REVERSE ENGINEERING OF SPHERE WIRELESS CHARGING PAD

REPORT BY: GRACE & RUCHA
THING TWO 97101W
AMERICAN HIGH SCHOOL FREMONT, CA, US

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INTRODUCTION:

WHAT IS THE SPHERE WIRELESS CHARGING PAD?

The Sphere Wireless Charging Pad is a 69 x 9 mm cylindrical-shaped wireless charger with an input power of DC 5V/1500 mA and an output power of 5W. To charge devices, the Sphere Wireless Charging Pad must be directly plugged into the wall using a Micro-USB cable.

DISASSEMBLY PROCESS

EQUIPMENT:

- safety goggles
- gloves
- measuring tape
- a screwdriver
- a thin paperclip or pliers
- Sphere Wireless Charging Pad

Figure 2.1.1: The paperclip, pliers, and screwdriver.

Figure 2.1.2: Safety goggles.

Figure 2.1.3: Gloves.

PROCEDURE:

STEP 1:
Obtain the necessary equipment and put on safety goggles and gloves* to take the necessary precautions while handling electronics. (Figure 2.1)

STEP 2:
Carefully stick the pliers or the paperclip into the gap on the backside of the Sphere Wireless Charging Pad (Figure 2.2.1 and 2.2.2).

Figure 2.1.4: Sphere wireless charging pad.

Figure 2.2.1: Sticking the paperclip into the back of the charging pad.

Figure 2.2.2: Prying open the back of the charging pad.

*Gloves were taken off to take clear pictures of the tools and components.

STEP 3:
Gently remove the white silicon adhesive (Figure 2.3.1). Find the screw holding the PCB board and the plastic case and twist the screwdriver counterclockwise to remove it. (Figure 2.3.2 & 2.3.3).

STEP 4:
Remove the blue silicon gel from the PCB board (Figure 2.4).

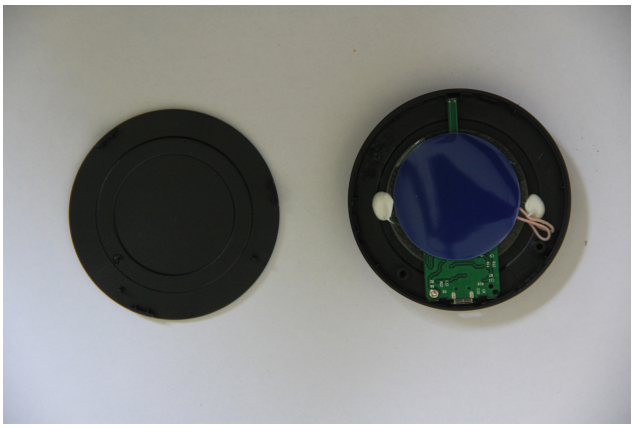


Figure 2.2.3: The wireless charging pad after prying open the back.

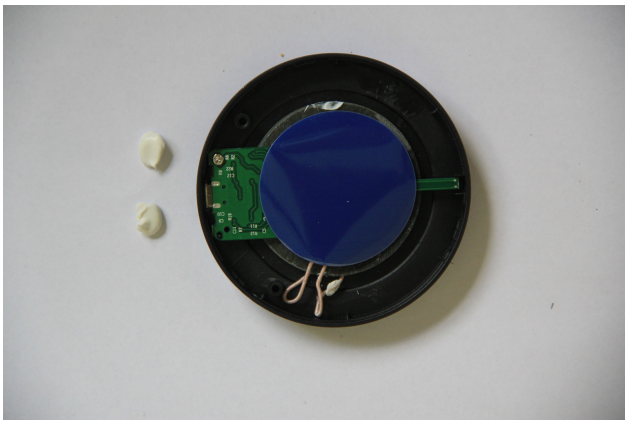
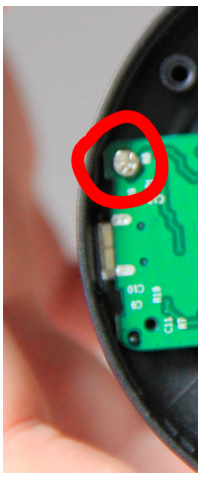
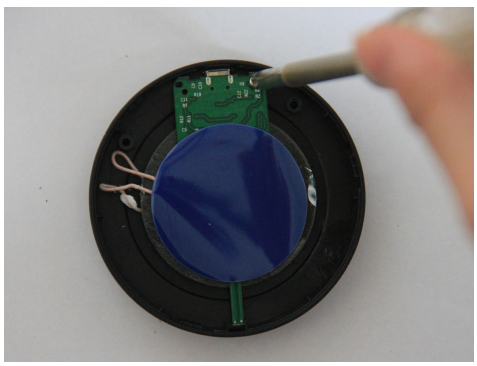
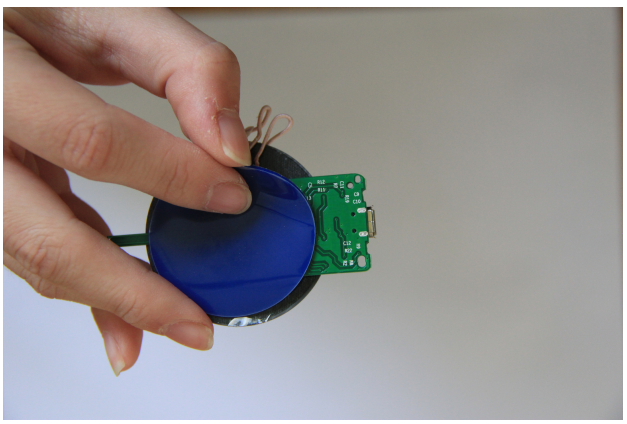


