A Compact Wireless Transmit for DC Charging

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ABSTRACT

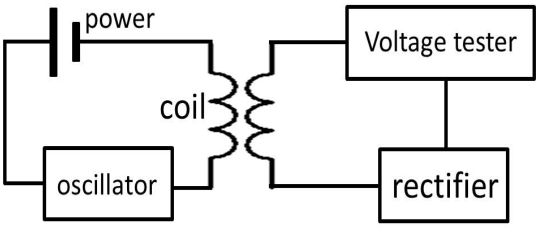
The efficiency of wireless charging is nowadays still considerably low. There is a lot of room for improvement in terms of power saving upon charging. Wireless chargers can be separated into two types of coupled resonant and electromagnetic induction. Electromagnetic induction is technically more mature, but it is limited to a relatively short operation distance as well. Frequency regulation is currently not commercially available, only to have an advantage of using a feedback system to control the transmitter. Generally speaking, it is difficult to generate a sensible current for changing when using a direct current (DC) source. In this project, I found that the transmission efficiency of wireless chargers can be greatly improved when the power transmission is coupled to the following circuits: (1) a customized automatic on-and-off switching circuit that repeatedly couple-and-decouple the charger to the DC source at a customized frequency for a continuous supply of induction current; (2) an oscillation circuit (that converses DC waveform into an AC one) coupled to a frequency-matching power amplifier; (3) a multi-core receiver coil to avoid skin effect; and (4) a voltage doubler rectifier circuit that converts AC power back to DC one at the receiver side.

OBJECTIVES

1. The use of radio transmission mode to transmit DC power supply various types of electronic products (e.g.: a motor (Model EV), the lamp (LED), buzzer, rechargeable batteries, etc. ...)
2. arrival: non-contact power supply, remote power transmission, multi-way power transmission reception point use a coil as a transmitting antenna to convert DC to AC principle, and use a half-bridge converter and a full bridge converter as the transmitter,
3. Use the full-bridge rectifier which can change AC into DC as a receiver, mean while connect a buck converter in order to increase the current supply use.
4. As for the coil, use the self-adhesive multi-core coil to reduce the skin effect, and to improve the resistance to flow in the frequency domain

THE DESIGN

Fig. 1 Wireless power transmission module



1. Power: DC under 30 volts.
2. DC to AC inverter: this design.
3. AC to DC rectifier: this design.
4. Multi-core coil: multiply cores in series.

Fig. 2 The coil

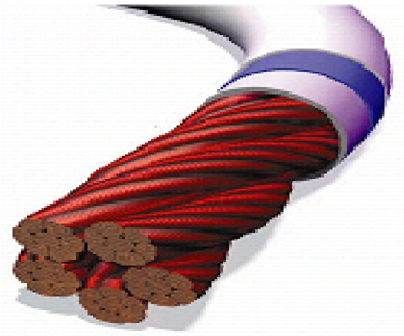
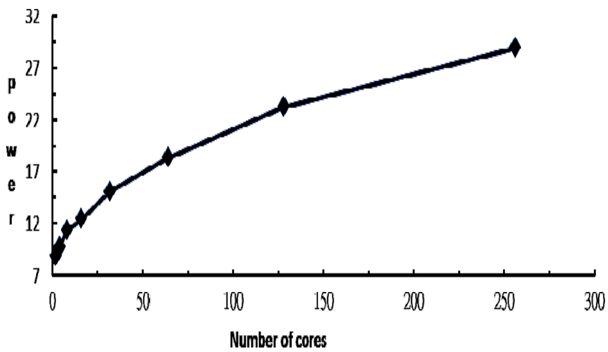


