

ember[®]

Power over Ethernet LED Lighting

May 13-14

GROUP MAY 13-14

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- **Introduction**
- Project Plan
- Design
- Implementation
- Testing

PROBLEM STATEMENT

Build an Affordable, Controllable
and Efficient Lighting Solution.



COMMON SOLUTIONS

	Wall Switches	X10
Price per Light	\$5	\$25
Control	N/A	Slow Unreliable
Efficiency	Incandescent / CFL Low - Medium	Incandescent / CFL Low - Medium
Installation	Electrician	Electrician
Cabling	High Voltage Power	High Voltage Power / Control



MODERN SOLUTIONS

	Insteon	Vantage
Price per Light	\$50	\$250
Control	High Speed Semi-Reliable	High Speed High Reliability
Efficiency	Incandescent / CFL Low - Medium	Incandescent / CFL Low - Medium
Installation	Electrician	Electrician
Cabling	High Voltage Power	High Voltage Power Low Voltage Control

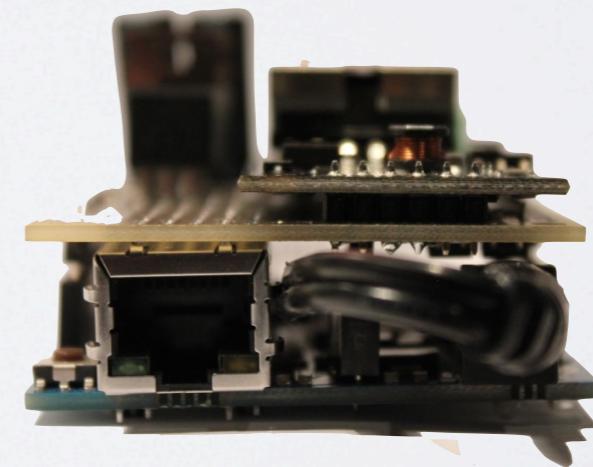
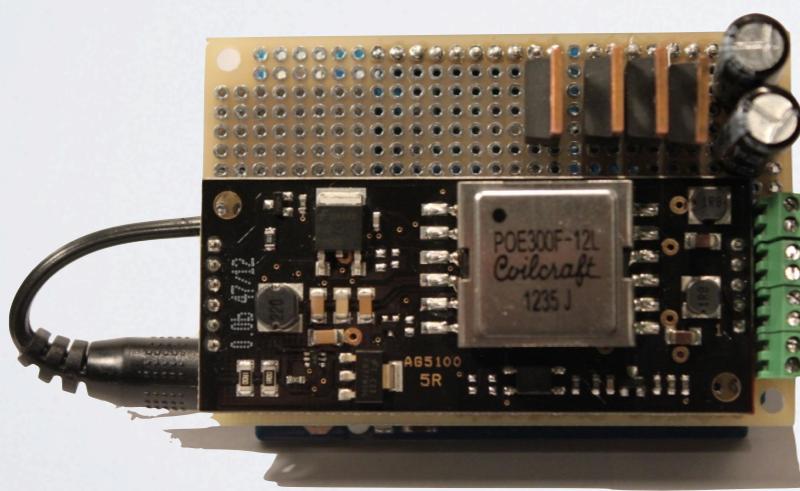
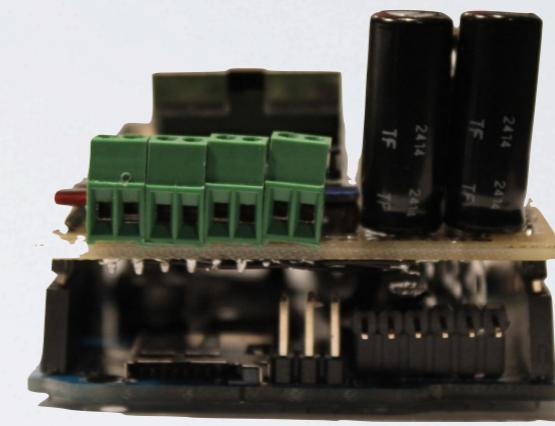
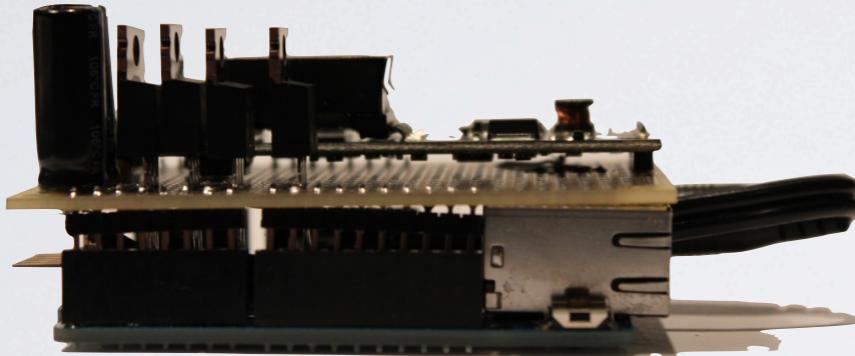