Figure 2.3.1: Removing the white silicon adhesive.





Figures 2.3.2 & 2.3.3: Removing the screw circled in red.



Figures 2.4: Removing the blue silicon gel.

DEVICE COMPONENT ANALYSIS

PCB OVERVIEW:

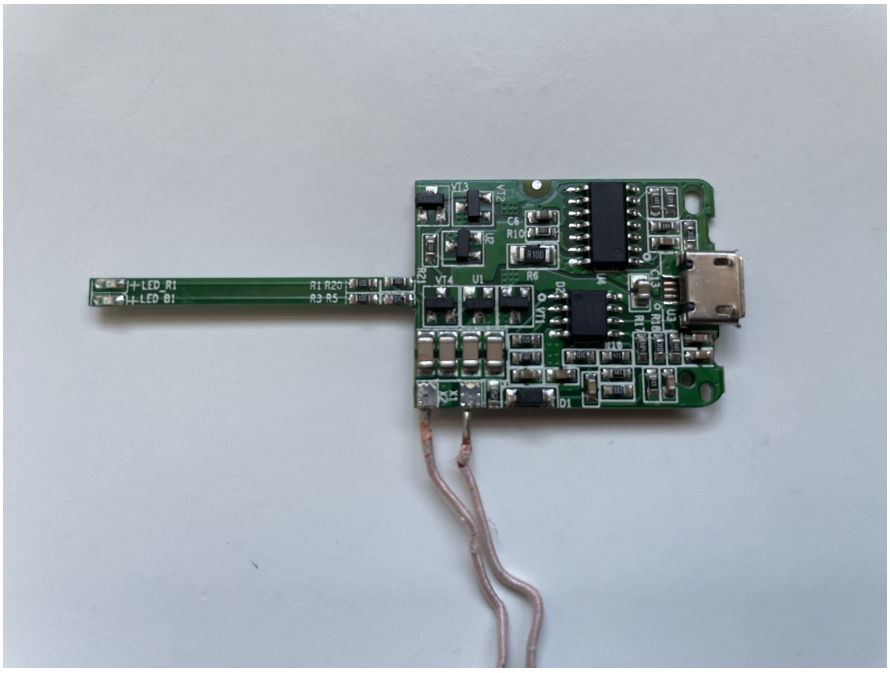


Figure 3.1: Front view of PCB

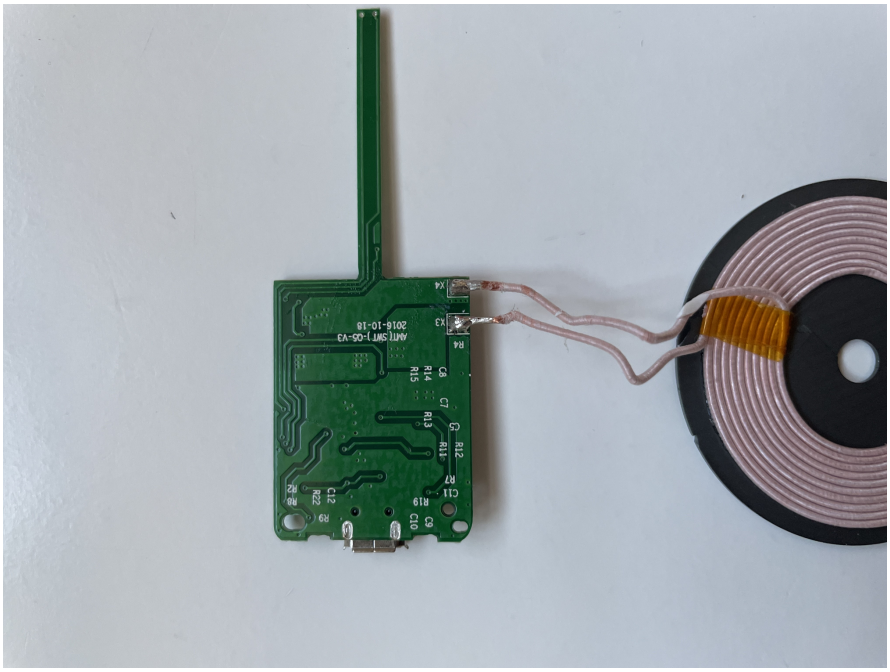
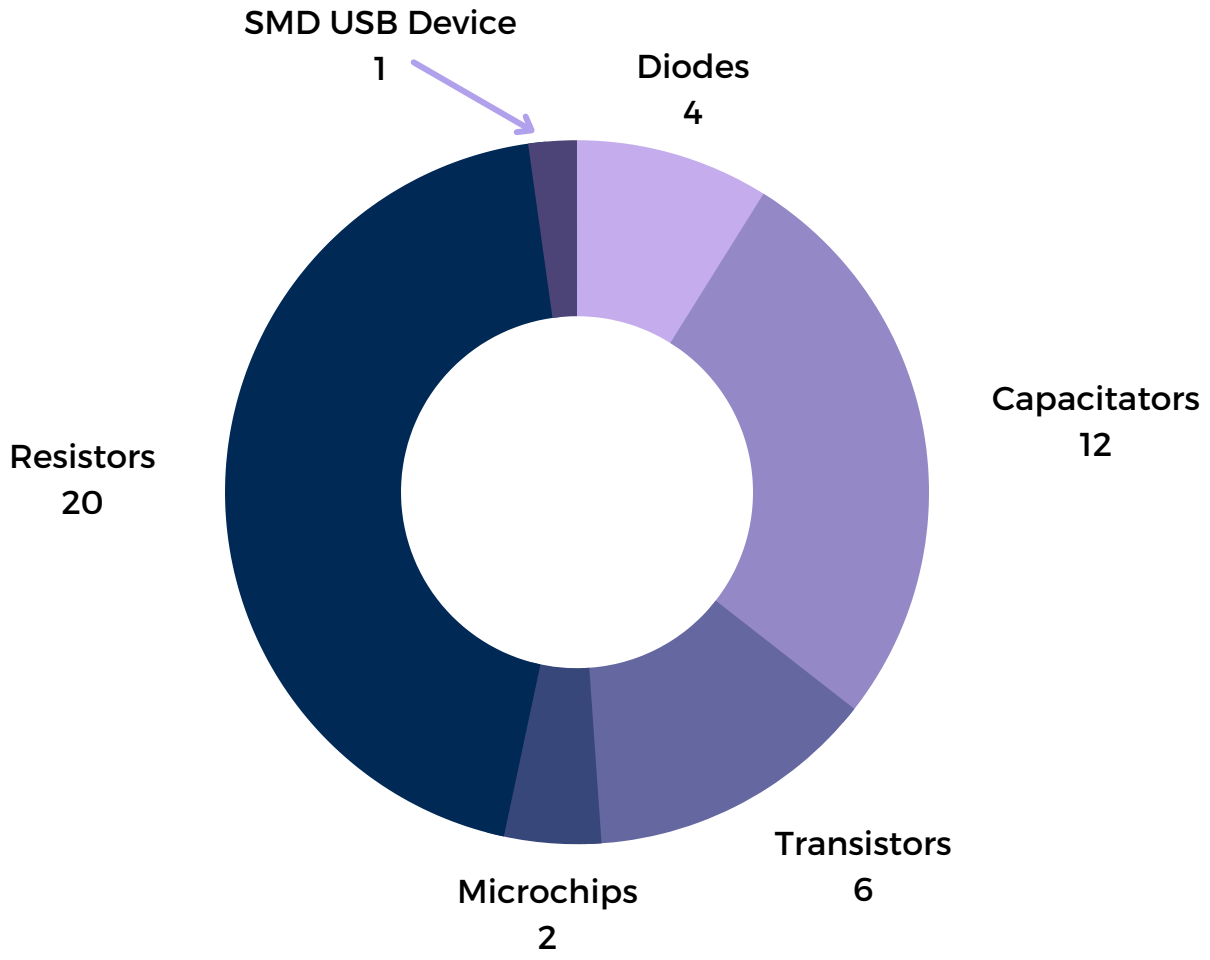


Figure 3.2: Back view of PCB

ANALYSIS PROCESS:

We analyzed the wireless charger and its components by first researching how a wireless charger generally works. By getting that background information, we were then more effectively able to deduce why some of the specific components were in the locations they were, what their use was, and how essential they were towards the entire process. We also heavily researched components of a PCB board, since both of us have had limited experience working with them and identifying their parts. We looked at the serial numbers printed on the SMD components and searched it up on Google to find datasheets and further investigate their use in the charger. Certain components' datasheets were also not on the internet, making it especially difficult to properly identify their function and use on the PCB.

