

## Levitating Globe

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## Introduction

### Abstract

Science, technology, engineering, and math (STEM) based academic courses have historically had a difficult time generating interest from American students. While not an all-encompassing solution to the problem, our goal was to create an interactive levitating Earth model display which will serve as an effective demonstration of concepts and applications of magnetism and spark an interest in the field of physics. Stable levitation via magnetism was once thought to be infeasible two centuries ago, but advances in control systems have made it viable with powerful real-world applications. As a levitating Earth model, it is important to demonstrate the concept of rotation, which can be accomplished with the use of a motor. Motors rely on an interaction between two magnetic fields and serve as an opportunity to demonstrate how magnetic fields are the link between electrical and mechanical energy conversions. Finally, wireless power transfer is an emerging technology which can be used to deliver electrical energy across distances without the use of physical connections. Through further examination, it is discovered that magnetism is the driving force behind current wireless power transfer methods which are becoming prominent in commercial products.

### Need Statement

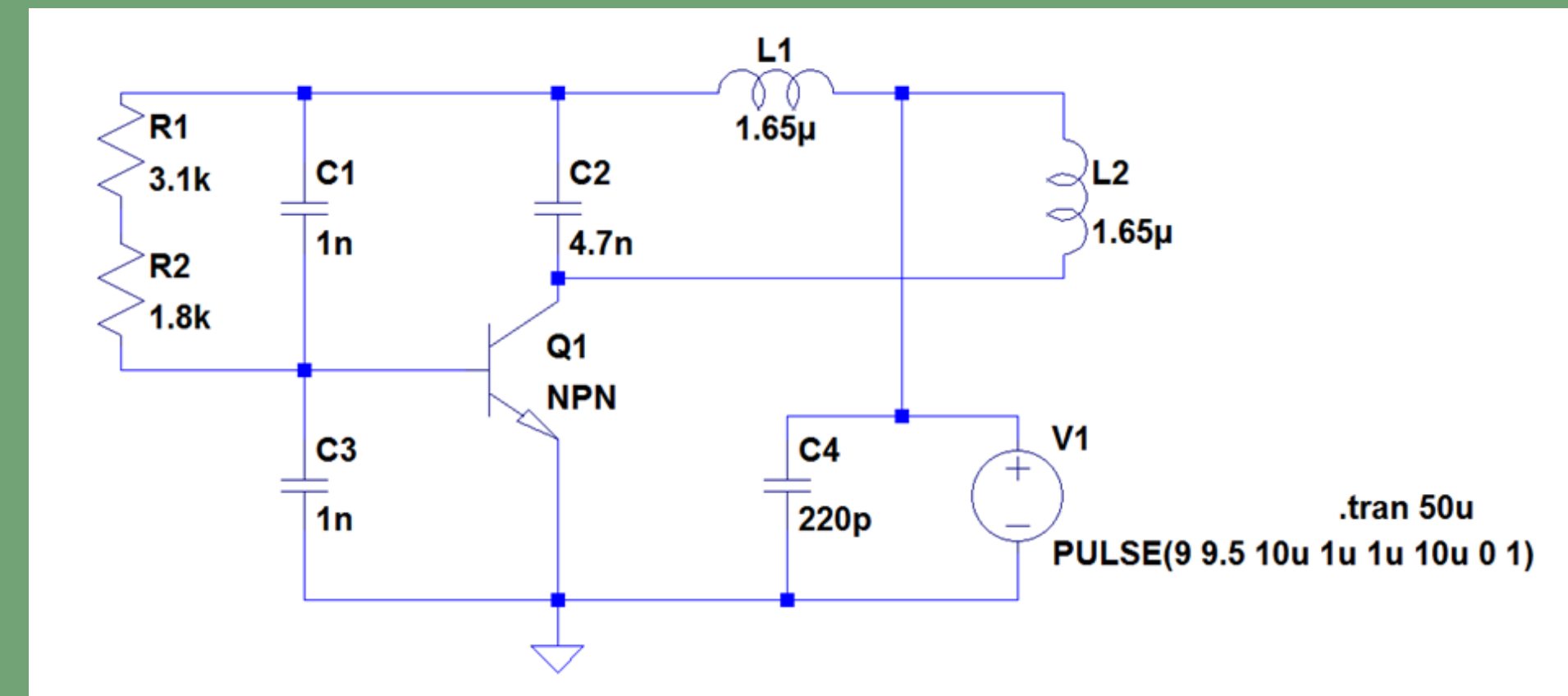
According to Teach for America, American students lag far behind their international peers in understanding of the subjects of science, technology, engineering, and math (STEM). The United States was ranked 25<sup>th</sup> in math and 17<sup>th</sup> in science among 27 industrialized nations. It is expected that 60% of jobs created in the 21<sup>st</sup> century will require STEM based skills, but only an estimated 20% of the current workforce possesses these skills. While STEM based jobs are generally among the most lucrative in America, among students who are proficient in math, up to 27% are disinterested in STEM subjects. There is a need to solve the disconnection between STEM subjects and student interest.