OUR SOLUTION

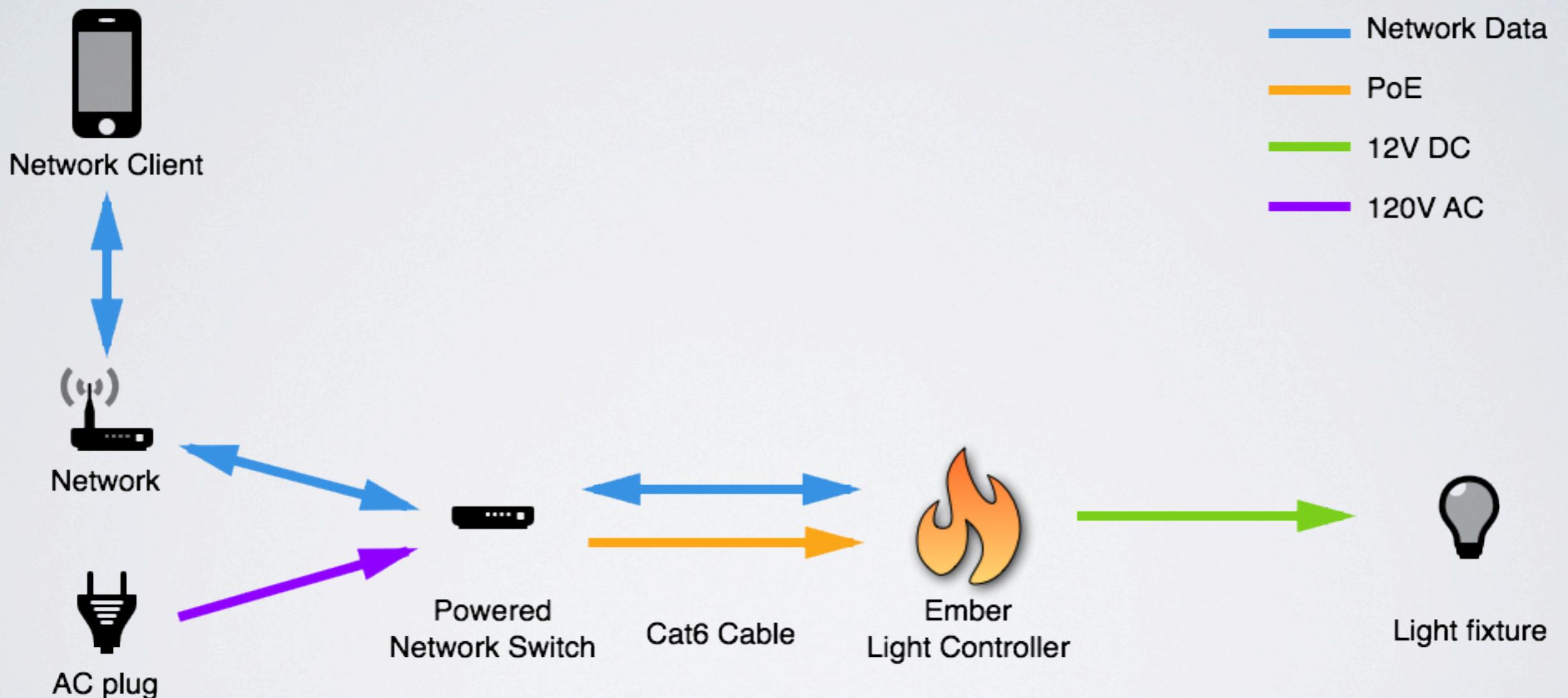
	Ember
Price per Light	\$50
Control	High Speed High Reliability
Efficiency	LED High
Installation	Unlicensed
Cabling	Low Voltage Power / Control



EMBER PHOTO



INSTALLATION DIAGRAM



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PROPOSED CONCEPT

Proposed Technology - Power over InifiniBand:

