

Study of wireless power transfer by Induction Technique

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Abstract: Electricity is the basic need of our world now a day. We are using wires for the transmission of the electrical power. And we are also facing a lot of problem due to the wires. Today we are bound to compromise with those problems because we are not having any other technology to transmission of power. Scientists and engineers are working to eliminate this problem by isolating the wires from the transmission lines. This technology is named as wireless power transfer system. According to near and far field there are some classifications of the wireless power transfer. Induction is the one of the near field or non radiative technique of the wireless power transfer system.

In this paper we have explained the brief idea about this technique. In this technique there will be the conversion of energy from electrical to magnetic energy in the transmitter and then transmitted. Again in the receiver the magnetic energy is converted in the electrical energy and supplied to the load. In this paper we have explained the method of the conversion of energy on both transmitter and receiver side. Also the function of the generated magnetic field is explained. Some practical results of our device are also explained in this paper.

Keywords: Electrical, Energy, Magnetic, Power, Wireless.

I. Introduction

This paper is going to introduce about a basic idea about the wireless power transfer. By one of the methods of non-radiative technique of wireless power transfer i.e. induction technique the power transfer will be done. In this technique electrical power will be converted in the magnetic form of the energy. Actually the transmitter will create time varying magnetic field and if any device/receiver comes in that region/field it will receive power. The device/receiver must have ability of conversion of magnetic energy in electrical energy. In this paper we will see such types of receiver and transmitter also. The relation between current and magnetic flux is also explained in this paper. This paper will give an idea to reduce the use of wires.

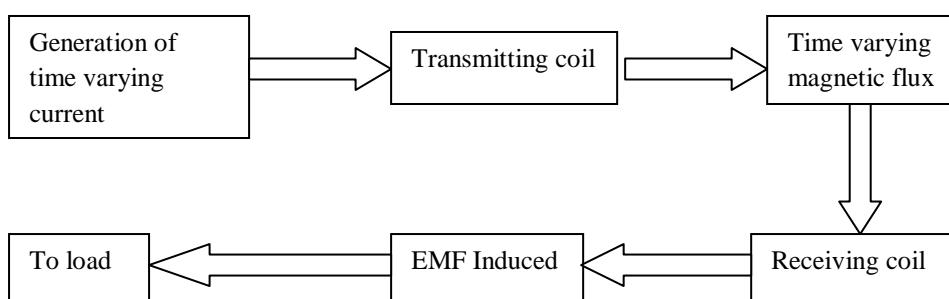


Figure 1- Block diagram

II. Power transmitter part

For the generation of time varying current we are taking a transistor for the switching purpose.

We are taking the basic circuit of common emitter in the npn transistor. In electronics, a common emitter amplifier is one of three basic single-stage bipolar-junction-transistor (BJT) amplifier topologies, typically used as a voltage amplifier.

In this circuit the base terminal of the transistor serves as the input, the collector is the output, and the emitter is common to both.

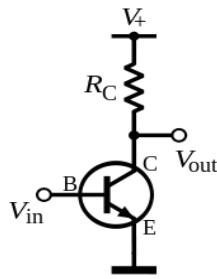


Figure 2- Common emitter circuit

As the Base/Emitter junction is forward-biased, the Emitter voltage, V_E will be one junction voltage drop different to the Base voltage. If the voltage across the Emitter resistor is known then the Emitter current, I_E can be easily calculated using Ohm's Law. The Collector current, I_C can be approximated, since it is almost the same value as the Emitter current.

Also we have,

$$A_i \triangleq \frac{i_{out}}{i_{in}}$$

$$\beta = \frac{i_{out}}{i_{in}}$$

Where $i_{out} = I_C$ (collector current) and $i_{in} = I_B$ (base current)

Therefore,

$$\beta = \frac{I_C}{I_B}$$

We can also say that,

$$I_C = \beta * I_B$$

From the above derivation we can see that I_C depends on the I_B .

So, by adding any inductive or capacitive component at the base of the npn transistor, we will get our required time varying current. That will produce the time varying flux.

By adjusting the value of impedance in the base side, we can get the required frequency of the current.

Finally we can conclude that by applying any signal at the base of the transistor, we will have current on collector of the same function as that of base current.

For the transmitting part as shown in the given circuit (Figure 3)

At the base of the transistor we have connected an inductor. On the collector side we have connected the transmitting coil, which is having same inductance as that of the inductor connected at the base.

