A Aplicação do Conhecimento Científico na Engenharia Elétrica

João Dallamuta
Henrique Ajuz Holzmann
(Organizadores)

Atena
Editora
Ano 2020

A Aplicação do Conhecimento Científico na Engenharia Elétrica

João Dallamuta
Henrique Ajuz Holzmann
(Organizadores)

Atena
Editora
Ano 2020

2020 *by Atena Editora*
Copyright © Atena Editora
Copyright do Texto © 2020 Os autores
Copyright da Edição © 2020 Atena Editora
Editora Chefe: Profª Drª Antonella Carvalho de Oliveira
Diagramação: Karine de Lima
Edição de Arte: Lorena Prestes
Revisão: Os Autores

Todo o conteúdo deste livro está licenciado sob uma Licença de Atribuição *Creative Commons*. Atribuição 4.0 Internacional (CC BY 4.0).

O conteúdo dos artigos e seus dados em sua forma, correção e confiabilidade são de responsabilidade exclusiva dos autores. Permitido o download da obra e o compartilhamento desde que sejam atribuídos créditos aos autores, mas sem a possibilidade de alterá-la de nenhuma forma ou utilizá-la para fins comerciais.

Conselho Editorial
Ciências Humanas e Sociais Aplicadas
Profª Drª Adriana Demite Stephani – Universidade Federal do Tocantins
Prof. Dr. Álvaro Augusto de Borba Barreto – Universidade Federal de Pelotas
Prof. Dr. Alexandre Jose Schumacher – Instituto Federal de Educação, Ciência e Tecnologia de Mato Grosso
Prof. Dr. Antonio Carlos Frasson – Universidade Tecnológica Federal do Paraná
Prof. Dr. Antonio Gasparetto Júnior – Instituto Federal do Sudeste de Minas Gerais
Prof. Dr. Antonio Isidro-Filho – Universidade de Brasília
Prof. Dr. Carlos Antonio de Souza Moraes – Universidade Federal Fluminense
Prof. Dr. Constantino Ribeiro de Oliveira Junior – Universidade Estadual de Ponta Grossa
Profª Drª Cristina Gaio – Universidade de Lisboa
Profª Drª Denise Rocha – Universidade Federal do Ceará
Prof. Dr. Deyvison de Lima Oliveira – Universidade Federal de Rondônia
Prof. Dr. Edvaldo Antunes de Farias – Universidade Estácio de Sá
Prof. Dr. Eloi Martins Senhora – Universidade Federal de Roraima
Prof. Dr. Fabiano Tadeu Grazioli – Universidade Regional Integrada do Alto Uruguai e das Missões
Prof. Dr. Gilmei Fleck – Universidade Estadual do Oeste do Paraná
Profª Drª Ivone Goulart Lopes – Istituto Internazionele delle Figlie de Maria Ausiliatrice
Prof. Dr. Julio Candido de Meirelles Junior – Universidade Federal Fluminense
Profª Drª Keyla Christina Almeida Portela – Instituto Federal de Educação, Ciência e Tecnologia de Mato Grosso
Profª Drª Lina Maria Gonçalves – Universidade Federal do Tocantins
Profª Drª Natiéli Piovesan – Instituto Federal do Rio Grande do Norte
Prof. Dr. Marcelo Pereira da Silva – Universidade Federal do Maranhão
Profª Drª Miranilde Oliveira Neves – Instituto de Educação, Ciência e Tecnologia do Pará
Profª Drª Paola Andressa Scortegagna – Universidade Estadual de Ponta Grossa
Profª Drª Rita de Cássia da Silva Oliveira – Universidade Estadual de Ponta Grossa
Profª Drª Sandra Regina Gardacho Pietrobon – Universidade Estadual do Centro-Oeste
Profª Drª Sheila Marta Carregosa Rocha – Universidade do Estado da Bahia
Prof. Dr. Rui Maia Diamantino – Universidade Salvador
Prof. Dr. Urandi João Rodrigues Junior – Universidade Federal do Oeste do Pará
Profª Drª Vanessa Bordin Viera – Universidade Federal de Campina Grande
Prof. Dr. William Cleber Domingues Silva – Universidade Federal Rural do Rio de Janeiro
Prof. Dr. Willian Douglas Guilherme – Universidade Federal do Tocantins

Ciências Agrárias e Multidisciplinar
Prof. Dr. Alexandre Igor Azevedo Pereira – Instituto Federal Goiano
Prof. Dr. Antonio Pasqualetto – Pontifícia Universidade Católica de Goiás
Profª Drª Daiane Garabeli Trojan – Universidade Norte do Paraná

Profª Drª Diocléa Almeida Seabra Silva – Universidade Federal Rural da Amazônia
Prof. Dr. Écio Souza Diniz – Universidade Federal de Viçosa
Prof. Dr. Fábio Steiner – Universidade Estadual de Mato Grosso do Sul
Prof. Dr. Fágner Cavalcante Patrocínio dos Santos – Universidade Federal do Ceará
Profª Drª Girlene Santos de Souza – Universidade Federal do Recôncavo da Bahia
Prof. Dr. Júlio César Ribeiro – Universidade Federal Rural do Rio de Janeiro
Profª Drª Lina Raquel Santos Araújo – Universidade Estadual do Ceará
Prof. Dr. Pedro Manuel Villa – Universidade Federal de Viçosa
Profª Drª Raissa Rachel Salustriano da Silva Matos – Universidade Federal do Maranhão
Prof. Dr. Ronilson Freitas de Souza – Universidade do Estado do Pará
Profª Drª Talita de Santos Matos – Universidade Federal Rural do Rio de Janeiro
Prof. Dr. Tiago da Silva Teófilo – Universidade Federal Rural do Semi-Árido
Prof. Dr. Valdemar Antonio Paffaro Junior – Universidade Federal de Alfenas

