RESEARCH ARTICLE OPEN ACCESS

Wireless Transmission of Electrical Power Overview of Recent Research & Development

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ABSTRACT –
The Aim Of This Research Work Is To Give A Overview Of Recent Researches And Development In The Field Of Wireless Power Transmission. The Methods Applied For Wireless Power Transmission Like Induction, Electromagnetic Transmission, Evanescent Wave Coupling, Electrodynamics Induction, Radio And Microwave And Electrostatic Induction ,Are Discussed. This Study Also Focuses On The Latest Technologies, Merits And Demerits In This Field. Proposed Work Are Discussed.
Index Terms - Wireless Power Transfer, RF/Microwave Radiation, Qi, Witricity, Magnetron.

Date Of Submission: 31-03-2018 Date Of Acceptance 16-04-2018

I. INTRODUCTION

In The Past, Product Designers And Engineers Have Faced Challenges Involving Power: The Continuity Of Supplied Power, Recharging Batteries, Optimizing The Location Of Sensors, And Dealing With Rotating Or Moving Joints. Although Those Challenges Remain, New Demands That Arise From Increased Use Of Mobile Devices And Operation In Dirty Or Wet Environments Mean That Designers Require New Approaches To Supplying Power To Equipment. Wireless Power Transmission From The Time Of Tesla Has Been An Underdeveloped Technology. Tesla Had Always Tried To Introduce Worldwide Wireless Power Distribution System. But Due To Lack Of Funding And Technology Of That Time, He Was Not Able To Complete The Task. Then Onwards This Technology Has Not Been Developed Up To The Level Which Would Be Completely Applicable For Practical Purpose. Research Has Always Been Going On And Recent Developments Have Been Observed In This Field. Despite Advances Wireless Power Transmission Has Not Been Adopted For Commercial Use.

II. LITERATURE SURVEY

*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 First 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.

Nikola Tesla Has Been The Pioneer In The Field Of Wireless Transmission Of Electrical Power. He Started Efforts On Wireless Transmission At 1891 In His "Experimental Station" At Colorado. Nikola Tesla Successfully Lighted A Small Incandescent Lamp By Means Of A Resonant Circuit Grounded On One End. A Coil Outside Laboratory With The Lower End Connected To The Ground And The Upper End Free. The Lamp Is Lighted By The Current Induced In The Three Turns Of Wire Wound Around The Lower End Of The Coil.

Fig. 1 Tesla Coil

*William C. Brown Contributed Much To The Modern Development Of Microwave Power Transmission Which Dominates Research And Development Of Wireless Transmission Today. In The Early 1960s Brown Invented The Rectenna Which Directly Converts Microwaves To DC Current. He Demonstrated Its Ability In 1964 By Powering A Helicopter From The Solely Through Microwaves.

Fig .2 Powering A Helicopter From The Solely Through Microwaves.

*Mitsubishi Heavy Industries, Ltd. (MHI) Has Conducted Ground Demonstration Testing Of "Wireless Power Transmission," A New Technology Presently Under Development To Serve As The Core Technology Of The Space Solar Power Systems (SSPS) That Are Expected To Be The Power Generation Systems Of The Future. With Successful Completion Of The Test At The Company's Kobe Shipyard & Machinery Works, MHI Has Now Verified The Viability Of Long-Distance Wireless Power Transmission.

Fig.3 Mitsubishi Transmitter

III. METHODS OF WIRELESS TRANSMISSION OF ELECTRICAL POWER

A. Induction

The Principle Of Mutual Induction Between Two Coils Can Be Used For The Transfer Of Electrical Power Without Any Physical Contact In Between. The Simplest Example Of How Mutual Induction Works Is The Transformer, Where There Is No Physical Contact Between The Primary And The Secondary Coils. The Transfer Of Energy Takes Place Due To Electromagnetic Coupling Between The Two Coils.