Fig.3.The numbers of core in the coils



1. The skin effect results in a non-linearly increase of the output power with the numbers of core in the coils (Fig.3).
2. In reducing the capacitor-effect generated between two cores, a thin flat-core coil with low resistance should be used (Fig.4).
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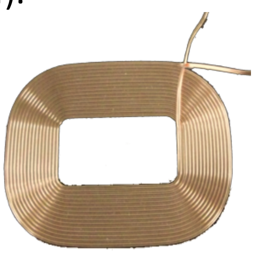
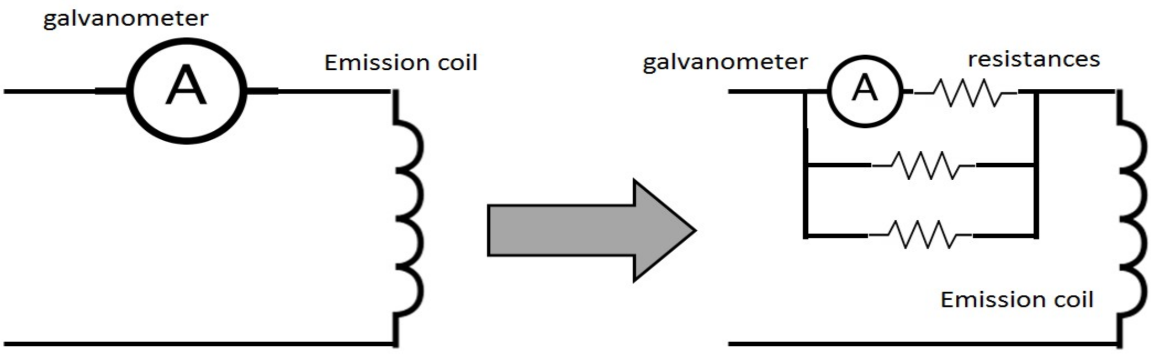


Fig.4 thin flat core coil

Fig. 5 Full-frequency reflect board

1. In enhancing the EM wave in the emitting or receiving end, a thin Fe Fe_3O_4 plate (Fig. 5) is attached to one side of the coil.
2. This plate acts as a reflector, which not only re-direct the EM wave to focus on one side of the coil, but also acts as a safety board to circuit. Reduce the possibility of the EM wave being absorbed by other components in the possibility of the EM wave being absorbed by other components in the circuit.

Fig.6 Test excessive current



1. The maximum value galvanometer can detect only up to 0.6A, so I change electronic schematic in another way. (Fig.6)
2. We connect three small resistors in parallel, and series connect one with galvanometer, so that it will get 1/3 of total current.

Inductance on coils

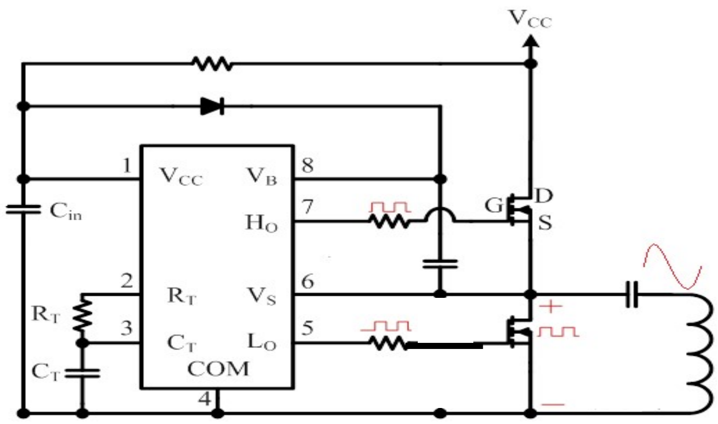
We need to form current and voltage, and the formula is as follow:
$Z_L=2\pi fL$, Z_L=inductive reactance, f=frequency, L=inductance

$Z=\sqrt{R^2+(Z_L-Z_C)^2}$ There is no capacitive reactance so Zc=0.

Results and Discussion

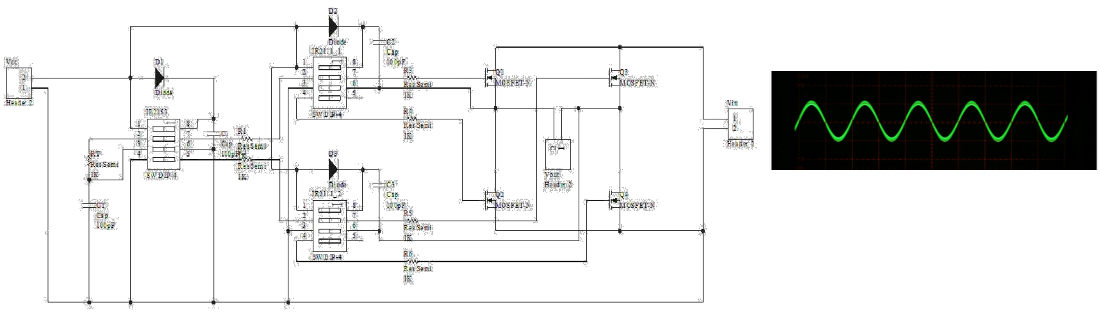
A.Resonance capacitor

Fig.6.Half-bridge converter



1. The DC current does not continuously generate induce current ,but AC does ,so use an automatic switch(like ticker timer or oscillator) to change DC into AC
2. A modified half-bridge converter (Fig.6) is used to transform DC signals to AC ones. The square waves signal is amplified by using two coupled transistors.