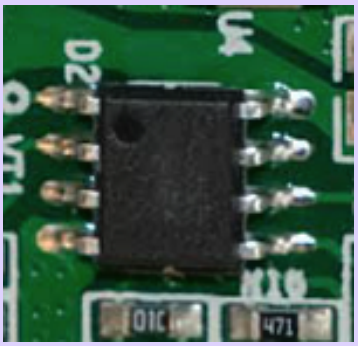
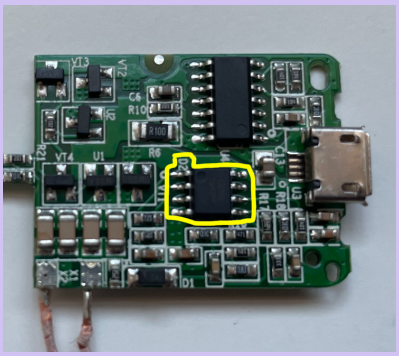
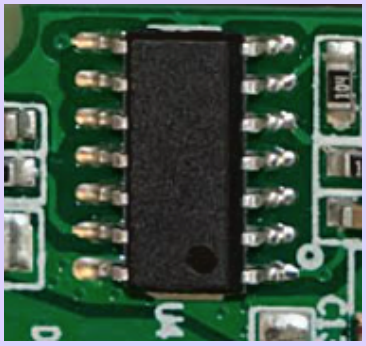
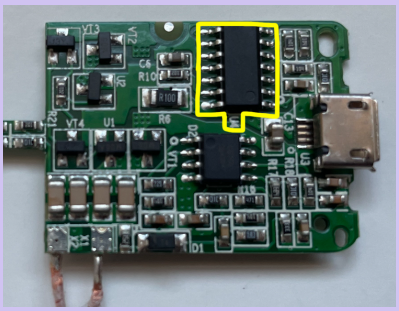
COMPONENT DISTRIBUTION*



*Estimates based on visual observations

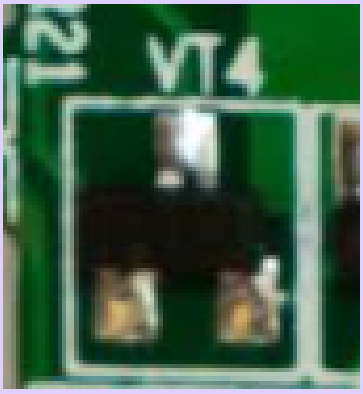
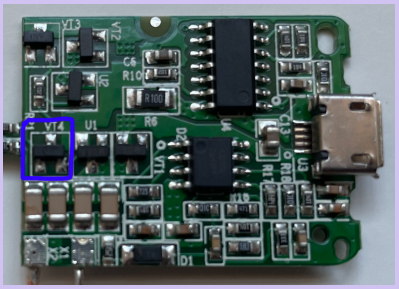
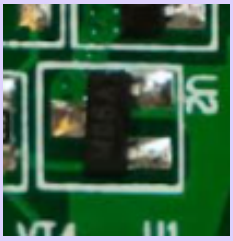
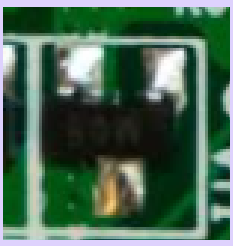
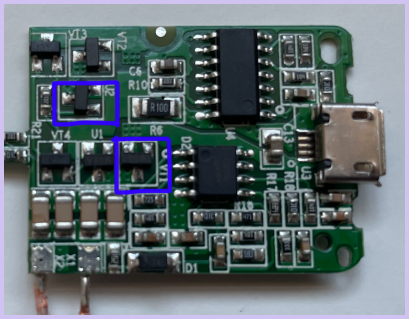
MICROCHIPS:

Microchips, also known as integrated circuits or ICs, are sets of electronic circuits printed on a small, flat piece of silicon. They can turn currents on and off and are essential in current managment.

DESCRIPTION	IMAGE	LOCATION
GS358 - Dual Operational Amplifier Microchip This microchip is used to regulate the voltage in the system. With its low power usage and ability to operate from one power source, it is perfect for battery operated systems (like the wireless charger) to function for a long time. Datasheet		
Unidentified Microchip Due to its lack of markings, we were unable to find its specific use, but we theorize it is used to regulate the electrical signals due to the wireless charger's high-power nature and volatility. No datasheet found.		