B. Electromagnetic Transmission

Electromagnetic Waves Can Also Be Used To Transfer Power Without Wires. By Converting Electricity Into Light, Such As A Laser Beam, Then Firing This Beam At A Receiving Target, Such As A Solar Cell On A Small Aircraft, Power Can Be Beamed To A Single Target. This Is Generally Known As “Power Beaming”.

C. Evanescent Wave Coupling

Researchers At MIT Believe They Have Discovered A New Way To Wirelessly Transfer Power Using Non-Radiative Electromagnetic Energy Resonant Tunnelling. Since The Electromagnetic Waves Would Tunnel, They Would Not Propagate Through The Air To Be Absorbed Or Wasted, And Would Not Disrupt Electronic Devices Or Cause Physical Injury Like Microwave Or Radio Transmission. Researchers Anticipate Up To 5 Meters Of Range.

D. Electrodynamic Induction

Also Known As "Resonant Inductive Coupling" Resolves The Main Problem Associated With Non-Resonant Inductive Coupling For Wireless Energy Transfer; Specifically, The Dependence Of Efficiency On Transmission Distance. When Resonant Coupling Is Used The Transmitter And Receiver Inductors Are Tuned To A Mutual Frequency And The Drive Current Is Modified From A Sinusoidal To A Non-Sinusoidal Transient Waveform. Pulse Power Transfer Occurs Over Multiple Cycles. In This Way Significant Power May Be Transmitted Over A Distance Of Up To A Few Times The Size Of The Transmitter.

E. Radio And Microwave

Power Transmission Via Radio Waves Can Be Made More Directional, Allowing Longer Distance Power Beaming, With Shorter Wavelengths Of Electromagnetic Radiation, Typically In The Microwave Range. A Rectenna May Be Used To Convert The Microwave Energy Back Into Electricity. Rectenna Conversion Efficiencies Exceeding 95% Have Been Realized. Power Beaming Using Microwaves Has Been Proposed For The Transmission Of Energy From Orbiting Solar Power Satellites To Earth And The Beaming Of Power To Spacecraft Leaving Orbit Has Been Considered.

F. Electrostatic Induction

Also Known As "Capacitive Coupling" Is An Electric Field Gradient Or Differential Capacitance Between Two Elevated Electrodes Over A Conducting Ground Plane For Wireless Energy Transmission Involving High Frequency Alternating Current Potential Differences Transmitted Between Two Plates Or Nodes.

IV. CURRENT TECHNOLOGY IN THE FIELD OF WIRELESS POWER TRANSMISSION AND CHARGING

1) Qi: Qi (Pronounced "Chee") Is A Wireless Charging Standard Developed By WPC [30]. A Typical Qi-Compliant System Model Is Illustrated In Figure 10a. Qi Standard Specifies Interoperable Wireless Power Transfer And Data Communication Between A Wireless Charger And A Charging Device. Qi Allows The Charging Device To Be In Control Of The Charging Procedure. The Qi-Compliant Charger Is Capable Of Adjusting The Transmit Power Density As Requested By The Charging Device Through Signalling. Qi Uses The Magnetic Inductive Coupling Technique, Typically Within The Range Of 40 Millimetres. Two Categories Of Power Requirement Are Specified For Qi Wireless Charger, I.E.

• Low-Power Category Which Can Transfer Power Within 5W On 110 To 205 Khz Frequency Range.
• Medium-Power Category Which Can Deliver Power Up To 120W On 80-300 Khz Frequency Range.

Generally, A Qi Wireless Charger Has A Flat Surface, Referred To As A Charging Pad, Of Which A Mobile Device Can Be Laid On Top. As Aforementioned, The Tightness Of Coupling Is A Crucial Factor In The Inductive Charging Efficiency. To Achieve Tight Coupling, A Mobile Device Must Be Strictly Placed In A Proper Alignment With The Charger.

