All About Transferring Power Wirelessly

Battery technology can be said to be at its peak now. So it is high time that alternative sources of charging came into play. This article focuses on wireless power transfer technology and the opportunities provided by it

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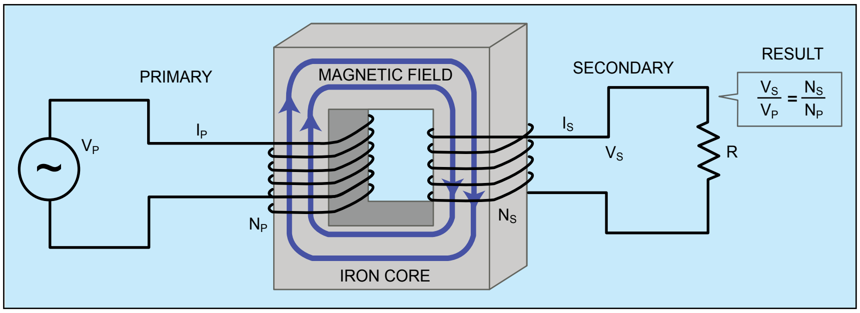

Fig. 1: Coupling

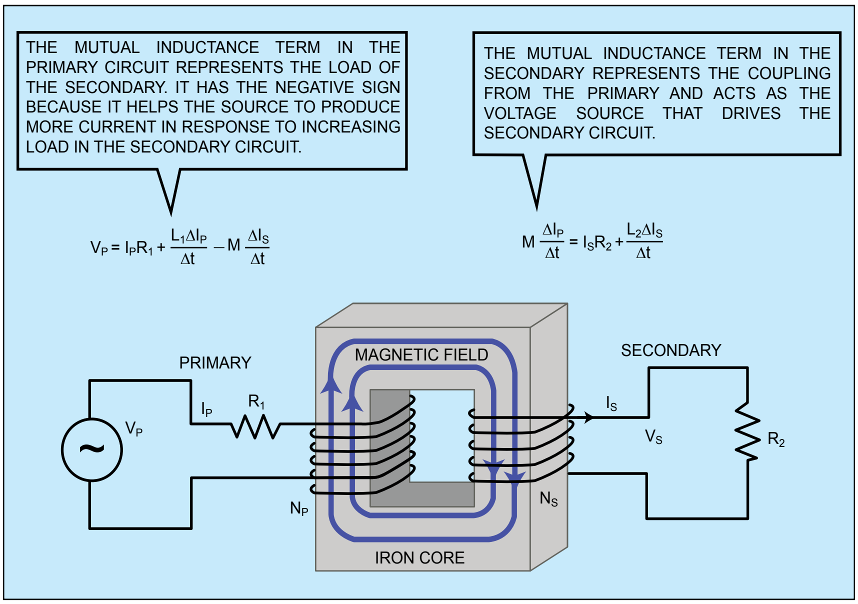

Fig. 2: Mutual inductance

One of the biggest challenges before consumer electronics makers today is to increase the battery life of their devices on a single charge. As more powerful processors, larger memory and extra sensors are added to devices for improved performance, these consume far more power than their predecessors. Improving battery technology is one way to counter this problem, but advances in battery technology seem to have peaked now.

The only option left is to look at alternative sources of charging a device without causing inconvenience to the user. Wired chargers are a hassle for most users, and that's where the novel idea of utilising wireless charging came up.

What's wireless power transfer?

Simply put, wireless power transmission refers to a power source that supplies a system with energy without the hassle of interconnecting wires. Wireless power transmission problems differ from those of wireless telecommunications, such as radio. While in wireless power efficiency is considered to be the more significant parameter, in wireless tecommunications the proportion of energy received becomes critical only if it is too low for the signal to be distinguished from the background noise.

There are more than a couple of technologies that enable wireless power transfer, each having its own merits and demerits.

Coupling. It is defined as the transfer of electrical energy from one part of the circuit to another. For example, energy can be transferred from a power source to an electrical load by means of conductive coupling, which may be either hard-wire or resistive. Also, AC potential may be transferred from one segment to another (having a DC potential) using a capacitor.

Mutual inductance. It is defined as the phenomenon by which a change of current in a coil induces an emf in another coil placed near the first coil. The primary coil is the one in which current changes, while the coil in which emf is induced is called the secondary coil.

