

# Wireless Power Transfer

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wireless power transfer is the second edition of a well received first book which published in 2012 it represents the state of the art at the time of writing and addresses a unique subject of great international interest in terms of research most of the chapters are contributed by the main author though as in the first edition several chapters are contributed by other authors the authors of the various chapters are experts in their own right on the specific topics within wireless energy transfer compared to the first edition this new edition is more comprehensive in terms of the concepts discussed and the range of current industrial applications which are presented such as those of magnetic induction from the eleven chapters of the first edition this second edition has expanded to twenty chapters more chapters on the theoretical foundations and applications have been included this new edition also contains chapters which deal with techniques for reducing power losses in wireless power transfer systems in this regard specific chapters discuss impedance matching methods frequency splitting and how to deploy systems based on frequency splitting a new chapter on multi dimensional wireless power transfer has also been added the design of wireless power transfer systems based on bandpass filtering approach has been included in addition to the two techniques using couple mode theory and electronic circuits the book has retained chapters on how to increase efficiency of power conversion and induction and also how to control the power systems furthermore detailed techniques for power relay including applications which were also discussed in the first edition have been updated and kept the book is written in a progressive manner with a knowledge of the first chapters making it easier to understand the later chapters most of the underlying theories covered in the book are clearly relevant to inductive near field communications robotic control robotic propulsion techniques induction heating and cooking and a range of mechatronic systems

focusing on inductive wireless power transfer wpt which relies on coil resonators and power converters this book begins by providing the background and basic theories of wpt which are essential for newcomers to the field then two major challenges of wpt power transfer distance and efficiency are subsequently addressed and multi resonator wpt systems which not only offer a way to extend power transfer distance but also provide more flexibility are investigated recent findings on techniques to maximize the power transfer efficiency of wpt systems e g maximum efficiency point tracking are also introduced without the constraint of cables wireless power transfer wpt is an elegant technique for charging or powering a range of electrical devices e g electric vehicles mobile phones artificial hearts etc given its depth of coverage the book can serve as a technical guideline or reference guide for engineers and researchers working on wpt

wireless power transfer wpt is a promising technology used to transfer electric energy from a transmitter to a receiver wirelessly without wires through various methods and technologies using time varying electric magnetic or electromagnetic fields it is an attractive solution for many industrial applications due to its many benefits over wired connections this book discusses the theory and practical aspects of wpt technology

wireless power transfer wpt enables power to be transferred from a grid or storage unit to a device without the need for cable connections this can be performed by inductive coupling of magnetic fields as well as by direct radiative transfer via beams of electromagnetic waves commonly radiowaves microwaves or lasers inductive coupling is the most widely used wireless technology with applications including charging handheld devices rfid tags chargers for implantable medical devices and proposed systems for charging electric vehicles applications of radiative power transfer include solar power satellites and wireless powered drone aircraft

wireless power transfer presents a detailed overview of multiple objective wireless power transfer wpt technologies including the latest research developments and emerging applications wireless power

transfer principles and applications offers comprehensive coverage of all key aspects of wireless power transfer wpt technologies including fundamental theory intelligent control configuration analysis and emerging power electronics techniques this unique resource is the first book of its kind to provide in depth discussion of energy transmission control schemes with emphasis on omni directional vector control energy encryption based security control demand based optimal designs for transmitter pickup and self resonance coils multiple objective power distribution and maximum efficiency and power control under various conditions in addition this text presents the methodologies and approaches of emerging multiple objective wpt technologies discusses various applications for wireless charging techniques including contactless power for electric vehicles in flight charging for unmanned aerial vehicles and underwater wireless charging covers both intermittent and continuous impedance matching methods for different classes of coils features more than 400 high quality illustrations and numerous figures and tables throughout wireless power transfer principles and applications is an invaluable technical reference for academic researchers and industry professionals in power and energy engineering and an excellent textbook for postgraduate courses in relevant areas of industrial and electronic engineering

wireless power transfer for e mobility fundamentals and design guidelines for wireless charging of electric vehicles provides a comprehensive resource for researchers and engineers engaged in the development of automotive wpt systems the book opens with an overview of wireless technologies for power transfer and their evolution over time then focusing on the application of this technology to electric mobility highlighting its importance in terms of impact and perspectives on the development of sustainable transport and autonomous driving chapters discuss the fundamentals of electromagnetic field in wpt systems and the circuit modelling in addition they examine core current electric vehicle systems and present day automotive wpt standards design techniques of magnetic couplers including compensation networks are explored in depth alongside power electronics techniques for automotive wpt systems both stationary and dynamic automotive wpt systems are rigorously assessed finally the

