A Mobile Phone Charger Design Based on High Voltage Induction Current

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Abstract. This paper introduces the principle of electromagnetic induction of the high tension line. With the aid of the spark plug, induced charge can be transferred to the high voltage winding in the form of short pulse and then generate induced current .With the appropriate circuit, the induced current can be converted to dc 5V voltage for mobile phone charging. This paper designed this kind of conversion circuit, and demonstrates that the transformer output short pulse signals of 8V~ 25V can be converted to 5V dc voltage.

Introduction

Today's phones are big-screen phones that use relatively fast power and have to be recharged almost every day. When traveling, we often encounter the situation that the mobile phone is out of power, even if we bring a charger, this situation happens from time to time, so it is an exciting thing to design a device that can be charged at any time. This paper mainly studies how to charge the mobile phone through the induction current of the high voltage line. Firstly, the induction current is received through the antenna device, and then the circuit is converted into the dc 5V voltage required by the mobile phone.

Two questions now stand in the way. First, is the charger safe? Second: how to ensure that the obtained induced current can meet the requirements of charging? First answer the first question. As for the safe distance of high voltage, the following data can be obtained according to article 5 of the implementation rules of the regulations on the protection of power facilities, as shown in table 1: safe distance under different voltages.

Table 1. Safe distances at different voltages

voltage (KV)	10	35	66-110	220	330
Minimum safety Distance (m)	1.5	3	4	5	6

When the distance is greater than the safe distance above, the person is safe. For the second question, the principle of induced current will be explained below.

When traveling, high voltage cable is often encountered, so as long as there is a high voltage cable, then it can be convenient to charge the phone, the following describes the principle.

Principle of High Voltage Induced Current

According to the principle of electromagnetic field generation: a changing electric field produces a magnetic field, and a changing magnetic field produces an electric field. In the process of transmission, because the delivery is alternating current (ac), frequency of 50 Hz, the change of current alters the magnetic field around directly cause the high tension line, the direction of the magnetic field lines to the right hand spiral rule, changing magnetic field and electric field changes, such changes of electromagnetic field around the high tension line, also known as the power frequency electromagnetic field.

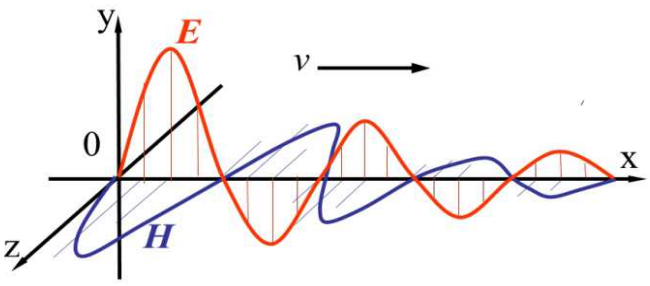

Figure 1. Schematic diagram of electromagnetic field propagation

Human Induced Voltage Analysis

When the human body in high voltage transmission lines, can produce induced voltage and induced current, of course under different induction electric field intensity, the value of the induced voltage is different, in the human body, for example, a rough estimate of the size of the induced voltage, respectively with field strength value is 4 KV/m, 5 KV and 10 KV/m/m, for example, consider the human body in the condition of the insulation and grounding body, due to the height of the high-voltage transmission lines are usually far greater than the body height (1.8 m), and the power frequency electric field generated by the high voltage transmission line characteristics as follows: The vertical component of the electric field intensity near the ground is basically uniform and perpendicular to the ground, and the horizontal component can be ignored. Therefore, it can be equivalent to simplify the electric field, that is, the electric field generated by the three-phase transmission line is equivalent to the uniform electric field, and an infinite cylindrical capacitor model is used to replace the uniform electric field. The following data are obtained, as shown in table 2 below: values of human induced voltage at different intensity field intensities.

Table 2. Values of human induced voltage under different field intensities

Electric field intensity （KV/m）	4	5	10
Human induced voltage（KV）	0.392	0.490	0.982

The data in table 2 shows that the induced voltage of the human body ranges from hundreds of volts to thousands of volts, which is enough to provide a voltage source for mobile phone charging.

Calculation of the Induced Voltage of the Receiving Antenna

If the receiving antenna is placed within a safe distance of the human body from the high-voltage line, and is used to collect the induced charge generated by the induced electric field, what is the induced voltage that can be generated? The simulation is calculated by the analog charge method below.