TRANSISTORS:

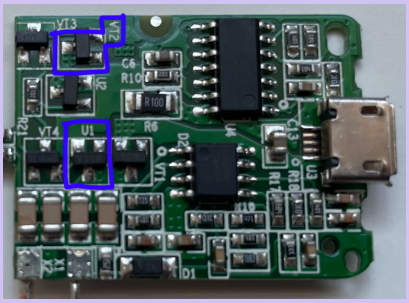
Transistors are used for amplifying, controlling, and generating electrical signals. It only lets a current flow in it one way, allowing it to effectively control signals. In a high-power device like a wireless charger, they are extremely important to make sure the device runs smoothly.

DESCRIPTION	IMAGE	LOCATION
S9015 - PNP SOT-23 Plastic-Encapsulate Transistor This transistor is likely used as a current amplifier due to the copper tracks that lead from a resistor into this transistor, which then flows into a voltage detector to ensure it has not dialed up the voltage too high. Datasheet		
APM2306A - N-Channel Enhancement Mode MOSFET Used for power management to reduce energy needed before another charge. Datasheet	 	

XC61FN2512LB - SOT-23 XC61F series Voltage Detector

Voltage detector with built-in delay circuit so the current does not overload the system.

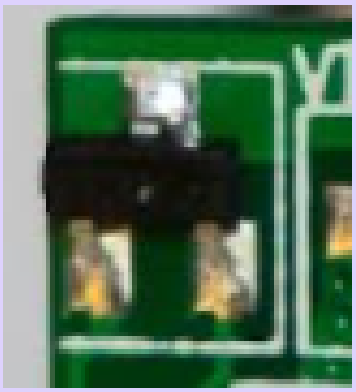
Datasheet

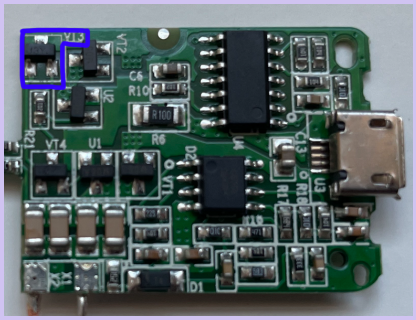


S8050 - NPN SOT-23 Plastic-Encapsulate Transistor

This transistor is a good general use transistor, but is likely used in a switch relay in this circuit due to the copper tracking that comes from a transistor and flows into another transistor.

Datasheet



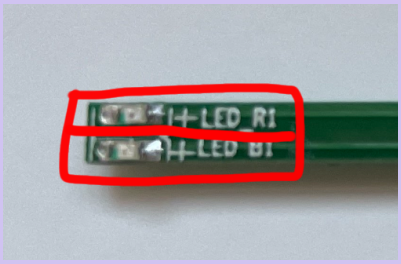


DIODES:

Diodes are mainly used to draw signals from a supply, control the size of a signal, mix signals, and turn AC into DC voltage. In a high-power device like a wireless charger, the current control function of diodes are essential.

LEDs (light emitting diodes)

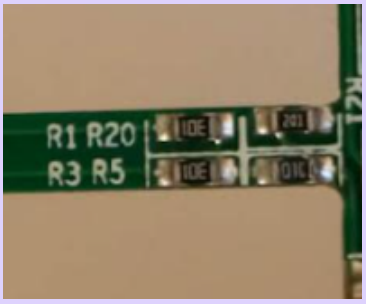
Gives off light when it is charging; orange light when in the process of charging, and green light when fully charged.

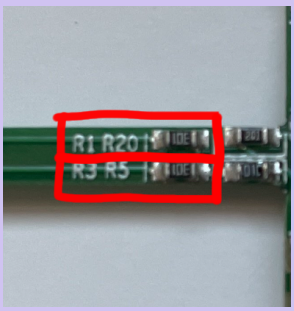


TV30C5V0 - SMD Transient Voltage Suppressor

Voltage detector so that the current does not overload the system.

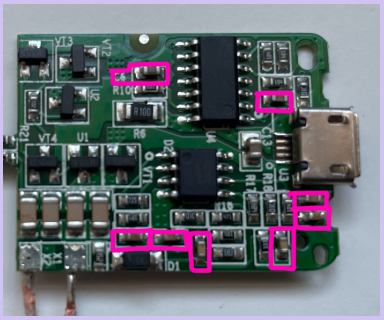
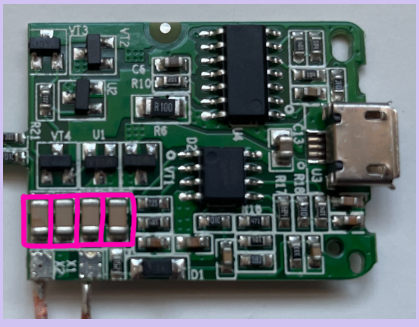
Datasheet





