ECEB Artwork Illumination

Fadi Al Zuabi | Ansel Higgs | Lance Pan
Group 23
ECE 445 Senior Design
December 10, 2018

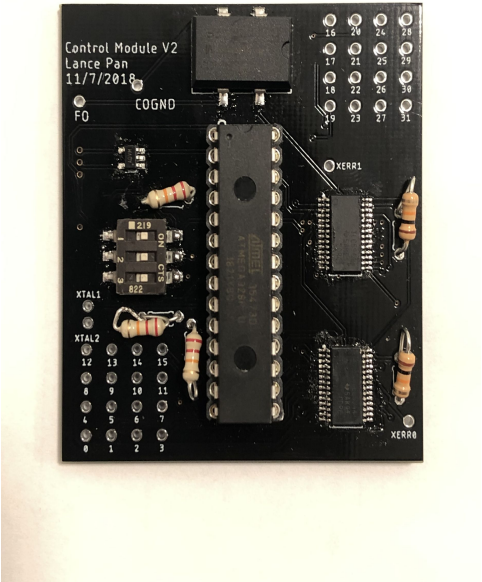
Introduction

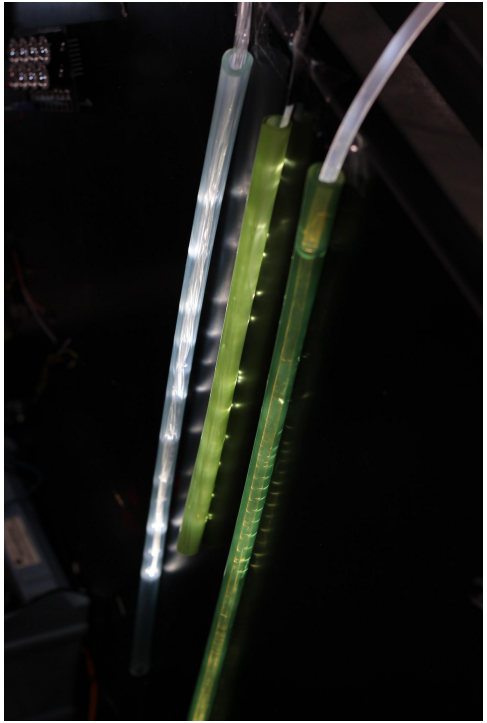
- Illuminate the glass artwork in the ECEB lobby with fiber optic cables
- Integrates seamlessly with the artwork to effectively illuminate each tube while minimizing leakage light

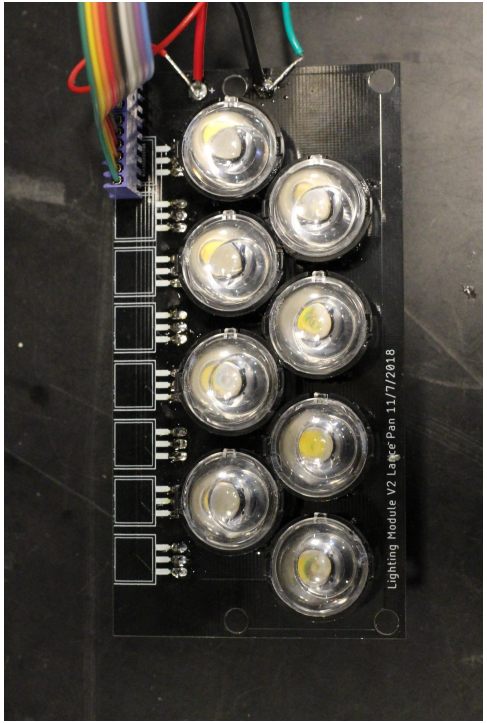
Objectives

- Control over light intensity for each hanging column of tubes
- Modular control unit and lighting board
- Remotely controllably with industry standard equipment

