NESLA Coil

Group 32

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Problem Statement

- A revolution beginning with the release of 8-bit masterpieces like *Super Mario Bros.* and *The Legend of Zelda* on the Nintendo Entertainment System has made video game music an iconic, well appreciated, cultural symbol in the digital era.
- This project strives to create classic NES music by producing the sounds in a novel way. Instead of a traditional diaphragm speaker, we will be using the electrical discharge output from a Tesla Coil.
- The “singing arcs” will be produced by controlling the switching frequency of our switching circuit. This will be determined by pulse-width-modulating a stream of digital audio samples from a Raspberry Pi’s GPIO output interface.

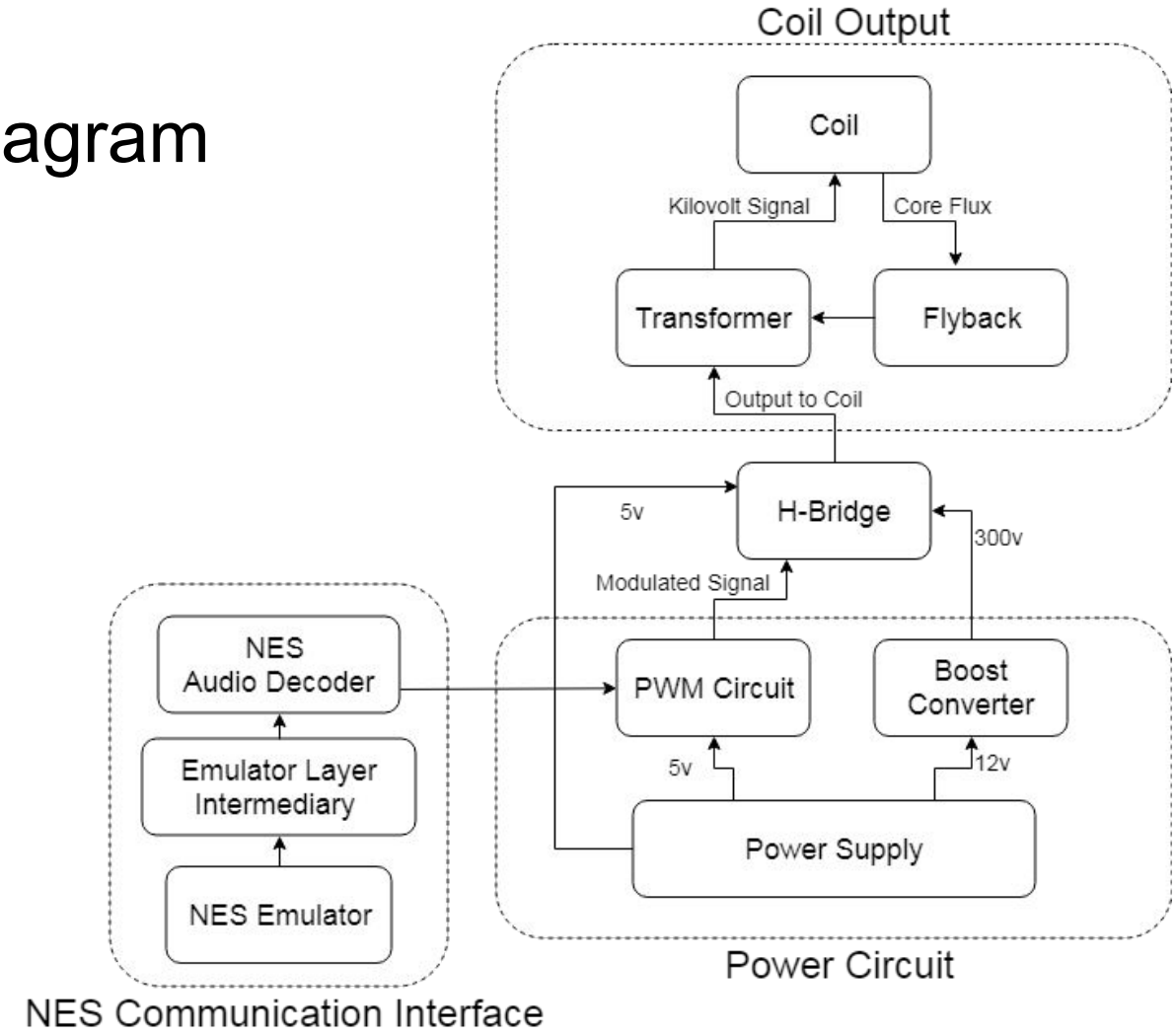
High-Level Requirements

- The Tesla Coils' toroidal top load should be able to emit sparks between 8 to 10 inches in length.