The analog charge method was first put forward in 1969. Its principle is to replace the continuous distributed free charge or bound charge with a group of discrete analog charge. This idea is proved by the uniqueness theorem of electromagnetic field. The superposition principle is used to simulate the equivalent spatial electric field distribution under the same boundary conditions.

Let's calculate the amount of induced charge and induced voltage that can be accumulated by a receiving antenna. The coordinate system as shown in Figure 2 is established, where h=12m is the vertical height between the high-voltage line and the ground, R=0158m is the equivalent radius of the high-voltage line, y=2m is the vertical distance between the antenna and the ground, the length of the antenna is taken as 0.5m, and the induced voltage of the receiving antenna is about 5.020kv.

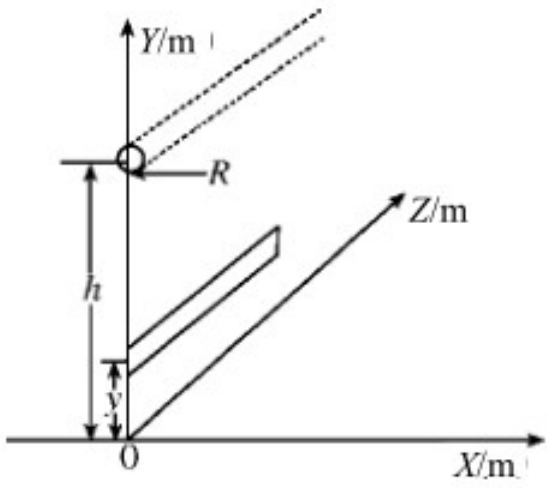

Figure 2. Schematic diagram of antenna placement by single-phase high-voltage wire

It can be seen from the above calculation and analysis that the induced voltage generated by the induced electric field is enough to provide the voltage source required for charging the mobile phone. How to convert the induced voltage into the voltage required by the mobile phone? The following will be specific analysis.

Induction Current Charger Circuit Design

To design a dc voltage with a stable output of 5V, the voltage source can be obtained from the induced voltage generated by the high-voltage line, and then the dc 5V voltage can be obtained through a series of circuit transformations.

Block Diagram of Overall Circuit Design Structure

The block diagram of the whole circuit is shown below:

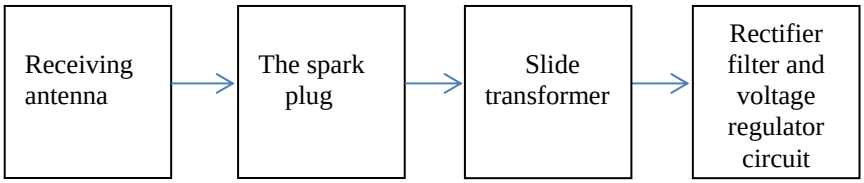

Figure 3. Block diagram of inductive current charging circuit

Specific Design of Induction Charging Circuit

In the above block diagram, the receiving antenna is used to collect the electric field to generate induced voltage, and can also collect the electric field through a human body or a bicycle. Spark plug is very important in this design. It needs to transmit the induced charge to the high voltage winding of the transformer in the form of short pulse. Suitable ac voltage transformer is used to output, it must be given the high tension line transmission voltage differences and differences between the distance of the receiving antenna and the high tension line, these two parameters can make the high voltage transformer voltage is unstable, and finally in order to obtain stable dc 5V voltage, output voltage of the transformer has to be relatively stable, so choose flexible sliding transformer to control the output voltage value, in order to meet the requirements of mobile phone charging voltage, output voltage stability of the sliding transformer between 7V ~ 25V; Rectifier, filter and voltage regulator can choose mature circuit. The specific circuit diagram is given below, as shown in figure 3: schematic diagram of mobile phone charger circuit, original ac signal of u1 and u2, and effective values of u1 and u2 respectively.