- Protocol for high performance computing
- Partially implemented in VHDL by previous group
- Mesh connected



PROPOSED CONCEPT

InfiniBand Disadvantages:

- Difficult to distribute power via mesh
- Unnecessary bandwidth for control
- High cost (hardware and development time)



REVISED CONCEPT

Technology - Power over Ethernet / Microcontroller:

- Low cost / standard parts available
- Standardized power distribution
- Connects in an ethernet network structure



REQUIREMENTS

Functional:

- Powered by PoE+ (802.3at)
- Supply power to LED light fixtures
- Accept commands from any device on the local network
- Use open platforms and protocols to facilitate integration



REQUIREMENTS

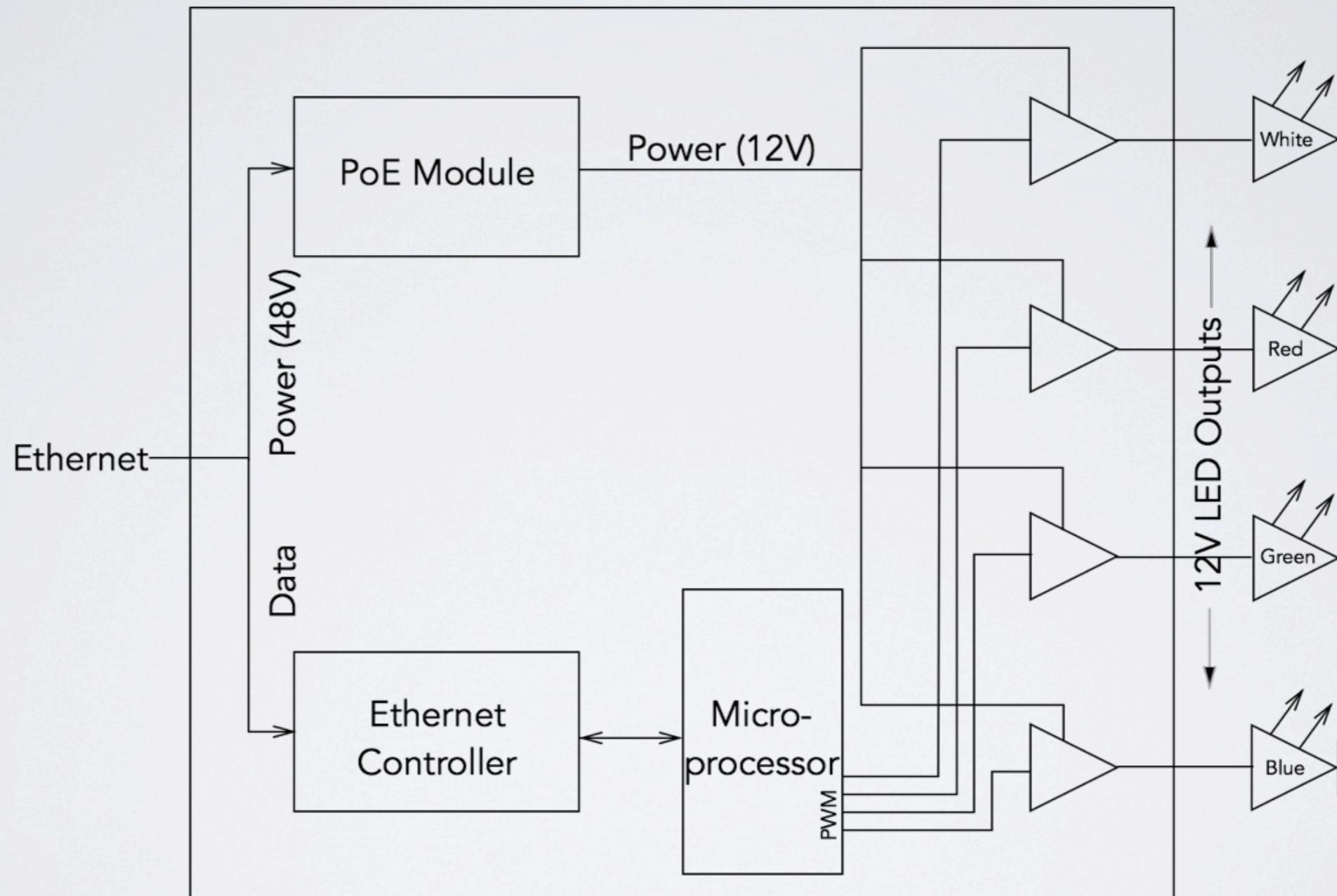
Non-Functional:

