MPT demonstration in 1975 at the Venus Site of JPL Goldstone Facility (fig 2). Distance between a transmitting parabolic antennas, whose diameter was 26m, and a rectenna array, whose size was 3.4 m x 7.2 m, was 1 mile.

Group demonstrated fuel free airplane flight experiment with MPT in 1987 which was called SHARP (Stationary High Altitude Relay Platform) with 2.45 GHz.

CHAPTER 2, FIG 2.3: STATIONARY HIGH ALTITUDE RELAY PLATFORM.

In USA, there were many MPT research and development projects after W. C. Brown: for instance, retro directive microwave transmitters, rectenna, new devices and microwave circuit technologies.
In Japan, there were many field MPT experiments such as fuel free airplane flight experiment with MPT phased array with 2.411 GHz in 1992, ground to ground MPT experiment with Power Company and universities in 1994 95.

CHAPTER 2, FIG 2.4: GROUND TO GROUND MPT EXPERIMENT IN JAPAN IN 1994 95

2. WHAT IS WITRICITY?

WiTricity is nothing but wireless electricity. Transmission of electrical energy from one object to another without the use of wires is called as WiTricity. WiTricity will ensure that the cell phones, laptops, iPods and other power hungry devices get charged on their own, eliminating the need of plugging them in. WiTricity technology *is* transferring electric energy or power over distance without wires. With the basics of electricity and magnetism, and work our way up to the WiTricity technology. Even better, because of WiTricity some of the devices won't enquire batteries to operate. No, this concept of wireless electricity is not new. In fact it dates back to the 19th century, when Nikola Tesla used conduction based systems instead of resonance magnetic fields to transfer wireless power. Further,

CHAPTER 4

3. NEED OF WITRICITY

Now a days there is a Rapid development of autonomous electronics like Laptops, Cell phones, House hold robots and all those devices typically relay on chemical energy storage(Battery) As they are becoming daily needs to present generation, Wireless energy transfer would be useful for many applications as above and they need midrange energy.

CHAPTER 4, FIG 4.1: WIRELESS ENERGY TRANSFER

3.1 WITRICITY TECHNOLOGY IS DIFFERENT THAN TRADITIONAL MAGNETIC INDUCTION

At first glance, WiTricity technology for power transfer appears to be traditional magnetic induction,

such as is used in power transformers, where conductive coils transmit power to each other wirelessly, over very short distances. In a transformer, an electric current running in a sending coil induces another current in a receiving coil .

CHAPTER 5

4. RECENT TRENDS

1. ANTENNAS FOR MICROWAVE POWER TRANSMISSION

All antennas can be applied for both the MPT system and communication systems, for example, Yagi Uda antenna, horn antenna, parabolic antenna, micro strip antenna, phased array antenna or any other type of antenna.

2. RECENT TECHNOLOGIES FOR TRANSMITTERS

The technology employed for generation of microwave Radiation is an important subject for the MPT system. We need higher efficient generator/amplifier for the MPT system than that for the wireless communication system.

CHAPTER 5, FIG 5.1: PHASED ARRAY USED IN JAPANESE FIELD MPT EXPERIMENT

3. MAGNETRON

Magnetron is a crossed field tube in which electrons emitted from the cathode take cyclical path to the anode. The magnetron is self-oscillatory device in which the anode contains a resonant RF structure. The magnetron has long history from invention by A. W. Hull in 1921.

4. SEMICONDUCTOR AMPLIFIER

After 1980s, semiconductor devices became dominant in microwave world instead of the microwave tubes. This was driven by advances in mobile phone networks. The semiconductor device is expected to

Expand microwave applications, for example, phased array and active integrated antenna (AIA), because of its manageability and mass productivity. After 1990s, some MPT experiments were carried out in Japan with phased array of semiconductor amplifiers.

Typical semiconductor devices for microwave circuits are FET (Field Effect Transistor), HBT (Hetero junction Bipolar Transistor), and HEMT (High Electron Mobility Transistor). Present materials for the semiconductor devices are Si for lower frequency below a few GHz and GaAs for higher frequency.. It is easy to control phase and amplitude through the microwave circuits with semiconductor devices, for example, amplifiers, phase shifters, modulators, and so on.

