

# Indiana University – Purdue University Fort Wayne Opus: Research & Creativity at IPFW

---

Computer and Electrical Engineering Technology &  
Information Systems and Technology Senior Design  
Projects

School of Engineering, Technology and Computer  
Science Design Projects

---

4-30-2014

## Audio Modulated Tesla Coil

Ben Angel

*Indiana University - Purdue University Fort Wayne*

Brandon Bodeker

*Indiana University - Purdue University Fort Wayne*

Corey Delaney

*Indiana University - Purdue University Fort Wayne*

Follow this and additional works at: [http://opus.ipfw.edu/etcs\\_seniorproj](http://opus.ipfw.edu/etcs_seniorproj)



Part of the [Computer Sciences Commons](#), and the [Engineering Commons](#)

---

### Opus Citation

Ben Angel, Brandon Bodeker, and Corey Delaney (2014). Audio Modulated Tesla Coil.  
[http://opus.ipfw.edu/etcs\\_seniorproj/965](http://opus.ipfw.edu/etcs_seniorproj/965)

This Senior Design Project is brought to you for free and open access by the School of Engineering, Technology and Computer Science Design Projects at Opus: Research & Creativity at IPFW. It has been accepted for inclusion in Computer and Electrical Engineering Technology & Information Systems and Technology Senior Design Projects by an authorized administrator of Opus: Research & Creativity at IPFW. For more information, please contact [admin@lib.ipfw.edu](mailto:admin@lib.ipfw.edu).

# **Audio Modulated Tesla Coil**

**Final Project Report**

**4/30/2014**

**Ben Angel - EET**

**Brandon Bodeker - EET**

**Corey Delaney - EET**

**Professor: Dr. Lin**

**Project Advisor: Dr. Momoh**

**Submitted to:**

**Paul I. Lin, Professor of ECET 491 Senior Design II**

**Department of Computer, Electrical, and Information Technology**

**College of Engineering, Technology, and Computer Science**

**Purdue University Fort Wayne Campus**

## Abstract

The purpose of this project is to design and construct a Tesla coil to receive an audio input and modulate the power output from the coil with the input audio to create an outputted sound similar to the inputted sound. The project consists of three main parts: The first part is research into the area of Tesla coil theory, secondly comes the design and construction of the project, then thirdly the testing and troubleshooting of the system all of which will provide us with opportunities to learn and really get an idea for how the system operates. Probably the most critical part of the project, the research, is what will provide the group with a foundation both physically, with the hardware and schematics, and mentally, in terms of understanding how the technology works and becoming familiar with the inner workings of the system.

Construction of the coil entails the building of an enclosure as well as the development of both a primary and secondary coil (as per parameters found online). Design of the system will encompass the research performed up to this point and implement it into the development of an overall system design as well as the procurement of parts to satisfy the system parameters. It will be crucial to ensure that the design used be able to perform and meet the standards set at the beginning of the project proposal. When the testing and troubleshooting begins is when the individual team members will be able to really show and use their abilities learned and honed to this point in order to make the overall system operate properly and safely.

The completed Tesla coil shall provide an end product that can accept any audio input via ¼” jack or 3.5mm jack and play the sound through the outputting arcs of electricity from the Tesla coil through the atmosphere. The system shall also have the ability to safely manipulate the input power to directly affect the output signal as well as provide a safe and controlled means of powering the system down; in the end providing a relatively safe and entertaining new way of outputting and experiencing sound.

### **Keywords**

Step-up transformers - the process of taking an input voltage and current and manipulating it to the desired specific values

Traces – small “wires” on a circuit board that connect components

IGBT – “Insulated-gate bipolar transistor” is, essentially, an electronic switch capable of switching extremely fast

MIDI – digital audio file type

IC’s – “integrated circuit”; meaning there are quite a few electrical components creating a small circuit all contained within a single small chip, or “microchip”

LCR meter – electrical meter that measures inductance, capacitance, impedance, and resistance

Resonant – electrical signal that varies in amplitude as if it were vibrating naturally

Modulator – something that changes manipulates or varies an electrical frequency/signal

Toroid – Donut shaped metal fixture atop a Tesla coil that serves as a means of capacitance of voltage before it discharges into the atmosphere

Zuesaphone – Term used to refer to a Tesla coil capable of outputting a musical tunes

Primary – Coil of copper in a Tesla coil whose purpose is the amplification of Current