System Overview

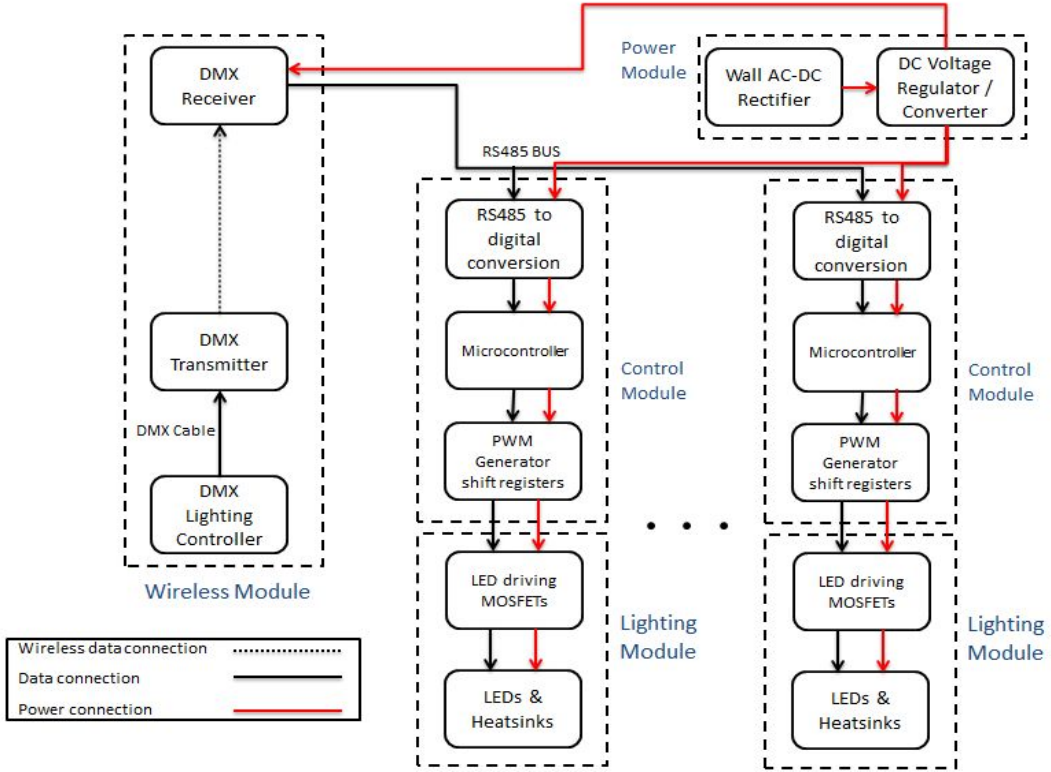






System Overview

Block Diagram

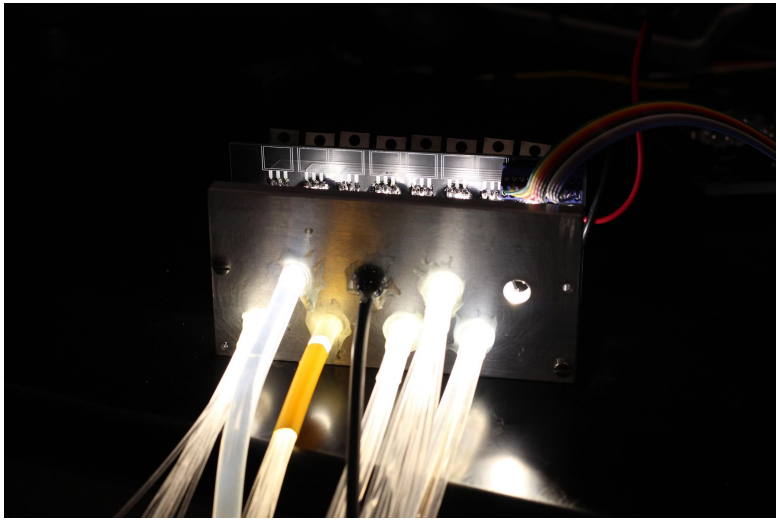


System Overview

- Hardware
  - Lighting grade fiber optic cables
  - LED driver boards, PWM control module, RS485 transceiver
  - DC power supply, voltage boost regulator
- Control
  - DMX lighting controller, DMX receiver & transmitter

Fiber Optic Cables

- Key focus on aesthetics and light transfer efficiency
- Two dominant options: Stranded and Solid Core
- Mounting Plate used to hold cables in place with 8mm wide drilled holes



Fiber Optic & Tube Demo

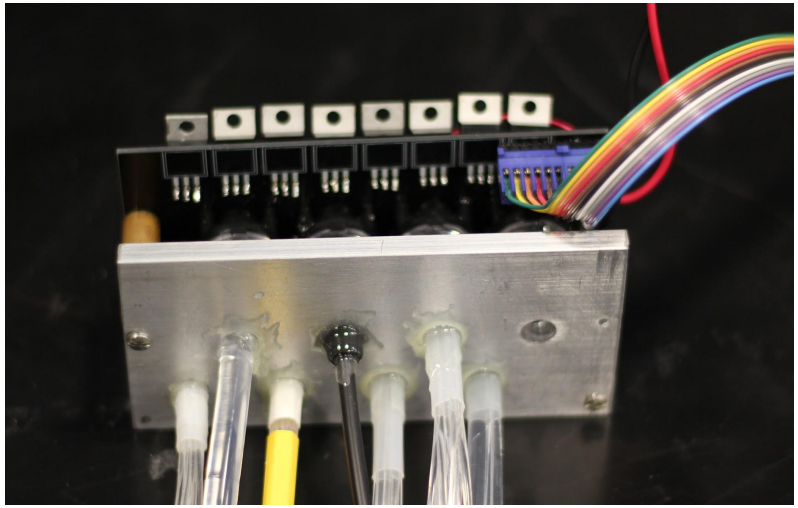
Lenses

- LEDs give off very diffuse light
- Two sets of lenses focus light to ~7mm diameter region
- Mounted directly onto lighting module