Fig. 7. Circuit and output of the full-bridge converter.



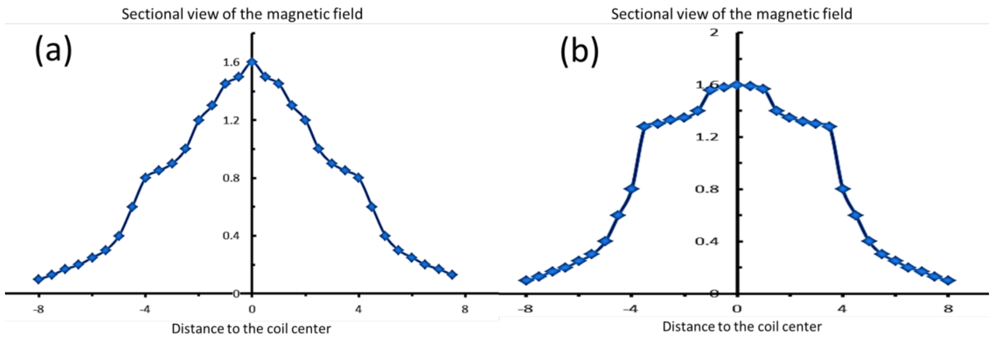
1. Coupling two separated half-bridge inverters in parallel to form a

full-bridge converter (Fig.7).

2. Output powers as well as the range of working frequency were found to be largely enhanced, through the increases in the adjustable parameters.
3. A resonant capacitor (marked R in Fig. 7) at the end of the converter is used to couple the frequency between the transmitter and the receiver, for reinforcing the square wave amplitude and for resonance receiving.
4. Transform power of the converter at 32 W with an efficiency of 74% can be achieved.

B. Focusing magnetic field

Fig. 8 Magnetic field distributions around the coils: without and (b) with magnetic condensers.



1. Using coil diameter: 8 cm
2. This figure is measured via the coil diameter from the center outward.
3. Magnetic field will quickly dissipate over the coils range
4. Magnetic field condenser consists of four inter-crossed stripes,

placed on the back-side of the coil, is used to direct the magnetic field onto the center of the device (Fig. 8).

5. This is found to be capable of increase the working distance of the charger by 21%.

C. Optimization

Fig. 9. More turns of coils, will obtained higher inductance, and stronger power.

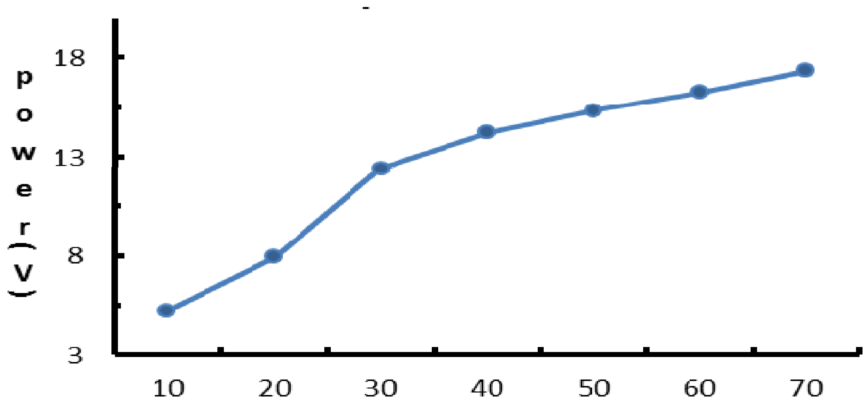


Fig. 10. A larger diameter for the coil produces a smaller inductance and less power. A smaller wire for accommodating more turns in the coil is the key.

