# Conceptual Design of a Universal Wireless Battery Charger based on “Induced EMF” in a Standard TRS connector

Mr. Vijay A. Kanade

**Abstract**—Wireless charging is a technique of transmitting power through the air to an electrical device for the purpose of restoring energy. Recently, the wireless charging technology has been significantly advanced in terms of efficiency and functionality. The paper presents an application of a wireless charger which clearly shows the benefit in terms of reduced costs for users to identify the best chargers to replenish energy for their mobile devices. The concept addresed in the paper relates to the universal wireless battery charger for portable electronic equipments and gadgets such as mobile phones, audio devices, etc. The Wireless Battery Charger using Standard TRS Connectors based on “Induced EMF” aims at providing unique charging facility to all the portable electronic devices of different brands manufactured around the world. The new concept forms the basis of a new generation of wireless universal charging platform for a wide range of electronic gadgets and equipments.

**Index Terms**—Wireless Universal battery charger, Magnetic Field Sensor, Induced Current, Induced emf.

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## 1 Introduction

Wireless charging technology enables wireless transfer of energy from a power source (e.g., a charger) to a receiving junction (e.g., a mobile device) across an air gap between the two entities. The technology provides convenience, feasibility and better user experience. Using wireless charging has many benefits. Firstly, it improves user-friendliness as the hassle from wiring of connecting cables is removed. Different brands, companies and different models of devices can use the same charger. Secondly, it enhances flexibility of charging ‘n’ no. of devices simultaneously thus improving the scalability of the charger. Thirdly, wireless charging can provide on-demand power, avoiding an overcharging problem and minimizing energy costs. In 2014, many leading smartphone manufacturers, e.g., Samsung, Apple and Huawei, have released their products equipped with built-in wireless charging capability [6]. The approach presented here utilizes the benefit of TRS connectors which perform the dual functionality of transmitting audio signals and charging the electronic device with ease.

## 2. Background

The mobile phone market is a vast industry growing at a brisk rate, and has spread into rural and urban areas as essential means of communication. The problem faced by every mobile user or users of other electronic equipments today is that of a charger. Though universal chargers have been defined, yet they fail to replace the chargers of individual mobile phones, brands, gadgets, etc as each device has its charger designed in a specific manner. The idea specified here is based upon the wireless charging through the TRS connectors. Consider any mobile brand, electronic quipment manufacturing company like Blackberry, Apple, Nokia, Samsung, Sony, etc supplying electronic appliances in India. If we observe these electronic gadgets we may conclude from their makeup that all these devices utilize two standards of TRS connectors, 2.5mm wide and 3.5mm wide for their audio operation. Thus by using this facility of TRS connector one can not only listen to audio signals, but the devices can be evenly charged with the help of the slot of the TRS connector.

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## 3. CONCEPT

When a coil of wire is placed in a changing magnetic field, a current is induced in a wire. This current flows because something is producing an electric field that forces the charges around the wire. (It cannot be the magnetic force since the charges are not initially moving). This "something" is called an **electromotive force**, or **emf**, even though it is not a force. Instead, emf is like the voltage provided by a battery. A changing magnetic field through a coil of wire therefore must *induce* an emf in the coil which in turn causes current to flow.

Briefly stated, Faraday's law says that a changing magnetic field produces an electric field. If charges are free to move, the electric field will cause an emf and a current. For example, if a loop of wire is placed in a magnetic field so that the field passes through the loop, a change in the magnetic field will induce a current in the loop of wire. A current is also induced if the area of the loop changes, or if the area enclosing magnetic field changes. So it is the change in **magnetic flux**, defined as

$$\boldsymbol{\Phi} = \int B.dA = BA \cos \boldsymbol{\theta}$$

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that determines an induced current. **A** is the area vector; its magnitude is the area of the loop, and its direction is perpendicular to the area of the loop, and $\theta$ is the angle between **A** and the magnetic field **B**. The last equality (removing the integral) is valid only if the field is uniform over the entire loop.

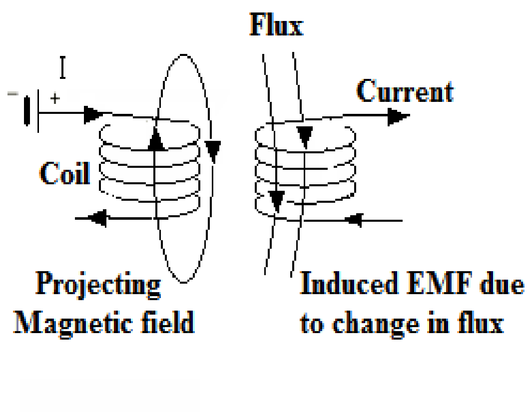


FIG 1: INDUCED EMF IN A COIL DUE TO CHANGE IN MAGNETIC FLUX

### DESCRIPTION:

Current is produced in a conductor when it is moved through a magnetic field because the magnetic lines of force are applying a force on the free electrons in the conductor and causing them to move. This process of generating current in a conductor by placing the conductor in a changing magnetic field is called **induction**. This is called induction because there is no physical connection between the conductor and the magnet. The current is said to be induced in the conductor by the magnetic field.