### Objective Statement

The objective of this project is to create an Earth model globe levitating through the use of magnetism. The device will serve as a demonstration of magnetic concepts and spark an interest in the field of physics for students of any age. The rotation of the Earth model will be powered wirelessly and remove the need for batteries.

## Wireless Power System

A Hartley oscillator was created in order to convert 9V DC into a 1.2MHz AC sinusoidal voltage. This voltage produces a current in the transmission inductor which produces an alternating magnetic field. The transmission inductor is composed of 4 turns of 12AWG magnet wire.



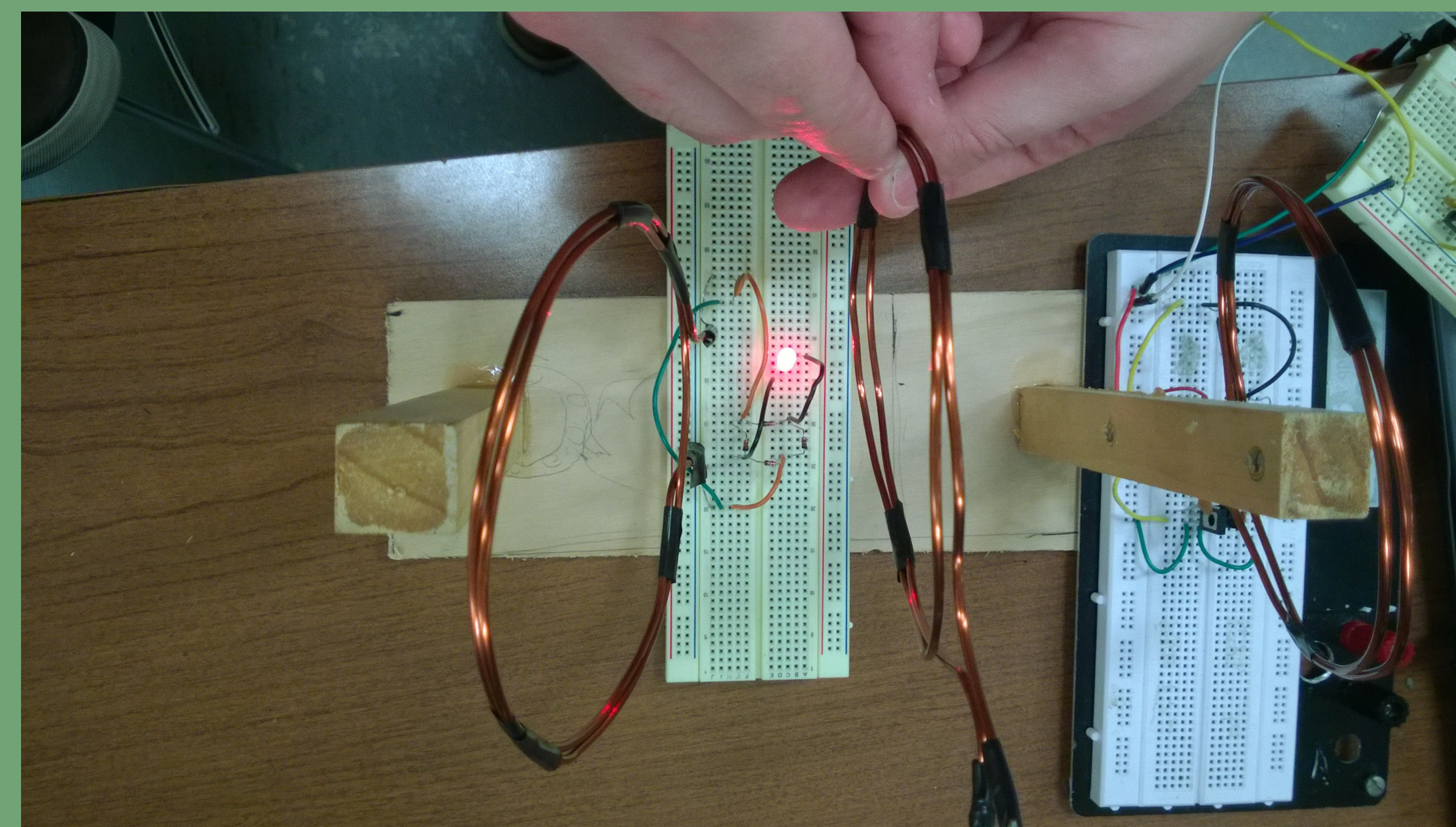
The exciter coil is also composed of 4 turns of 12AWG magnet wire. This coil has minimized reactance due to a parallel capacitor which tunes this LC circuit to resonance at 1.2MHz. The coil generates its own magnetic field and boosts the maximum distance of energy transfer from the transmitter coil to the receiver coil.