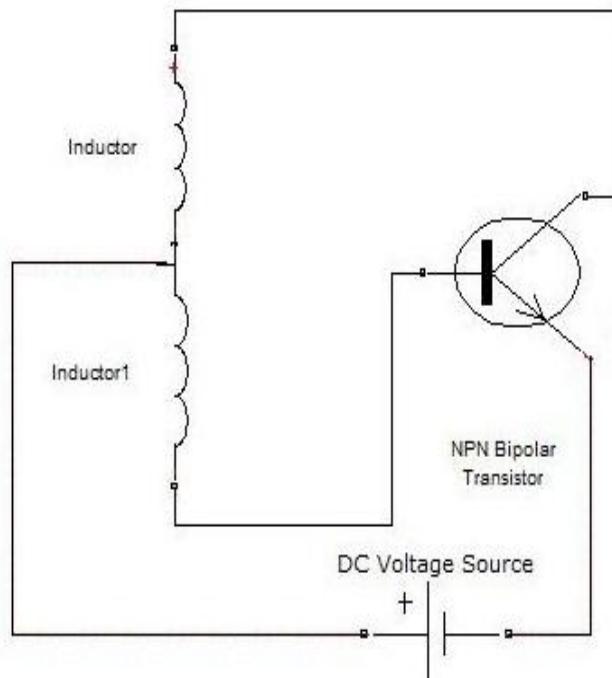


Figure 3- circuit of power transmitter part

In the circuit the inductance of both the inductor is same. We have used magnetic wire of 26 gauges for the coil of transmitter. The coils are used for both purpose

- For transmission of power,(generates time varying magnetic flux)
 - Provide inductance on the base of transistor for switching purpose.

There are some other methods also we are having for the triggering of the base. They are given below,

1. By the use of the combination of some inductive and capacitive components with appropriate value.
 2. By the use of a function generator.

By any method we have to generate a time varying current, which will pass through transmitting coil, which is connected across the collector part of the transistor. And this coil will generate a time varying magnetic field.

Now by reversing the same process we will get a required current from this magnetic flux at the receiver side.

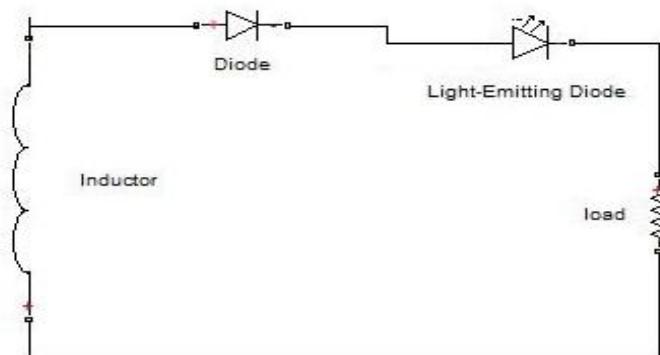


Figure 4- circuit of power receiving part

III. Power Receiveing Part

In this circuit at the place of inductor we have used coil of magnetic wire. The wire is of 26 gauges. The inductance of this coil is same to the total inductance of the coil at transmission side.

When we place the coil in the range of the time varying magnetic field of transmission coil the emf will be induced in the receiving coil according to the Lenz's law.

So with the help of these two circuits we can transmit power in air without any use of wire.

Figure 4- circuit of power receiving part

IV. Derivation of the magnetic field from the OERSTED's equation

In this derivation we will see the relation between the magnetic field (dB) and the current (I).

From OERSTED's equation.

$$dB = \frac{\mu_0 I d\ell \sin\theta}{\pi r^2}$$

Vector representation is given by,

we have assumed that the direction of the distance between the point at which magnetic field is to be calculated is perpendicular to the wire carrying current .so we have dl is perpendicular to r .

So,

$$\overline{dl \times r} = dl * r * \sin\theta \quad \text{when } \theta = 90^\circ$$

$$\overline{dl \times r} = dl * r * 1 \quad [\text{because } \sin 90^\circ = 1]$$

By putting this value to the equation (1),

$$dB = \frac{\mu_0 I dl * r}{\pi r^3}$$

$$dB = \frac{\mu_0 I dl}{\pi r^2}$$

By integrating on both sides, we will have,

$$B = \frac{\mu_0 I l}{\pi r^2}$$

Here, l will be total length of the wire.