- High Speed Control
- No delay
- Smooth dimming
- Easy Installation
- Standard Cable
- No license required

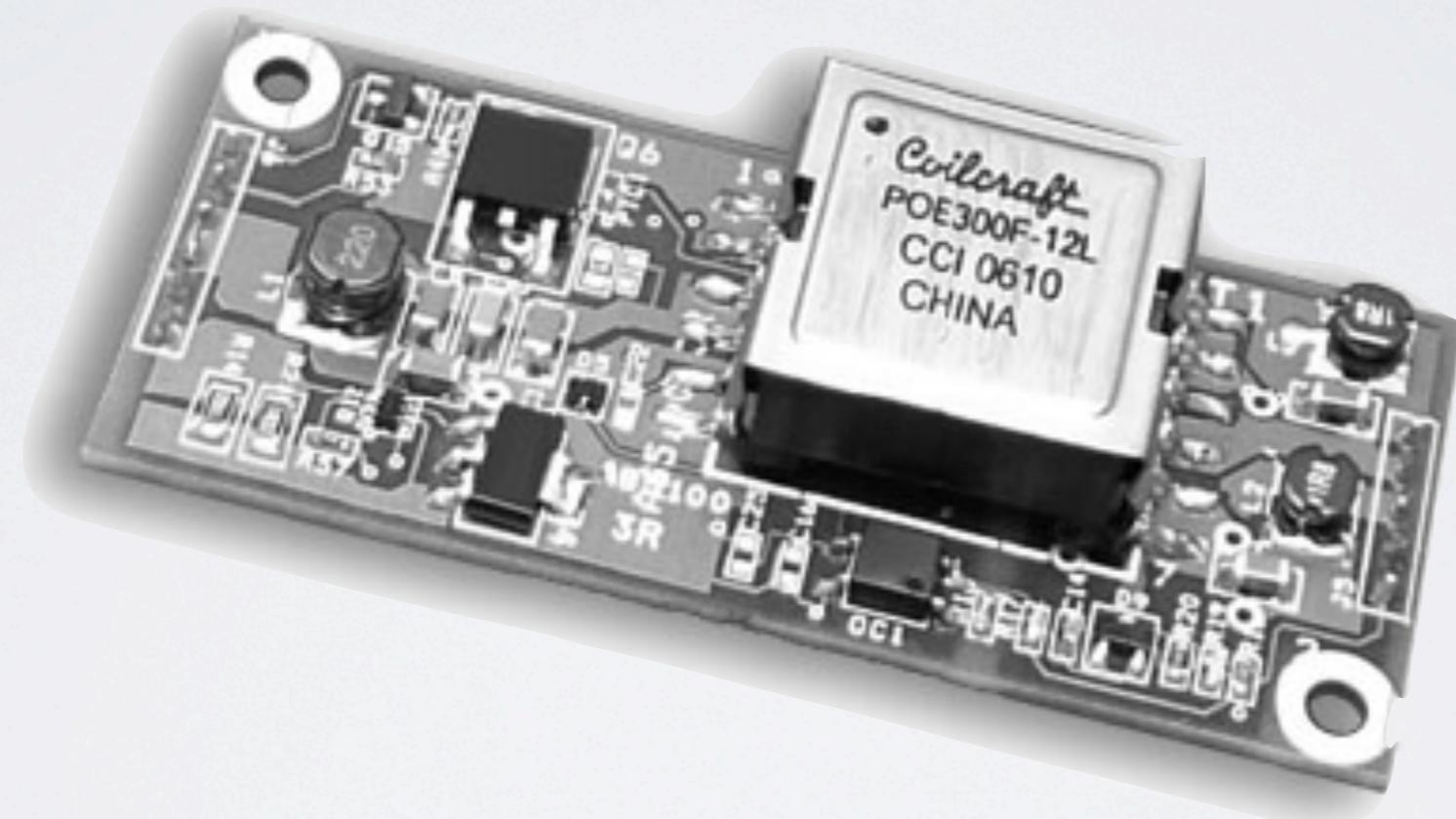


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HARDWARE DESIGN



POE MODULE - SILVERTEL AG5100



POWER OVER ETHERNET MODULE

SilverTel Ag5100:

- Implements IEEE 802.3at powered device standard in hardware
- Allows device to be identified by PoE switch
- Input: 48-52V DC
- Output: 12V DC (for amplifiers and microcontroller)