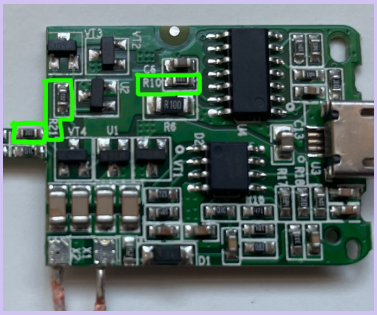
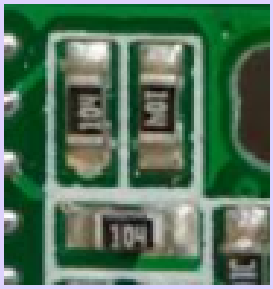
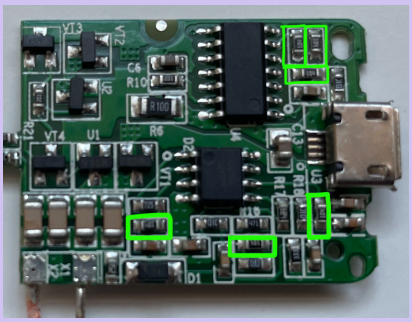
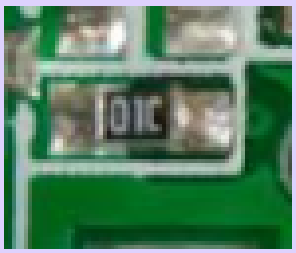
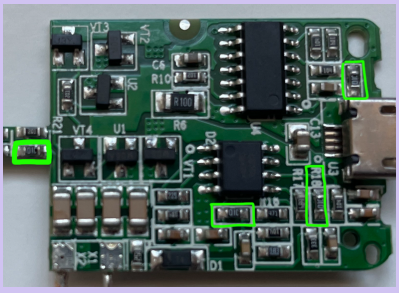
CAPACITORS

Capacitors are used to store charge, essential for a current-driven electronic device like a wireless charger. Their sheer number across the PCB shows how important it is to have these capacitors.

DESCRIPTION	IMAGE	LOCATION
Small capacitors These capacitors store enough energy for some of the smaller processes on the PCB.		
Large capacitors These larger capacitors are better for higher-energy processes on the PCB and store more energy in them than the smaller capacitors.		

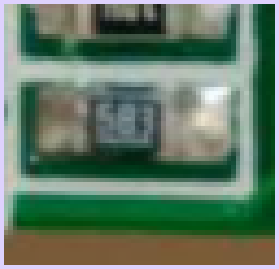
RESISTORS:

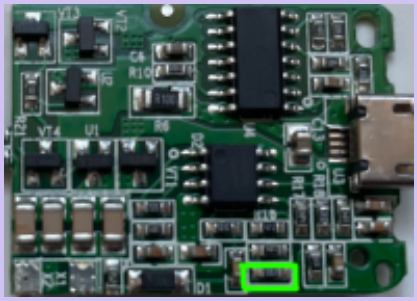
Resistors are used to ensure that all electrical components are getting the adequate amount of charge that they need, and are essential in preventing voltage spikes in electronics. The more resistance a resistor has, less power flows from the power sources to other electronic parts.

DESCRIPTION	IMAGE	LOCATION
201 Resistor 200 Ohms of resistance		
104 Resistor 100k Ohms of resistance		
01C Resistor 10k Ohms of resistance		