- The Tesla Coil's electrical discharge should be able to emit sound waves that cover the entire set of audio waveforms from the sound channels on the Nintendo Entertainment System's APU.

- The Tesla Coil's audio modulation inputs should be transparent to the NES APU. Meaning that to the NES APU, the Tesla Coil outputting the sound is equivalent to the standard Television Diaphragm speaker it was originally designed for.

Block Diagram



Physical Design

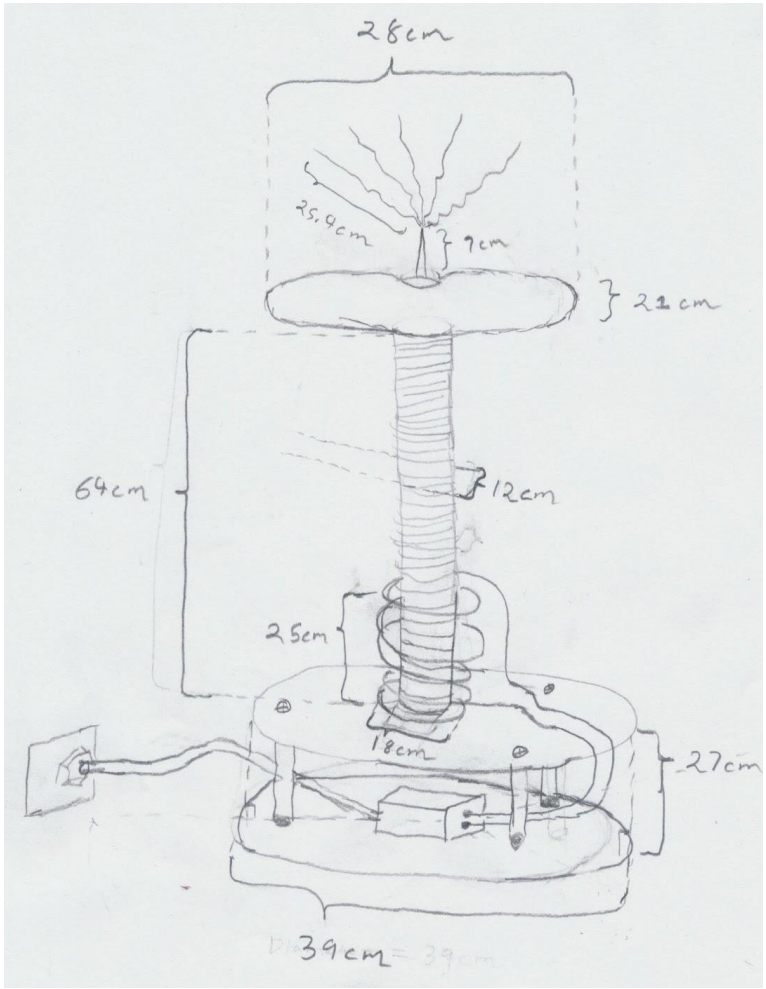
Toroidal Capacitance
11.51pF

Secondary Coil Capacitance
9.48 pF

Secondary Inductance
29.4 mH

Primary Inductance
0.006 mH

Resonant Frequency
202 kHz



Equations

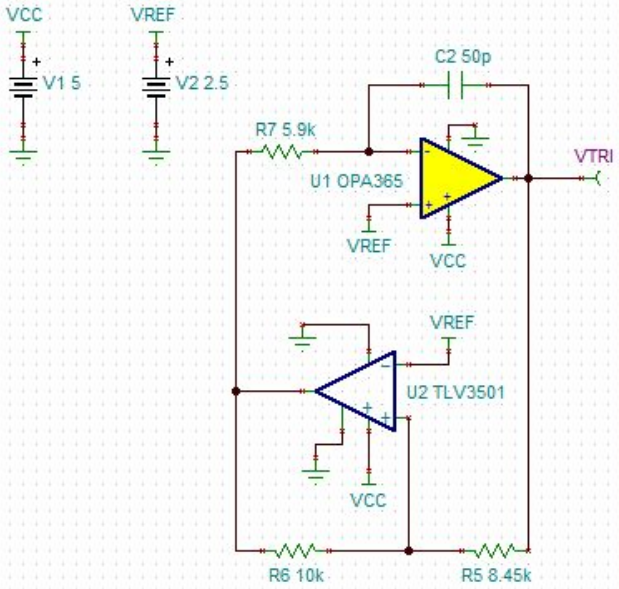
$$C_S = \begin{cases} \dfrac{1.8\frac{pF}{cm}(D-d)}{\ln\left(8\frac{D-d}{d}\right)}; \dfrac{d}{D} < \dfrac{1}{4} \\ 0.37D + 0.23d; \dfrac{d}{D} > \dfrac{1}{4} \end{cases}$$

