Wireless Charging Transmission Power Adjustment and Design

D/N: AN0558EN

Introduction

A wireless charging device is divided into two parts, a wireless charging transmitter (Tx) and a wireless charging receiver (Rx). The main functions of the Tx part is LC resonance control and ID recognition. The Tx is powered by the USB interface and provides power for the Rx through its LC resonance mode and simultaneously recognises ID information returned from the Rx. Holtek's dedicated wireless charging IC provides the necessary control signals for this to happen. This application note will introduce how to debug the Tx LC resonance power control to allow users to have an increased understanding of Holtek's wireless charging device.

Functional Description

Through this application note, the following explanation will be provided.

1. Calculate the correct resonance inductance and capacitance according to a formula.
2. Appropriately adjust the PWM frequency and Duty to control the transmitted power.

Fig 1. BP45F0044 Charging Cradle Hardware Block Diagram
Operating Principles

1. Tx coil:
   Inductance: 6.7\,\mu{}\text{H}.
   Style: 30\,\text{mm} diameter, with magnetic disk.
   Manufacturer & Part Number: XKT, XKT-L29.

2. Rx coil:
   Inductance: 10\,\mu{}\text{H}.
   Style: 30\,\text{mm} diameter, without magnetic disk.
   Manufacturer & Part Number: XKT, XKT-L12.

Hardware Description

1. In order to adjust the Tx power, the Rx terminal extracted load current circuit should be prepared as shown in the figure below.

![Fig 2. Rx Standard Extracted Test Circuit](image)

L1 is an Rx coil, C1 is a resonance capacitor, D1–D4 form a full-bridge rectifier and R1 is an electronic load.

2. The Tx circuit diagram is shown below.

![Fig3. Tx Circuit Diagram](image)
3. Parallel resonance frequency design: By proper inductor selection, capacitor design selection, PWM frequency and Duty design, a complete ideal parallel LC resonant solution can be designed.

- Component Design

As the coil inductance usually has limitations on its dimensions and number of turns, a decision should be first made about which coil is to be selected. After this, an appropriate resonance frequency can be selected after which the LC resonance formula, \( f_0 = \frac{1}{2\pi\sqrt{LC}} \), can be used to calculate the resonance capacitance.

In this application note, the Tx coil inductance is 6.7\( \mu \)H and the resonance capacitance is 223nF. Component error problems should be noted during capacitor selection. There are two methods to avoid component errors. One is that the actual selected capacitance is smaller than the calculated capacitance and the center frequency is designed to be higher. The other is to reduce the actual operating frequency. Refer to the following description.

- Program Parameter Adjustment

Holtek has simplified the resonance adjustment so that users can quickly and correctly adjust the required resonance frequency. In the Holtek provided code, users can directly modify the “LCFreq” and “PWMDuty” parameters until the power is correctly received by the Rx. In this application note, the preselected resonance frequency is 130kHz and the MCU frequency is 16MHz.

**Step1: Calculate the preliminary LCFreq parameter**

The desired resonance frequency should be determined first. In this application note, the preselected resonance frequency is 130kHz, with the other parameters being adjusted using an oscilloscope.

\[ \frac{16\text{MHz}}{130\text{kHz}} = 123 \]

then fill 123 in the LCFreq parameter of the program.

**Step2: Observe the oscilloscope**

The PWM waveform in the figure below is the reverse waveform. When the PWM signal is high the NMOS will be off otherwise when the PWM signal is low the NMOS will be on. It can be observed that the best zero-point switch is to switch the PWM signal when the sinusoidal wave is at its zero-point.

Taking this application note as an example, the default design operating frequency is 130kHz. Here users can observe whether the waveform is switched at its zero-point. After repeated tests, the resonance waveform is shown in the following figure.
Step 3: Calculate the Rx resonance frequency
This application note uses a resonance frequency of 130kHz. By using
the resonance formula $f_0 = \frac{1}{2\pi \sqrt{\frac{L}{L}}}$, and by choosing an Rx inductance of 10µH, an Rx capacitance of 149.88nF can be calculated.
An Rx capacitance can be appropriately selected with a smaller value of 148nF.

Step 4: Record Rx power
Here, the Tx-Rx power parameter settings have been completed. Using the Rx standard extracted test circuit described above, use the electronic load CV Mode to supply a load current close to the Tx-Rx coil to achieve the required distance. The load current condition is in the 5V CV Mode with a coil spacing of 4mm. At this time, record the electronic load extracted wattage, sinusoidal wave Vpeak and efficiency.
If it is found that the efficiency is too low for this step, refer to the attached coil and efficiency diagram to select an appropriate coil.
Note: Efficiency = Rx(watts)/Tx(watts).

Step 5: Complete
After completing the above adjustment, the Rx extracted power is as follows:
Electronic load CV mode 5V can be driven with a current of 40.3mA (0.21W) with an efficiency of 50.1%.

Considerations
This application note discussed the relationship between coil power and efficiency, with a coil spacing of 4mm. Refer to the following table to select an appropriate coil.
Note: “30mm twisted 6.7µ: single 10µ” shows that the coil diameter is 30mm, Tx is a twisted line, inductance is 6.7µH, Rx is 10µH single core wire.
Fig. 5 Coil Power-Efficiency Comparison Table

<table>
<thead>
<tr>
<th>Tx Coil Diameter</th>
<th>Inductance</th>
<th>Part No.</th>
<th>Rx Coil Diameter</th>
<th>Inductance</th>
<th>Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>30mm</td>
<td>6.7µH</td>
<td>XKT-L29</td>
<td>30mm</td>
<td>10µH</td>
<td>XKT-L12</td>
</tr>
<tr>
<td>20mm</td>
<td>10µH</td>
<td>XKT-L17</td>
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<tr>
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<td>10µH</td>
<td>XKT-L28</td>
<td>10mm</td>
<td>20µH</td>
<td>XKT-L11</td>
</tr>
</tbody>
</table>

Conclusion

Through this application note, users can correctly calculate the LC resonance frequency to select an appropriate resonance capacitance and then setup PWM parameters to meet the required power. The coil power-efficiency comparison table for the test data can be used to quickly obtain an appropriate coil diameter, type, and achievable power and efficiency. Users can select suitable solutions according to their circuit requirements.

Reference Material


For more details consult the Holtek website at www.holtek.com.

Versions and Modification Information

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<th>Date</th>
<th>Author</th>
<th>Issue Release</th>
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<td>2020.03.27</td>
<td>Minhsien, Zheng</td>
<td>V1.00</td>
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