Currently, new materials are under development to enable semiconductor devices yield increased output power and efficiency.

CHAPTER 5, FIG 5.2: COMPACT MICROWAVE ENERGY TRANSMITTER WITH THE PCM (COMET)

The COMET includes DC/Converters, a control circuit of the phase controlled magnetron with 5.8 GHz, a heat radiation Circuit, a wave guide, and an antenna.

5. RECENT TECHNOLOGICAL TRENDS

5.5.1 RETRO DIRECTIVE BEAM CONTROL

A microwave power transmission is suitable for a power transmission from/to moving transmitters/targets. Therefore, accurate target detection and high efficient beam forming are important. Retro directive system is always used for SPS.

5.5.2 ENVIRONMENTAL ISSUES

One of the characteristics of the MPT is to use more intense microwave than that in wireless communication systems. Therefore, we have to consider MPT safety for humans.

5.5.3 INTERACTION WITH ATMOSPHERE

In general, effect of atmosphere on microwaves is quite small. There are absorption and scatter by air, rain, and irregularity of air refraction ratio. In 2.45 GHz and 5.8 GHz, the absorption by water vapor and oxygen Dominate the effect in the air. Especially, it is enough to consider only absorption by the oxygen in the microwave frequency. It is approximately 0.007 dB/km. In the SPS case, the amount of total absorption through the air from space is approximately 0.035 dB

5.5.4 INTERACTION WITH SPACE PLASMAS

6. RECENT TRENDS: WIRELESS POWER TRANSMISSION – RECEIVERS AND RECTIFIERS

Point to point MPT system needs a large receiving area with a rectenna array because one rectenna element receives and creates only a few W. Especially for the SPS, we need a huge rectenna site and a power network connected to the existing power networks on the ground. On contrary, there are some MPT applications with one small rectenna element such as RF ID.

5.6.1 RECENT TECHNOLOGIES OF RECTENNA

The word “rectenna” is composed of “rectifying circuit” and “antenna”. The rectenna can receive and rectify a microwave power to DC. The rectenna is passive element with a rectifying diode, operated without any power source. RECENT TECHNOLOGIES OF RECTENNA ARRAY

The rectenna will be used as an array for high power MPT because one rectenna element rectifies a few W only.

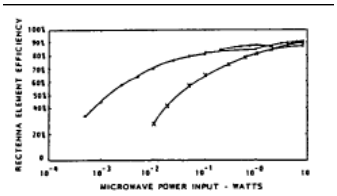
For usual phased array antenna, mutual coupling and phase distribution are problems to solve. For the rectenna array.

7. EFFICIENCY

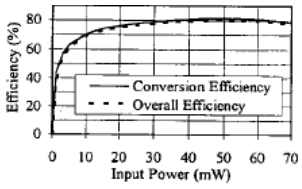
We classify the MPT efficiency roughly into three stages; DC RF conversion efficiency which includes losses caused by beam forming, beam collection efficiency which means ratio of all radiated power to collected power on a receiving antenna, and RF DC conversion efficiency.

5.7.1 BEAM COLLECTION EFFICIENCY

The beam collection efficiency depends on the transmitter and receiver aperture areas, the wavelength, and the separation distance between the two antennas.



(a) Efficiency of 2.45GHz Rectenna[1]



(b) Efficiency of 5.8GHz Rectenna[2]

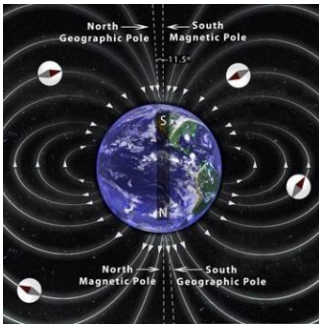
CHAPTER 5, FIG 5.7: EFFICIENCY OF RECTENNA ELEMENT

CHAPTER 6

6. THE BASIC IDEA OF TRANSFORMING ELECTRICITY TO WITRICITY

6.1 ELECTRICITY

The flow of electrons (current) through a conductor (like a wire), or charges through the atmosphere (like lightning). A convenient way for energy to get from one place to another!