Ciências Biológicas e da Saúde
Prof. Dr. André Ribeiro da Silva – Universidade de Brasília
Profª Drª Anelise Levay Murari – Universidade Federal de Pelotas
Prof. Dr. Benedito Rodrigues da Silva Neto – Universidade Federal de Goiás
Prof. Dr. Edson da Silva – Universidade Federal dos Vales do Jequitinhonha e Mucuri
Profª Drª Eleuza Rodrigues Machado – Faculdade Anhanguera de Brasília
Profª Drª Elane Schwinden Prudêncio – Universidade Federal de Santa Catarina
Prof. Dr. Ferlando Lima Santos – Universidade Federal do Recôncavo da Bahia
Prof. Dr. Gianfábio Pimentel Franco – Universidade Federal de Santa Maria
Prof. Dr. Igor Luiz Vieira de Lima Santos – Universidade Federal de Campina Grande
Prof. Dr. José Max Barbosa de Oliveira Junior – Universidade Federal do Oeste do Pará
Profª Drª Magnólia de Araújo Campos – Universidade Federal de Campina Grande
Profª Drª Mylena Andréa Oliveira Torres – Universidade Ceuma
Profª Drª Natiéli Piovesan – Instituto Federacl do Rio Grande do Norte
Prof. Dr. Paulo Inada – Universidade Estadual de Maringá
Profª Drª Vanessa Lima Gonçalves – Universidade Estadual de Ponta Grossa
Profª Drª Vanessa Bordin Viera – Universidade Federal de Campina Grande

Ciências Exatas e da Terra e Engenharias
Prof. Dr. Adélio Alcino Sampaio Castro Machado – Universidade do Porto
Prof. Dr. Alexandre Leite dos Santos Silva – Universidade Federal do Piauí
Prof. Dr. Carlos Eduardo Sanches de Andrade – Universidade Federal de Goiás
Profª Drª Carmen Lúcia Voigt – Universidade Norte do Paraná
Prof. Dr. Eloi Rufato Junior – Universidade Tecnológica Federal do Paraná
Prof. Dr. Fabrício Menezes Ramos – Instituto Federal do Pará
Prof. Dr. Juliano Carlo Rufino de Freitas – Universidade Federal de Campina Grande
Prof. Dr. Marcelo Marques – Universidade Estadual de Maringá
Profª Drª Neiva Maria de Almeida – Universidade Federal da Paraíba
Profª Drª Natiéli Piovesan – Instituto Federal do Rio Grande do Norte
Prof. Dr. Takeshy Tachizawa – Faculdade de Campo Limpo Paulista

Conselho Técnico Científico
Prof. Msc. Abrãao Carvalho Nogueira – Universidade Federal do Espírito Santo
Prof. Msc. Adalberto Zorzo – Centro Estadual de Educação Tecnológica Paula Souza
Prof. Dr. Adaylson Wagner Sousa de Vasconcelos – Ordem dos Advogados do Brasil/Seccional Paraíba
Prof. Msc. André Flávio Gonçalves Silva – Universidade Federal do Maranhão
Profª Drª Andreza Lopes – Instituto de Pesquisa e Desenvolvimento Acadêmico
Profª Msc. Bianca Camargo Martins – UniCesumar
Prof. Msc. Carlos Antônio dos Santos – Universidade Federal Rural do Rio de Janeiro
Prof. Msc. Claúdia de Araújo Marques – Faculdade de Música do Espírito Santo
Prof. Msc. Daniel da Silva Miranda – Universidade Federal do Pará
Profª Msc. Dayane de Melo Barros – Universidade Federal de Pernambuco

Dados Internacionais de Catalogação na Publicação (CIP)
(eDOC BRASIL, Belo Horizonte/MG)

A642 A aplicação do conhecimento científico na engenharia elétrica [recurso eletrônico] / Organizadores João Dallamuta, Henrique Ajuz Holzmann. – Ponta Grossa, PR: Atena Editora, 2020.

Formato: PDF
Requisitos de sistema: Adobe Acrobat Reader
Modo de acesso: World Wide Web
Inclui bibliografia
ISBN 978-85-7247-932-5
DOI 10.22533/at.ed.325201701

1. Engenharia elétrica – Pesquisa – Brasil. I. Dallamuta, João. II.Holzmann, Henrique Ajuz.
CDD 623.3

Elaborado por Maurício Amormino Júnior – CRB6/2422

Atena Editora
Ponta Grossa – Paraná - Brasil
www.atenaeditora.com.br
contato@atenaeditora.com.br

Atena Editora
Ano 2020

APRESENTAÇÃO

A engenharia elétrica tornou-se uma profissão há cerca de 130 anos, com o início da distribuição de eletricidade em caráter comercial e com a difusão acelerada do telégrafo em escala global no final do século XIX.

Na primeira metade do século XX a difusão da telefonia e da radiodifusão além do crescimento vigoroso dos sistemas elétricos de produção, transmissão e distribuição de eletricidade, deu os contornos definitivos para a carreira de engenheiro eletricista que na segunda metade do século, com a difusão dos semicondutores e da computação gerou variações de ênfase de formação como engenheiros eletrônicos, de telecomunicações, de controle e automação ou de computação.

Produzir conhecimento em engenharia elétrica é portando pesquisar em uma gama enorme de áreas, subáreas e abordagens de uma engenharia que é onipresente em praticamente todos os campos da ciência e tecnologia.

Neste livro temos uma diversidade de temas, níveis de profundidade e abordagens de pesquisa, envolvendo aspectos técnicos e científicos. Aos autores e editores, agradecemos pela confiança e espírito de parceria.

João Dallamuta
Henrique Ajuz Holzmann

SUMÁRIO

SUMÁRIO

CAPÍTULO 19

WIRELESS CHARGER MANUFACTURING USING INDUCTIVE METHOD

Data de aceite: 03/01/2020

Maryam Liaqat
Department of Physics
University of Okara,
Pakistan
Sulman Joseph
Department of Physics
University of Agriculture,
Faisalabad, Pakistan
Shamsa Maqsood
Department of Physics
University of Agriculture,
Faisalabad, Pakistan
Ali Raza
Department of Physics
University of Agriculture,
Faisalabad, Pakistan
Sana Aslam
Department of Physics
University of Agriculture,
Faisalabad, Pakistan
Waseem Imtiaz
Department of Physics
University of Agriculture,
Faisalabad, Pakistan
Muhammad Furqan Shoukat
Department of Physics
University of Agriculture,
Faisalabad, Pakistan

ABSTRACT: Wireless devices are not new; data become wireless long time ago. Because life of mobile phone device is always been a problem for the manufactures and people complain about it. Therefore scientists are rapidly trying to fulfill the demand of the people to charge safe and wirelessly. On demand of mobile users due to less charging time of android/cell phones, there is at most desire of wireless gadget for charging. In the design of a circuit a transmitter and a receiver circuit is used. The transmitter circuit has AC to DC rectifier circuit and then it is modulated to pulse width modulator circuit. Primary and secondary coils are connected by mutual induction and an emf is induced in a secondary coil. AC to DC bridge rectifier is used to transmit voltages to the mobile phone. Microcontroller with timer circuit is used to avoid over charging. It works on Faraday's law of electromagnetic induction for significant reasons.