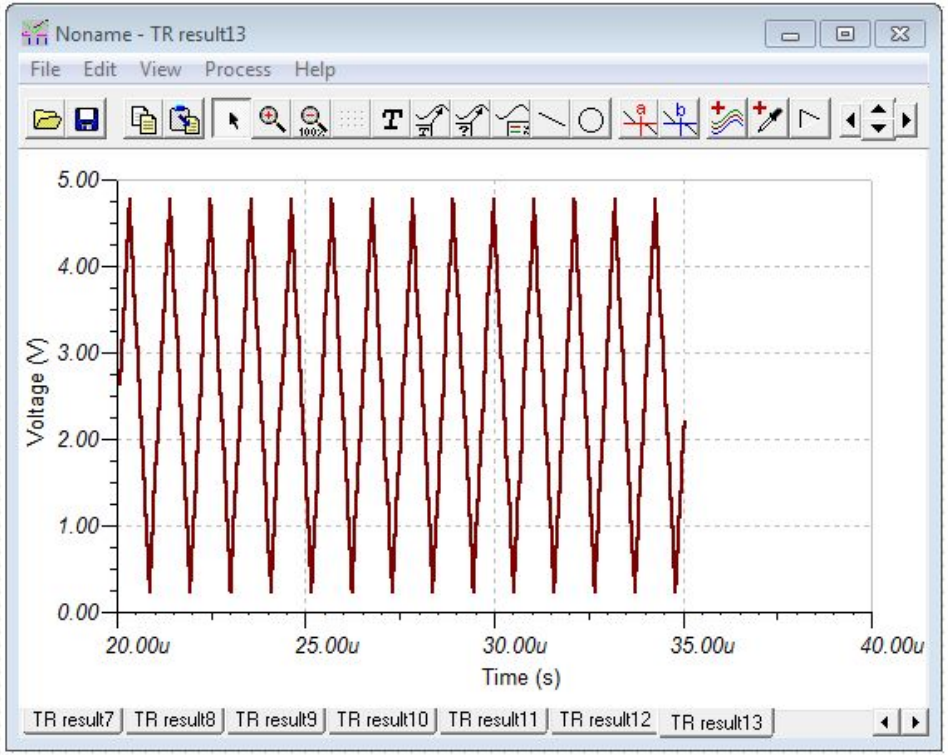
Let C_S be the toroidal top load's capacitance [pF]
Let D be the toroidal top load's outer diameter [cm]
Let d be the toroidal top load's inner diameter [cm]