The receiver coil is composed of 8 turns of 12AWG magnet wire. This coil is smaller than the others in order to fit inside of the 4 inch diameter globe. In order to bring this coil to resonance at 1.2MHz, it is paired with a 3.3µF capacitor. The receiver coil feeds 1.2MHz AC into a diode bridge rectifier to produce DC for the 6RPM gear motor. The motor and receiver/rectifier circuit are mounted on the bottom of a plastic coated magnet which makes up the levitating device.

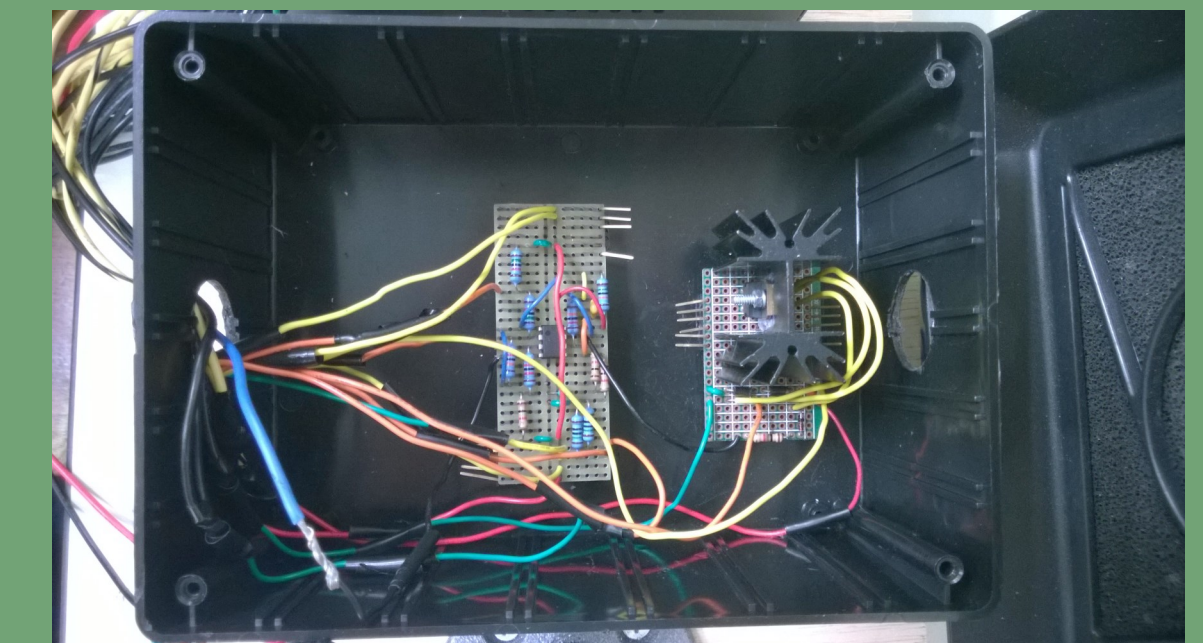


In order to provide a visual demonstration, the circuit was reproduced to power an LED. The distance between the transmitter and receiver coil is 6" with the exciter coil boosting the magnetic field.