problems of electromagnetic compatibility and electromagnetic field safety are described with particular attention to shielding techniques for the mitigation of magnetic field emissions addressing essential knowledge from foundational to advanced levels wireless power transfer for e mobility provides practical guidance to engineers and researchers developing the future of electric mobility provides an advanced foundation for research and current industrial applications in automotive wpt systems develops proven methodologies linked to some case studies using examples drawn from global practice explores the role of wpt in near future mobility scenarios with featured coverage of electrified transportation includes an extensive usage of equations from matlab spice and comsol

this book describes the fundamentals and applications of wireless power transfer wpt in electric vehicles evs wireless power transfer wpt is a technology that allows devices to be powered without having to be connected to the electrical grid by a cable electric vehicles can greatly benefit from wpt as it does away with the need for users to manually recharge the vehicles batteries leading to safer charging operations some wireless chargers are available already and research is underway to develop even more efficient and practical chargers for evs this book brings readers up to date on the state of the art worldwide in particular it provides the fundamental principles of wpt for the wireless charging of electric vehicles car bicycles and drones including compensation topologies bi directionality and coil topologies information on international standards for ev wireless charging design procedures for ev wireless chargers including software files to help readers test their own designs guidelines on the components and materials for ev wireless chargers review and analysis of the main control algorithms applied to ev wireless chargers review and analysis of commercial ev wireless charger products coming to the market and the main research projects on this topic being carried out worldwide the book provides essential practical guidance on how to design wireless chargers for electric vehicles and supplies matlab files that demonstrate the complexities of wpt technology and which can help readers design their own chargers

nikola tesla dream in the early 20th century of a world wireless system led him to build the wardencllyffe tower a prototype base station serving as an emitter for his world wireless system the base station was to supply wireless supply of electrical energy to a distant receiver this book builds upon that dream and is a result of intensive research interest in powerline machine to machine communications and wireless power transfer globally wireless energy transfer or witricity wireless electricity transfers electricity instead of data the technology is useful in cases where instantaneous or continuous energy is needed but interconnecting wires are inconvenient hazardous or impossible the transfer is made through inductive coupling and electromagnetic radiation inductive coupling provides optimum power delivery to a receiver load if both the emitter and the receiver achieve magnetic resonance concurrently energy transfer systems mostly use antennas operating in their near field regions as fossil energy sources are being depleted rapidly worldwide and oil prices soar solar energy enhanced with wireless power transfer wpt have become reasonable alternatives for renewable energy and power harvesting they are finding use in transportation electric and hybrid vehicles very fast trains and the emerging field of internet of things this book is written by the leading experts on wireless energy transfer technology and its applications it introduces and explains the technology in great details and provides the theory and practice of wpt through the two approaches of coupled mode theory and circuit theory both approaches are dependent on resonance techniques the level of presentation is suitable for design and training in depth coverage is provided on near field concepts coupled mode theory and models circuit models of inductive antennas radiative and inductive wireless power transfer wireless power relay concepts optimization techniques for wireless power transfer systems control of wireless power transfer systems wireless charging concepts wireless energy transfer applications in electric vehicles embedded medical systems and propagation in human tissues each chapter is written by experts on a selected aspect of wireless energy transfer the authors have gone to great lengths to provide worked examples to assist the reader in working through some of the difficult concepts and to allow more understanding the book is an excellent foundation for applying wireless energy transfer

technologies in most fields including transportation communication home automation biomedical systems and home appliances the book is recommended to practitioners and engineers in the power industry students in universities and research institutes honours and post graduate students in physics electrical electronic engineering and computer science will find the book easy to read and apply because of the mode of presentation

technologies that enable powering a device without the need for being connected with a cable to the grid are gaining attention in recent years due to the advantages that they provide they are a commodity to users and provide additional functionalities that promote autonomy among the devices emerging capabilities and applications of wireless power transfer is an essential reference source that analyzes the different applications of wireless power transfer technologies and how the technologies are adapted to fulfill the electrical magnetic and design based requirements of different applications featuring research on topics such as transfer technologies circuitual analysis and inductive power transfer this book is a vital resource for academicians electrical engineers scientists researchers and industry professionals seeking coverage on device power and creating autonomy through alternative power options for devices