INTRODUCTION

Mobile communication has become a great need of today. We have to communicate to other people via mobile phones, tabs, PADs, and laptop computers. And we can take these devices with us to any place any time. But these small machines also consume power and have to be recharged again and again. So we have to put the charger in the socket and have to attach our mobile phone to the charger for recharging it and a lot of time is wasted in this procedure.

Moreover the wires and cables used to transmit electrical power could be damaged which is also a serious issue. From this discussion we can see that we are facing a lot of problems through the use of wires and cables, and a lot of time is wasted is this whole procedure.

By the use of wireless systems of power transmission we can have following benefits which are simply amazing and can save

- People from many hazards.
- Battery of our portable devices.
- A lot of time.
- Our devices from damages of overcharging.

Moreover we can

- Use our devices with comfort.
- Take our device to the place where electricity is not available.

From the above discussion we can see that there are a lot of benefits of wireless system and we can say that in reality wireless system is a smart system. Let us have a brief look upon the methods of transferring power wirelessly. Now we will see that from how many ways we can transfer power wirelessly. So some of the ways of transferring power wirelessly are as follow:

1. Radio charging.
2. Resonance charging.
3. Inductive charging.

1.1 Radio charging

Radio charging is the process of transferring power wirelessly in which radio waves are used to

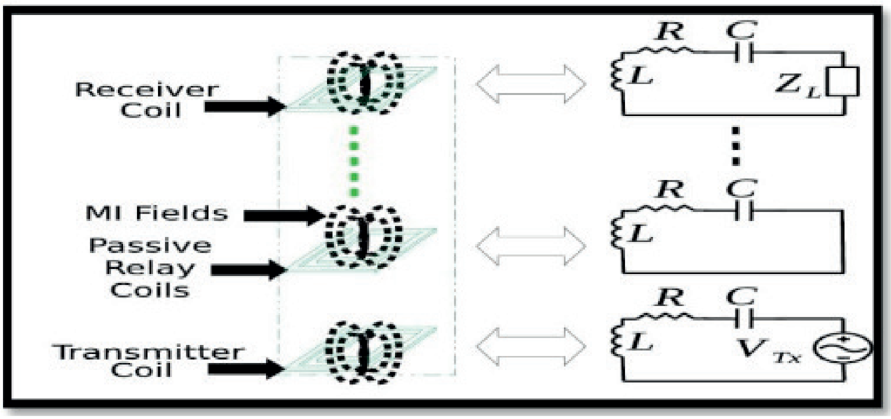


Figure 1: Transmitting coils

transfer power. Radio charging is a method used for transferring power and charging the devices which are small for example the battery of laptop computer requires enough power that radio charger cannot deliver. The range also limits the effectiveness of radio charging which works on the same principle as an AM/FM radio does. The reception will be better if receiver is closer to the transmitter. In this case of wireless radio charging better reception is translates to a stronger charge for the item.

1.2 Resonance charging

The devices such as robots, cars, laptop computers and vacuum cleaners etc., which requires large amount of power, can be charged wirelessly through resonance charging method. In this process of charging a copper coil is attached to the power source which is the sending unit and a other coil is attached to the device which have to be charge or recharge. The frequency for the coil must be same which makes it possible.

- A new method is developed in order to charge mobile phones by using micro waves.

1.3 Inductive Charging

Inductive charging is the process which is based upon **Faraday's Law** of electromagnetic induction and the process of mutual induction is used to transfer power from one place to another by wireless method. Now let us have a look that how energy is transferred from one place to another without any physical connection between two devices. What is the mechanism actually happening in this whole process?

Same question arises in the mind of Necolus Tesla and he started the research on this that could we transfer energy and after Wireless Power Technology is emerging as a practical solution for providing energy for devices at remote distances.

This paper will focus on the technology of inductively coupled wireless power transfer. This provides a safe, efficient, and convenient method of transferring power to remote static devices, or recharging portable devices. This revolves around the principle of Resonant Magnetic Coupling. Which can be applied to acquire maximum transfer of power contactless, thereby facilitating the individual to charge his electronic equipment efficiently.

WPT technology can provide charging systems with low maintenance costs, high reliability, and the ability to operate even in extreme environments. However, a wireless battery charging system requires more power stages than a wired battery charging system. The wireless battery charging system needs a WPT system that consists of a power transmitter and a power receiver. An exclusive controller is also required to regulate the output of WPT system since the power transferred to the receiver of WPT system is not regulated whenever the load changes. The inverter or converter in power electronics is usually controlled by three methods; pulse width modulation (PWM), frequency modulation (FM), and amplitude modulation. The AM method requires an additional stage for the DC-DC converter in order to control the amplitude of the input voltage. On the other hand, both PWM and FM need no additional stage since the inverter or converter uses power semiconductor switches for the power conversion.

For this reason, when PWM or FM is applied to the power transmitter of a WPT system, the power transferred to the receiver can be easily regulated. Nevertheless, high current stress and large power loss are generated since the voltage and current in the power transmitter are not in phase. Due to times, problem regulation circuits such as synchronous rectifiers or impedance tuners are necessary in the receiver of a WPT system. Furthermore, battery-charging circuits such as low-dropout (LDO) regulators or synchronous buck converters are required for the battery charging. Figure 1 shows a conventional wireless battery charging system. As mentioned above, the conventional system consists of the following five key power stages; AC-DC converter, power transmitter of WPT system, power receiver of WPT system, regulation circuit, and battery-charging circuit.

For the wireless battery charging system, the power receiver, regulation circuit, and battery charging circuit must be embedded inside portable electronic devices or electric vehicles, but there is usually not enough space for these power stages. In addition to this problem, the regulation and battery-charging circuits generate huge heat and raise the problem of thermal stress on the electronic devices while being charged. A direct wireless battery charging system is proposed. The regulation and battery charging proposed system is only made of AC-DC converter, power transmitter, and power receive. The type of the applied WPT system is a series-series compensated wireless power transfer (SS-WPT) system, and it is connected directly to the battery. Generally, the output of SS-WPT system has inherent characteristic as a current source. Hence, without the help of dedicated regulation and battery charging circuits, the battery can be charged directly from the WPT system by adjusting the output voltage of the existing AC-DC converter in front of the WPT system according to the constant-current constant-voltage (CC-CV) charging profile or a multi-step current charging profile.

The paper is organized the inherent current-source characteristics of the SS-WPT system are described. The implementation of the CC-CV charging or MCC charging profile in the proposed wireless battery charging system is explained. Experimental verification is presented in Section 4, and finally, Section 5 draws the conclusions.