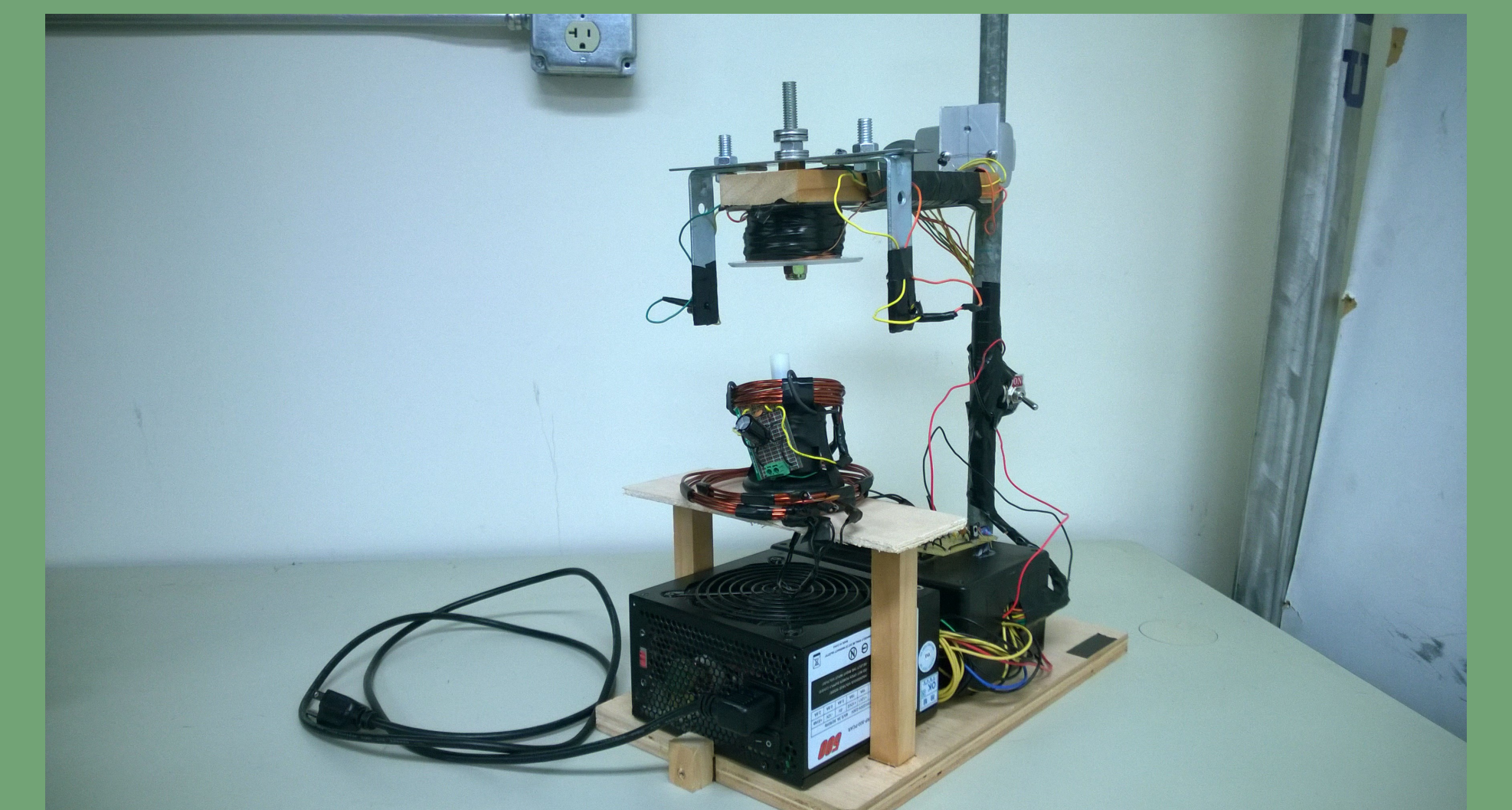


## Construction

The infrared levitation circuit was placed inside of a black plastic box and held down with pin headers glued to the base of the box. The TIP102 transistor in this circuit becomes hot quickly even with the attached heatsink. A CPU fan was mounted on the lid of the box above the heatsink, and draws cool air into the box which is ventilated through the side. Wires from the modified ATX power supply are connected to the levitation circuit inside of the box.