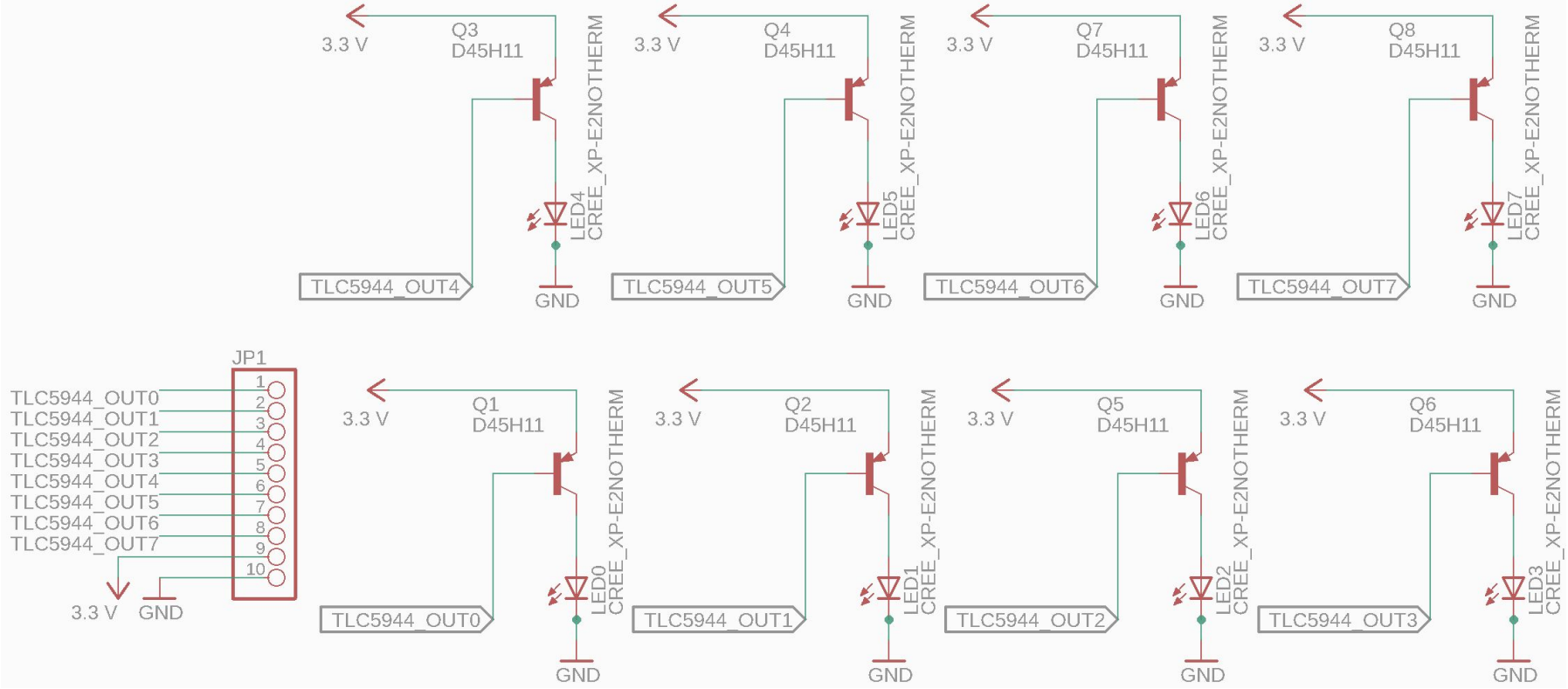
Fiber Optic Cables Demo

LED Drivers

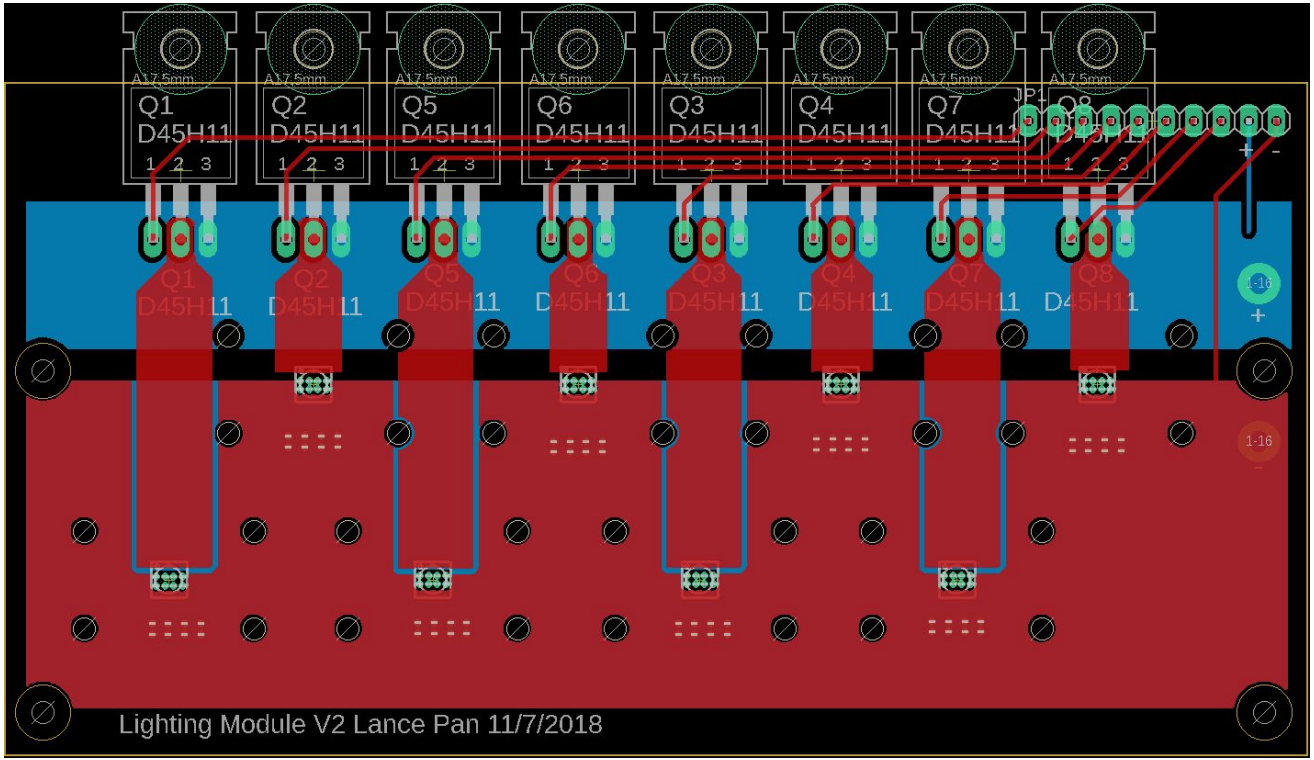
- Lights for 30 tubes per section of artwork split into 4 groups of 8
- Maximum power of 24 Watts per board at 3 Watts per LED
- LEDs controlled by bipolar junction transistors connected to constant current output of control board
- Active heat management



LED Drivers (Schematic)



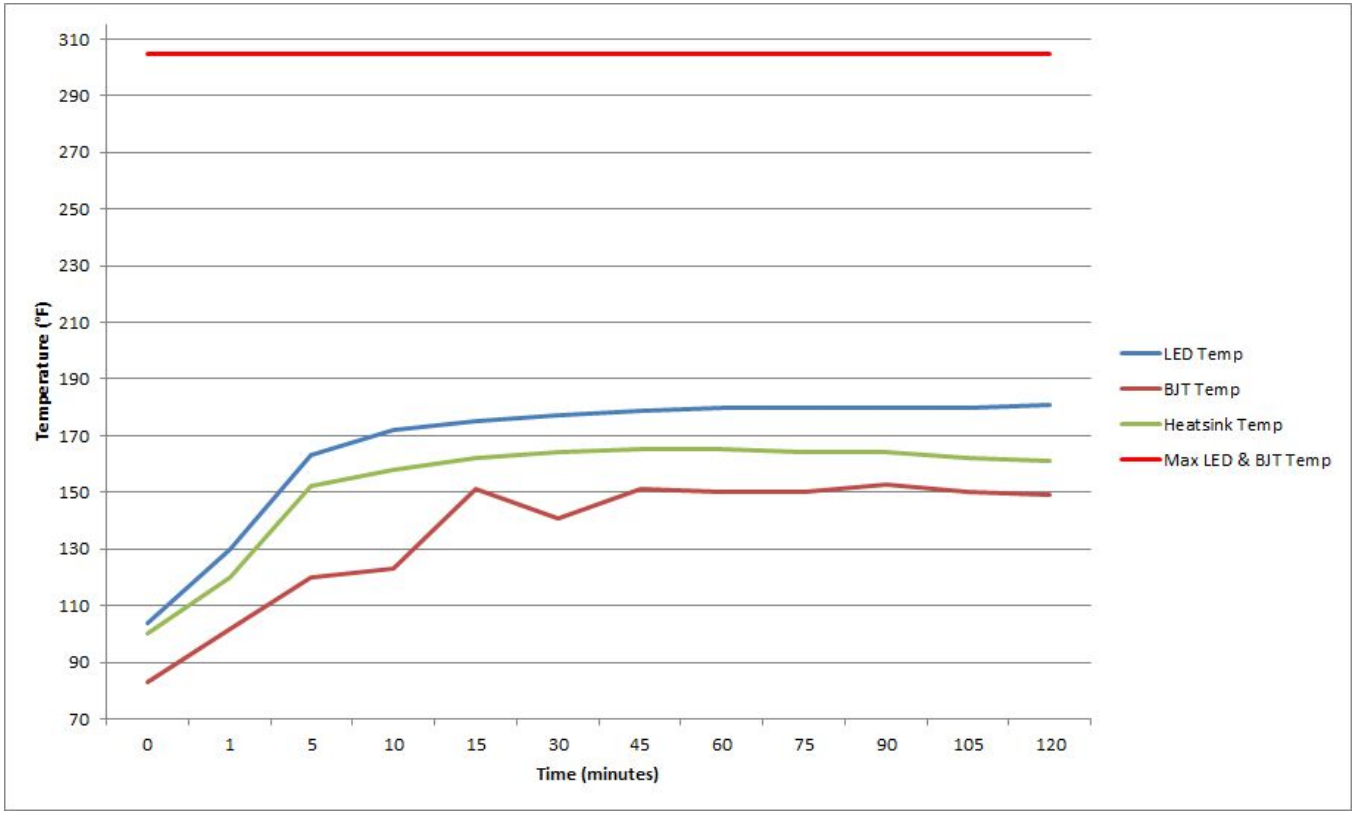
LED Drivers (PCB Layout)



LED Drivers (Thermal Management)