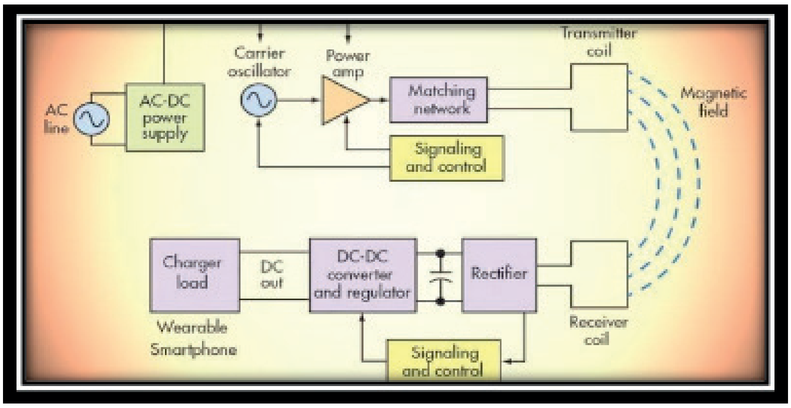


Figure 2: System Block Diagram

Wireless power transmission (WPT) is an efficient way for the transmission of electric power from one point to another through vacuum or atmosphere without the use of wire or any physical material. By using WPT, power can be transmitted using inductive coupling for short range, resonant induction for mid-range and Electromagnetic Wave power transfer. By using this technology, it is possible to supply power to places, which is hard to do using conventional wires. Currently, the use of inductive coupling is in development and research phases. The most common wireless power transfer technologies are the electromagnetic induction and the microwave power transfer. For efficient midrange power transfer, the wireless power transfer system must satisfy three conditions: (a) high efficiency, (b) large air gap, (c) high power. The microwave power transfer has a low efficiency. For near field power transfer this method may be inefficient, since it involves radiation of electromagnetic waves. Wireless power transfer can be done via electric field coupling, but electric field coupling provides an inductively loaded electrical dipole that is an open capacitor or dielectric disk. External objects may provide a relatively strong influence on electric field coupling. Magnetic field coupling may be preferred, since external objects in a magnetic field have the same magnetic properties as empty space. Electromagnetic induction method has short range. Since magnetic field coupling is a nonradioactive power transfer method, it has higher efficiency. However, power transfer range can be increased by applying magnetic coupling with resonance phenomenon applied on. A magnetic field is generated when electric charge moves through space or within an electrical conductor.

Solar energy is energy obtained from the Sun. Hence solar panels are used here to generate power and stored it in batteries. The stored energy is then used to charge mobile phone wirelessly as well as to supply energy for other home appliances. In order to avoid unnecessary use of energy, effective energy saving technique is used by using ARM7 LPC2148 microcontroller. To improve the easiness and efficiency of electrical appliances have been the main motivation throughout this paper. Since the power transmitter needs to be continuously informed about battery power needs and state of charge, a communication link is required. The communications channel is implemented through an amplitude modulation of the power drawn from the transmitter.

In the power transmitter section, an AC-DC stage converts the AC voltage provided by the electrical grid into a DC bus level. A DC-AC converter, supplied by the DC bus level, generates the AC power signal. In the power receiver section, a rectifier converts the AC power signal out of the resonant tank into a DC voltage level, suitable for battery charging. The DC bus rail out of the rectifier has been chosen equal to a 7V value. Information towards the power transmitter is generated through a power modulation of the coupling circuit resonant curve. The load modulation follows a differential bi-phase encoding scheme, as described in Qi-standard specifications. The amount of transmitted power is controlled by varying Figure 1 – General architecture of a wireless battery charger the frequency and duty-cycle of the half-bridge stage. A frequency range of 110k 205 kHz and a duty-cycle range of 10% 50% are fixed by the PC standard. Since for low power levels the total power dissipation is mainly affected by switching losses, the half-bridge configuration is more suitable than a full-bridge one. Conduction losses could be reasonably neglected for the specific application.

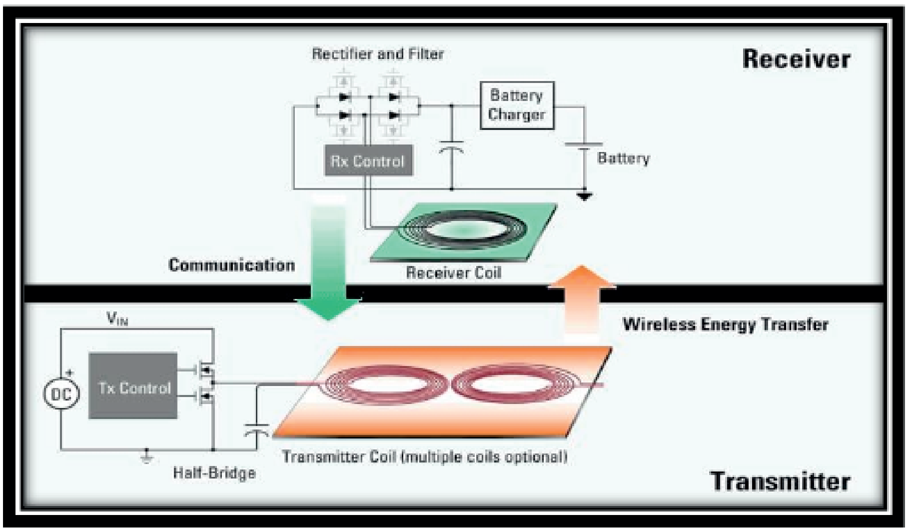


Figure 3: Transmission of Voltages

The modulation network consists of two parts: one is connected to the AC-side of the rectifier; the other is connected to the DC-side. The load device is modeled through a current generator. The system has been simulated in SPICE environment to evaluate system performances in terms of power conversion efficiency. Several simulation sessions have been carried out under different operating conditions.

Faraday's Law of Mutual Induction:-

Faraday's law of induction (briefly, Faraday's law) is a basic law of electromagnetism.

