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Data Transfer and Wireless Changing Over Electro Magnetic Field

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Abstract

In this model we have proposed an electromagnetic induction based system for short range wireless data transfer and wireless charging as an alternative to Wi-Fi and other conventional wireless techniques especially for data transmission to mobile phones and hand hold devices. We have already seen the advancement in the field of wireless charging of mobile phones now with help of our proposed model we can also incorporate the feature of data transmission in the same module used for wireless charging. Our system utilizes the property of induction that when an input pulse changing the magnetic flux is applied at the transmitter then a similar pulse with 180 degrees phase shift is received at the receiver. By utilizing this method we can effectively transmit data (in short range) with quite a cheap circuitry.

Keywords*: Internet of thing (IoT), Power consumption, Smart devices, Automation*

1. Introduction

Wireless communication can be stated as the exchange of information between two or more nodes or points in the absence of a physical electrical conductor.

Radio is the most common wireless technology used. The range of radio communication can be as short as a few meters to as far as thousands or even millions of kilometers such as in space-radio communications. The radio communication can be in the form of various types including mobile, fixed and portable applications such as cellular telephones, two way radios, GPS units and wireless networking. Other applications of radio communication include Personal Digital Assistants (PDA), television remotes, wireless computer accessories like mice, keyboard and headsets, garage door openers, cordless telephones, RFID tags and many more.

The medium for wireless communication include various electromagnetic wireless technologies like light, electrical fields, magnetic field, *etc.*

In our proposed model we are making use of electromagnetic induction as the bases of communication. The electromagnetic induction can be described by the Faraday's law of induction which states that if a closed circuit (a single closed loop of wire/coil to be specific) is placed in such a magnetic field whose magnitude keeps on changing causing the magnetic flux through the coil to change accordingly then a potential difference will develop or an electromotive force will be induced in that loop whose value will be governed by the formula given below ,

$$\mathcal{E} = -\frac{d\Phi_B}{dt} \tag{1}$$

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In the above formula (eq.1) $\mathcal{E}$ stands for the induced electromotive force (EMF) and ΦB is the magnetic flux through the closed circuit. The direction of the induced electromotive force is governed by Lenz's law.

Later on from the above formula a modified and more practical version was developed by Maxwell in the Maxwell-Faraday equation which is stated below

$$\mathcal{E} = -N\frac{d\Phi_{\mathrm{B}}}{dt} \tag{2}$$

In the above equation (eq.2) N stands for the number of identical turns in the coil and the rest of the parameters have the same meaning as they had in Faraday's law of electromagnetic induction.

The magnetic flux through the cross section of the coil can be measured through the following formula:-

$$\Phi_{\mathrm{B}} = \iint_{\Sigma(t)} \mathbf{B}(\mathbf{r},t)\cdot d\mathbf{A}\ , \tag{3}$$

Where,

- dA is an infinitesimal element of the cross section of coil through which the field lines are passing
- B is field passing through the cross section of the coil
- B•dA is the infinitesimal element of magnetic flux passing through the coil

In other words, the magnetic flux through the coil increases as the number of field lines passing through the coil increases

From the above (eq.3) we can conclude that magnetic flux associated with the coil can be changed— either by changing the magnetic field B or changing the area of loop (area through which magnetic field lines pass) --

And as the flux associated with the coil changes it results in the induction of EMF in accordance with the Faraday's law of electromagnetic induction.The voltage which is induced in the coil can be measure by cutting the coil to form an open loop and then attaching a voltmeter to both its ends to measure the voltage.

According to the Lorentz force law (in SI units),

$$\mathbf{F} = q\left(\mathbf{E} + \mathbf{v}\times\mathbf{B}\right) \tag{4}$$

the EMF induced in the coil is:

$$\mathcal{E} = \frac{1}{q}\oint_{\mathrm{wire}} \mathbf{F}\cdot d\boldsymbol{\ell} = \oint_{\mathrm{wire}} \left(\mathbf{E} + \mathbf{v}\times\mathbf{B}\right)\cdot d\boldsymbol{\ell} \tag{5}$$

Where,

E,B and dℓ stands for electric field, magnetic field and infinitesimal length element along the wire.

Electricity and magnetism are inseparable entities.Existence of one of these entities can't be complete without the simultaneous exitence of the other.

The relationship between the simultaneous existence of these entities is explained in detail by Einstein's theory of special relativity.

This theory explains how a scenerio which may appear to be completely magnetic or electric to one observer may appear as a combination of both to another observer which makes the individual existence of both these entities dependent on the frame of reference. Thus, special relativity considers electricity and magnetism as a single, inseparable phenomenon called electromagnetism, which is quite similar to the way space and time are related.