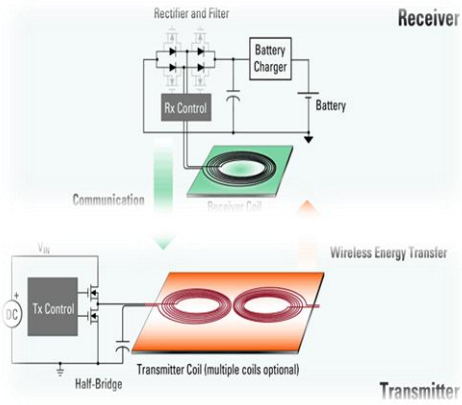


Fig. 4 Qi Transmitter And Receiver

2) Microwave Transmitter

The Most Current Research And Proposals Use Microwaves As The Frequency Range Of Choice For Transmission. At Present An Efficiency Of 76% Is Possible Using Current Technology For Microwave Power Transmission. For Transmission Efficiency The Waves Must Be Focused So That All The Energy Transmitted By The Source Is Incident On The Wave Collection Device. Higher Frequencies Are Also Impractical Because Of The High Cost Of Transmitters And The Relative Low Efficiency Of Current Optical And Infrared Devices.

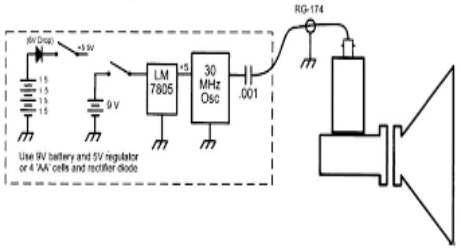


Fig. 5 Microwave Transmitter Circuit Diagram

The Most Common Transmitters For Microwaves Are The Travelling Wave Tube (TWT), Klystron And Magnetron. The TWT Is Far Too Expensive And Power Restrictive Making It Impractical For The Task Of Power Transmission. The Klystron Has Been The DC To Microwave Converter Of Choice However It Is Also Somewhat Expensive. Many Researchers Are Looking To Use Magnetrons Instead Because They Are Cheap And Efficient. Magnetron Frequency Output Is Not As Precisely Controllable As The Klystron Or TWT But Power Transmission Is More Lenient To Frequency Fluctuations Than Communication Systems Are. One Of The More Common Proposals Would Be For An Array Of Magnetrons To Be Used As The Transmitter. One Of The Main Advantages To Using Many Smaller Magnetrons As Opposed To A Few Klystrons Is That 300 W To 1kw Magnetrons Are Already Mass Produced For Microwave Ovens. The Efficiency Of
Magnetron Is Inconsistently Reported.

3) Use Of Microwave Power Transmission In Solar Power Satellites (SPS)

Solar Power Generating Satellites Launched Into Space And Transmitting Power To Earth Stations. This Idea Was First Proposed In 1968 And All Of The Experiments Have Only Been Carried Out In Terrestrial Laboratories. The SPS Satellites Would Be Put In High Earth Orbit At Geosynchronous Location. This Would Allow Them To Receive Light 99% Of The Year. A Large Rectenna Array Facility Will Be Built On The Earth To Collect The Incoming Microwaves. To Maintain A Good Lock On The Rectenna The Satellite Will Need To Be Built With A Retrodirective Transmitter Which Locks On To A Pilot Beam Emanated From The Ground Station.

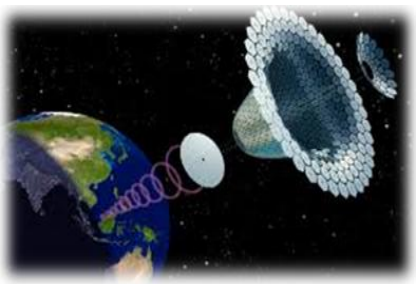


Fig.6 MPT In Solar Power Satellites (SPS)

Since Most Of The Research Is Done In The 2.4 Ghz To 5.8 Ghz Range There Are Some Spectrum Regulatory Issues To Deal With. Also Since The Retro Directive Antenna System Is Unproven. There Is The Health Concern That The Microwave Beam Could Veer Off Target And Microwave Some Unsuspecting Family. However, A Japanese Government Agency Is Planning To Send Up 10 To 100 Kw Low Earth Orbit Satellite To Prove Its Feasibility.