$$L_w = \frac{r^2 N^2}{9r + 10l}$$

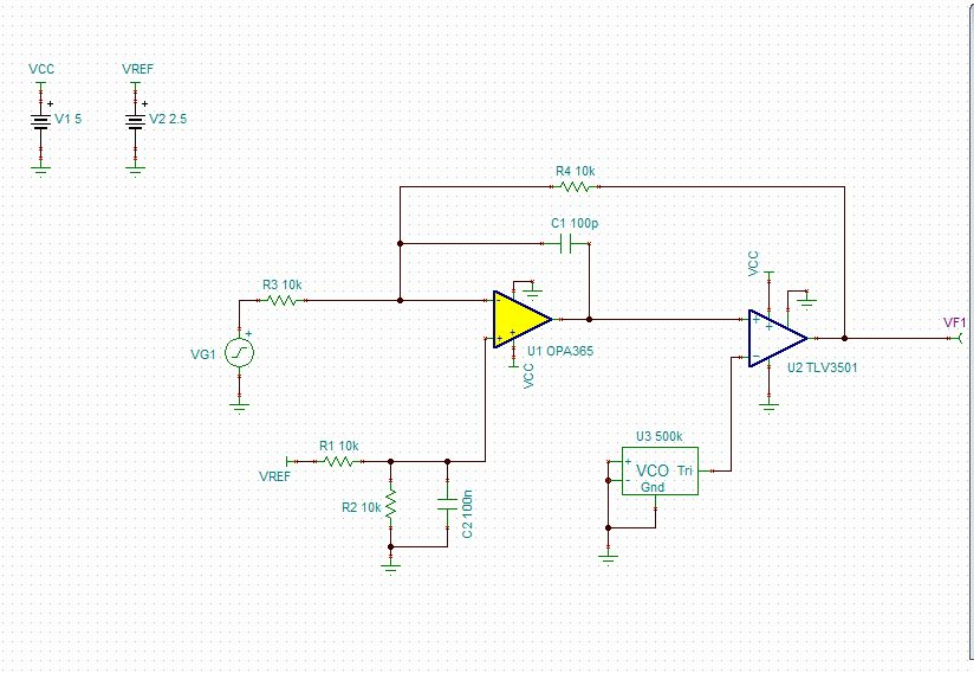
Let L_w be the solenoid inductance [μH]
Let r be the radius of the coil [in]
Let l be its length [in]
Let N be the number of windings around the solenoid's core