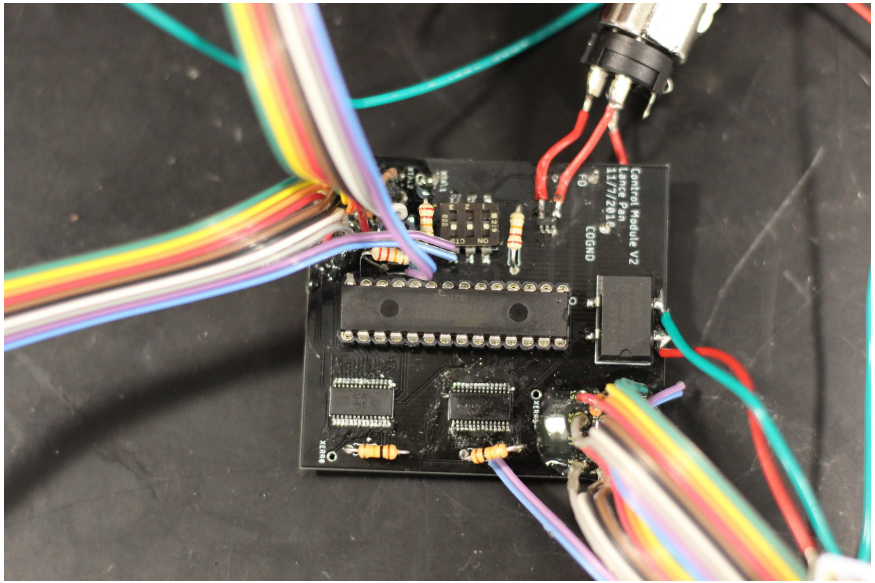
- Longevity of LEDs must be maximized as repairs would possibly require deconstructing part of the artwork and lighting system
- Thermal vias placed on the PCB underneath LEDs
- Heatsink and fan mounted to back of PCB
- LEDs verified to operate at maximum intensity without exceeding rated temperature

LED Drivers (Thermal Management)