Capacitance. Capacitance is the ability of a body to store an electrical charge. Any object that can be electrically charged exhibits capacitance. A common form of energy storage device is parallel-plate capacitor. In a parallel-plate capacitor, capacitance is directly proportional to the surface area of the conductor plates and inversely pro-

Advantages

1. Much lower risk of electrical shock or shorting out due to moisture as there are no exposed conductors
2. Protected, corrosion-free connections as all the electronics is enclosed, away from water or oxygen in the atmosphere
3. Safer for medical implants—recharging/powering through the skin rather wires penetrating the skin lowers the risk of infection
4. Convenience—the device can be placed on or close to a charge plate or stand rather than having to connect a power cable to it

Disadvantages

Lower efficiency, increased heat. Two main deterrents of inductive charging are its lower efficiency and increased resistive heating in comparison to the direct contact method. Implementation methods that use lower frequencies or older drive technologies charge much more slowly and generate more heat within most portable electronics, which is a big drawback.

Costly. Inductive charging requires drive electronics and coils in both the device and the charger, thus increasing the complexity and cost of manufacturing.

Slower charging. Due to the much lower efficiency, devices take longer to charge when the supplied power is equal.

Inconvenience. When a mobile device is connected to a cable for charging, it can still be freely moved around and operated. In most implementations of inductive charging (including the popular Qi standard), the mobile device must be left on the charging pad, which limits mobility.

portional to the separation distance between the plates (wireless power transfer through capacitive coupling explained later).

Laser. Laser is a device that emits light (electromagnetic radiation) through a process of optical amplification based on stimulated emission of photons. The term 'laser' is an acronym for 'Light Amplification by Stimulated Emission of Radiation.' The emitted laser light is notable for its high degree of spatial and temporal coherence.

Types of wireless electrical energy transfer

The aforementioned technologies work on different methods of electrical energy transfer without using a wired connection:

Electromagnetic induction. When magnetic flux flowing through a coil changes, an electromotive force (emf) is induced in the coil along with current. The famous Faraday's law (which relates to the induced emf in any closed loop including a closed circuit) is the central principle behind electromagnetic induction. Induction can be also be used as a means of wireless power transfer.

A changing current in one coil induces emf in another coil. The coils are not in contact and in this way energy can be very simply transported over short distances. The largest drawback of this method is that the short distance required for induction limits its application to very close-range situations.

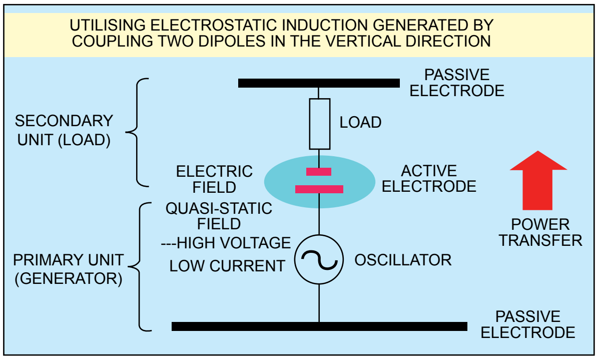

Fig. 3: Capacitive diagram

Electromagnetic radiation (microwave). Rectenna is the key component of wireless power transfer by radio waves. It is a combination of a rectifying circuit and an antenna. The antenna receives the electromagnetic power, which is converted into DC electric power by the rectifying circuit.

A simple rectenna can be constructed from a Schottky diode placed between the antenna dipoles. Schottky diodes are used because these have the lowest voltage drop and highest speed and therefore waste the least amount of power due to conduction and switching.

Since portable devices have small dimensions, the rectenna too should be small in size. A small antenna area results in a low amount of received power, which is a huge drawback. Because of these limitations, wireless power transfer using radio waves is mainly suitable for low-power applications like low-power wireless sensors.

Wave coupling. WiTricity (evanescent wave coupling) is a technique that has recently been investigated by MIT researchers.

It basically extends the principle of magnetic induction to mid-range applications up to a few metres. The main differentiator is the use of resonance. If the sender and the receiver have the same magnetic resonant frequency, energy can be efficiently transported while losses to the non-resonant environment are extremely small in comparison. Using resonance, for the same geometry, power can be transported approximately a hundred times more efficiently than without resonance.

One of the benefits of WiTricity is that since most common materials don't interact with magnetic fields, obstructing objects do not have much influence on the passage of WiTricity. The same goes for human tissue as well and hence health risks are low. The coils used for WiTricity are too large to be used in a cell phone, but the receiving coil can be reduced in size. According to the researchers at MIT, the transmitted power can be kept constant if the size of the sending coil is increased to keep the product of the sizes of both coils equal.

Electrostatic induction (capacitive coupling). In capacitive interface, the field is confined between conductive plates, alleviating the need for magnetic flux guiding and shielding components that add bulk and cost to inductive solutions. The realisable amount of coupling capacitance is limited by the available area of the device, imposing a design constraint on contactless power delivery.