583 Resistor

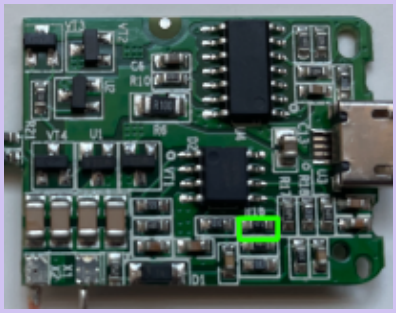
58k Ohms of resistance





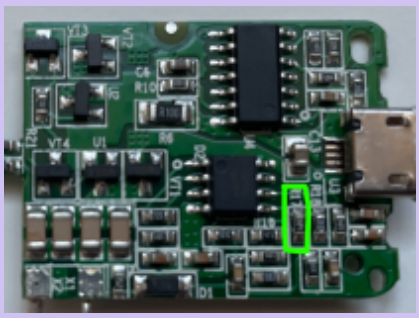
471 Resistor

470 Ohms of resistance



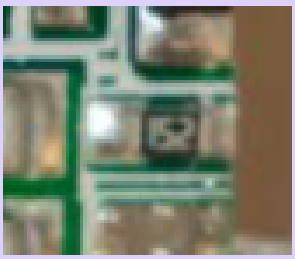
684 Resistor

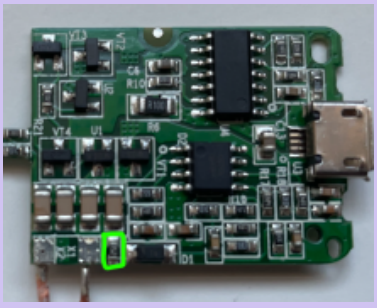
680k Ohms of resistance



152 Resistor

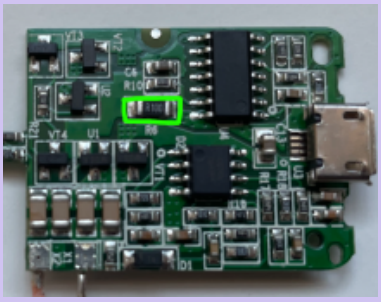
1.5k Ohms of resistance





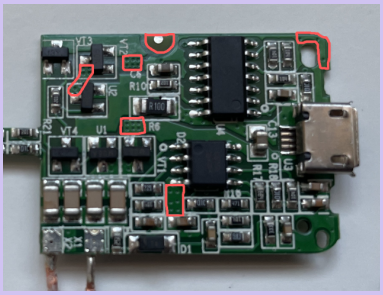
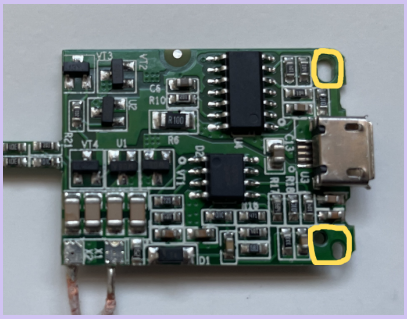
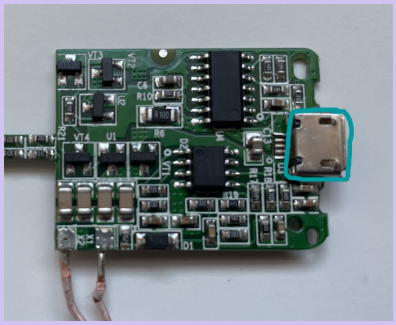
R100 Resistor

0.1 Ohms of resistance



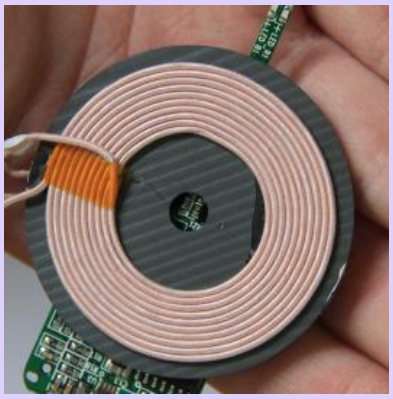
MISCELLANEOUS:

These parts did not fit in with any of the other categories listed above, but are still a vital part of the system.

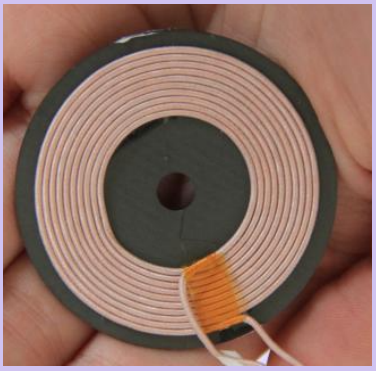
DESCRIPTION	IMAGE	LOCATION
Vias These small holes are used as a way to get an electrical current between copper layers in the PCB. They only go through one side of the board, and do not go fully through. They are varying sizes, and can either be filled with copper or left empty.		
Through Holes These holes allow for stronger connections between the layers of the PCB. They can either be plated with copper or left empty.		
SMD USB Device When the charger is plugged in with its Micro-USB cable, the device itself gets energy with this. The energy goes into the cable, which is plugged into the SMD device, which connects to capacitor on the PCB to store energy.		

Copper wire coil

This coil is used in wireless charging by using electromagnetic induction to transfer an electric charge from the wireless charger to the device that needs to be charged. The shape is in a coil to maximize the amount of copper the charger has for the limited amount of space it has available to use.

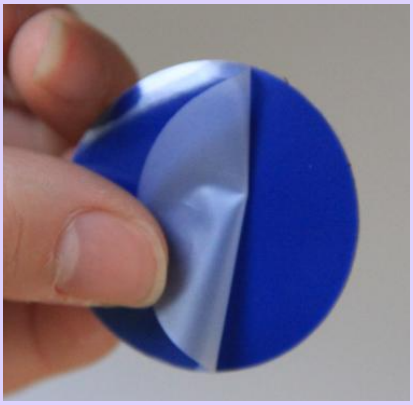


On the very top of the charger, resting on top of the metal coil rest

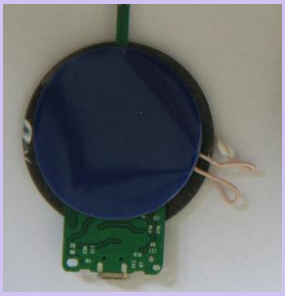


Gel silicon membrane

This membrane is soft and circular in shape and is on the very back of the charger. Because silicon is an insulator, it is likely used to keep the entire charger cool and stop it from overheating. The top of it was sticky and stuck to the bottom of the PCB.