2. Related Work

The number of smartphone manufacturers is offering the capability to use wireless charging to maintain a better and top place among its competitors in terms of features. Also, external wireless charging covers are also being manufactured to provide wireless charging capabilities to the low end devices. With the growing advancement in wearable, companies are trying hard to integrate the power of wireless technology in them providing solutions of wireless data transfer and wireless charging.

As advancements continue to be made, wireless charging will likely become more ubiquitous and convenient. Discussed below, are some of the products using the benefit of wireless technology and capturing the market by providing better features to the users.

Choetech Iron Stand Qi Wireless Charger

Choetech's Iron stand [2] wireless charger is a triple coil wireless charger which enables the user to charge their phones by simply placing the qi enabled smartphone on its wireless charging pad. It even lets you use your smartphone while charging so that you can enjoy using your smartphone while the battery is being juiced up.

The device includes triple coil because the placement of the receiving coil inside the smartphone is at different positions. The three coil arrangement eliminates the problem of proper alignment and let the users charge their smartphones hassle free in any alignment they want with the best efficiency at any angle The product is certified with FCC, CE and ROHS standards and premium quality components are used in the manufacturing of this product. Proper techniques for safe and reliable use are also covered by integrating a small chip indies the wireless charging pad that not only maintains the track og overheating or over charging but also automatically cuts the power supply in case of shot circuit.

The Choetech stand is 4 inches tall which allows enough space for your smartphone to rest in portrait mode as well as they will overhang at the edges in the landscape mode. This not only allows the conformability for the users but also makes it easy to quickly pick up the device and putting the phone's screen rather than the charger on display. This Choetech Iron Stand's three coil charging lets the users to place their phone at any angle they want, being it a portrait or landscape, upright or upside down. Its three way induction coils makes sure you get efficient charging at any angle your phone is in. It also props up the device for easier viewing or access to the screen, which is ideal if you want to use your phone for playing back media or simply don't want it wobbling away on a circular pad as you prod away at the virtual keyboard.

Choetech's Iron stand even has four blue LED's on the side of the device which give notifications to the users and makes the device easy to use even at the night time. The LEDs give notifications about when the power is connected, status of the wireless charging and also about the standby mode. Its continuous and flashing LEDs patterns helps differentiates notifications. The wireless charging depends entirely on the phone and when the charging is complete, the Choetech stand automatically goes to the standby mode.

Choetech Iron stand is the new innovation in the wireless charging and continues to be the one of the best products in the terms of efficiency and price.

Seagate Wireless Plus

The Seagate Wireless Plus [1] wirelessly features a 1TB of storage which can be shared to upto eight different mobile devices at once. It can relay Wi-Fi Internet access and works efficiently and fast as a portable data storage bank or a mobile media server. When it is connected to a computer it can worlk like a normal portable hard drive. The Seagate Wireless Plus supports a single-band Wi-Fi (802.11n) with a data transfer speed up to

150Mbps. The design of the hard drive includes a box that houses an internal storage bank, a Wi-Fi point and an internal battery. Its measurement includes just 0.8 inch by 3.5 inches by 5 inches, weighing only half a pound yet with so many features.

The Seagate Wireless Plus includes a standard SATA port and comes with USB 3.0 adapter and a standard USB 3.0 cable. The devices features an automatic internal battery charge when connected to a computer, but can only work either as a media server or a portable drive at a given time, not both at once. When working as a portable drive, the Seagate Wireless Plus comes with a few folders for different types of content including default libraries as Videos, Music, Photos, and Documents. New folders can also be created and synced. When it is switched to work as a wireless media server it automatically organizes the data from all the folders and differentiates them into specific categories so that the user can browse through their connected clients using the Seagate Media app.

The Seagate Wireless Plus comes with a power adapter and a power connector to charge the hard drive through a wall socket. The new Wireless Plus comes fully charged and is preloaded with default HD content and music to check your device for the first use. The Seagate's Wireless plus follows the 802.11n Wi-Fi protocol and supports a streaming setup providing a speed of up to 150Mbps. As mentioned before, it can support eight different Wi-Fi clients at a single time to simultaneously stream the media content across the device. The wireless Plus device works within the range of 2.4GHz and yet to be improved to work on the bandwidth of 5GHz.

Many more portable devices like Seagate wireless plus have been in the market such as Backup Plus but the Wireless plus is formatted with the NTFS file system and support only this file system to work. It however comes with different software drivers and in order to make it work in a system that doesn't support a NTFS file format.