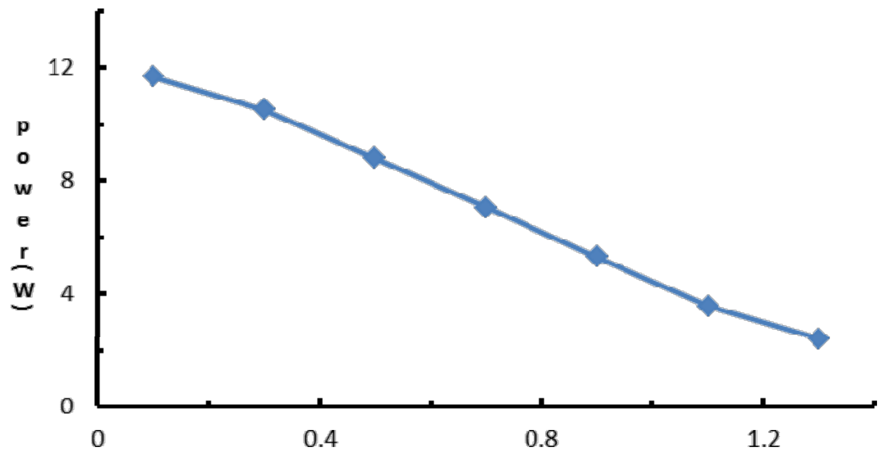


Fig. 11. With the Self-adhesive multi-core coils, the thicker the lines, the smaller the inductance and power obtained.

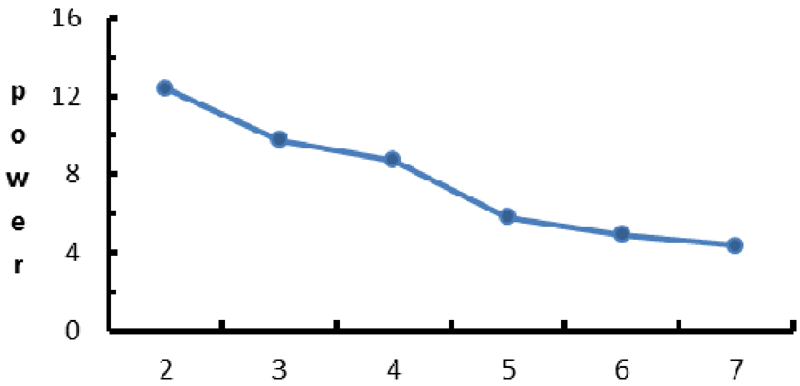
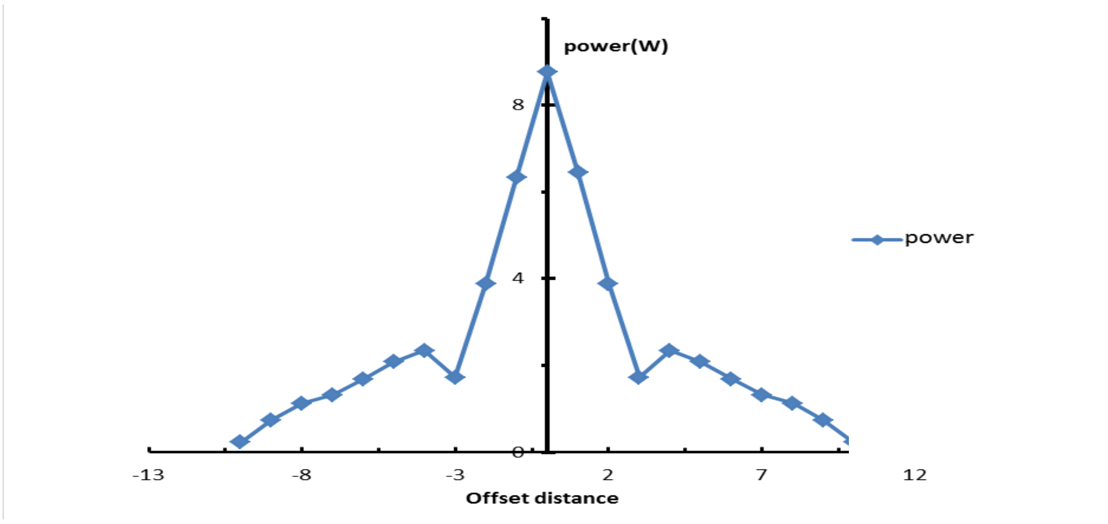


Fig.12 Single-core receives coil horizontal distance and power .When two coils match together, I will get more voltage.



D.Receiver

Fig. 13

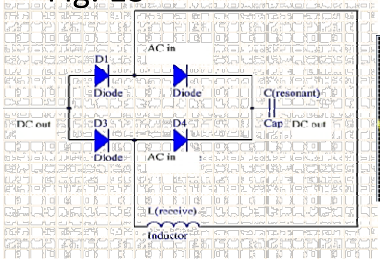
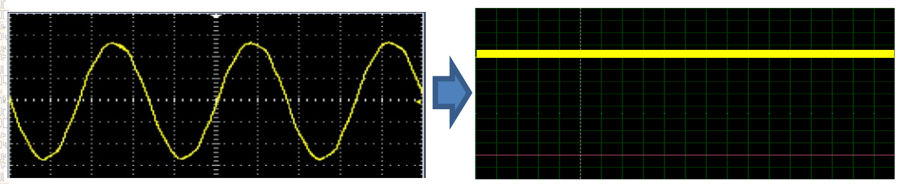


Fig. 14



The receiver is in a form of a full-bridge rectifier (Fig. 13).