what is wireless power transfer the transmission of electrical energy in the absence of cables as a physical connection is referred to variously as wireless power transfer wpt wireless power transmission wpt wireless energy transmission wet or electromagnetic power transfer ept in a system for wirelessly transmitting power a transmitter device is propelled by electric power derived from a power source this drives the device to generate a time varying electromagnetic field which in turn transmits power across space to a receiver device the receiver device then extracts power from the field and supplies it to an electrical load by removing the need for cables and batteries the technology of wireless power transfer may increase the portability convenience and safety of an electronic gadget for all of its users it is helpful to employ wireless power transmission in order to power electrical equipment in situations

where physically connecting cables would be difficult harmful or otherwise impossible how you will benefit i insights and validations about the following topics chapter 1 wireless power transfer chapter 2 microwave chapter 3 electromagnetic compatibility chapter 4 antenna radio chapter 5 klystron chapter 6 near and far field chapter 7 index of electronics articles chapter 8 resonator chapter 9 spark gap transmitter chapter 10 loop antenna chapter 11 index of electrical engineering articles chapter 12 grid dip oscillator chapter 13 coupling electronics chapter 14 inductive charging chapter 15 dielectric resonator antenna chapter 16 wrel technology chapter 17 resonant inductive coupling chapter 18 qi standard chapter 19 magnetoquasistatic field chapter 20 glossary of electrical and electronics engineering chapter 21 history of the tesla coil ii answering the public top questions about wireless power transfer iii real world examples for the usage of wireless power transfer in many fields iv 17 appendices to explain briefly 266 emerging technologies in each industry to have 360 degree full understanding of wireless power transfer technologies who this book is for professionals undergraduate and graduate students enthusiasts hobbyists and those who want to go beyond basic knowledge or information for any kind of wireless power transfer

this book describes systematically wireless power transfer technology using magnetic resonant coupling and electric resonant coupling and presents the latest theoretical and phenomenological approaches to its practical implementation operation and its applications it also discusses the difference between electromagnetic induction and magnetic resonant coupling the characteristics of various types of resonant circuit topologies and the unique features of magnetic resonant coupling methods designed to be self contained this richly illustrated book is a valuable resource for a broad readership from researchers to engineers and anyone interested in cutting edge technologies in wireless power transfer from mobile cable free re charging of electric vehicles smart phones and laptops to collecting solar electricity from orbiting solar farms wireless power transfer wpt technologies offer consumers and society enormous benefits written by innovators in the field this comprehensive resource explains the



fundamental principles and latest advances in wpt and illustrates key applications of this emergent technology key features and coverage include the fundamental principles of wpt to practical applications on dynamic charging and static charging of evs and smartphones theories for inductive power transfer ipt such as the coupled inductor model gyrator circuit model and magnetic mirror model ipts for road powered evs including controller compensation circuit electro magnetic field cancel large tolerance power rail segmentation and foreign object detection ipts for static charging for evs and large tolerance and capacitive charging issues as well as ipt mobile applications such as free space omnidirectional ipt by dipole coils and 2d ipt for robots principle and applications of capacitive power transfer synthesized magnetic field focusing wireless nuclear instrumentation and future wpt a technical asset for engineers in the power electronics internet of things and automotive sectors wireless power transfer for electric vehicles and mobile devices is an essential design and analysis guide and an important reference for graduate and higher undergraduate students preparing for careers in these industries

wireless power transfer allows the transfer of energy from a transmitter to a receiver across an air gap without any electrical connections technically any device that needs power can become an application for wireless power transmission the current list of applications is therefore very diverse from low power portable electronics and household devices to high power industrial automation and electric vehicles with the rise of iot sensor networks and industry 4.0 the presence of wireless energy transfer will only increase in order to improve the current state of the art models are being developed and tested experimentally such models allow simulating quantifying predicting or visualizing certain aspects of the power transfer from transmitter s to receiver s moreover they often result in a better understanding of the fundamentals of the wireless link this book presents a wonderful collection of peer reviewed papers that focus on the modelling of wireless power transmission it covers both inductive and capacitive wireless coupling and includes work on multiple transmitters and or receivers

this book introduces the most state of the art wireless power transfer technologies for electric vehicles from the fundamental theories to practical designs and applications especially on the circuit analysis methods resonant compensation networks magnetic couplers and related power electronics converters moreover some other necessary design considerations such as communication systems detection of foreign and living objects emi issues and battery charging strategies are also introduced to provide sufficient insights into the industrial applications finally some future points are mentioned in brief different from other works all the wpt technologies in this book are applied in real ev applications whose effectiveness and reliability have been already tested and verified from this book readers who are interested in the area of wireless power transfer can have a broad view of modern wpt technologies readers who have no experience in the wpt area can learn the basic concept analysis methods and design principles of the wpt system for ev charging even for the readers who are occupied in this area this book also provides rich knowledge on engineering applications and future trends of ev wireless charging