One requirement for this electromagnetic induction to take place is that the conductor, which is often a piece of wire, must be perpendicular to the magnetic lines of force in order to produce maximum force on the free electrons. The direction that the induced current flows is determined by the direction of the lines of force and by the direction of the wire moving in the magnetic field.

If an AC current is fed through a piece of wire, the electromagnetic field that is produced is constantly growing and shrinking due to the constantly changing current in the wire. This growing and shrinking magnetic field can induce electrical current in another wire that is held close to the first wire. The current in the second wire will also be AC and in fact will look very similar to the current flowing in the first wire.

## 4 TECHNICAL DETAILS

The body of the charger consists of **3 parts**:

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### 4.1 THE CHARGING CIRCUIT:

The electronic circuit is plugged in a socket during the charging process. It consists of an electric circuit used in the conventional charger. The circuit possesses a “coil” that allows a current ‘I’ to flow through the coil and generate a magnetic field with respect to the strength of flowing current. The coil generates a changing magnetic field with the constant flow of current.

### 4.2 TRS CONNECTOR

The TRS connector is provided with another coil along with the magnetic field sensors. When the TRS connector is brought in the vicinity of the charger, magnetic field is induced in the coil of the connector in response to the changing magnetic filed in the first coil (i.e. of the charger). The connector completes the circuit within the cell and synchronizes the cell phone components for performing the task of powering the electronic device. The connector is provided with a magnetic field sensor for regulating and controlling the induced magnetic field within the TRS connector. The magnetic field sensor captures the change in the magnetic field produced in the coil of a plug-in charging component and assist in regulating and optimizing the strength of induced magnetic field (i.e. in the TRS connector) for charging the cell phone, etc.

### 4.3 MAGNETIC FIELD SENSOR

The TRS connector is provided with a magnetic field sensor e.g. searchcoil magnetometer. The basic searchcoil magnetometer is based on Faraday’s law of induction—which states that the voltage induced in a coil is proportional to the changing magnetic field in the coil. This induced voltage creates a current that is proportional to the rate of change of the field. The sensitivity of the search-coil is dependent on the permeability of the core, and the area and number of turns of the coil. In order for the search-coil to work, the coil must either be in a varying magnetic field or moving through a magnetic field. This allows the search-coil to detect a static or changing magnetic field [3].

## 5 METHODOLOGY

The methodology for implementation of a wireless charger involves manipulation of the charging circuit by embedding a coil withing the charger. The process also involves adding a coil in a TRS connector for inducing magnetic field in the coil to produce a current for charging the electronic device.

### 5.1 BLOCK DIAGRAM

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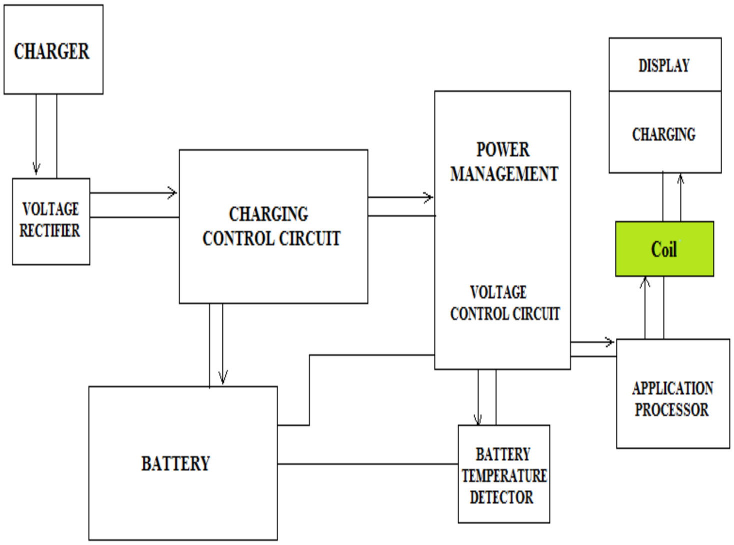


FIG 2: BLOCK DIAGRAM OF THE CHARGING CIRCUIT [5]

#### DESCRIPTION

The plug-in charger will have the conventional circuitry for charging the device [5]. The charger will send the electric signals to the voltage rectifier (i.e. AC to DC current). This rectifier will then forward the signals to a charging control circuit for regulating the DC durrent at an optimum level. The control circuit will send the signals for the voltage regulation, also referred as power management. The voltage control circuit will then forward the signals to the application processor for delivering power to a receiving device. The application processor further sends these generated signals to the coil inserted within the charger. The electrons within the coil are set into motion due to the force transmitted by the application processor and thus current starts flowing within the coil.