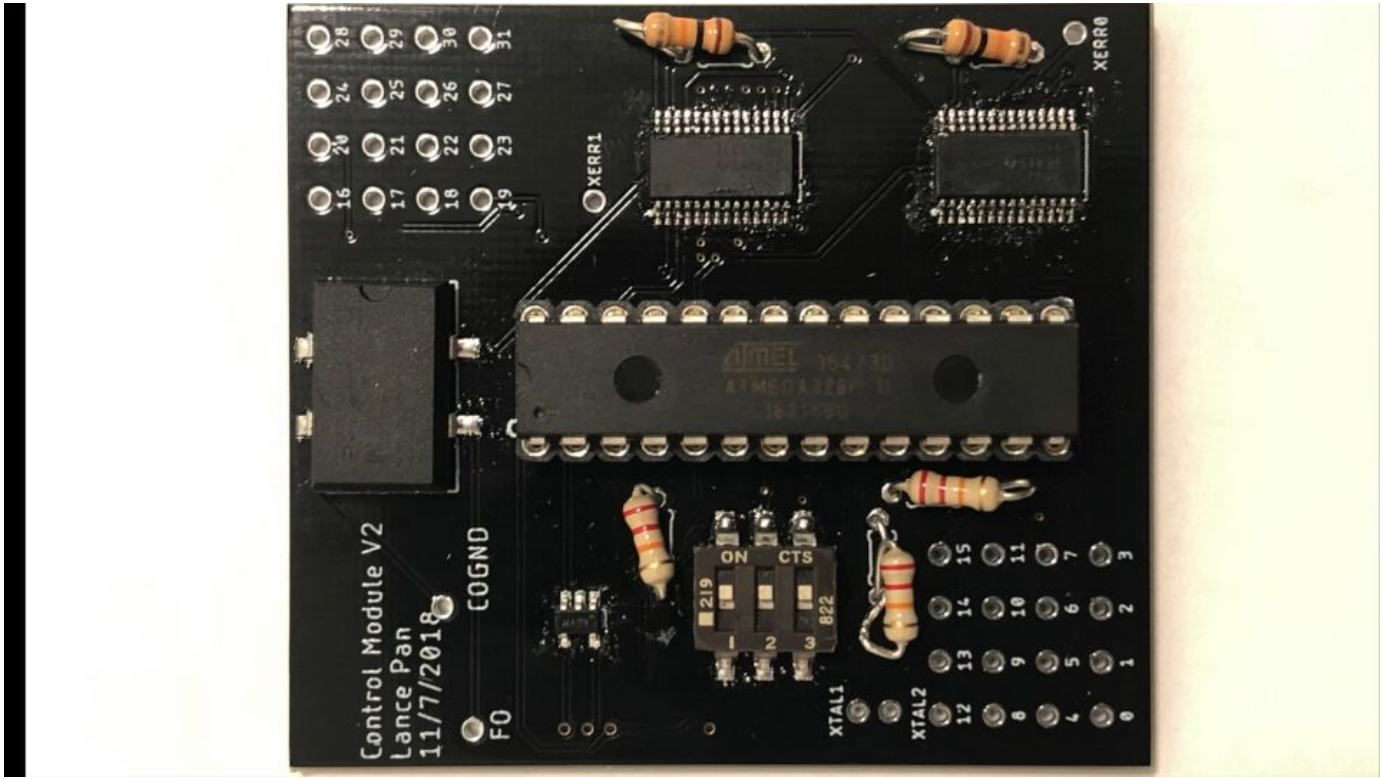


Control Module

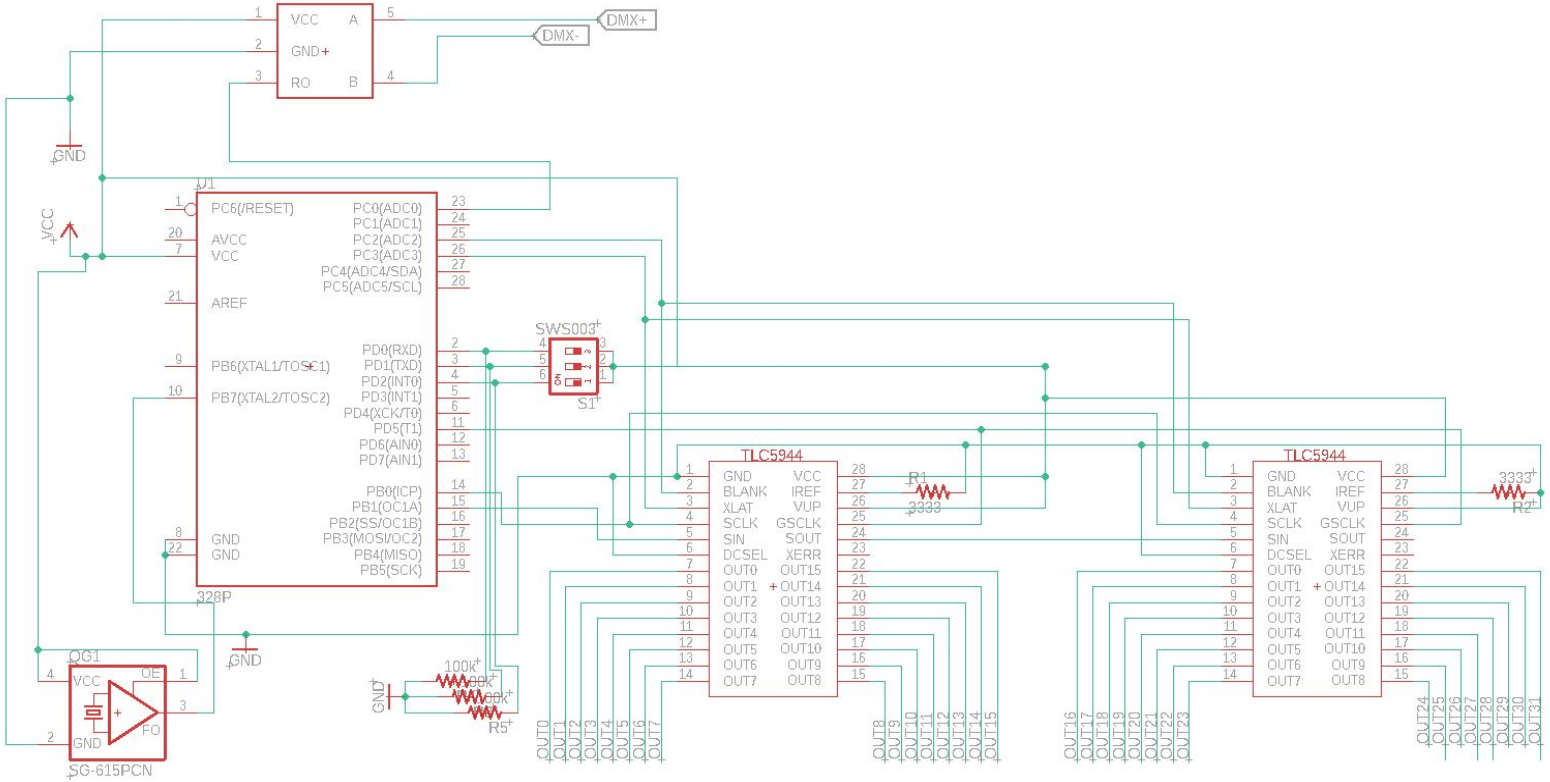
- Takes in differential level DMX512 control signal, converts to digital logic
- Microcontroller interprets control signal and outputs to PWM drivers
- 2x PWM drivers on each board with 16 outputs each



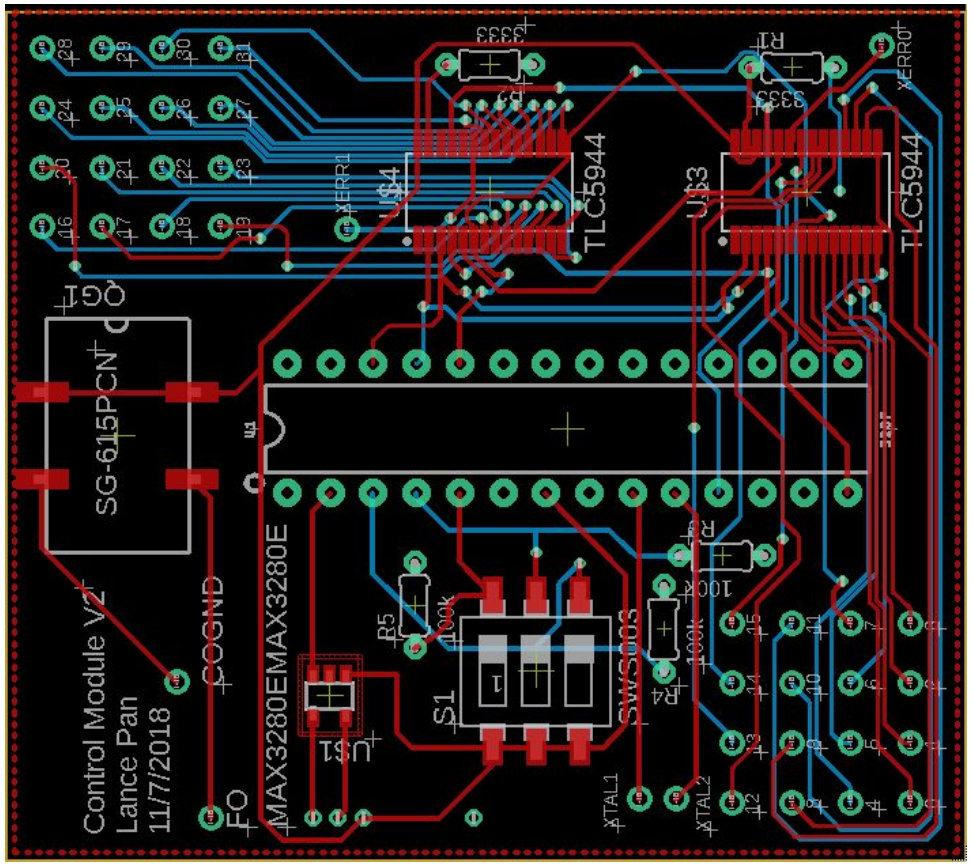
Control Module



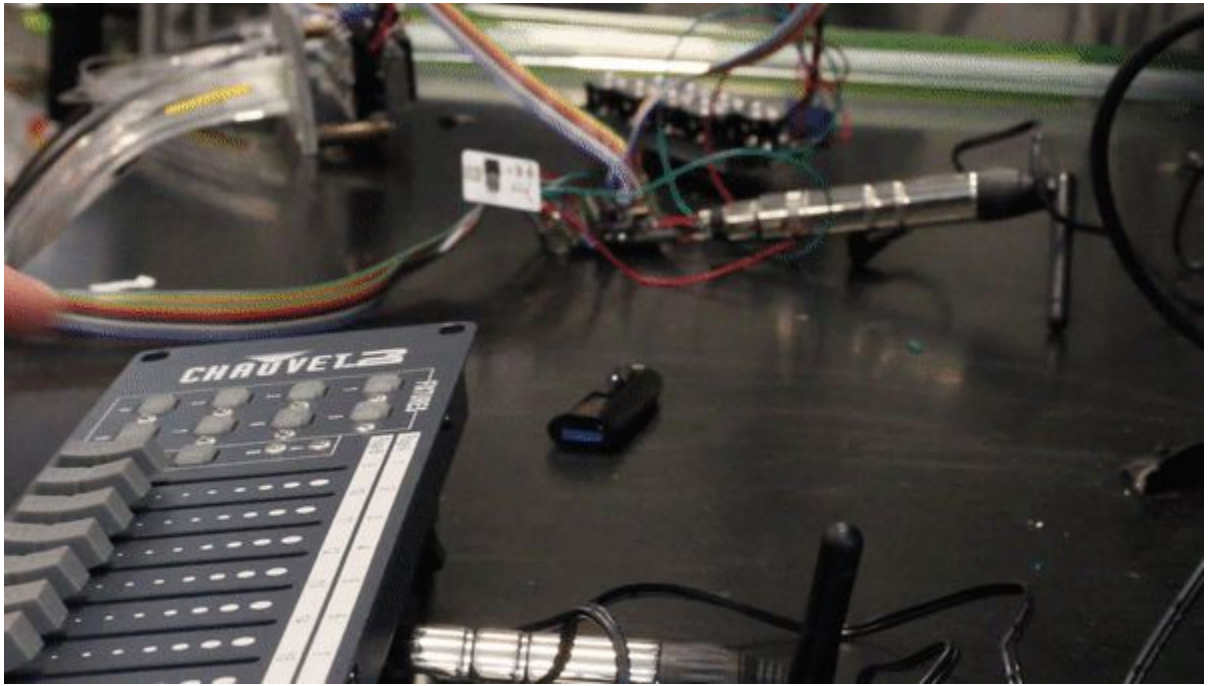
Control Module (Schematic)