In our device we know the value of $\textcolor{brown}{l}$ and $\textcolor{brown}{r}$. So, we can take $\textcolor{brown}{l}$ and $\textcolor{brown}{r}$ as constant.

$$B = \frac{\mu_0 l}{\pi r^2} \quad \dots \dots \dots \quad (2)$$

So, we can say that $B \propto I$

Let us take, $\frac{\mu_{OI}}{\pi r^2}$ = a constant “ k_1 ”

$$B = k_1 I$$

Now as we know the magnetic flux $\varphi = \text{area} \times \text{magnetic field}$.

$$\varphi = \text{area} \times \mathbf{B}$$

$$\varphi = \text{area} \times B$$

$$\varphi = k_2 I \quad [\text{Where } k_2 = \text{area} \times k]$$

We can take area as a constant

So, we can conclude that magnetic flux depends on the property of current I .

If J is time varying then the magnetic field will also be time varying

V Figures and TABLES

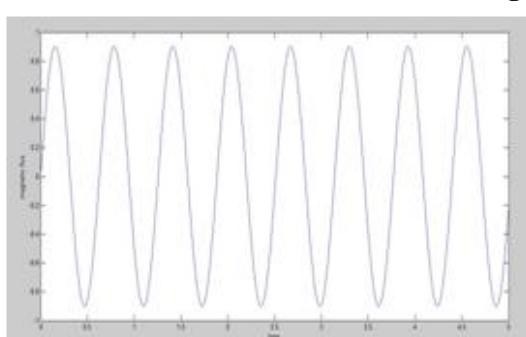


Figure 5

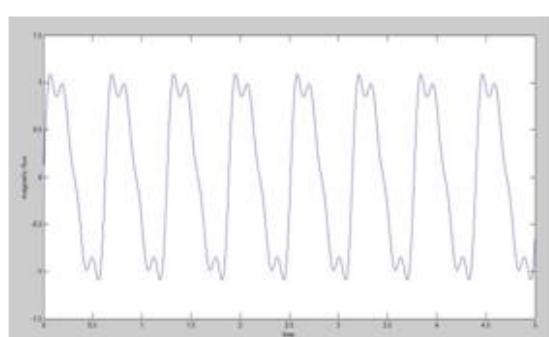


Figure 6

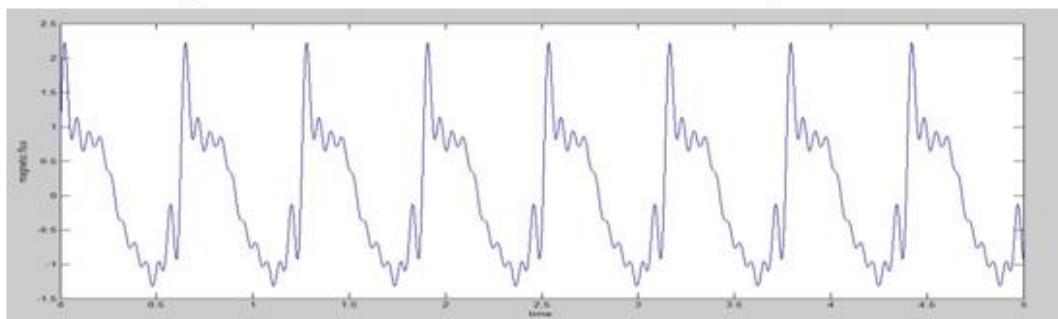


Figure 7

These three graphs of flux vs. time are plotted with the help of matlab software version 7.9.0.529(R2009b)

As we know from the equation,

$$\varphi = k_2 I$$

That means magnetic flux depends on the current.

In our simulation we have taken three different value of current for

Figure 5, $I = 5 \sin(w*t)$

Figure 6, $I = 5 \sin(w*t) + \sin(1*w*t) + \sin(2*w*t) + \sin(3*w*t) + \sin(4*w*t)$

Figure 7, $I = 5 \sin(w*t) + \sin(1*w*t) + \sin(2*w*t) + \sin(3*w*t) + \sin(4*w*t) + \sin(5*w*t) + \sin(6*w*t) + \sin(7*w*t) + \sin(8*w*t) + \sin(9*w*t) + \sin(10*w*t) + \cos(1*w*t) + \cos(1*w*t) + \cos(2*w*t) + \cos(3*w*t)$

[Here "w" represent the angular frequency and "t" represents time]

From the above result we can conclude that the function of magnetic flux depending on the function of current.

In figure 6 and figure 7 we can see that in the magnetic field different number of frequency is present with respect to the current supplied to the coil.