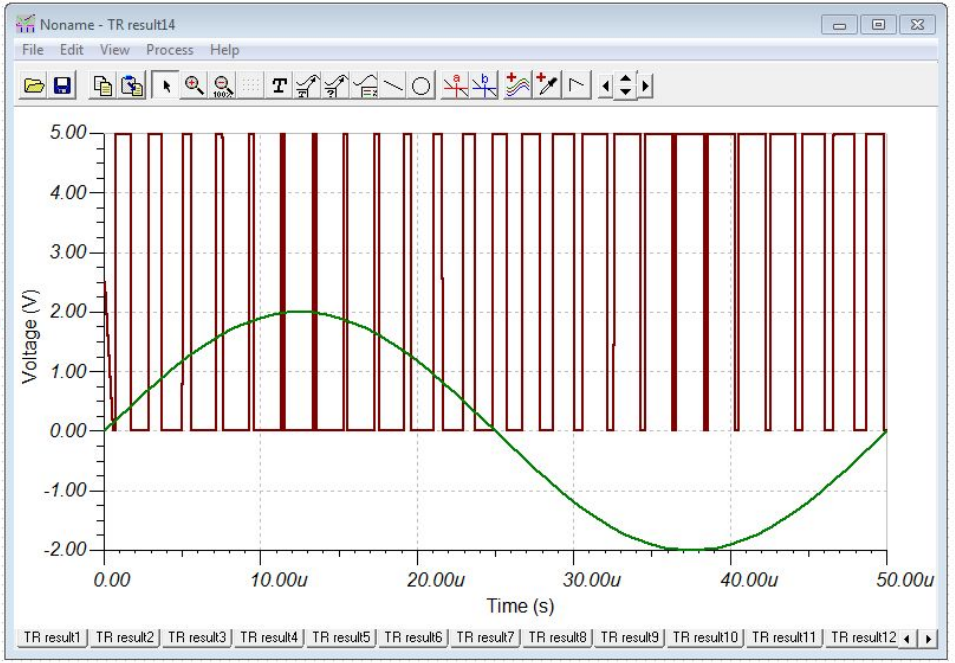
PWM: Triangle Wave generator



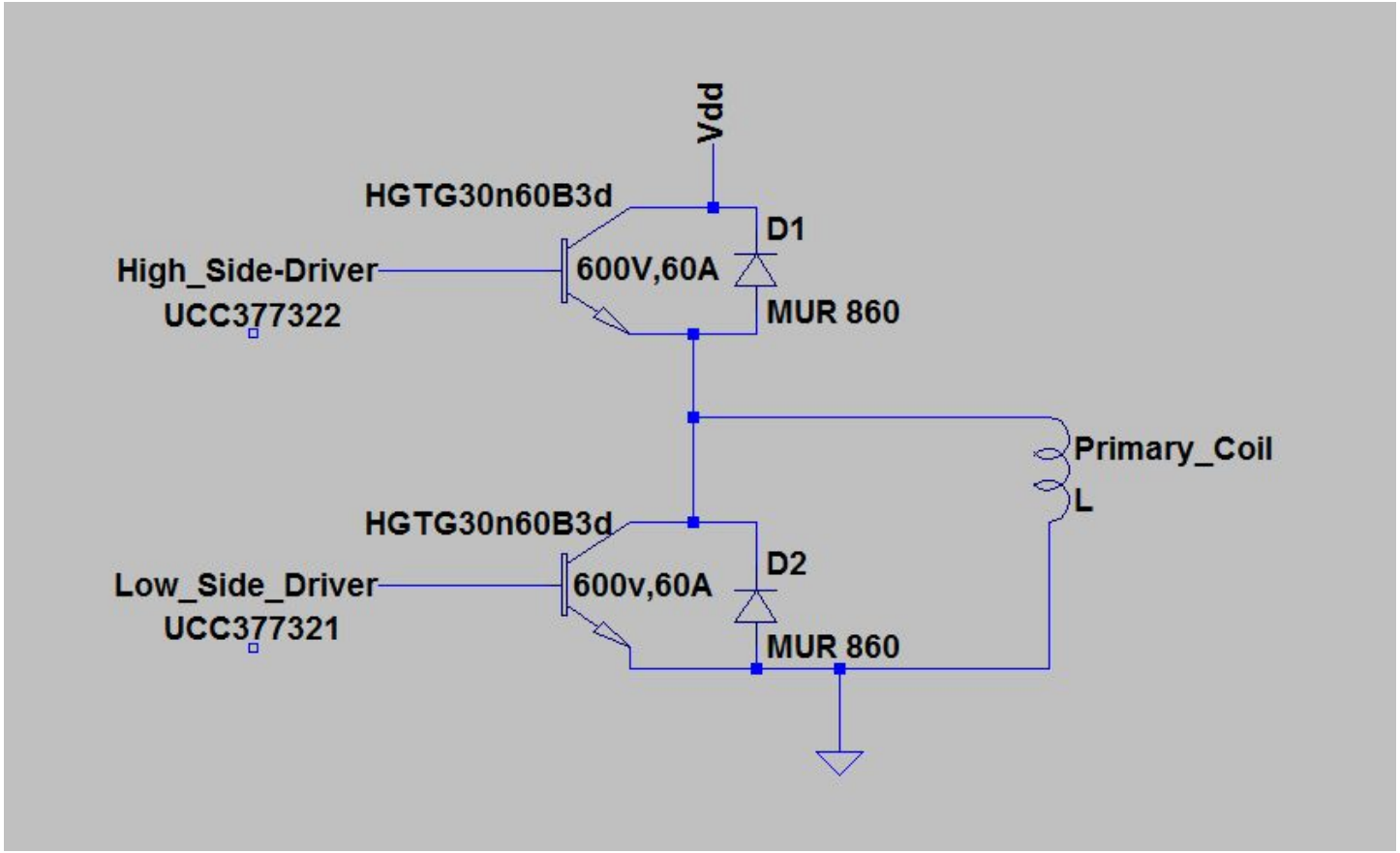


PWM: Comparator With Error Correction

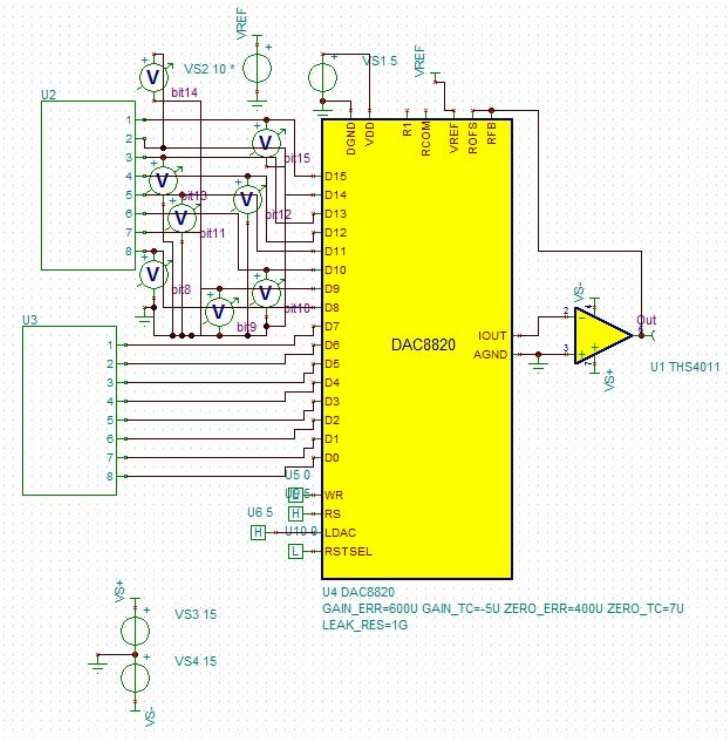


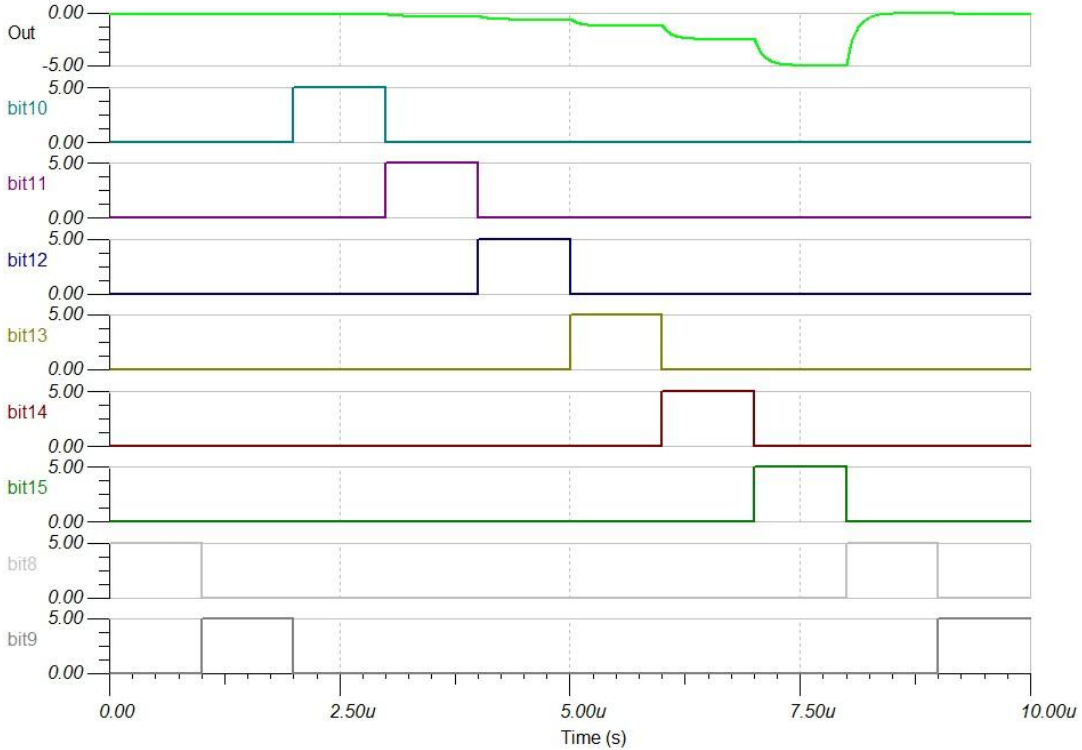


Switching Circuit: Basic Design



Digital to Audio Converter





Data Sheets: DAC

DAC IC: DAC8820

- http://www.ti.com/lit/ds/symlink/dac8820.pdf

THS4011

- http://www.ti.com/lit/ds/symlink/ths4011.pdf

Data Sheets: PWM

Triangle Wave Generator

- Op amp: OPA2365 http://www.ti.com/lit/ds/symlink/opa2365-q1.pdf
- Comparator: TLV3502 http://www.ti.com/lit/ds/sbos507a/sbos507a.pdf

Error Amplifier and Comparator

- Op amp: OPA2365 http://www.ti.com/lit/ds/symlink/opa2365-q1.pdf
- Comparator: TLV3502 http://www.ti.com/lit/ds/sbos507a/sbos507a.pdf

Data Sheets: Switching Circuit

- BJT: HGTG30n60B3d
  http://www.mouser.com/ds/2/149/HGTG30N60B3D-1010379.pdf
- Power Diode: http://www.onsemi.com/pub/Collateral/MUR820-D.PDF
- Gate Driver (High_Side): UCC37322
- http://www.ti.com/lit/ds/symlink/ucc37322.pdf
- Gate Driver (Low_Side): UCC37321
  http://www.ti.com/lit/ds/symlink/ucc37321.pdf