Secondary – Coil of wire whose purpose is the conversion of high current to high voltage

## Table of Contents

<b>Abstract</b> .....	2
<b>List of Illustrations</b> .....	5
<b>List of Tables</b> .....	6
<b>Executive Summary</b> .....	7
<b>Chapter 1: Introduction</b>	
Problem Topic .....	8
Background .....	8
Primary Purpose .....	9
Overview .....	9
<b>Chapter 2: System Design Overview and Research</b>	
Feasibility .....	11
Design Process .....	11
Legal Aspects .....	13
System Scope .....	14
<b>Chapter 3: Hardware</b>	
Circuit Design .....	16
Construction .....	16
<b>Chapter 4: Unit Testing and System Integration</b>	
Hardware Testing and Validation .....	20
System Integration, Testing, and Validation .....	21
<b>Chapter 5: Project Management</b>	
Schedule and Time Management .....	33
Resource and Cost Management .....	35
Quality Management .....	35
Risk Management .....	35
Project Procurement .....	36

## **Table of Contents (Cont.)**

**Chapter 6: Conclusion.....37**

### **Appendices**

<b>A</b>	<b>System Schematics .....</b>	<b>38</b>
<b>B</b>	<b>Multisim Simulation Set-ups .....</b>	<b>42</b>
<b>C</b>	<b>Parts Lists .....</b>	<b>46</b>
<b>D</b>	<b>Datasheets.....</b>	<b>49</b>
<b>E</b>	<b>Populating Components.....</b>	<b>51</b>

## List of Illustrations

- Figure 1: Top level system block diagram
- Figure 2: Full system assembly with completed Primary Coil
- Figure 3: Primary Coil Construction
- Figure 4: Secondary Coil Construction
- Figure 5: Primary and secondary coil inductance and resistance values
- Figure 6: Approximate pulse width potentiometer settings
- Figure 7: Top down diagram of Midi Interface Board integrated setup
- Figure 8: Demonstration of MIDI Interface board using guitar
- Figure 9: Top down diagram of integrating Half-Bridge power board
- Figure 10: Self-starting operation
- Figure 11: IGBT polarity scope capture
- Figure 12: IGBT output waveform rise/fall time measurements zoomed out
- Figure 13: IGBT output waveform rise/fall time measurement of 230ns (<250ns)
- Figure 14: Output of half-bridge board (yellow) vs output of capacitor bank (blue)
- Figure 15: Tuning setup for secondary coil resonant frequency
- Figure 16: Primary coil resonant frequency tuning
- Figure 17: Secondary resonant frequency
- Figure 18: Completed coil assembly
- Figure 19: Gantt chart
- Figure 20: Risk matrix
- Figure 21: Primary current sense and over current schematic
- Figure 22: Primary current feedback and external modulator input to the gate driver schematic
- Figure 23: Display board schematic
- Figure 24: Buck transformer with the 5 and 15VDC regulators
- Figure 25: Over-temperature sensor circuit
- Figure 26: Half-bridge power section with primary capacitors
- Figure 27: High voltage power supply and bleeder circuit
- Figure 28: Primary current sense Multisim layout/simulation
- Figure 29: Display Board Multisim layout/simulation
- Figure 30: AC buck transformer to 5VDC and 15VDC regulators Multisim layout/simulation
- Figure 31: Over temperature sensor Multisim layout/simulation
- Figure 32: Half-bridge circuit with primary (MMC) capacitors Multisim layout/simulation
- Figure 33: Current feedback and modulator input, going to the gate driver Multisim layout/simulation
- Figure 34: High voltage DC bus supply and bleeder circuit Multisim layout/simulation
- Figure 35: Populated DRSSTC boards built up, prior to being cut away from each other
- Figure 36: MMC capacitor bank
- Figure 37: Unpopulated Midi Interface board
- Figure 38: Completed MIDI interface board

## List of Tables

Table 1: Self Resonate board probed readings

Table 2: Midi Interface board probed readings

Table 3: Frequencies of specific notes on a keyboard and guitar

Table 4: Work breakdown per team member

Table 5: Total system cost breakdown

Table 6: Risk assessment data sheet

Table 7: Driver parts list

Table 8: Driver parts list cont.

Table 9: Modulator parts list

Table 10: Parts list with datasheet link (1)

Table 11: Parts list with datasheet link (2)