For media content to synchronize, Seagate also announced a version of free Seagate Media app for all the platforms including Android, iOS and Kindle Fire devices. The app's UI is easy and supports various features for streaming the media across the devices. Its newer version is being improved and fast to use than the previous version. The Seagate's Wireless plus is preconfigured with the Wi-Fi network making it easier for the users to use it for the first time.. It connects to the Wi-Fi clients such as smartphones and tablets in no time. The Seagate media app works in both vertical and horizontal position giving an ease of use to the user. It also has the option to play your music in the background while working on the Seagate Media App. Overall, the Seagate Wireless device has captured the market with its new and innovative technology and has been on the top among its competitors.

In our proposed model we are also trying to develop a related technology which would enable wireless data transfer using magnetic induction.

3. Proposed Model

Wireless Communication is the method of establishing communication between two points without the use of any electrical conductor or wire .In our model we have proposed an electromagnetic induction based system for short range wireless data transfer as an alternative to Wi-Fi and other conventional wireless techniques especially for data transmission to mobile phones. We have already seen the advancement in the field of wireless charging of mobile phones and now with the help of our proposed model we can also incorporate the feature of data transmission in the same module used for wireless charging. Our system utilizes the property of induction that when an input pulse changing the magnetic flux is applied at the transmitter then a similar pulse with 180 degrees phase shift is received at the receiver. By utilizing this method we can effectively transmit data (in short range) with quite a cheap circuitry.

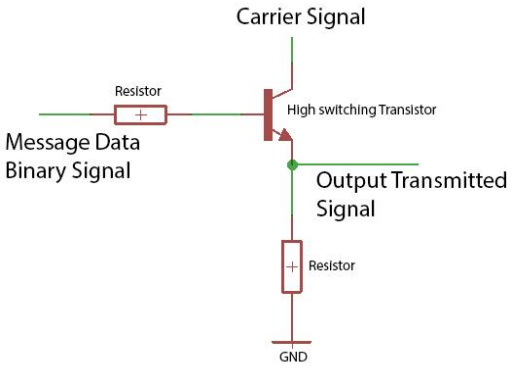

Figure 1. Transmitter Circuit

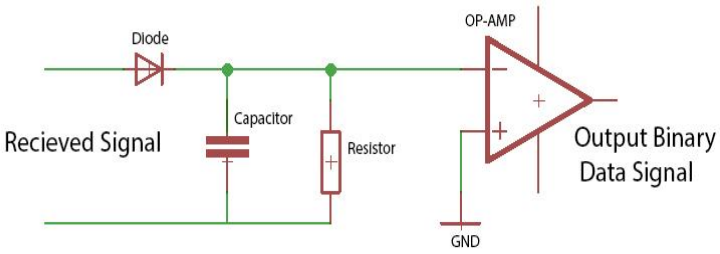

Figure 2. Reciever Circuit

Our model can be segmented into smaller working blocks each having a dedicated task to be performed. Our model starts with the encoder which receives the data to be transmitted in binary (one & zeros) form. As we know that these ones and zeros are nothing but voltage levels 5V and 0V (3.3V and 0V in some cases) and when the encoder receives such voltage inputs then it converts it into square waves (5V and 0V). Now these square waves after amplification are fed to the BASK (Binary Amplitude Shift Keying) circuit which is one of the most optimal coding technique which can be used for data transmission by using electro-magnetic induction because the path loss varies when operation frequency of data transmission changes and as the impedance of each coil varies with the operation frequency same is the reason why the implementation of other modulation techniques like Frequency Shift Keying, Phase Shift keying for data transmission are hard to execute. Therefore different symbols should be sent at the same frequency which can be achieved by using BASK coding technique.

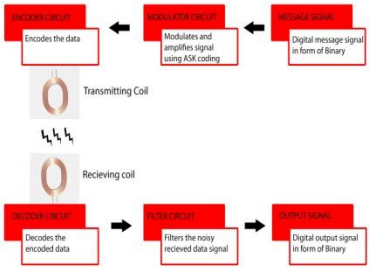

Figure 3. System Block Diagram

3.1 Working necessary

In the beginning the data to be transmitted which is in the form of square pulse (5v for 1 and 0v for 0) are fed to the input pin of amplification chip ULN 2803.The output of this chip is further fed to the base of the transistor BC547 .The collector of this transistor is connected to the carrier signal of amplitude 10V and frequency of 1MHz .With this circuitry each time a positive pulse is received by the base of the transistor, the transistor enters the active region resulting in collector current approximately equal to emitter current which means each time a positive pulse *i.e*. binary 1 is given to the base of transistor the emitter current gains an amplitude(which can be adjusted using resistor) with frequency equal to 1Mhz.