It is the fundamental operating principle of transformers, inductors, and many types of electrical motors, generators and solenoids. The Maxwell–Faraday equation (listed as one of Maxwell's equations) describes the fact that a spatially varying (and also possibly time varying, depending on how a magnetic field varies in time) electric field always accompanies a time-varying magnetic field, while Faraday's law states that there is EMF (electromotive force, defined as electromagnetic work done on a unit charge

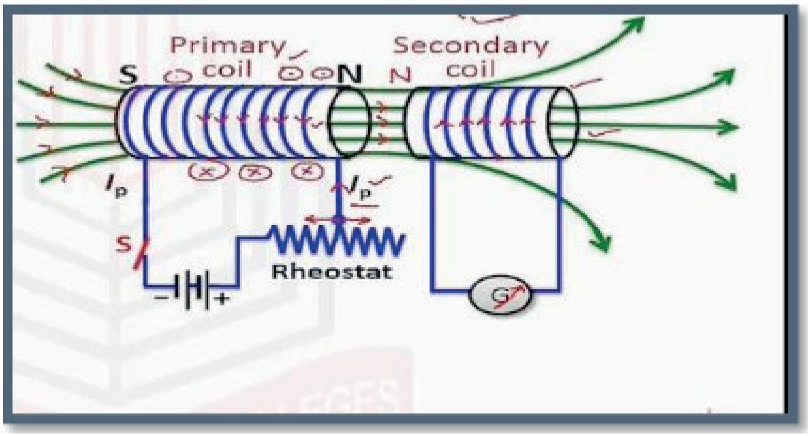


Figure 4: Mutual induction

when it has traveled one round of a conductive loop) on the conductive loop when the magnetic flux through the surface enclosed by the loop varies in time. Historically, Faraday's law had been discovered and one aspect of it (transformer EMF) was formulated as the Maxwell–Faraday equation later. Interestingly, the equation of Faraday's law can be derived by the Maxwell–Faraday equation (describing transformer EMF) and the Lorentz force (describing motional EMF). The integral form of the Maxwell–Faraday equation describes only the transformer EMF, while the equation of Faraday's law describes both the transformer EMF and the motional EMF. The changing magnetic flux of the left coil induces a current in the right coil. Faraday's disk is the first electric generator, a type of Homo polar generator.

Electromagnetic induction was discovered independently by Michael Faraday in 1831and Joseph Henry in 1832. Faraday was the first to publish the results of his experiments. In Faraday's first experimental demonstration of electromagnetic induction (August 29, 1831), the wrapped two wires around opposite sides of an iron ring (torus) (an arrangement similar to a modern transformer). Based on his assessment of recently discovered properties of electromagnets, he expected that when current started to flow in one wire, a sort of wave would travel through the ring and cause some electrical effect on the opposite side. He plugged one wire into a galvanometer, and watched it as he connected the other wire to a battery. Indeed, he saw a transient current (which he called a "wave of electricity") when he connected the wire to the battery, and another when he disconnected it. This induction was due to the change in magnetic flux that occurred when the battery was connected and disconnected. Within two months, Faraday had found several other manifestations of electromagnetic induction. For example, he saw transient currents when he quickly slid a bar magnet in and out of a coil of wires, and he generated a steady (DC) current by rotating a copper disk near the bar magnet with a sliding electrical lead ("Faraday's disk"). Michael Faraday explained electromagnetic induction using a concept he called lines of force.

However, scientists at the time widely rejected his theoretical ideas, mainly because they were not formulated mathematically. An exception was James Clerk Maxwell, who in 1861–62 used Faraday's ideas as the basis of his quantitative electromagnetic theory. In Maxwell's papers, the time-varying aspect of electromagnetic induction is expressed as a differential equation which Oliver Heaviside referred to as Faraday's law even though it is different from the original version of Faraday's law, and does noted scribe motional EMF. Heaviside's version (see Maxwell–Faraday equation below) is the form recognized today in the group of equations known as Maxwell's equations.

Lenz's law, formulated by Emil Lenz in1834,describes "flux through the circuit", and gives the direction of the induced EMF and current resulting from electromagnetic induction (elaborated upon in the examples below).

Faraday's experiment showing induction between coils of wire: The liquid battery (right) provides a current which flows through the small coil (A), creating a magnetic field. When the coils are stationary, n current is induced. But when the small coil is moved in

or out of the large coil (B), the magnetic flux through the large coil changes, inducing a current which is detected by the galvanometer (G).

Faraday's law

Qualitative statement: The most widespread version of Faraday's law states:

The closed path here is, in fact, conductive.

Quantitative: The electromotive force around a closed path is equal to the negative of the time rate of change of the magnetic flux enclosed by the path. The closed path here is conductive.

Quantitative: The definition of surface integral relies on splitting the surface Σ into small surface elements. Each element is associated with a vector dA of magnitude equal to the area of the element and with direction normal to the element and pointing "outward" (with respect to the orientation of the surface).For a loop of wire in a magnetic field, the magnetic flux ΦB is defined for any surface Σ whose boundary is the given loop. Since the wire loop may be moving. The definition of surface integral relies on splitting the surface Σ into small surface elements. Each element is associated with a vector dA of magnitude equal to the area of the element and with direction normal to the element and pointing "outward" (with respect to the orientation of the surface).We write Σ(t) for the surface. The magnetic flux is the surface integral:

$$\Phi\mathbf{B}=\iint_{\Sigma(t)} \boldsymbol{B}(t).\,\boldsymbol{dA}$$

Where dA is an element of surface area of the moving surface Σ (t), B is the magnetic field and B· dA is a vector dot product representing the element of flux through dA. In more visual terms, the magnetic flux through the wire loop is proportional to the number of magnetic flux lines that pass through the loop. When the flux changes—because B changes, or because the wire loop is moved or deformed, or both—Faraday's law of induction says that the wire loop acquires an EMF, E, defined as the energy available from a unit charge that has travelled once around the wire loop. (Note that different text books may give different definitions. The set of equations used throughout the text was chosen to be compatible with the special relativity theory.) Equivalently, it is the voltage that would be measured by cutting the wire to create an open circuit, and attaching a voltmeter to the leads. Faraday's law states that the EMF is also given by the rate of change of the magnetic flux:

$$\varepsilon = -\frac{d\Phi B}{dt}$$

Where is the electromotive force (EMF) and ΦB is the magnetic flux. The direction of the electromotive force is given by Lenz's law. The laws of induction of electric currents in mathematical form was established by Franz Ernst Neumann in 1845. Faraday's law contains the information about the relationships between both the magnitudes and the directions of its variables. However, the relationships between the directions are not explicit; they are hidden in the mathematical formula of **Left Hand Rule for Faraday's Law.**

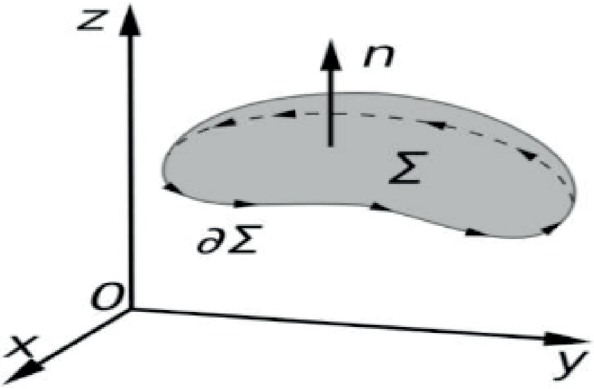
The sign of ΔΦB, the change in flux, is found based on the relationship between the magnetic field **B**, the area of the loop A, and the normal n to that area, as represented by the fingers of the left hand. It is possible to find out the direction of the electromotive force (EMF) directly from Faraday's law, without invoking Lenz's law. A left hand rule helps doing that, as follows. Align the curved fingers of the left hand with the loop (yellow line). Stretch your thumb. The stretched thumb indicates the direction of n (brown), the normal to the area enclosed *of t* by the loop. If ΔΦB is positive, the direction of the EMF is the same as that of the curved fingers (yellow arrowheads). If ΔΦB is negative, the direction of the EMF is against the arrowheads.