the wireless power transfer concept is continuously and rapidly evolving and new challenges arise every day as a result of these rapid changes the need for up to date texts that address this growing field from an interdisciplinary perspective persists this book organized into ten chapters presents interesting novel solutions in the exploitation of the near and far field techniques of wireless power transfer that will be used in the near future as well as a bird s eye view of some aspects related to an emerging technological area that will change our lives and will change the paradigm of how we use electrical equipment the book covers the theory and also the practical aspects of technology implementation in a way that is suitable for undergraduate and graduate level students as well as researchers and professional engineers

the new edition of this established work on wireless power transfer updates include output characteristics of multi hop systems technologies new experimental data developments on regulation

and standardization wpt for dynamic ev charging and far field wpt

wireless power transfer techniques have been gaining researchers and industry attention due to the increasing number of battery powered devices such as mobile computers mobile phones smart devices intelligent sensors mainly as a way to replace the standard cable charging but also for powering battery less equipment the storage capacity of batteries is an extremely important element of how a device can be used if we talk about battery powered electronic equipment the autonomy is one factor that may be essential in choosing a device or another making the solution of remote powering very attractive a distinction has to be made between the two forms of wireless power transmission as seen in terms of how the transmitted energy is used at the receiving point transmission of information or data when it is essential for an amount of energy to reach the receiver to restore the transmitted information transmission of electric energy in the form of electromagnetic field when the energy transfer efficiency is essential the power being used to energize the receiving equipment the second form of energy transfer is the subject of this book

shinohara and co authors present a comprehensive and in depth discussion of all current wireless power transfer wpt methods and meet the growing need for a detailed understanding of the advantages disadvantages and applications of each method wpt is a game changing technology not only for iot networks and sensors but also for mobile chargers long flying drones solar powered satellites and more and the list of potential applications will continue to grow each author s chapter is based on a minimum of 13 years and a maximum of over 30 years of research experience on selected wpt technologies to explain the theory and advantages and disadvantages of this to various applications the book provides an insight into wpt theories and technologies including inductive coupling for short distance wpt radio waves for long distance wpt optical wpt using lasers supersonic wpt in water and more the characteristics of each wpt method are compared theoretically and technically the differences of each wpt method are explained with reference to the different theories techniques and suitable

applications the reader will gain an understanding of the recent and future commercial market and regulations regarding wpt they will be able to apply this knowledge to select the appropriate wpt method for their desired application this book is appropriate for students wpt researchers and engineers in industry who are developing wpt applications

this book presents a system level analysis of inductive wireless power transfer wpt links the basic requirements design parameters and utility of key building blocks used in inductive wpt links are presented followed by detailed theoretical analysis design and optimization procedure while considering practical aspects for various application domains readers are provided with fundamental yet easy to follow guidelines to help them design high efficiency inductive links based on a set of application specific target specifications the authors discuss a wide variety of recently proposed approaches to achieve the maximum efficiency point such as the use of additional resonant coils matching networks modulation of the load quality factor  $q$  modulation and adjustable dc dc converters additionally the attainability of the maximum efficiency point together with output voltage regulation is addressed in a closed loop power control mechanism numerous examples including matlab octave calculation scripts and ltspice simulation files are presented throughout the book this enables readers to check their own results and test variations facilitating a thorough understanding of the concepts discussed the book concludes with real examples demonstrating the practical application of topics discussed covers both introductory and advanced levels of theory and practice providing readers with required knowledge and tools to carry on from simple to advanced wireless power transfer concepts and system designs provides theoretical foundation throughout the book to address different design aspects presents numerous examples throughout the book to complement the analysis and designs includes supplementary material numerical and circuit simulation files that provide a hands on experience for the reader uses real examples to demonstrate the practical application of topics discussed

wireless power transfer allows the transfer of energy from a transmitter to a receiver across an air gap without any electrical connections technically any device that needs power can become an application for wireless power transmission the current list of applications is therefore very diverse from low power portable electronics and household devices to high power industrial automation and electric vehicles with the rise of iot sensor networks and industry 4.0 the presence of wireless energy transfer will only increase in order to improve the current state of the art models are being developed and tested experimentally such models allow simulating quantifying predicting or visualizing certain aspects of the power transfer from transmitter s to receiver s moreover they often result in a better understanding of the fundamentals of the wireless link this book presents a wonderful collection of peer reviewed papers that focus on the modelling of wireless power transmission it covers both inductive and capacitive wireless coupling and includes work on multiple transmitters and or receivers

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