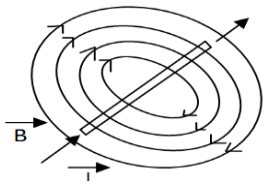


CHAPTER 6, FIG 6.1: AN ILLUSTRATION REPRESENTING THE EARTH'S MAGNETIC FIELD

6.2 MAGNETISM

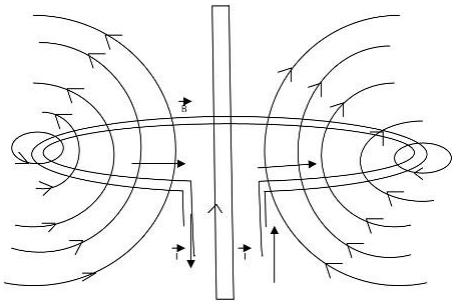
A fundamental force of nature, which causes certain types of materials to attract or repel each other. Permanent magnets, like the ones on your refrigerator and the earth‘s magnetic field, are examples of objects having constant magnetic fields ELECTROMAGNETISM

A term for the interdependence of time varying electric and magnetic fields. For example, it turns out that an oscillating magnetic field produces an electric field and an oscillating electric field produces a



magnetic field.

CHAPTER 6, FIG 6.2: FUNDAMENTALS OF MAGNETIC FIELD



CHAPTER 6, FIG 6.3: THE BLUE LINES REPRESENT THE MAGNETIC FIELD THAT IS CREATED WHEN CURRENT FLOWS THROUGH A COIL.

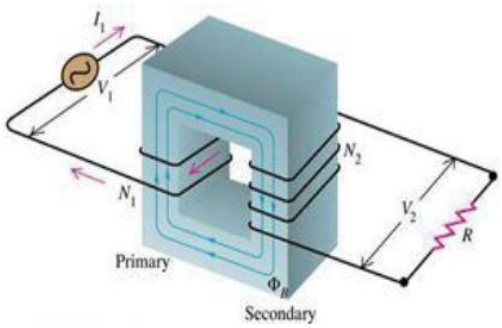
As electric current, I, flows in a wire, it gives rise to a magnetic field, B, which wraps around the wire. When the current reverses direction, the magnetic field also reverses its direction.

6.3 MAGNETIC INDUCTION

A loop or coil of conductive material like copper, carrying an alternating current (AC), is a

The current generated in the second coil may be used to power devices. This type of electrical power transfer from one loop or coil to another is well known and referred to as magnetic induction. Some common examples of devices based on magnetic induction are electric transformers and electric generators.

6.4 ENERGY/POWER COUPLING

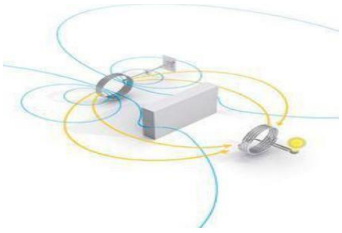


CHAPTER 6, FIG 6.4: MAGNETIC INDUCTION

An electric transformer is a device that uses magnetic induction to transfer energy from its primary winding to its secondary winding, without the windings being connected to each other. It is used to transform AC current at one voltage to AC current at a different voltage.

6.5 WITRICITY TECHNOLOGY

Witricity power sources and capture devices are specially designed magnetic resonators that efficiently transfer power over large distances via the magnetic near field. These proprietary source and device designs and the electronic systems that control them support efficient energy transfer over distances that are many times the size of the sources/devices themselves.