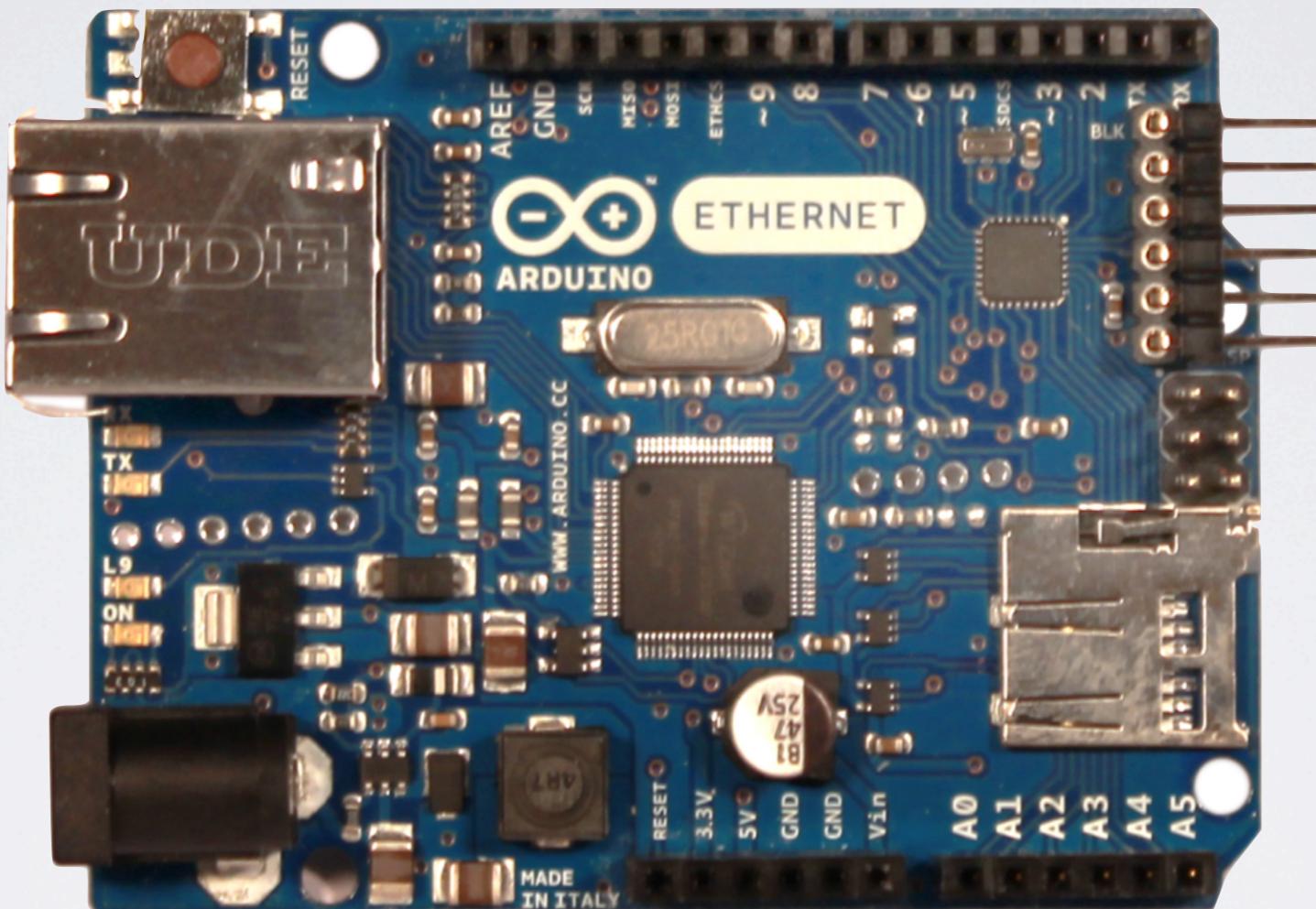


AMPLIFIER

- LED Driver (MOSFET Amplifier):
 - Input: PWM Signal (low-power)
 - Output: PWM Signal (high-power)



ARDUINO ETHERNET



ARDUINO ETHERNET

Microprocessor / Ethernet Controller

ATMega328 / W5100

- Convert TCP commands to PWM signals to control brightness and color of LEDs
- mDNS server - discoverable without knowing IP address
- Input: TCP commands
- Output: PWM signal (low-power)