V. LATEST INVENTION AND EXPERIMENTS

A. Writricity

The New Technology Called Witricity Is Based On Using Coupled Resonant Objects [10]. Two Resonant Objects Of The Same Resonant Frequency Tend To Exchange Energy Efficiently, While Interacting Weakly With Extraneous Off-Resonant Objects.

A Child On A Swing Is A Good Example Of This. A Swing Is A Type Of Mechanical Resonance, So Only When The Child Pumps Her Legs At The Natural Frequency Of The Swing Is She Able To Impart Substantial Energy.

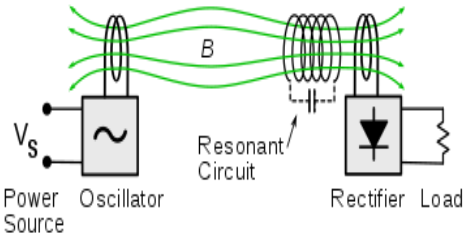


Fig. 7 Witricity Image Of How The Fields Works

The Investigated Design Consists Of Two Copper Coils, Each A Self-Resonant System. One Of The Coils, Attached To The Power Source, Is The Sending Unit. Instead Of Irradiating The Environment With Electromagnetic Waves, It Fills The Space Around It With A Non-Radiative Magnetic Field Oscillating At Mhz Frequencies. The Non-Radiative Field Mediates The Power Exchange With The Other Coil (The Receiving Unit), Which Is Specially Designed To Resonate With The Field. The Resonant Nature Of The Process Ensures The Strong Interaction Between The Sending Unit And The Receiving Unit, While The Interaction With The Rest Of The Environment Is Weak.

Fig. 8 Team Of MIT Worked For WPT

B. Mitsubishi Solar Wireless Project

A Successful Ground Test Of A System Designed To Ultimately Collect Solar Power From Orbit And Beam It Back Down To Earth Was Announced In Japan This Week By Mitsubishi Heavy Industries. The Wireless Power Demonstration Saw 10 Kilowatts Sent Over Microwaves From A Transmitting Unit To A Receiver 500 Meters (1,640 Ft) Away. Mitsubishi Says The Reception Of The Power Sent Through The Air Was Confirmed Through The Illumination Of Lights Using Part Of The Power Transmitted. The Company Did Not Confirm What Percentage Of The Power Sent Actually Made It To The Receiver, However, Which Is A Key Question As The Ultimate Goal Is To Relay Power From Orbit Thousands Of Miles Above Earth. Previous Tests Of The Technology Yielded Only A Tiny Fraction Of The Power Sent From One Hawaiian Island To Another.

No One Is Expecting A Huge Orbiting Solar Farm And Corresponding Massive Microwave Power Beam To Be Ready Overnight, Of Course. Mitsubishi Says That The Successful Test Conducted At The Company's Kobe Shipyard And Machinery Works Has Verified The Viability Of The Concept, And That The

Transmission Distance And Power Load Mark New Milestones For The Technology. Perhaps Just As Important, The Testing Confirmed The Performance Of The Control System That Will Regulate The Microwave Beam Itself. This Is A Big Deal, Because If The Proposed Microwave Connection Between An Orbiting Power Station And Large Receiver Units On A Man-Made Island In Tokyo Bay Were Ever Fired Up At Full Power, It Would Be Strong Enough That Workers Would Need To Wear Protective Clothing – Not The Kind Of Thing You'd Want To Zap 100,000 People Wandering Through Shinjuku With By Accident.