On the very bottom of the charger, under the PCB in the middle of the charger



Tape

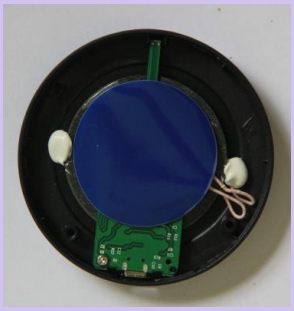
The clear, orange tape is used to hold the copper coil to the metal rest to keep it secure and stop it from moving around.

Wrapping around the top of the copper coils

White silicon adhesive

This secures the metal rest for the copper coils into the inside of the charger. It is likely a medium-cure silicon sealant due to its drop-like shape and slightly squishy yet firm texture.

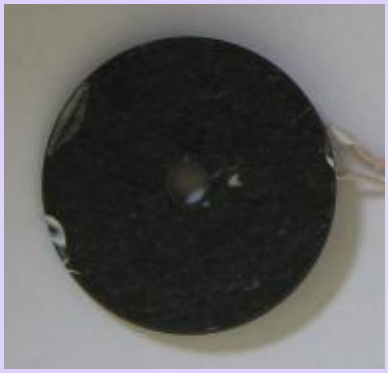
Towards the bottom of the charger, securing the bottom of the metal rest to the inside of the charger



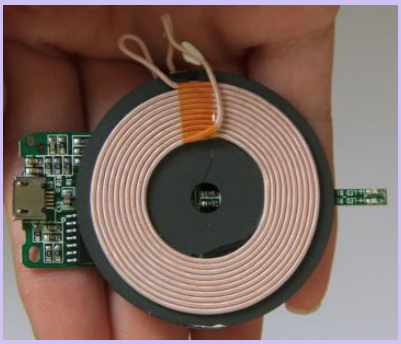
Metal rest for copper coils

Metal works as an inductor to create a stronger electromagnetic field around the copper coils in order to charge the mobile device more effectively.

(Bottom view)



Under copper coils, on top of PCB



Plastic case

It encases the entire structure in a compact yet secure fashion for increased portability. It has a Micro-USB port on its side to be plugged into the wall to be charged. The case is also plastic because it acts as an insulator, so it is much less likely to warm up or get overly heated as compared to inductors like metals.

(Top & bottom cases)

Enveloping all components on top & on the bottom

FINAL REPORT SUMMARY

Wireless chargers are becoming a more integral part of modern life with each passing day. Because of this, we decided to deconstruct an inexpensive Sphere Wireless Charging Pad to truly understand its inner mechanisms.

The circuit board was very small and rather simple in its electrical components. A majority of its SMD components components were resistors, followed by capacitors. This distribution speaks to its high-energy nature. Capacitors are absolutely essential for this mechanism, because without it, the entire circuit could not hold any power and would thus fail to function. A majority of the capacitors are focused around the micro USB port and the copper coils, which makes sense because that is where the brunt of the power is collected and then used. Resistors were scattered throughout the the PCB to maintain an acceptable voltage. Many of the other components, like the various diodes and microchips, were also voltage detectors, showing how integral it is to manage the heat and voltage of the charger.

At a high level, the PCB works by getting power through its micro USB cable. As it is plugged in, energy flows into the capacitors near it, and through the copper tracking, it travels through the PCB board into the copper coils. All throughout the way, there are numerous resistors, transistors, and microchips that is keeping the voltage level in check to ensure both the mobile device and the charger itself do not get damaged. Because of how much energy is contained in the capacitors, overheating is a very real possibility if there is not enough voltage detection and suppression throughout the entire system.

After the power flows into the copper coils, an oscillating electromagnetic field is created as the power flows in and out of the coils. The charger's electromagnetic field interacts with the mobile device's electromagnetic field that is has from its own induction coil made from copper. As the two fields interact, the electrons move around flow into the mobile device's battery.

The most significant part of breaking down the charger was realizing how much voltage control and detection goes into a wireless charger. Mobile devices are sensitive to extreme heat and electric charges, and the charger itself creates lots of heat from the sheer amount of power it stores and cycles. As such, numerous precautions are taken to ensure that nothing goes wrong and everything continues to run smoothly, like adding "checkpoints" for the current through resistors and adding a silicon gel membrane to insulate the charger. The future of wireless charging is developing before our very eyes, and it is exciting to think about what lays ahead.

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