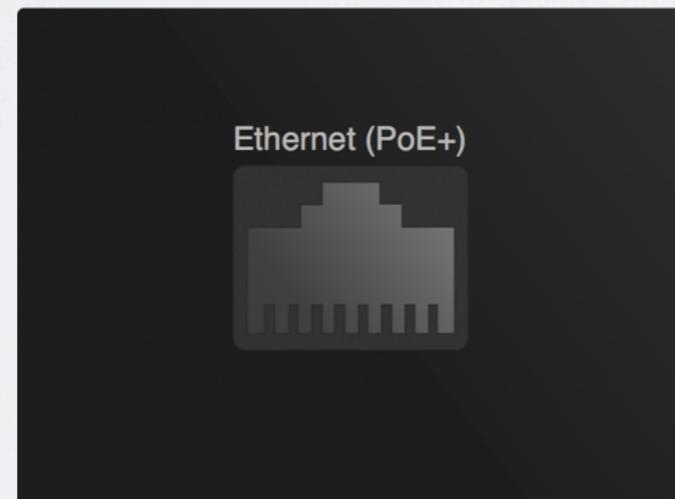


CASE RENDER

Top



Input Side



Output Side



NETWORK API

Command	Effect
on	Enables the white output to last non-zero set command.
off	Disables the white output
set <white>	Sets the white output to the specified value
colorOn	Enables the color output to last non-zero set command.
colorOff	Disables the color output.
redSet <level>	Set the red output.
greenSet <level>	Sets the green output.
blueSet <level>	Sets the blue output.
colorSet <red> <green> <blue>	Sets the color output to the specified RGB value.
colorDim <level>	Dims the color output. Maintains ratio between colors.
ember <white> <red> <green> <blue> <colorDim>	Format of Ember's response to all requests.