Find the sign of ΔΦB, the change in flux. Determine the initial and final fluxes (whose difference is ΔΦB) with respect to the normal n, as indicated by the stretched thumb. If the change in flux, ΔΦB, is positive, the curved fingers show the direction of the electromotive force (yellow arrow heads). If ΔΦB is negative, the direction of the electromotive force is opposite to the direction of the curved fingers (opposite to the yellow arrowheads). For a tightly wound coil of wire, composed of N identical turns, each with the same ΦB, Faraday's law of induction states that

$$\varepsilon = -N\frac{d\Phi B}{dt}$$

Where N is the number of turns of wire and ΦB is the magnetic flux through a single loop.

Maxwell–Faraday equation



The Maxwell–Faraday equation states that a time-varying magnetic field always accompanies a spatially varying (also possibly time-varying), non-conservative electric field, and vice versa. The Maxwell–Faraday equation is (in SI units) where ∇× is the curl operator

And again E(r, t) is the electric field and B(r, t) is the magnetic field. These fields surface Σ, its boundary ∂Σ, and orientation n set by the right-hand rule.

$$\nabla \times E = -\frac{\partial B}{\partial t}$$

Can generally be functions of position rand time *t.*

The Maxwell–Faraday equation is one of the four Maxwell’s equations, and therefore plays a fundamental role in the theory of classical electromagnetism. It can also be written in an integral form by the Kelvin–Stokes theorem, thereby reproducing Faraday’s law:

$$\oint_{\partial\Sigma} \boldsymbol{E} \,.\, \boldsymbol{dl} = -\int_{\Sigma} \frac{\partial \boldsymbol{B}}{\partial \boldsymbol{t}} \,.\, \boldsymbol{dA}$$

Where as indicated in the figure: Σ is a surface bounded by the closed contour ∂Σ, E is the electric field, B is the magnetic field. Dl is an infinitesimal vector element of the contour ∂Σ, Da is an infinitesimal vector element of surface Σ. If its direction is orthogonal to that surface patch, the magnitude is the area of an infinitesimal patch of surface. Both dl and dA have a sign ambiguity; to get the correct sign, the right-hand rule is used, as explained in the article Kelvin– Stokes theorem. For a planar surface

Σ, a positive path element dl of curve ∂Σ is defined by the right-hand rule as one that points with the fingers of the right hand when the thumb points in the direction of the normal n to the surface Σ. The integral around ∂Σ is called a path integral or line integral.

Notice that a nonzero path integral for E is different from the behavior of the electric field generated by charges. A charge generated E-field can be expressed as the gradient of a scalar field that is a solution to Poisson's equation, and has a zero path integral. See gradient theorem. The integral equation is true for any path ∂Σ through space, and any surface Σ for which that path is a boundary. If the surface Σ is not changing in time, the equation can be rewritten:

$$\oint_{\partial\Sigma} \boldsymbol{E} \, . \, \boldsymbol{dl} = - \int_{\Sigma} \frac{\partial \boldsymbol{B}}{\partial t} \, . \, \boldsymbol{dA}$$

The surface integral at the right-hand side is the explicit expression for the magnetic flux ΦB through Σ. The electric vector field induced by a changing magnetic flux, the solenoid component of the overall electric field, can be approximated in the non-relativistic limit by the following volume integral equation: The four Maxwell's equations (including the Maxwell–Faraday equation), along with Lorentz force law, are a sufficient foundation to derive *everything* in classical electromagnetism. Therefore, it is possible to "prove" Faraday's law starting with these equations.

Proof:

The starting point is the time-derivative of flux through an arbitrary surface Σ (that can move or be deformed) in space: (by definition). This total time derivative can be evaluated and simplified with the help of the Maxwell–Faraday equation and some vector identities; the details are in the box below: Consider the time-derivative of magnetic flux through a closed boundary (loop) that can move or be deformed. The integral can change over time for two reasons: The integrand can change, or the integration region can change. These add linearly, therefore: where t0 is any given fixed time. We will show that the first term on the right-hand side corresponds to transformer EMF, the second to motional EMF (from the magnetic Lorentz force on charge carriers due to the motion or deformation of the conducting loop in the magnetic field). The first term on the right-hand side can be rewritten using the integral form of the

Maxwell–Faraday equation: Next, we analyze the second term on the right-hand side:

The proof of this is a little more difficult than the first term; more details and alternate approaches for the proof can be found in the references. As the loop moves and/or the area swept out by a vector element dl of a loop ∂Σ in time dt when it has moved with velocity vl. deforms, it sweeps out a surface (see the right figure). As a small part of the loop dl moves with velocity vl over a short time dt, it sweeps out an area which vector is dA sweep = vl dt× dl (Note that this vector is toward out from the display in the right figure). Therefore, the change of the magnetic flux through the loop due to the deformation or movement of the loop over the time dt is Here, identities of triple scalar products are used. Therefore, where vl is the velocity of a part of the loop ∂Σ. Putting these together results in,

The result is: where ∂Σ is the boundary (loop) of the surface Σ, and vl is the velocity of a part of the boundary.

In the case of a conductive loop, EMF (Electromotive Force) is the electromagnetic work done on a unit charge when it has traveled around the loop once, and this work is done by the Lorentz force. Therefore, EMF is expressed as where is EMF and v is the unit charge velocity. In a macroscopic view, for charges on a segment of the loop, v consists of two components in average; one is the velocity of the charge along the segment vt, and the other is the velocity of the segment vl (the loop is deformed or moved). Vt does not contribute to the work done on the charge since the direction of VT is same to the direction of Mathematically, since is perpendicular to as and are along the same direction.