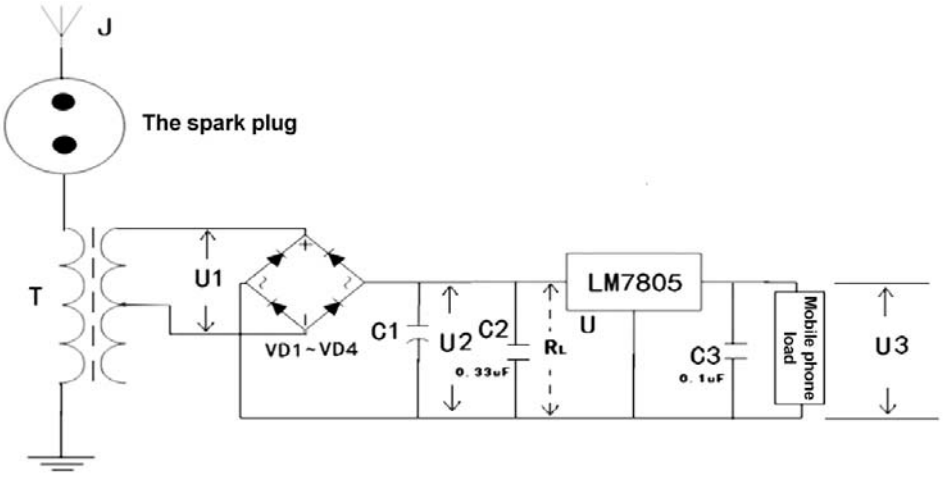

Figure 4. Schematic diagram of inductive current charging circuit

In the circuit diagram, J is the induction antenna, T sliding transformer (adjustable transformer), and VD1~VD4 are bridge rectifier circuits. C1 and C2 are filtering capacitors; LM7805 is a dc stabilizer block, generating a 5V dc voltage, and C3 is a filter capacitor.

Calculation and Analysis of Charging Circuit Parameters

Because of the ac voltage transmission lines, so the antenna of induced electric field induced voltage and ac voltage, size ranging from a few hundred volts to several kilovolts, after the spark plug discharge produced into short pulse voltage, the transformer will produce ac short pulse voltage output, by adjusting the transformer winding turn ratio, make the U1 between 8V ~ 25V, more like transformer, switch power supply here for 15V output as an example to analyze. Convert the ac voltage into dc voltage. To ensure the safety, when selecting the rectifier block, the high-voltage withstand value shall be selected. The model of the rectifier block here is KBU606. The effective values of U1 are calculated according to the following formula (1):

$$U1 = \sqrt{\frac{1}{\tau}\int_0^T u1^2(t)dt} \tag{1}$$

Where, u1 is the short ac pulse signal output by the transformer. If the filter behind is removed and the voltage stabilizing circuit is removed, it is not difficult to get from formula 1: the effective value of signal u2 after bridge rectification is also 15V.

$$U2 = U1 = 15V \tag{2}$$

In addition to the filter and voltage regulator circuit, the value of U2 will change, and C1 is the filter capacitor. The size of C1 is related to the output current and U1 cycle. Generally, when the current is less than 1A, C1 takes 1000uF ~ 2000uF, and 1000uF electrolytic capacitor is selected here. It can be seen from the circuit that the entire filtering effect depends on the values of C1 and C2, as well as the equivalent resistance RL at both ends of C2, and the value of U2 can be approximated by formula (3) below.

$$U2 = \sqrt{2}U1(1 - \frac{T}{4R_L(C1 + C2)}) \tag{3}$$

T is the period of u1, which is 0.02 seconds (the high-voltage transmission frequency is 50HZ). As can be seen from the volt-ampere characteristic curve of LM7805, its input impedance is often large. Generally, U2=1.2 u1 =18V is taken under the condition that formula (4) is satisfied in engineering.

$$R_L C = \frac{(3 \sim 5)T}{2} \tag{4}$$

The input voltage range of LM7805 is between 9V and 35V, and when U1 is controlled between 8V and 25V, the input voltage of LM7805 is between 9.6v and 30V, meeting the requirements of the input voltage of the voltage regulator. The above analysis can meet our needs. It should be noted here that the C2 and C3 values are typical LM7805 application circuits, which will not be explained in detail here.

Conclusion

This paper proves the feasibility of using the induced voltage of the high-voltage line to generate a stable 5V dc voltage. The next step is to verify the accuracy of this conclusion through experiments. There are two points in this paper that do not carry out detailed theoretical analysis, but only carry out the quantitative explanation of verification. Although it does not hinder the overall demonstration, the subsequent demonstration still needs to be strict. First, the magnitude of the induced voltage of the high-voltage line is related to the function of the shape and position of the object that collects the induced charge. Second, the spark plug output of short pulse voltage and voltage regulator between the exact function of the input.

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