NETWORK API

```
colorSet 255 255 0\n
```

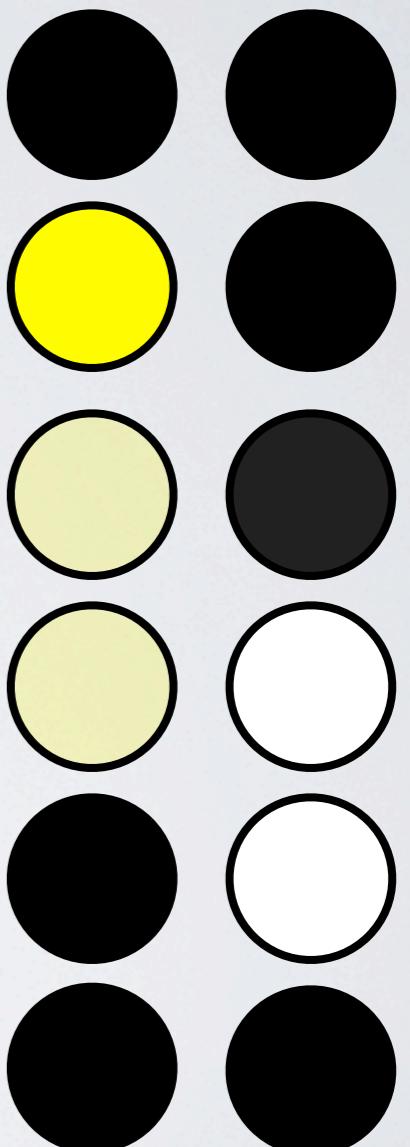
```
colorDim 128\n
```

```
on\n
```

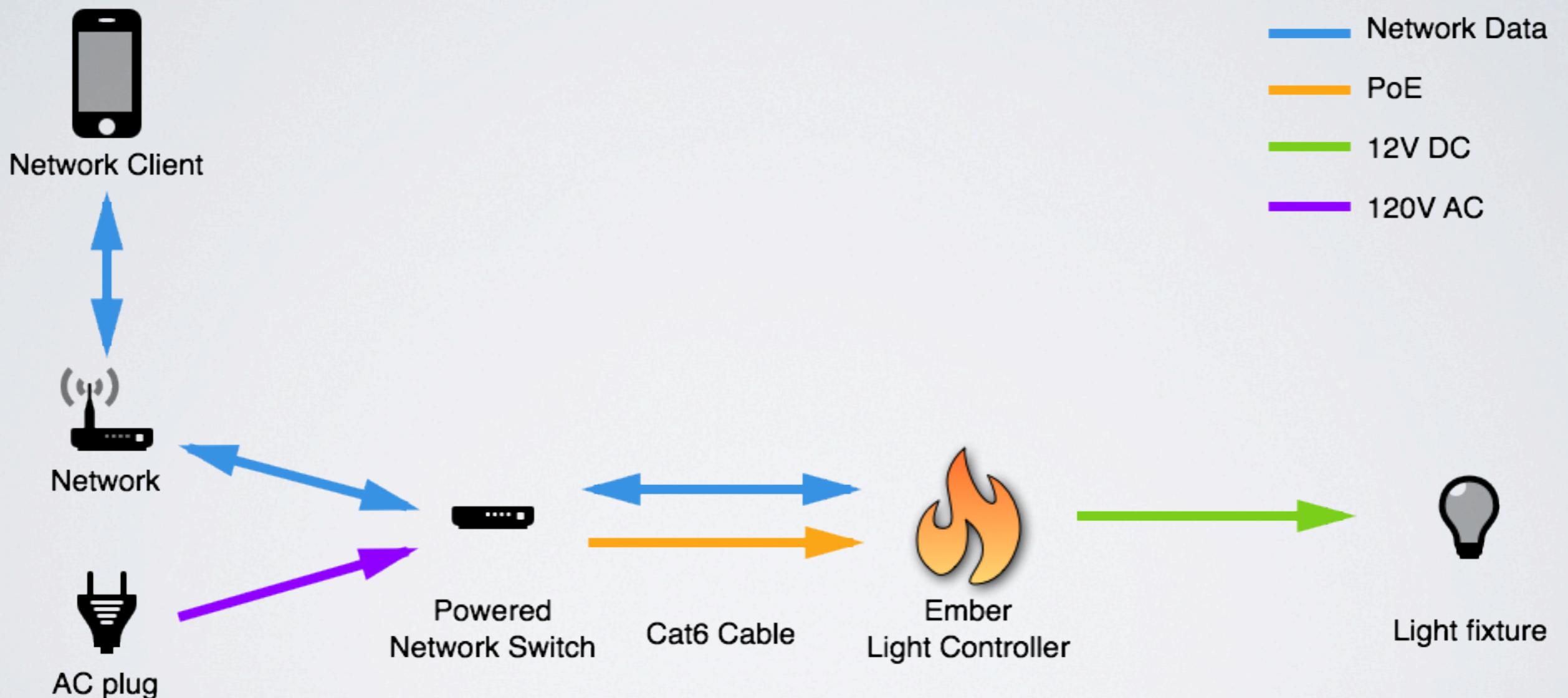
```
colorOff\n
```

```
off\n
```

Color LED White LED



INSTALLATION DIAGRAM



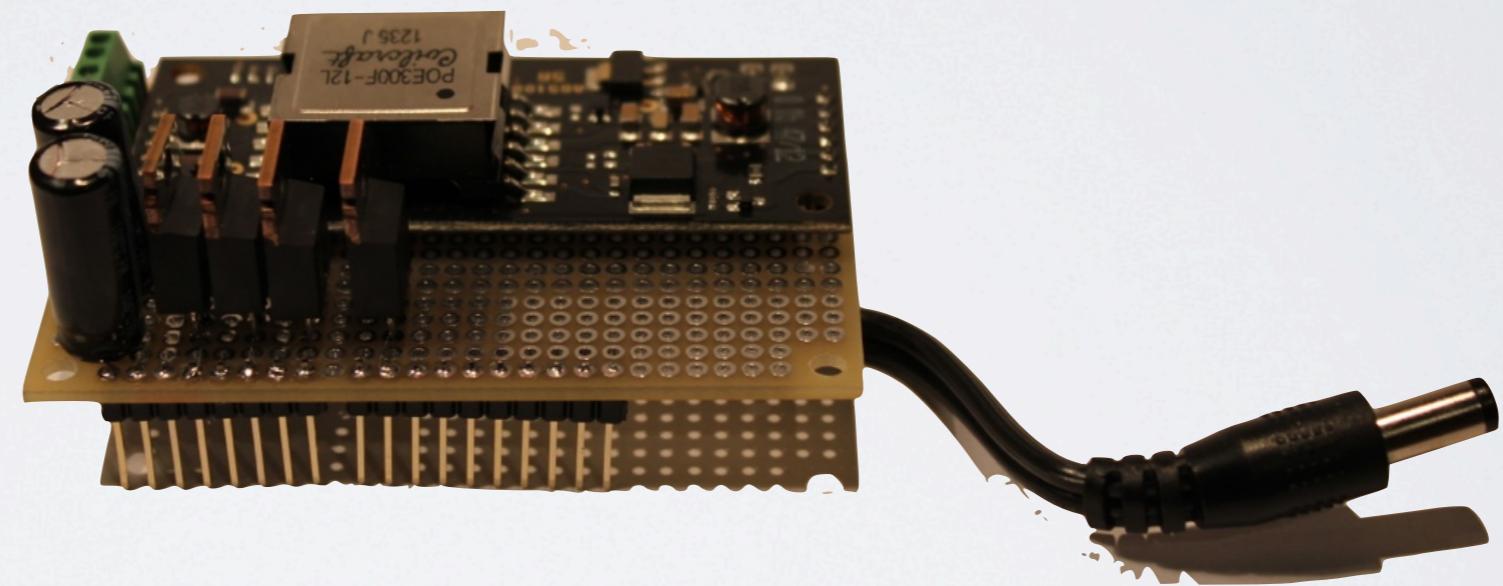
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HARDWARE