Control Module (PCB Layout)



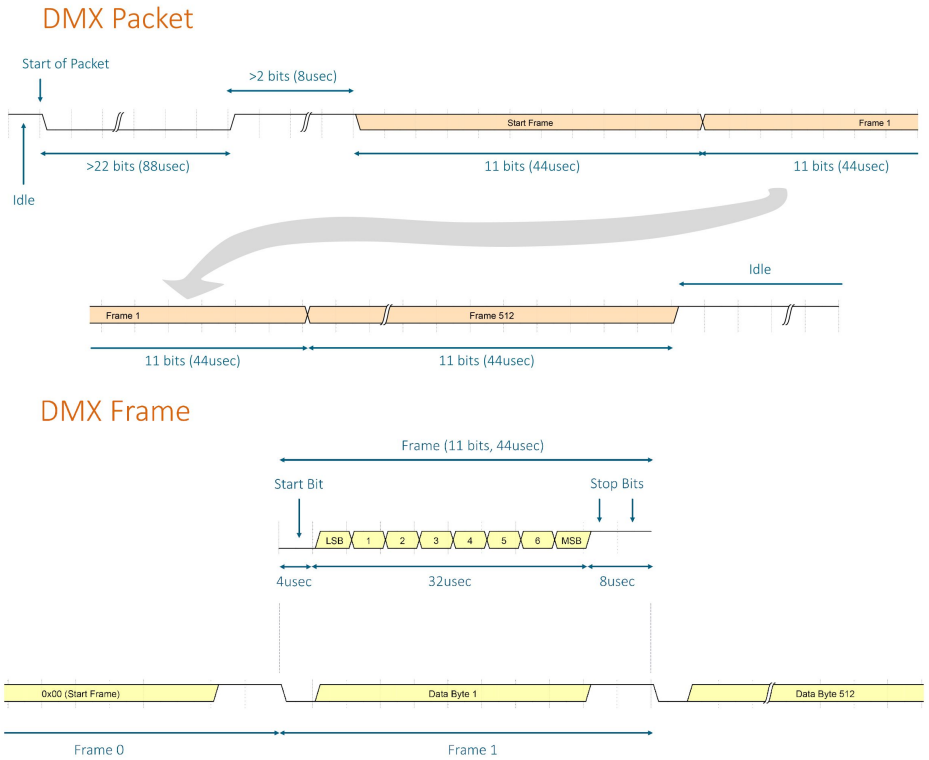
Control Module Demo



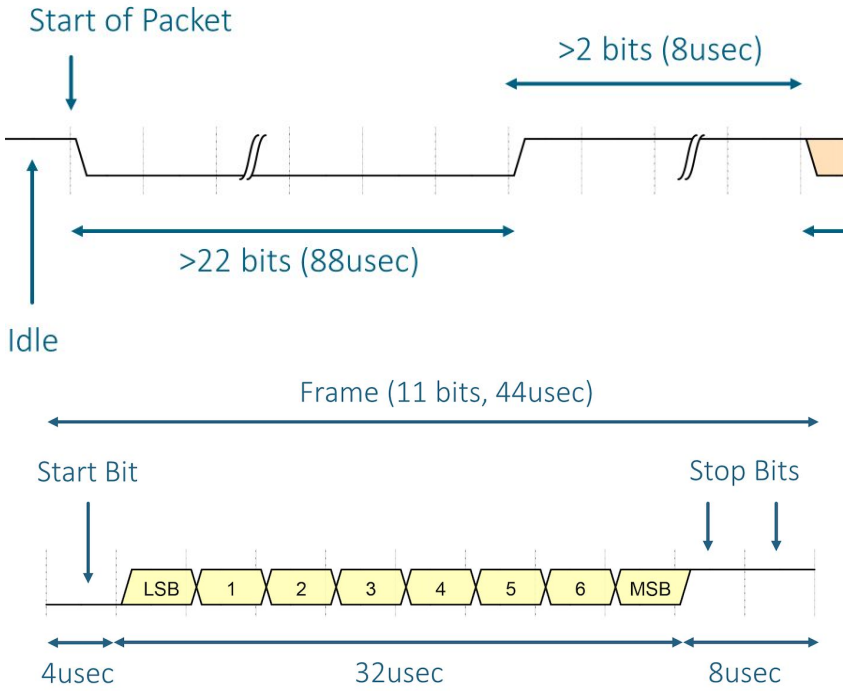
DMX512 Protocol:

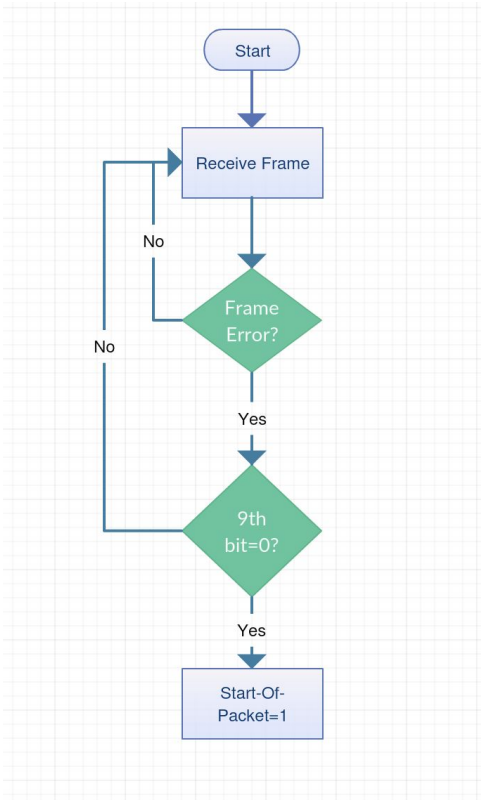
DMX512 protocol:

- Start-Of-Packet
- Start Frame (0x00)
- Up to 512 Frames
- Idle



Start-Of-Packet detection:





PWM Generator Set-up (tlc5944)

1) Set Dot Correction Registers and toggle Xlatch:

- 6-bit x 16 registers to sets the percentage of current for the outputs.
- Needs to be done once at the beginning.