This emitter current is fed to the transmitter coil which creates an alternating magnetic field till the time positive pulse exists at the base of the transistor *i.e*. till the time a binary one is the input.

Now this alternating magnetic field causes induced EMF in the receiver coil with approx. the same frequency as that of the carrier signal which is quite high (1MHz).This induced EMF is fed to the demodulation circuit in the receiver.

The induced signal is passed through a diode in series and after that capacitor in parallel .The output of this circuit is basically the envelope of the high frequency sinusoidal signal, which persists only for the time positive pulse *i.e*. binary 1 exists at the transmitter.

Further this envelope is fed to OPAM uA741, which is used to convert this envelope having ripples into a clear cut readily usable signal of 5V or 0V. While using the OPAM emphasis is laid on reference voltage level which is basically the voltage level above which if the voltage level of envelope reaches then the output is 5V and below which the voltage level of output signal will be 0V.

This output signal which is a square wave signal of 5V and 0V act as the data received which is given as the input to the device which receiving the data through this wireless data transmission technique.

4. Experimental Results

The proposed electromagnetic induction based wireless data transmission module is being deployed for 2 sets of input data and each stage of data transmission is being tested continuously for the change. Also the results are being viewed for each bit and screenshots are taken. A CRO is used for viewing each stage of data transmission. The system architecture of the proposed model is explained by the screen shots of the CRO given below which demonstrates each stage of data transmission.

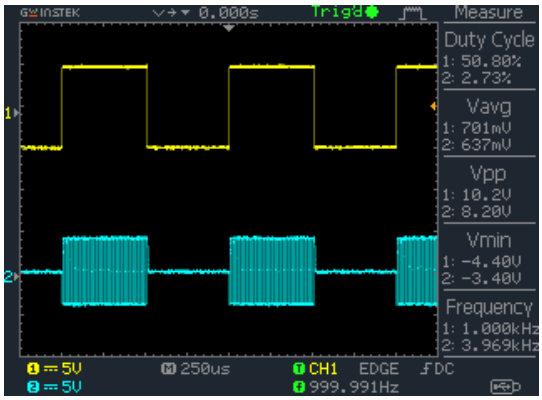

Figure 4. First Data Set and its Modulated Signal

In the above screen shot(Figure4) the first set of data is shown and it is clearly visible that for each binary 1 *i.e*. for a square wave of 5v, the encoder / modulator give our carrier signal as the output which has a frequency of 1MHz which continues for the same duration as the 5v pulse. These modulated high frequency pulses are now supplied to the transmitter coil where due to the high frequency of these pulses an alternating magnetic field of high frequency is generated.

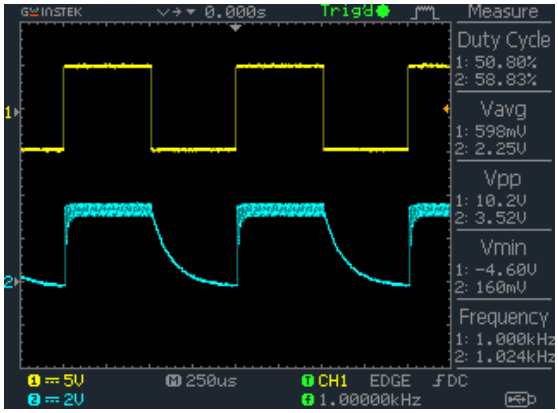

Figure 5. Received Pulses before Filtering (CH2) and Output Data Bits (CH1)

Due to the occurrence of high frequency alternating magnetic field EMF is induced in the receiver coil for same duration as that of the transmitted signal, which is passed through an envelope detector.The output of the envelope detector observed in the channel 2 of the CRO. Further the output of the envelope detector is passed through a comparator circuit which converts it into clear cut digital data bits in accordance with the applied reference voltage.