CHAPTER 6, FIG 6.5: WITRICITY POWER SOURCE

The WiTricity power source, left, is connected to AC power. The blue lines represent the magnetic near field induced by the power source. The yellow lines represent the flow of energy from the source to the WiTricity capture coil, which is shown powering a light bulb. Note that this diagram also shows how the magnetic field (blue lines) can wrap around a conductive obstacle between the power source and the

capture

CHAPTER 7

7. PRINCIPLE & EXPERIMENTAL DESIGN

7.1 BASIC PRINCIPLE

WiTricity is nothing but the short name of Wireless Electricity. The basic concept behind this is Magnetic Resonance. Two resonant objects of the same resonant frequency tend to exchange energy efficiently, while dissipating relatively little energy in extraneous off resonant objects. In systems of coupled resonances, there is often a general Strongly Coupled regime of operation. If one can operate in that regime in a given system, the energy transfer is expected to be very efficient. Midrange power

Transfer implemented in this way can be nearly Omni directional and efficient, irrespective of the geometry of the surrounding space, with low interference and losses into environmental objects. The above considerations apply irrespective of the physical nature of the resonances. Magnetic resonances are particularly suitable for everyday applications because most of the common materials do not interact with Magnetic Fields, so interactions with Environmental objects are suppressed even further. We were able to identify the strongly coupled regime in the system of two coupled magnetic resonances by exploring Non radiative (near field) magnetic resonant induction at Megahertz frequencies.

7.2 EXPERIMENTAL DESIGN

Experimental scheme consists of two Self resonant coils. One coil (source coil) is coupled inductively to an oscillating circuit; the other (device coil) is coupled inductively to a resistive load. Self-resonant coils rely on the interplay between distributed inductance and distributed capacitance to achieve resonance. The coils are made of an electrically conducting wire of total length land cross sectional radius a‘, wound into a helix of n‘turns, radius r‘, and height h‘. There is no exact solution for a finite helix in the literature, and even in the case of infinitely long coils, the solutions rely on assumption

CHAPTER 7, FIG 7.0: ENERGY TRANSFER BY COIL REPRESENTATION

7.3 RANGE AND RATE OF COUPLING

The range and rate of the proposed wireless energy transfer scheme are the first subjects of examination, without considering yet energy drainage from the system for use into work. An appropriate analytical framework for modeling this resonant energy exchange is that of the well-known Coupled Mode Theory (CMT) .Here, the field of the system of two resonant objects 1 and 2 is approximated by **F(r, t) =a_1 (t) F1(r) + a_2 (t) F2(r)**, here $F_{1,\ 2}$(r) are the modes of 1 and 2 alone, and then the field amplitudes a_1 (t) and a_2 (t). Since the extent of the near field into the air surrounding a finite sized resonant object is set typically by the wavelength, this mid-range non radiative coupling can only be achieved using resonant objects of Sub wavelength size.

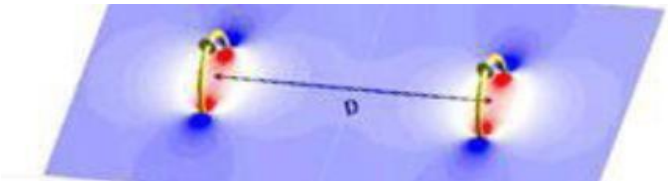
Such sub wavelength (λ/r) resonances can often be accompanied with a high radiation Q, so this will typically be the appropriate choice for the possibly mobile resonant device object.

7.4 PARAMETERS FOR DESIGNING AND SIMULATION

The coupled mode theory plays a vital role in solving the lower order equations of the system. Using perturbation technique of x(t)=A cos(ω 0t)+ B sin(ω 0t) The ratio κ/Γ is proportional to the Quality factor i.e. proportional to the power developed and inversely proportional to decay rate due to loss. so if κ/Γ is high the power output is high. The simulation process is going on in the above way such that to prove in strongly coupled mode at sub wavelength (λ/r) resonances by considering the following process.

7.5 RESONANT MAGNETIC COUPLING

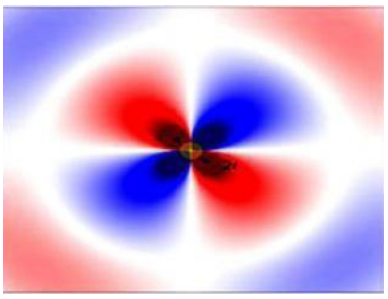
Magnetic coupling occurs when two objects exchange energy through their varying or oscillating magnetic fields.