2) Set GrayScale Registers and toggle Xlatch:

- 12-bit x 16 registers to control brightness.
- Will continuously be updated with the DMX data.

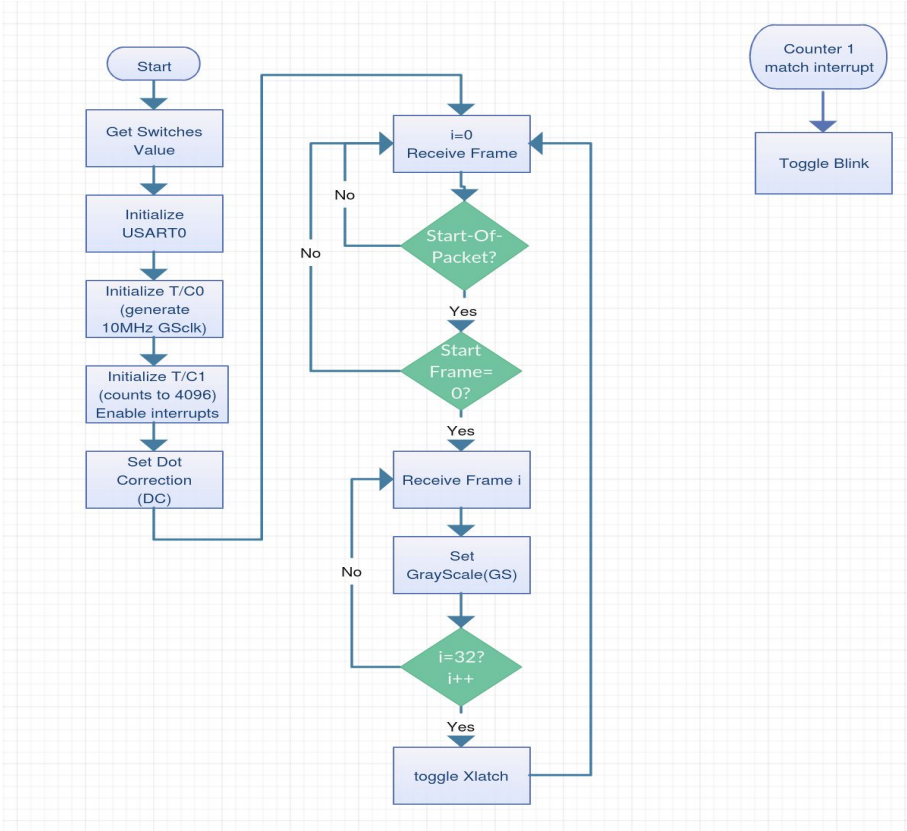
3) Run GSclk and reset every 4096 count

- GSclk always running and counts up.
- Must Toggle Blink every 4096 count.

Microcontroller: Features and Flowchart

Used Features of the ATmega328:

- USART0 to receive DMX
- Timer/Counter 0 to generate GSclk
- Timer/Counter 1 with interrupts to toggle Blink



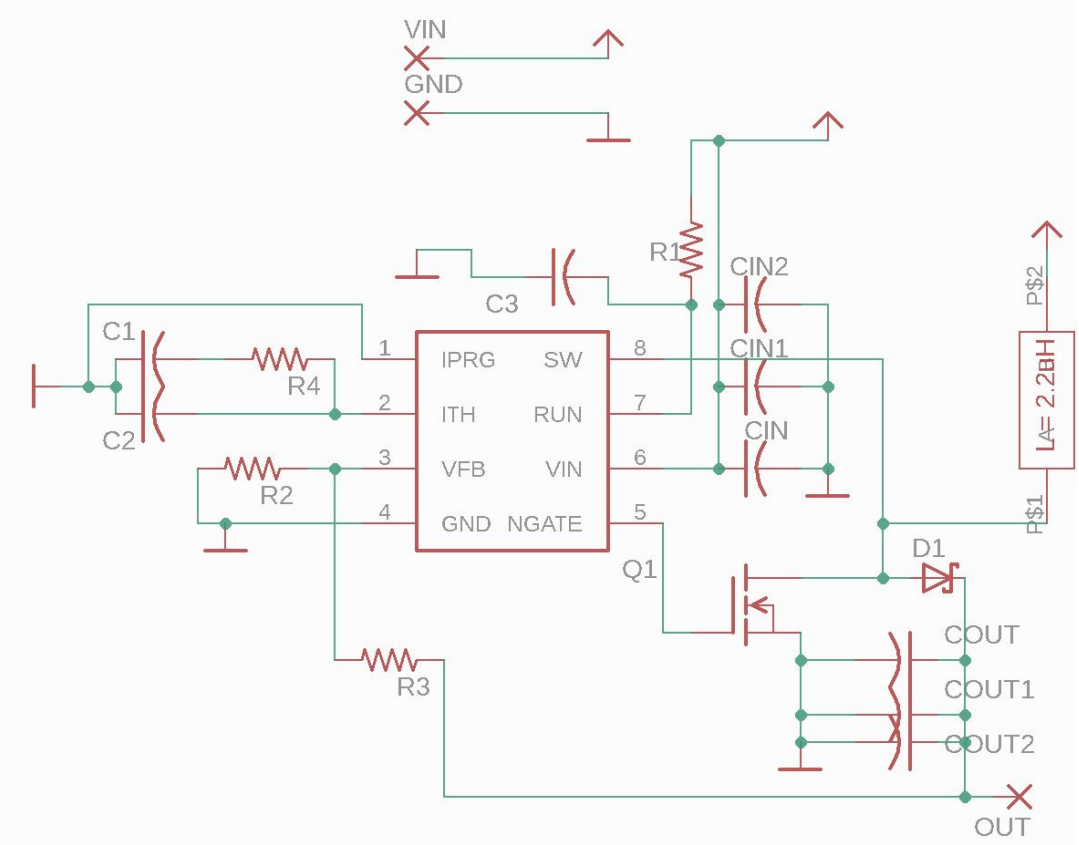
Power Supply

- Power supply selected at forward voltage of LEDs (3.3 Volts) to eliminate requirement of switching LED driver circuitry
- Improves efficiency, reduces circuit complexity, and reduces potential failure points
- A Potential power supply (model Mean Well RSP-200-3.3) was identified but not purchased, as lab bench supply was sufficient for testing