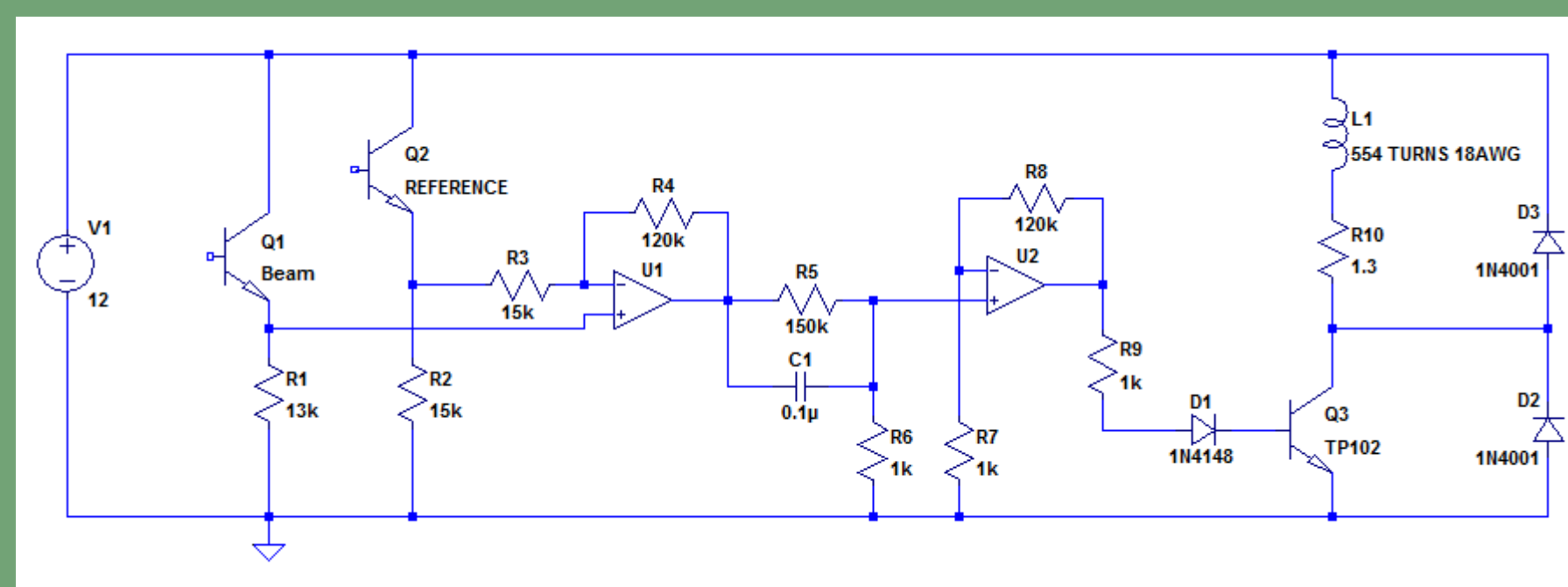


A wooden base was used as support for the entire device. A metal rod supports the electromagnet and infrared LED and phototransistor pairs, which are mounted on an adjustable clamp. The power supply and box containing the levitation circuit rest on the wooden base.