1. It can converse AC signals into DC, and is capable of coupling its frequency to that of the transmitter (Fig.14).
2. The frequency matching can largely improve the power received.

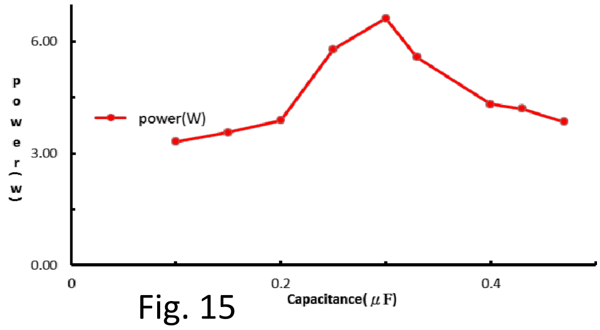
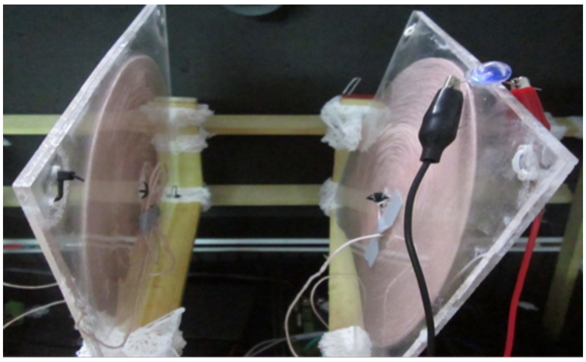


Fig. 15

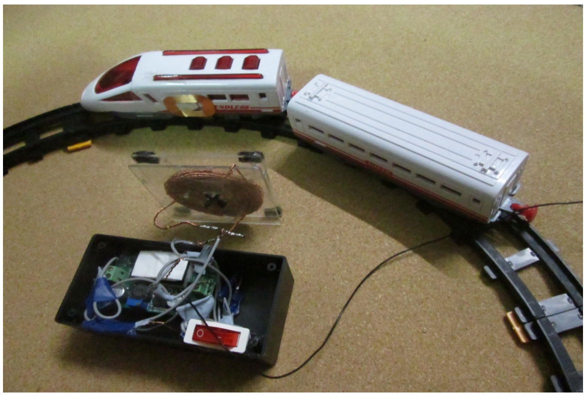
3. Remarkably, the power transmitted can also be tuned by the capacitor used in the circuit. A capacitance of 0.3 μF generates maximum power (Fig. 15).
4. Reduction of the voltage at the receiver end helps to increase the current for loading.

Practical applications

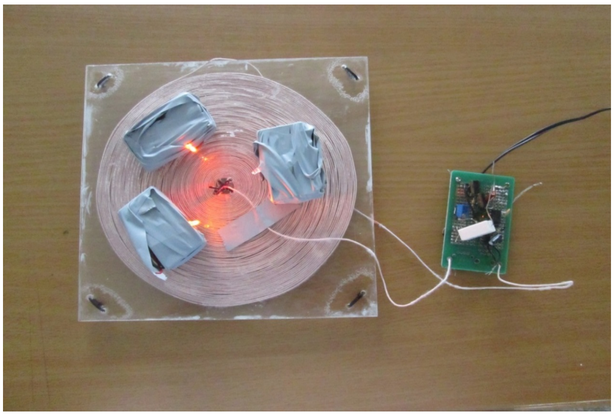
1. Transmission distance of the induction power can be as far as 20 cm .



2. It is capable of supply the power needed for a Four-Wheel Drive.



3. Recharging of a battery at 2.5 V with 100 hmA is feasible.



4. Capable of lighting up 8 LEDs in series.

Conclusions

The transmission efficiency of wireless chargers can be greatly improved when the power transmission is coupled to:

1. Customized automatic on-and-off switching circuit, which repeatedly couples and decouples the charger to the DC source at a customized frequency for a continuous supply of induction current.
2. An inverter circuit, which converses DC waveform into AC coupled to a frequency matching power amplifier.
3. A self-adhesive multicore receiver coil was used to avoid skin effect.
4. A full-bridge rectifier circuit that converts AC power back to DC at the receiver side.
5. At last the total; transmit power is29W 71％

References

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