Parallel-plate capacitance across a 1/4mm air gap is only 3.5 pF/cm^2, limiting typical interface capacitance to a few tens of picofarads. The required charging power is upwards of 2.5W (USB-specification). Existing capacitive power transfer (CPT) solutions either use much larger capacitors or are targeted at lower-power applications, such as coupling of power and data between integrated circuits, or transmission of power and data to biosignal instrumentation systems.

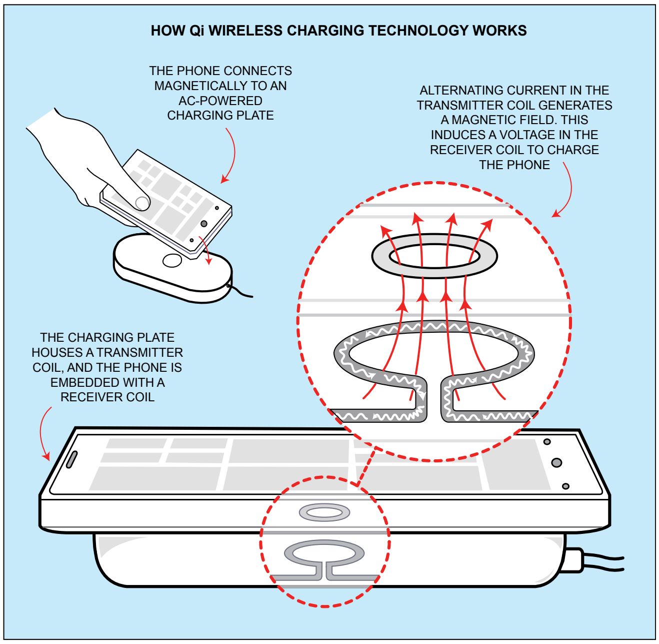

Fig. 4: Qi standard

Murata's capacitive-coupling wireless power transmission modules have two sets of asymmetric dipoles consisting of active and passive electrodes positioned vertically on the power transmitting and receiving sides. Power is transmitted utilising an induction field generated by coupling of the two sets of asymmetric dipoles. This configuration realises wireless power transmission with high position freedom and efficiency.

Applications

Wireless charging of consumer electronics. Automatic wireless charging of mobile electronics (laptops, phones, game controllers, etc) in homes, cars, offices and Wi-Fi hotspots is possible. Direct wireless powering of stationary devices is also facilitated, thus eliminating custom wiring, wall-wart power supplies and unsightly cables.

Wireless charging is done using an electromagnetic field to transfer energy between two objects via a charging station. Energy is sent through inductive coupling to an electrical device, which then uses that energy to charge batteries or run the device.

Wireless chargers typically use an induction coil to create an alternating electromagnetic field from within a charging base station. Another induction coil in the portable device takes power from the electromagnetic field and converts it back into electrical current to charge the battery.

Wirelessly charging of electrical vehicles. Researchers at Korea Advanced Institute of Science and Technology (KAIST) have developed an electric transport system, named the Online Electric Vehicle, OLEV, in which the vehicles get their power from cables underneath the surface of the road via non-contact magnetic charging. The power source is placed underneath the road surface and power is wirelessly picked up by the vehicle itself. Once logistics is worked out for this idea, the day isn't far off when charging vehicles without having to stop will become a reality.

The Qi standard

Qi (pronounced 'chee') is an interface standard developed by the Wireless Power Consortium for wireless electrical power transfer over distances of up to 40 millimetres (1.6 inches). The Qi system comprises a power transmission pad and a compatible receiver in a portable device. The mobile device is placed on top of the power transmission pad, which charges the device via magnetic induction.

Mobile device manufacturers that are complying to the standard include HTC, LG Electronics, Huawei, Motorola Mobility, Samsung, Nokia and Sony. They aim to create a global standard for wireless charging technology.

All in all

In this era of communications and connectivity, individuals have multiple technologies to support their day-to-day requirements. In this scenario of multiple gadgets, wireless power technology is emerging as a practical solution for portable devices. The predominant market for wireless power transfer is unarguably the consumer handheld market. Mobile equipment giants like Nokia, LG, Samsung, HTC and Mototrola have already become WPC Qi-compliant and offer compatible phones.

Pavan Pudipeddi, senior strategic marketing manager, Wireless Power and Battery Charge Management, Texas Instruments (TI), says, "At TI, we recognise the huge market available in the wireless energy domain. TI's goal is to become the premier supplier of wireless power solutions in the industry. Our receiver chips integrate a low-impedance, fully synchronous rectifier along with a low-dropout regulator, digital control, and accurate voltage and current loops. Recently, TI's bq51050B became the industry's first Wireless Power Consortium (WPC) 1.1 Qi-compliant wireless power receiver with integrated direct battery charger. It enables a faster, more efficient way of charging smartphones, wireless keyboards and other portable electronics." ●

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