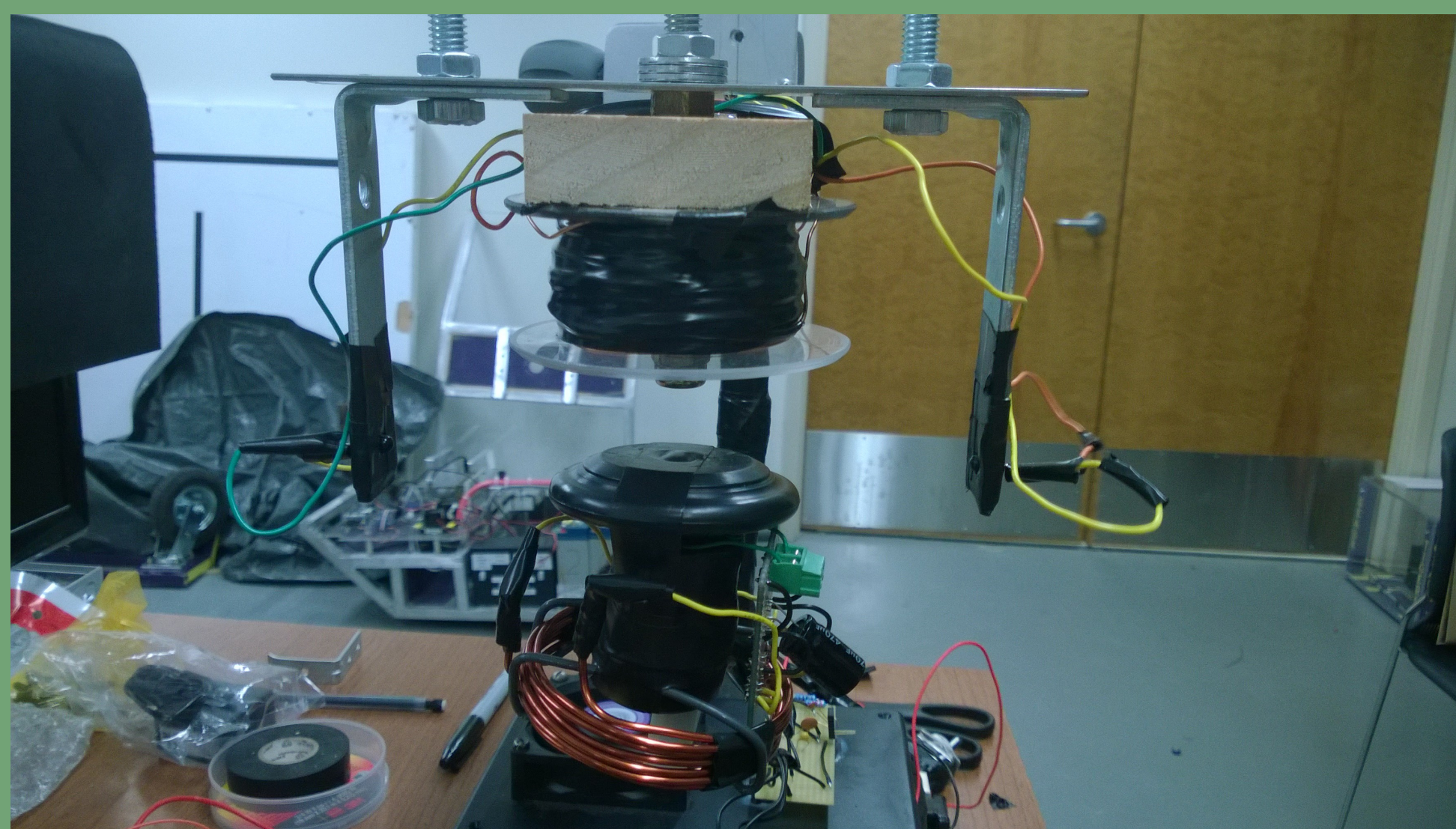


## Infrared Levitation System

Two infrared phototransistors are used in the levitation system. The first phototransistor is paired with an infrared LED which serves as the reference and automatically adjusts the system for changes in ambient lighting conditions. The second phototransistor detects the position of the levitated object based on the amount of infrared light received from its paired LED. The difference between these two signals is calculated by an op amp and used to stabilize the position of the levitated object. This is done by the op amp output current feeding the base of a TP102 transistor. This transistor adjusts current through a 554 turn 18AWG magnet wire solenoid to provide a powerful magnetic field.



The final calculated weight of the plastic globe model and its inner components is 13.8 ounces.



## Results

The globe levitates stably and is easy to place in its equilibrium position. The device should not be run for more than a few minutes at a time as there are several amps of continuous current through the solenoid while the globe is levitating. When the wireless power is applied to the levitating globe, the entire enclosure of the motor rotates due to the frictionless environment and it is not necessary to connect the plastic globe model to the motor's output shaft.

The entire system is light enough to be carried around, small enough to fit on a desk, and requires only one plug into a wall outlet. It is easy to bring to classrooms for demonstrations. The globe's internal magnet is strong enough that it can be securely attached to either the metal post holding the arm or the base of the solenoid.

The design process is an iterative one. Our final design was different in both look and size from our preliminary design, but we have stayed true to our objective: magnetic levitation and wirelessly powered rotation in an easy to present format.

Overall, we feel like the device serves as an effective demonstration of magnetic applications accomplishing our main goal.