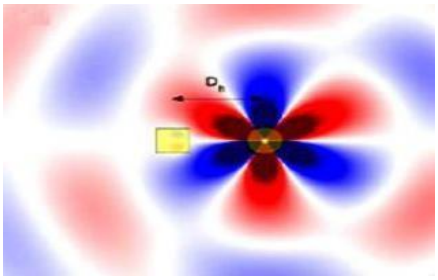
CHAPTER 7, FIG 7.1: ENERGY EXCHANGE

7.6 SIMULATION MODEL USING RESONANT MAGNETIC COUPLING

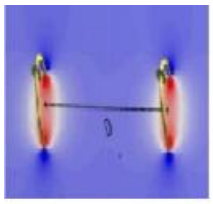
Two idealized resonant magnetic coils, shown in yellow. The blue and red color bands illustrate their magnetic fields. The coupling of their respective magnetic fields is indicated by the connection of the color bands. **Simulation Performance:** The results and performance given with and Without the External object in between the coils.



CHAPTER 7, FIG 7.2: ENERGY EXCHANGE (WITH EXTERNAL OBJECT)



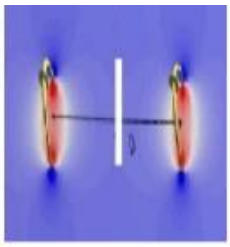
CHAPTER 7, FIG 7.3: ENERGY EXCHANGE (WITHOUT EXTERNAL OBJECT)



Two loops	D/r	Qrad	Q=ω/2Γ	ω/2κ	κ/Γ
R=30cm,a=2cm, ε=10,d=4mm,Qabs=4886.	3	30729	4216	63.7	68.7
	5	29577	4194	248	17.8

CHAPTER 7, FIG 7.4: RESULTS WITHOUT EXTRANEOUS OBJECTS I

If we include a man having muscles of electric permittivity ε=49+16i so that observed the results that only decay is somewhat raised but got the required κ/ Γ ratio.



Two loops	D/r	Qrad	Q=ω/2Γ	ω/2κ	κ/ Γ
R=30cm,a=2cm, ε=49+16i, d=4mm,Qabs=4886.	3	30729	4136	62.6	67.4
	5	29577	4106	235	17.6

CHAPTER 7, FIG 7.5: RESULTS WITH EXTRANEOUS OBJECTS I

CHAPTER 8

8. PERFORMANCE OF DESIGN

8.1 ADVANTAGES OF DESIGN

There are so many advantages with this Witricity concept, some of those are:

a) Unaffected by the day night cycle, weather or seasons.

b) This is an ecofriendly.

c) It is a boon for the devices which use midrange power.

8.2 LIMITATIONS OF DESIGN

a) The resonance condition should be satisfied, if any medium error is there possibility of power transfer.

b) If there is any possibility of Very Strong ferromagnetic material presence, then there may be a possibility of low power transfer due to radiation.

8.3 PARAMETRIC CONCLUSIONS FOR DESIGN

Wireless Electricity concept is a boon for devices which uses midrange energy. The Power transfer is explained with the help of Magnetic resonance and Coupled mode theory. By the above paper we can concludes the below points.

a) The optimal regime of efficient power transfer is strongly coupled regime.

b) High κ/Γ ratio gives high power output. If no change in κ/Γ ration no chance in power transfer.

c) Designed the parameters with FEFD method and simulated for the κ/Γ ratio changes with and without the external objects and concluded that there is no large variation in κ/Γ ratio.

CHAPTER 9

FEATURES AND BENEFITS

9.1 BENEFITS: WITRICITY TECHNOLOGY WILL MAKE YOUR PRODUCTS

a) More convenient

a) No manual recharging or changing batteries.

b) Eliminate unsightly, unwieldy and costly power cords.

9.2 MORE RELIABLE

a) Never run out of battery power.

b) Reduce product failure rates by fixing the weakest link‘: flexing wiring and mechanical interconnects.