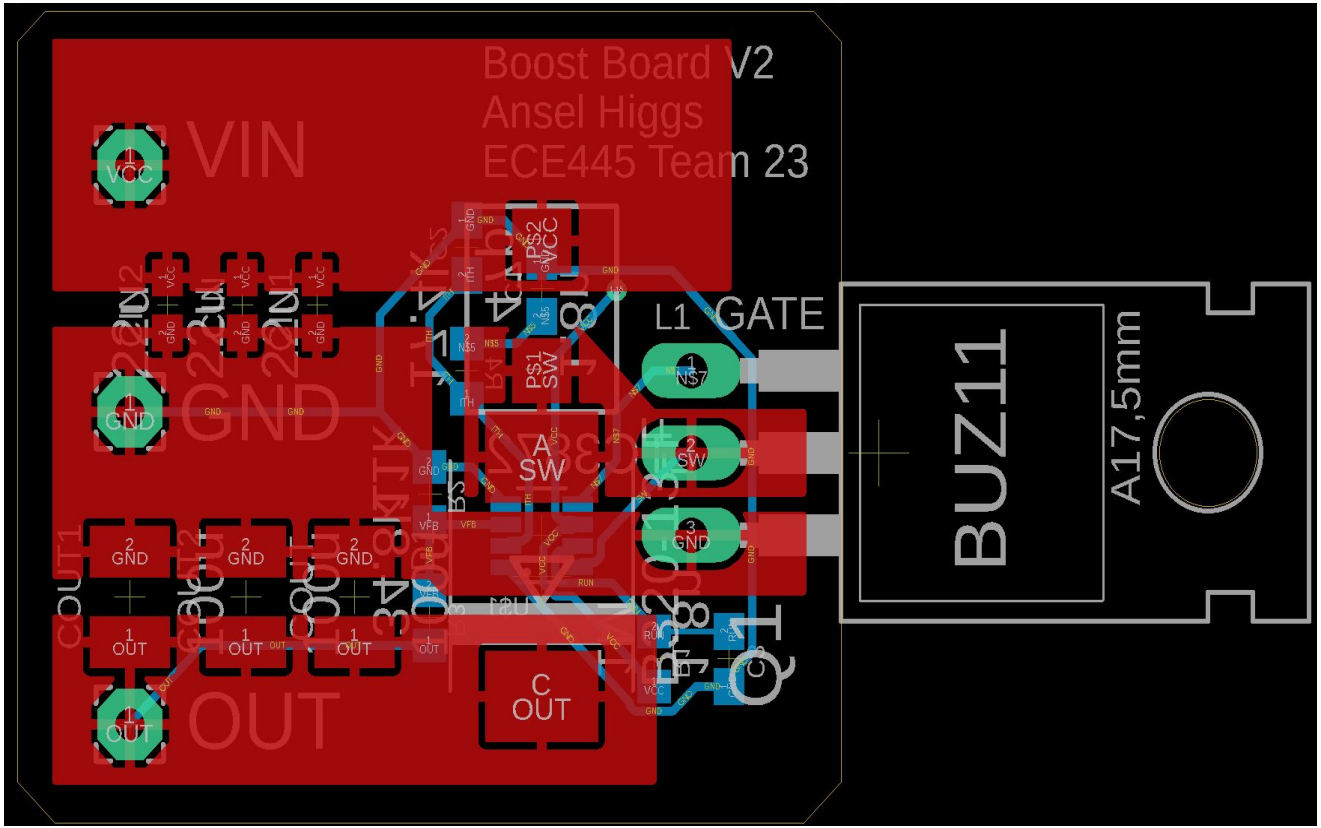
DC Voltage Converter

- Control module and DMX receiver operate at 5 Volts with low current requirement
- Step up 3.3 Volts from supply to 5 Volts using boost converter
- Based on LTC3872 current mode boost controller
- Input range 3.0 to 3.6 Volts, output 5 Volts at 1 Amp

DC Voltage Converter (Schematic)

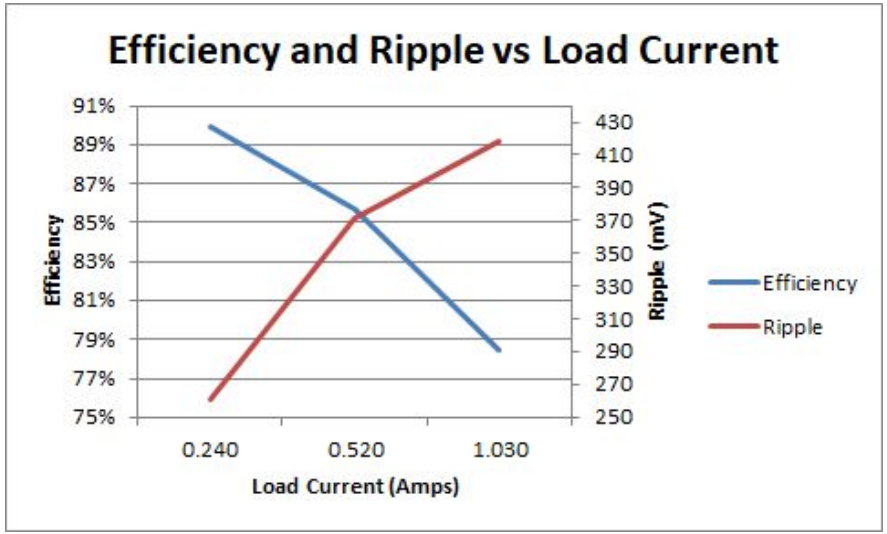


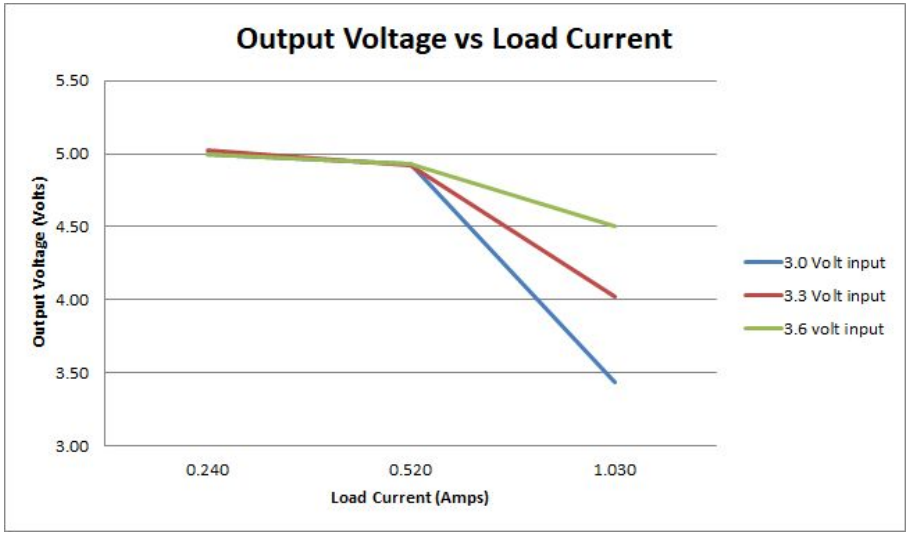
DC Voltage Converter (PCB Layout)



DC Voltage Converter

- Output voltage drops at large loads, potentially caused by lossy breadboard connections during testing





Conclusion and Future Work

System fully functional, but minor improvements to build quality would make assembly much easier (e.g. improved connections and more spacious layout)

Must decide on final fiber optic cable lighting element configuration

Add additional options for standalone control directly from microcontroller