### 5.2 TRS CONNECTOR

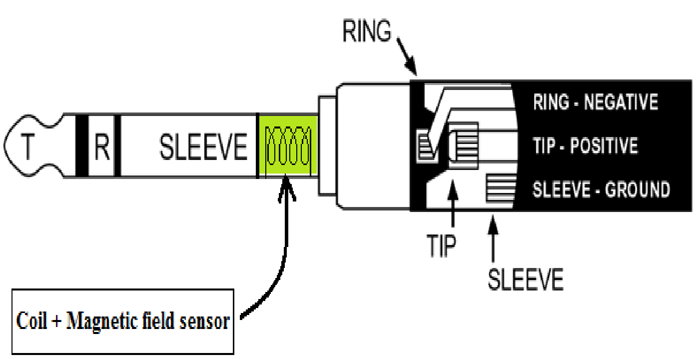


FIG 3: BLOCK DIAGRAM OF A TRS CONNECTOR WITH A "MAGNETIC FIELD SENSOR" COMPONENT [7]

#### DESCRIPTION

The TRS connector is provided with a coil and a magnetic sensor for regulating the induced magnetic field and current.

Thus initially, the charging circuit i.e. charger is plugged into the socket. The current 'I' is genrated within the coil of the charger. This changing current in turn produces a magnetic around the coil. Now, when any electronic device (e.g. mobile device) connected with a TRS connector is brought in the vicinity of the charger, magnetic field is induced in the coil of the TRS connector which in turn produces current 'I' within the connector. This current 'I' transfer's power through energy replenishment to the mobile device. Care should be taken that the device to be charged should be kept in the proximity of the charger with the TRS connector inserted into the device.

### 6. IMPLEMENTATION

When a mobile device is connected a TRS connector, the connector accomplishes the task of charging the device. Following is the representation of an end product of a wireless charger.

FIG 4: THE REPRESENTATION OF AN END PRODUCT OF A UNIVERSAL WIRELESS BATTERY CHARGER

### 6.1 WIRELESS OPTION:

The electronic device i.e. mobile device is provided with a wireless option to facilitate the usage of TRS connector based charger.

When a user connects the TRS connector following options will be displayed to the user. The option of "Headphone/Charger connected"will be shown on the display of the user device once the connector is inserted in the connector slot that recognizes the type (i.e. name) of connector. This option is analogous to the Bluetooth option displaying "Bluetooth device connected", which displays the name of the connected Bluetooth device.

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FOR AUDIO AND WIRELESS CHARGING

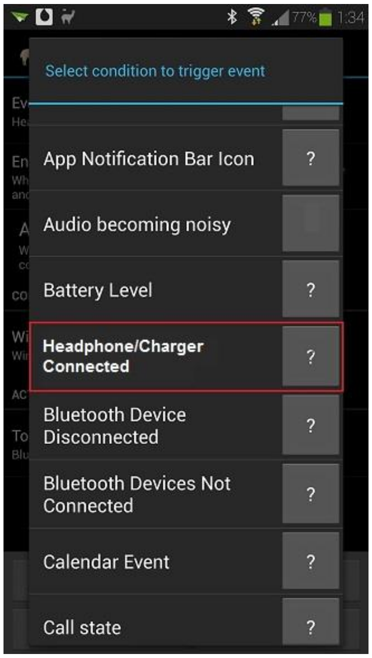


FIG 5: WIRELESS OPTION PROVIDED FOR A CELL

The user is furthur provided with the facility to enable/disable the charging of the device. Once the TRS connector is connected, the user can enable/disable the check boxes shown below. The user can choose either of the option as per the requirement. If the user wishes to only here the audio without charging the device, the user can simply disable the check box of charging. And if the user only wishes to charge the device without listening to the audio signals, he can disable the audio option.


FIG 6: CONNECTOR PROVIDED WITH AN ENABLE/DISABLE OPTION

## 7. ADVANTAGES

1. The mobile user need not carry charger all the time, as all the mobile phones are provided with either 2.5mm wide or 3.5mm wide TRS connector slots
2. Cell phones will become independent devices i.e. they won't be charger specific anymore.
3. Various electronic devices having the TRS connector slots could be charged with ease without any wiring.
4. Scalability.

## 8. APPLICATIONS

1. Mobile devices
2. I-pods
3. Audio players
4. Speakers, etc.

## 9. CONCLUSION

Wireless charging technology will become prevalent in the coming years especially for consumer electronics, mobile, and portable devices. The compact and lightweight product presented here is designed to cater for the growing number of mobile users worldwide. It will perform the task of a traditional charger along with the in-built functionality of transmitting audio signals. The efficiency of a single charger will be enhanced as it will serve the purpose of delivering the charging facility to 'n' no. of devices. The age old concept of "Induced EMF" serves the prime purpose of wireless charging of electronic equipments (e.g. mobile, etc) effectively. Along with this, the magnetic sensor helps in regulating the magnetic field induced within the connector. The idea demonstrated minimizes the cost of users in identifying the best charger to replenish energy of their devices.

## 10. ACKNOWLEDGEMENT:

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