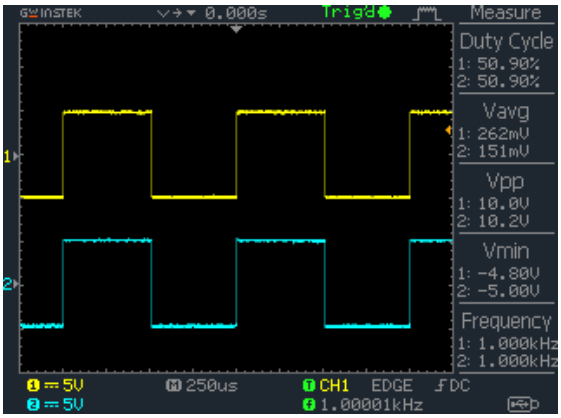

Figure 6. Final Output Bits (CH1) and the Input Data Set (CH2)

In the above screen shot(Figure6) you can see the comparison between the input data set and the received data set. As you can see the few bits are not matching edge to edge due to transmission loss and noise.

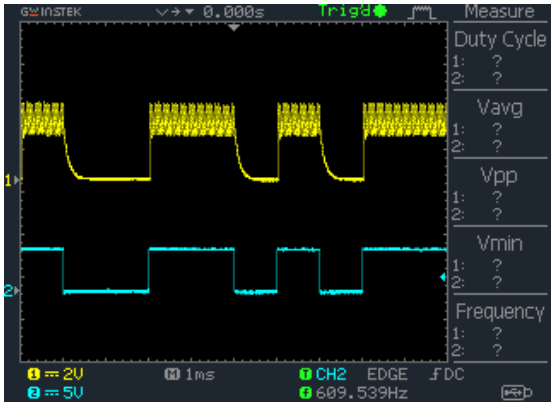

Figure.7 Second Data Set Received pulses before filtering (CH2) and output data bits (CH1)

This screen shot(Figure7) is taken for the second data set being sent and shows the intermediate stage of transmission *i.e*. the output of the envelope detector (CH1) and out of the module *i.e*. the received data bits.

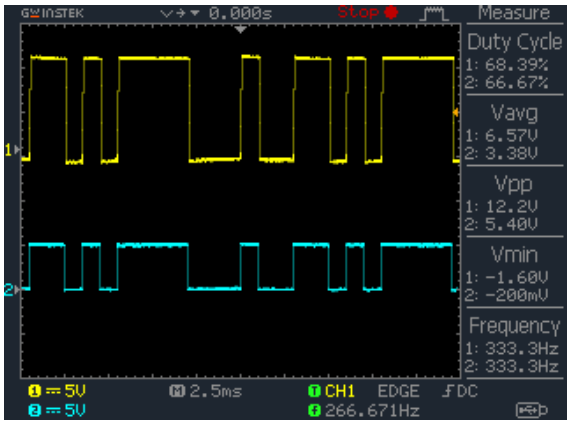

Figure 8. Second Data Set Sent (CH2) and the Received Data Bits (CH1)

In the above screen shot (Figure8) the second data set is shown along with the respective data set received.

The purpose of taking this data set was to observe the working of this model when the data set has consecutive 1's and 0's *i.e.* data bits are high(binary 1) for a longer duration followed by data bits to be low(binary 0) for a longer duration.

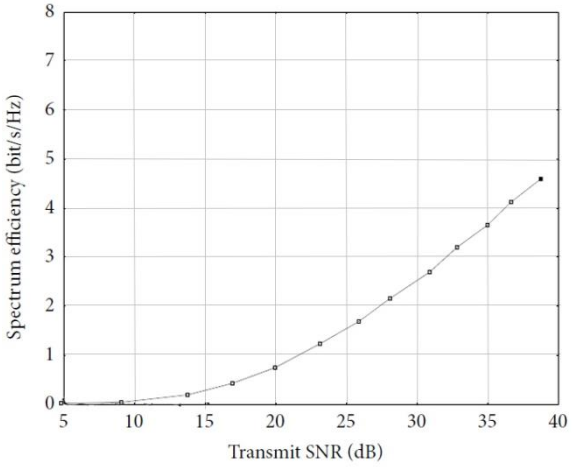

Figure 9. Spectrum Efficiency

The above graph illustrates the capacity of magnetic induction based communication using single input and single output design.

It shows the relationship between Signal to Noise Ratio and Spectrum Efficiency as per our experimental results.

As the signal to noise ratio increases the rate of successful data transmission also increases.

5. Conclusions

From the experimental results section it is clear that an electromagnetic induction based wireless communication system is setup, which is quite cheap but at the same time quite efficient.

By making use of this system the user can efficiently transmit and receive data wirelessly within a short range without the use of Wi-Fi or any internet connection.

Through this system an easy and reliable communication medium is provided to the user which can be made to work in parallel with the wireless chargers for the mobile phones and other electronic devices.

Thus by the use of this model the feature of wireless data transmission can also by incorporated in a single module used for wireless charging.

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