Now we can see that, for the conductive loop, EMF is same to the time-derivative of the magnetic flux through the loop except for the sign on it. Therefore, we now reach the equation of Faraday's law (for the conductive loop) as where. With breaking this integral, is for the transformer EMF (due to a time-varying magnetic field) and is for the motional EMF (due to the magnetic Lorentz force on charges by the motion or deformation of the loop in the magnetic field). It is tempting to generalize Faraday's law to state: If ∂Σ is any arbitrary closed loop in space whatsoever, then the total time derivative of magnetic flux through Σ equals the EMF around ∂Σ. This statement, however, is not always true and the reason is not just from the obvious reason that EMF is undefined in empty space when no conductor is present. As noted in the previous section, Faraday's law is not guaranteed to work unless the velocity of the abstract curve ∂Σ matches the actual velocity of the material conducting the EMF for non-thin-wire circuit's electricity. The two examples illustrated below show that one often obtains incorrect results when the motion of ∂Σ is divorced from the motion of the material.

Faraday's homo polar generator. The disc rotates with angular rate ω, sweeping the conducting radius circularly in the static magnetic field B (which direction is along the disk surface normal). The magnetic Lorentz force v × B drives a current along the conducting radius to the conducting rim, and from there the circuit completes through the lower brush and the axle supporting the disc. This device generates an EMF and a current, although the shape of the "circuit" is constant and thus the flux through the circuit does not change with time. A wire (solid red lines) connects to two touching metal plates (silver) to form a circuit. The whole system sits in a uniform magnetic field, normal to the page. If the abstract path ∂Σ follows the primary path of current flow (marked in red), then the magnetic flux through this path changes dramatically as the plates are rotated, yet the EMF is almost zero. After Feynman one can analyze like these by taking care that the path ∂Σ moves with the same velocity as the material.

Alternatively, one can always correctly calculate the EMF by combining Lorentz force law with the Maxwell–Faraday equation where it is very important to notice that (1) [vm] is the velocity of the conductor ... not the velocity of the path element dl and (2) in general, the partial derivative with respect to time cannot be moved outside, the integral since the area is a function of time".

Two phenomena:

Faraday's law is a single equation describing two different phenomena: the *motional* EMF generated by a magnetic force on a moving wire (see the Lorentz force), and the *transformer* EMF generated by an electric force due to a changing magnetic field (described by the Maxwell– Faraday equation). Faraday's law and relativity James Clerk Maxwell drew attention to this fact in his 1861 paper *On Physical Lines of Force*. In the latter half of Part II of that paper, Maxwell gives a separate physical explanation for each of the two phenomena.

A reference to these two aspects of electromagnetic induction is made in some modern textbooks. As Richard Feynman states: So the "flux rule" that the emf in circuit is equal to the rate of change of the magnetic flux through the circuit applies whether the flux changes because the field changes or because the circuit moves (or both) ... Yet in our explanation of the rule we have used two completely distinct laws for the two cases – v × B for "circuit moves" and $\nabla\times E = -\partial t\, B$ for "field changes".

Wireless Battery Charger Circuit Advantages:

Usage of separate charger is eliminated. Phone can be charged anywhere and anytime. It does not require wire for charging. Easier then plug into power cable.

Wireless Power Transfer Circuit Application:

Wireless charger scan be used to charge mobile, camera batteries, Bluetooth, headsets etc. This can be used in applications like car battery charger with little modification. This can also be used in medical devices.

Limitations of the Circuit:

Power is somewhat wasted due to mutual induction. It will work for very short distances only. If we want to use it for long distances, then the number of inductor turns should be high.

Methodology:

Inductive method for charging portable devices wirelessly is based upon Faraday's Law of mutual induction. The main principle upon which the design of our circuit is based have been

discussed in detail. The circuit diagram of our wireless battery charger is as follow.

Wireless mobile charger circuit design:-

Wireless battery charger circuit design is very simple and easy the circuit required only resisters, diodes, capacitors, copper coils, transformer and voltage regulator. In our wireless battery charger we use two circuits. The first circuit is transmitter circuit which is used to produce voltage wirelessly. The transmitter circuit consists of DC source, oscillator circuit and a transmitter coil. Oscillator circuit consist of two N-Channel

MOSFETS IRF 540, 4148 diodes. When the DC power is given to the oscillator, current starts flowing through the two coils L1, L2 and drain terminal of the transistor. At the same time some voltage is appeared at the gate terminals of the transistors. One of the transistors is in on state while other is off state. Thus

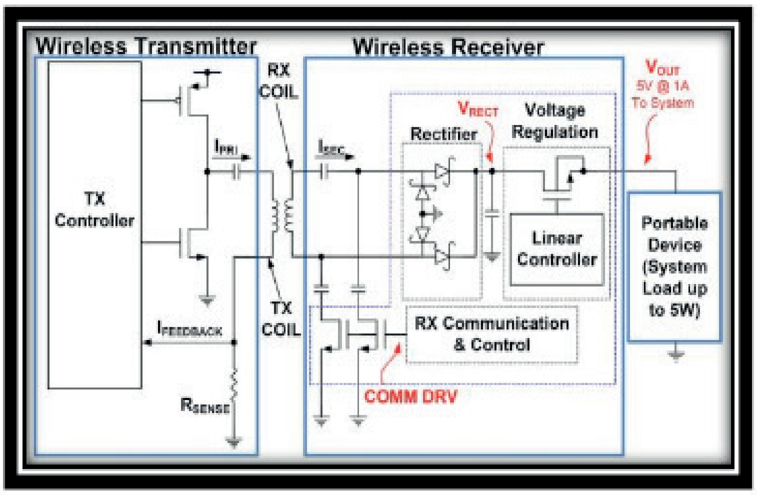


Figure 5: Wireless mobile circuit diagram

voltage at Drain of transistor which is in off state rises and it fall through the tank circuit made of 6.8 nf capacitors and transmitter coil of 0.674. Thus operating frequency is determined by using formula:

$$F=1/[2\pi(LC)]$$

In the second circuit that is receiver circuit consist of receiver coil, rectifier circuit and regulator. When the receiver coil is placed at distance near the inductor AC power is induced in the coil. This is rectified by the rectifier circuit and is regulated to DC 5 volt using 7805 regulator. The rectifier circuit consists of 1n4007 diode and capacitor 6.8nf. The output of regulator is connected to the battery.

How to operate this Wireless Power Transfer Circuit?

Initially, connect the circuit as shown in the circuit diagram and switch on the supply. Connect the battery charger at the output of the circuit. Place the receiver coil near the transmitter coil. You can observe the charging of battery.