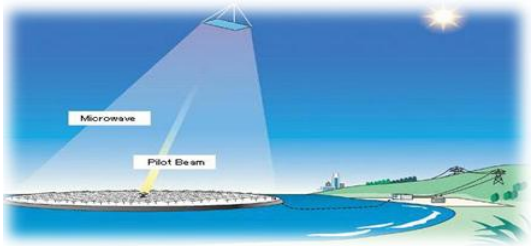


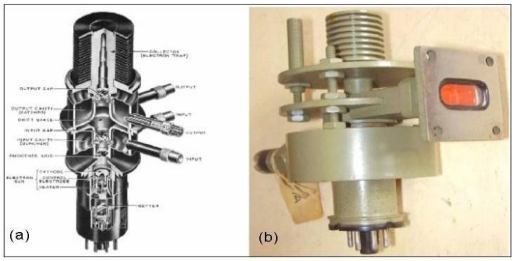
Fig.9 Mitsubishi Solar Project

VI. RECENT RESEARCH

Researches Have Been Going On In The Field Of Using Microwave Power Transfer And Many Technologies Are Being Developed Around The Globe.

1. Antennas: - In Some MPT Experiments In Japan, The Phased Array Antenna Was Adopted To Steer A Direction Of The Microwave Beam.

2. Transmitters: - Magnetron, Travelling Wave Tube Amplifiers, Klystron, Semiconductor Amplifiers.
3. Beam Control: - Target Detection, Propagation.



(C)
Fig. 10

VII. PROPOSED WORK

My Work Is Based On Transmission Threw Microwaves Because The Microwave Is Not Harmful To Human Beings. Its Frequency Range Is Between 0.6ghz To 300ghz.

I Am Going To Use A Transmitter And A Receiver. The Whole Process Will Complete Threw It.

I Am Using Magnetron As A Transmitter Which Is Able To Convert The Electricity Into The Electron Beam With The Frequency Range Of Microwave Or We Can Say It Convert Electricity Into A Microwave.

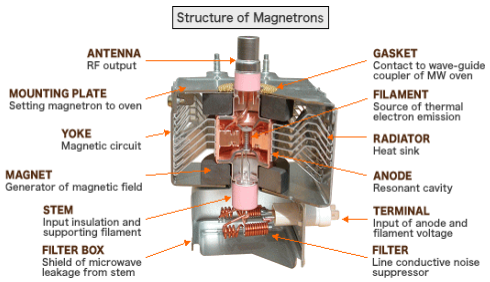


Fig. 11 Structure Of Magnetron

And The Other Hand A Receiver Is Also There Attached To The Passive Device Which We Want To Give Electricity. The Receiver Will Receive The Electricity In The Form Of Microwave Then It Will Convert It Into DC Voltage.

VIII. MERITS AND DEMERITS

A. Merits

The System Would Reduce The Cost Of Electrical Energy Used By The Consumer And Rid The Landscape Of Wires, Cables, And Transmission Towers. The Electrical Energy Can Be Economically Transmitted Without Wires To Any Terrestrial Distance, So There Will Be No Transmission And Distribution Loss. The Efficiency Of The Transmission Can Be As High As 96 Or 97 Per Cent, And There Are Practically No Losses.

B. Demerits

Calculating The Circulating Reactive Power, It Was Found That The Frequency Is Very Small And Such A Frequency Is Very Biologically Compatible.

IX. CONCLUSION

Wireless Power Transmission Of Electrical Power Can Considered As A Large Scope In Electrical Engineering For Future Prospects Of Power Generation And Transfer. Solar Power Satellites Are The Future Of Supplying Non Conventional Energy. The Various Methods And Aspects Regarding Wireless Transmission Of Electrical Power Are Discussed. The Evolution Of The Technology From The Time Of Tesla Has Been Overviewed.

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Himanshu Kumar Singh"Wireless Transmission of Electrical Power Overview of Recent Research & Development"InternationalJournal of Engineering Research and Applications (IJERA) , vol. 8, no. 4, 2018, pp. 56-60