Wireless Charging Self-Starting Electric Trolley

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Abstract. Wireless charging electric car includes: wireless charging module (transmitting end, receiving end), used to wirelessly charge the electric car to charge the farad capacitor installed on the car, so that the car can walk in a horizontal straight line. Farad capacitor for energy storage devices after wireless charging. The selfstarting circuit is connected to the farad capacitor and is used to judge the automatic driving when the charging is disconnected. Through this car model construction, the wireless charging self-start mode is realized, which solves the complexity of manual operation and simplifies operation.

1. System plan
The system is mainly composed of self-starting circuit, wireless charging module and trolley mechanical construction. The choice of these modules is demonstrated separately below.

1.1. Self-starting circuit selection
The thyristor (thyristor) and the triode are used to start the motor, and the thyristor has the advantages of small volume, high efficiency, long life and the like. In the automatic control system, it can be used as a high-power drive device to control high-power devices with low-power controls. It has been widely used in AC and DC motor speed control systems, power adjustment systems and servo systems. Its on-off state is determined by the gate G. Adding a positive pulse (or a negative pulse) to the gate G allows it to be turned forward (or reverse). The advantage of this device is that the control circuit is simple and has no reverse voltage problem, so it is especially suitable for AC non-contact switch.

A circuit composed of a thyristor is more energy-efficient and less intrusive, so a circuit composed of a thyristor is selected.

1.2. Wireless charging module selection
Electromagnetic induction type wireless charging, when the current of the power source passes through the coil (the power feeding coil of the wireless charger), a magnetic field is generated, and other unpowered coils (the power receiving coil of the mobile phone end) generate current near the magnetic field, and the disadvantage is that it can only be near the distance is charged and placed in a very demanding position, but at this stage it is more suitable for charging the car, and the technology is mature.

1.3. Car machinery selection
The car body adopts the circuit board, because it is lighter and thinner, it is not easy to be damaged; the lower body adopts the single motor to drive the rear wheel mode, the wheel adopts the four-wheel fixed way, the front wheel is linked by the crossbar, and the front wheel drive makes the car drive. A straight line along the trajectory of the front wheel makes the charging car travel more smoothly.
1.4. Car climbing drive mode
The front-drive type has good maneuverability and good starting acceleration, which is good for starting, accelerating and climbing, and has low power consumption.

1.5. Resonance Coupling Coil Winding Method
Flat coil structure: Although the inductance value is only a few microhenries or dozens of microhenries, it is small in size, relatively thin, and the emission area and receiving area are larger than other methods, saving space and improving the efficiency of the transmitting and receiving coils. A radio energy charging device that performs charging.

2. System theory analysis and calculation

2.1. Charging method
The constant current source is used to supply the 5V1A to the wireless charging transmitter, and the receiving end obtains the power to supply the capacitor to the energy storage through the intersection of the coils. The input energy formula = P * t, the energy formula at the receiving end = 1/2 * c * u * u, Input energy calculation: input energy = P * T

\[ P=UI \]

Acceptance energy formula: receiving energy = 1/2*C*U*U
Receiving energy is typically 70 to 100 joules
Energy conversion efficiency: efficiency 70/300*100%=23%
100/300*100%=33%
Energy conversion efficiency is around 23% to 33%

2.2. Startup method
When the stopwatch is powered off and the power is turned off after one minute, the thyristor and the triode in the circuit are judged to be powered off. After the power is turned off, the capacitor discharges the voltage to the motor through the tps63020 voltage regulator circuit to supply 5v voltage 1A to the motor, so that the motor drive car moves forward.

2.3. System theory analysis
The input energy is theoretically 300J, but the actual circuit loss is large, and the transmission efficiency is low, resulting in the actual received energy is only about 70-100J.

2.4. Error Analysis
The charging efficiency causes the capacitors to acquire different energies, which makes the trolleys travel different distances, measure and maximize the charging efficiency.
For the first time, the voltage for one minute of charging is 2.8V; the second time, the voltage for charging one minute is 3.2V; the third time, the voltage for one minute of charging is 3.8V. After many experiments, the energy obtained by the car and the emission of the coil are found. The distance between the end and the receiving end is very different.
3. Circuit and program design

3.1. Self-starting circuit schematic

![Circuit diagram](image)

Figure 1. Circuit diagram.

Add a heat-dissipating resistor on the outside to dissipate heat to make the heat dissipation better and prevent the circuit from burning out.

The 5V1A and the farad capacitor of the wireless charging transmitter are 5.5V10F. The capacitor voltage is regulated by the TPS63020 and input to the motor.

4. Test plan and test results

4.1. Test plan

First, build the hardware circuit by module and test the success separately, then build the discrete modules together to test the overall function. After testing, our self-starting circuit, wireless charging module, and car mechanics are all working properly.

4.2. Test conditions and instruments

Test conditions: Check multiple times, the simulation circuit and hardware circuit must be exactly the same as the system schematic, and the check is correct, the hardware circuit guarantees no solder joint.

Test equipment: high-precision digital millivoltmeter, digital multimeter, pointer multimeter, constant voltage current source.

4.3. Test results and analysis

(1) Test results (data)

1) After testing, all parts of the system are working properly.

   For the first test, the measured data at both ends of the capacitor for 1 minute is 2.8V, and the trolley can run 0.7m. The second test 1 minute capacitance measured at both ends of the 3.2V, the car can run 2.9m. In the third test, the data measured at both ends of the capacitor for 1 minute is 3.8V, and the trolley can run 4.5m. Therefore, in order to make the car start better, the driving distance is farther, charging is more suitable in 1 minute and a half, because some residual voltage cannot be completely released, the final voltage is not enough to drive the motor, and a certain amount of electric energy is wasted.

2) Analysis of radio energy transmission methods
The transmitting coil and the receiving coil of the magnetic induction resonant type wireless energy transmission system have the same frequency. When the same driving signal is generated in the transmitting coil and the receiving coil, the two coils resonate, and the impedance in the magnetic coupling loop is minimized when generating resonance. The side transmitting coil can efficiently transfer electric energy to the receiving coil B on the secondary side through magnetic field coupling.

4.4. The calculation of wireless charging circuit
(1) Frequency the coil resistance R, the coil distribution capacitance C, and the coil inductance L constitute an RL C resonance circuit, and the resonance frequency is:

\[ f = \frac{1}{2\pi\sqrt{LC}}. \]

(2) Inductance
In general, the winding of the coil is tight, the number of turns of the coil is large, and the inductance of the coil is relatively large; the core of the coil is larger than the inductance of the coil without the core. For resonantly coupled coils, the magnitude of the inductance is determined by the entire magnetically coupled resonant radio energy system. The resonant coupled coil inductance is calculated as:

\[ L = \mu_0 N^2 r [\ln((8r)/a) - 1.75]. \]

After measurement: \( r = 4.5 \text{ cm}, N = 4, a = 0.2 \text{ cm} \), calculated: \( L = 3 \times 10^{-6} H \).

(3) Capacitance
The winding of each winding of the resonant coupling coil is regarded as a uniform cylinder. The interturn capacitance between the two coils is:

\[ C_i = (2\pi^2 r e / \ln(h/2a) + \sqrt{(h^2 / (2a) - 1)}) . \]

5. Conclusion
According to the above test data, the design meets the design requirements. The car can charge the Farad capacitor using a wireless charging device for a certain period of time (more than 1 minute), and can automatically start the circuit after the power is turned off, and can drive a certain distance after starting. If the charging time is right, the car can climb to a certain height.

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