CONCLUSIONS

We discussed different wireless power transfer techniques and briefly overviewed inductive method of power transfer as it is best way to deliver power wirelessly to our portable devices. Wireless battery charging has many advantages in term of convenience because users simply need to place the device requiring power onto a mat or other surface to allow wireless charging to take place. We believe that our contribution in this work is successfully benefit society in terms of convenience, reduce wear of plugs and sockets, and application in medical environments. Reduced efficiency is one of the key challenges in wireless battery charging system due to resistive loses on the coil, stray coupling etc. Therefore inductive method was chosen to fulfill the requirements of the consumers because it is suitable for charging devices in both power and range level. The basic principle of this technology is explained, the last development and research are summarized, with an especial emphasis on inductive charging technology technical challenge and future development trends are also introduced.

It is concluded that power loss and efficiency are major problems for this design we noticed the potential problem whether the converted DC power will be significant enough to charge up the battery. Therefore the characteristics of the diodes should be mounted directly onto the antenna for a minimum power dissipation.

As the wireless technology is getting popular now a days the demand of battery is also increasing. The battery needs to recharged or changed eventually. Therefore I am inspired to design the wireless battery charger the wireless battery charger will eliminate all the hassle with the battery. As for now there are no known companies which develop the wireless battery charger. This means that the opportunity is very big. Also, people tend to spend more money for convenience. It gives more reason that this device will have a very good market.

REFERENCES

Poul,J.L., S.Sasirekha, D, N, Kumar D and P.S. Revanth. 2018. "A Working Model for Mobile charging using Wireless power Transmission". Science Pubto, 7(3.12): 584-588.

Singla,N. 2014." Wireless Charging of Mobile Phone Using Microwave or Radio Frequency Signals". Ijarcst, 1(2): 2347-2350.

Shahnawaz, S., A. Waheed and S. M. Bhat. 2017. "Wireless Charging of Mobile Phones Using Microwaves". Ijesmc, 6(6): 384-389.

Gupta, A., A.Tandon, A.Jeriya, N.Tanwar, R.Kumar and D.Kumar. 2016. "Automatic Wireless Mobile Charger". Research Publish, 1(4): 113-119.

Sharma, H. 2016. "Study & Survey on Wireless Charging and Technology". Ijerst, 10(12: 5281-5286.

Ansari, T. R., A. Khan and I. Ansari. 2015. "Wireless Charging of Mobile Battery via Optimization of RF Energy Harvesting System". Research Gate, 10: 14299-14307.

Lu, X. and P. Wang. 2014. "Wireless Charger Networking for Mobile Devices". Research Gate, 10: 1109-21125.

Qiu C., T. Chau, L.Chunhua and C.C. Chan. 2013. "Overview of Wireless Power for Electrical Vehicle Charging". Research Gate, 10: 1109-1118.

BR, P. 2018. "Wireless Charging of Implantable Pacemaker's Battery". Journal of Biosensors & Bioelectronics, 10(9):4172-4174.

Wang, Z. and X. Wei. 2015. "Design Considerations for Wireless Charging Systems with an Analysis of

Batteries”. Mdpi, 10: 3390-3410.

Fitra, M. and E. S. 2017. “Wireless Power for Mobile Battery Charger”. Indonesian Journal of Electrical Engineering and Computer Science, 10(6): 11591-11598.

Sadiku, M. N. O. (2007). “Elements of Electromagnetics”. (4th ed.). New York & Oxford: Oxford University Press. p. 386. ISBN 0-19-530048-3

KR, P.,R.Nerya and V.Kumar M. 2017. “Wireless Charging System for Electrical Vehicles”. Research Gate, 10: 4273-4278.

Al-Jaber, S. 2011. “Path Integral Approach to Faraday’s of Induction”. Research Gate, 10: 4233-4238.

Das, S. 2017. “Review paper on Wireless Power Transmission for Charging mobile devices”. Research Gate , 10: 18535-18541.

Thakkar, V. 2015 . “Faraday’s law in Moving Media”. Research Gate, 10: 13252-13263

Vaka, R. and R.K.Keshri. 2017. “Review on contact less Power Transfer for Electrical Vehicle Charging”. Mdpi, 10: 636-656.

Mahangade, S. and S. Mahangade. 2017. “ Electrical Vehicle Wireless charging”. Ijariit, 3:2454-2460

Giancoli, D. C. (1998). Physics: Principles with Applications (5th ed.). pp. 623–624.

Ulaby, F. (2007). “Fundamentals of applied electromagnetics”. (5th ed.). Pearson: Prentice Hall. p. 255. ISBN 0-13- 241326-4.

Maxwell, C . J (1904). “A Treatise on Electricity and Magnetism”. 2 (3rd ed.). Oxford University Press. pp. 178–179, 189.

Lenz, Emil (1834). “Ueber die Bestimmung der Rich Tung der durch elektodynamische Vertheilung erregten galvanischen Ströme” . Annalen der Physics and Chemie. 107 (31): 483–494.

Giuliani, G. 2000. “On Electromengnetic Induction”. Research Gate, 10: 1038-1056.

Vashi, I. Y. D. 2017. “Wireless Mobile Phones Charging-A Comprehensive Study”. International journal of Electromagnetics and Applications, 10: 5923-5930.

Jordan, Edward; Balmain, Keith G. (1968). “Faraday’s Law, which states that the electromotive force around a closed path is equal to the negative of the time rate of change of magnetic flux enclosed by the path”. Research Gate, 10: 5134-5138.

Hayt, William. (1989). “The magnetic flux is that flux which passes through any and every surface whose perimeter is the closed path”. Engineering Electromagnetics (5th ed.). McGraw-Hill. p. 312. ISBN 0-07-027406-1.

Feynman, R. P.,R. B. Leighton and M. L. Sands. 2006. . “The flux rule” is the terminology that Feynman uses to refer to the law relating magnetic flux to EMF”. Research Gate, 17(2):8053-8070.

Griffiths, David J. (1999). “Introduction to Electrodynamics”. (3rd ed.). Research Gate ,pp. 301–303. ISBN 0-13-805326-X.

Neumann and F.Ernst. 1846.”Allgemeine Gesetze der inducirten elektrischen Strome”. Bibcode:1846AnP...143...31N . doi:10.1002/andp.18461430103.

Yehuda S. 2014. “A Left Hand Rule for Faraday’s Law”. The Physics Teacher. 52: 48. Bibcode:2014PhTea..52...48S . doi:10.1119/1.4849156 .

ÍNDICE REMISSIVO