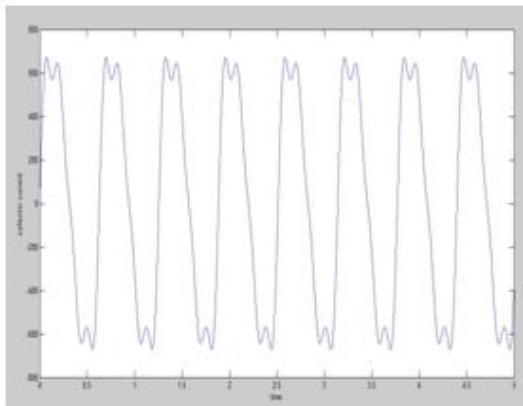


Figure 8

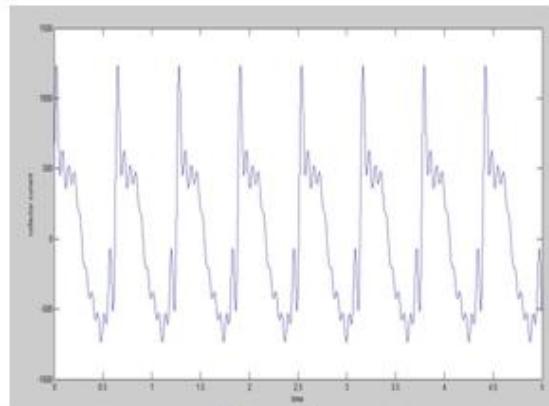


Figure 9

In the above two figure 8 and 9, we can see the relation between the base current and the collector current.

As we know that,

$$I_C = \beta * I_B$$

So, the property and the function of I_C totally depend on the I_B value.

For the BD139 transistor, we have the value of β for npn transistor is 100 approx.

So, by the help of matlab simulation we have the above two curve.

In figure 8, $I_B = 5 \sin(w*t) + \sin(w*t) + \sin(1*w*t) + \sin(2*w*t) + \sin(3*w*t) + \sin(4*w*t)$

And Figure 9, $I_B = 5 \sin(w*t) + \sin(1*w*t) + \sin(2*w*t) + \sin(3*w*t) + \sin(4*w*t) + \sin(5*w*t) + \sin(6*w*t) + \sin(7*w*t) + \sin(8*w*t) + \sin(9*w*t) + \sin(10*w*t) + \cos(1*w*t) + \cos(1*w*t) + \cos(2*w*t) + \cos(3*w*t)$

From the above result we can say that by controlling the value of I_B , the value of I_C and function can be controlled.

Table 1 In the above table, given values are the

SL.NO.	Numbers of turn in receiver coil	Induced voltage in coil (in mV)
1	30	1.1
2	24	0.8
3	18	0.3
4	12	0.2

experimental results of developed device.

In this device we have used a coil of 30 turns and 8cm diameter for transmitter coil. The magnetic wire is of 26 gauges. We have given 3V dc supply in the transmission coil.

When we placed the receiver coil of respective numbers of turns, we got the values of the voltages as given in the table. The magnetic wire is of 26 gauges in the receiver coil also. The diameter of all receiver coils is nearly 4cm. And the load is 1ohm (approx).

In this result we can see that from the same transmission coil, different numbers of receiving coil can absorbs power. All the different receiver coils are having different natural frequency. It indicates that our magnetic flux in transmission coil is produced due to the current, which is having function of different numbers of frequency.

VI. Conclusion

The transmission of power without wires is not a theory, it is now a reality. The electrical power can be economically transmitted without wires to any terrestrial distance.

In this device we have transmitted power up to 4-5cm of air gap without any help of wires. We have noticed that the harmonics of the current in the transmission coil leads the power loss in the form of magnetic energy. Due to the presence of harmonics in current, at the time of conversion of electrical energy into magnetic energy, some unwanted magnetic flux generated.

If we will manage to remove or reduce this harmonics from the current of the base in the npn transistor. This loss, we will be able to reduce.

There are some points we can conclude from the results of this project:-

- We can conclude that the function of magnetic flux depending on the function of current.
- We can say that by controlling the value of I_B , the I_C value and function can be controlled.
- We can say that our magnetic flux in transmission coil is produced due to the current, which is having function of different numbers of frequency.
- We can also increase the range of this device by increasing the value of frequency of the current of the transmission coil or by increasing the magnitude of magnetic flux.
- Magnitude of magnetic flux can be increased by increasing the value of voltage on transmission side

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