9.3 MORE ENVIRONMENTALLY FRIENDLY

a) Reduce use of disposable batteries.

b) Use efficient electric grid power ‘directly instead of inefficient battery charging.

9.4 ENERGY TRANSFER VIA MAGNETIC NEAR FIELD CAN PENETRATE AND WRAP AROUND OBSTACLES

The magnetic near field has several properties that make it an excellent means of transferring energy in a

typical consumer, commercial, or industrial environment. Most common building and furnishing

WiTricity applications engineering team will work with you to address the materials and environmental factors that may influence wireless energy transfer in your application.

CHAPTER 10

10.1 APPLICATIONS

WiTricity wireless power transfer technology can be applied in a wide variety of applications and environments. The ability of our technology to transfer power safely, efficiently, and over distance can improve products by making them more convenient, reliable, and environmentally friendly. WiTricity technology can be used to provide:

10.1.1 AUTOMATIC WIRELESS POWER CHARGING

When all the power a device needs is provided wirelessly, and no batteries are required. This mode is for a device that is always used within range of its WiTricity power source. When a device with rechargeable batteries charges itself while still in use or at rest, without requiring a power cord or battery replacement. This mode is for a mobile device that may be used both in and out of range of its WiTricity *power* source.

10.1.2 CONSUMER ELECTRONICS

Automatic wireless charging of mobile electronics (phones, laptops, game controllers, etc.) in home, car, office, Wi Fi hotspots… while devices are in use and mobile.

Direct wireless powering of stationary devices (flat screen TV‘s, digital picture frames, home theater accessories, wireless loud speakers, etc.) … eliminating expensive custom wiring, unsightly cables and wall wart power supplies.

Direct wireless powering of desktop PC peripherals: wireless mouse, keyboard, printer, speakers, display, etc… eliminating disposable batteries and awkward cabling.

10.1.3 INDUSTRIAL

Direct wireless power and communication interconnections across rotating and moving joints (robots, packaging machinery, assembly machinery, machine tools) … eliminating costly and failure prone wiring. Direct wireless power and communication interconnections at points of use in harsh environments (drilling, mining, underwater, etc.) … where it is impractical or impossible to run wires. Direct wireless

10.1.4 TRANSPORTATION

Automatic wireless charging for existing electric vehicle classes: golf carts, industrial vehicles. Automatic wireless charging for future hybrid and all electric passenger and commercial vehicles, at home, in parking garages, at fleet depots, and at remote kiosks.

Direct wireless power interconnections to replace costly vehicle wiring harnesses and slip rings.

10.2 OTHER APPLICATIONS

a) Direct wireless power interconnections and automatic wireless charging for implantable medical devices (ventricular assist devices, pacemaker, defibrillator, etc.).

b) Automatic wireless charging and for high tech military systems (battery powered mobile devices, covert sensors, unmanned mobile robots and aircraft, etc.).

c) Direct wireless powering and automatic wireless charging of smart cards.

d) Direct wireless powering and automatic wireless charging of consumer appliances, mobile robots, etc.

CHAPTER 11

11. SAFETY AND FUTURE SCOPE

11.1 IS WITRICITY TECHNOLOGY SAFE?

11.1.1 NON RADIATIVE ENERGY TRANSFER IS SAFE FOR PEOPLE AND ANIMALS

WiTricity technology is a non radiative mode of energy transfer, relying instead on the magnetic near field. Magnetic fields interact very weakly with biological organism's people and animals and are scientifically regarded to be safe. Professor Sir John Pendry of Imperial College London, a world renowned physicist .

11.2 FUTURE SCOPE OF WITRICITY

MIT's WiTricity is only 40 to 45% efficient and according to Soljacic, they have to be twice as efficient to compete with the traditional chemical batteries. The team's next aim is to get a robotic vacuum or a laptop working, charging devices placed anywhere in the room and even robots on factory floors. The researchers are also currently working on the health issues related to this concept and have said that in another three to five years' time, they will come up with a WiTricity system for commercial use.

Reference

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