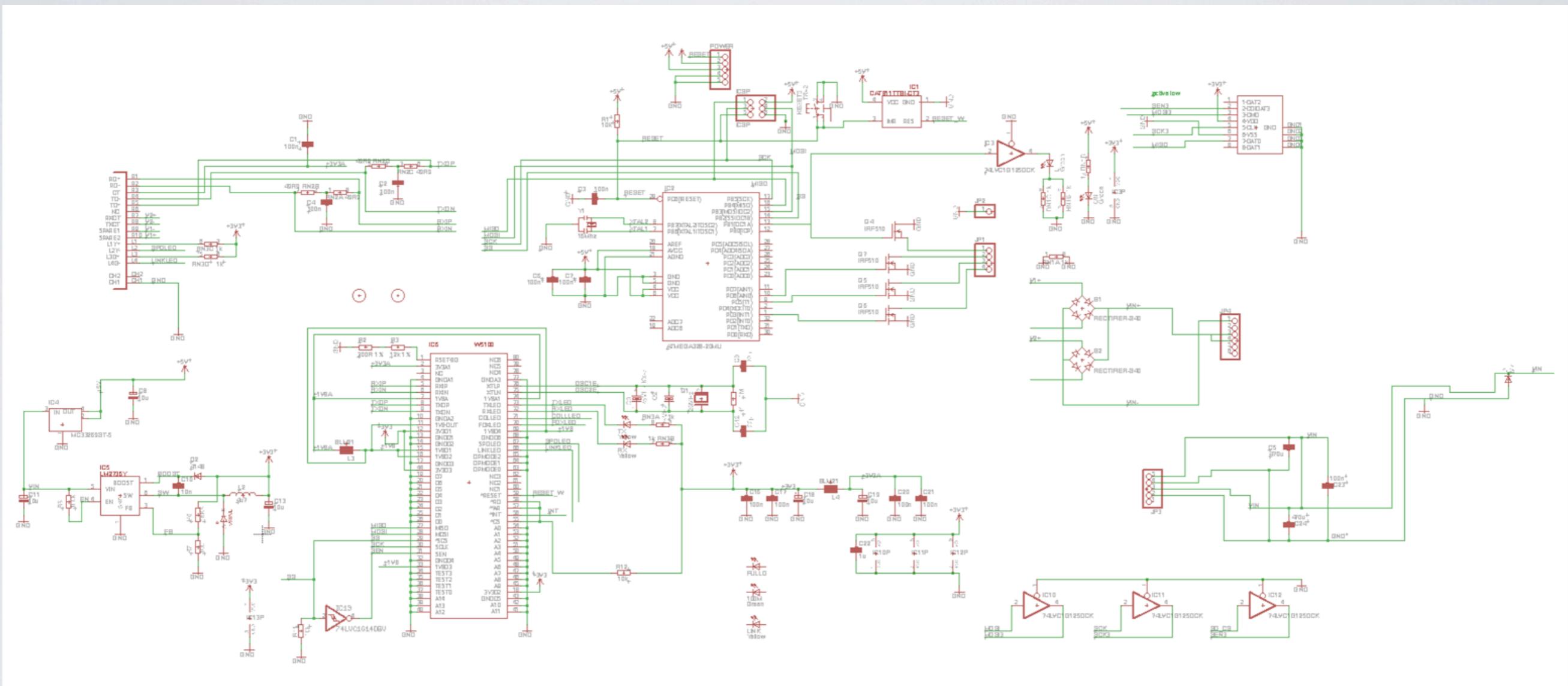
- Eagle CAD Layout / Schematic
- Ember Shield for Arduino Ethernet
 - PoE Module
 - LED Driver
 - Supporting traces and components



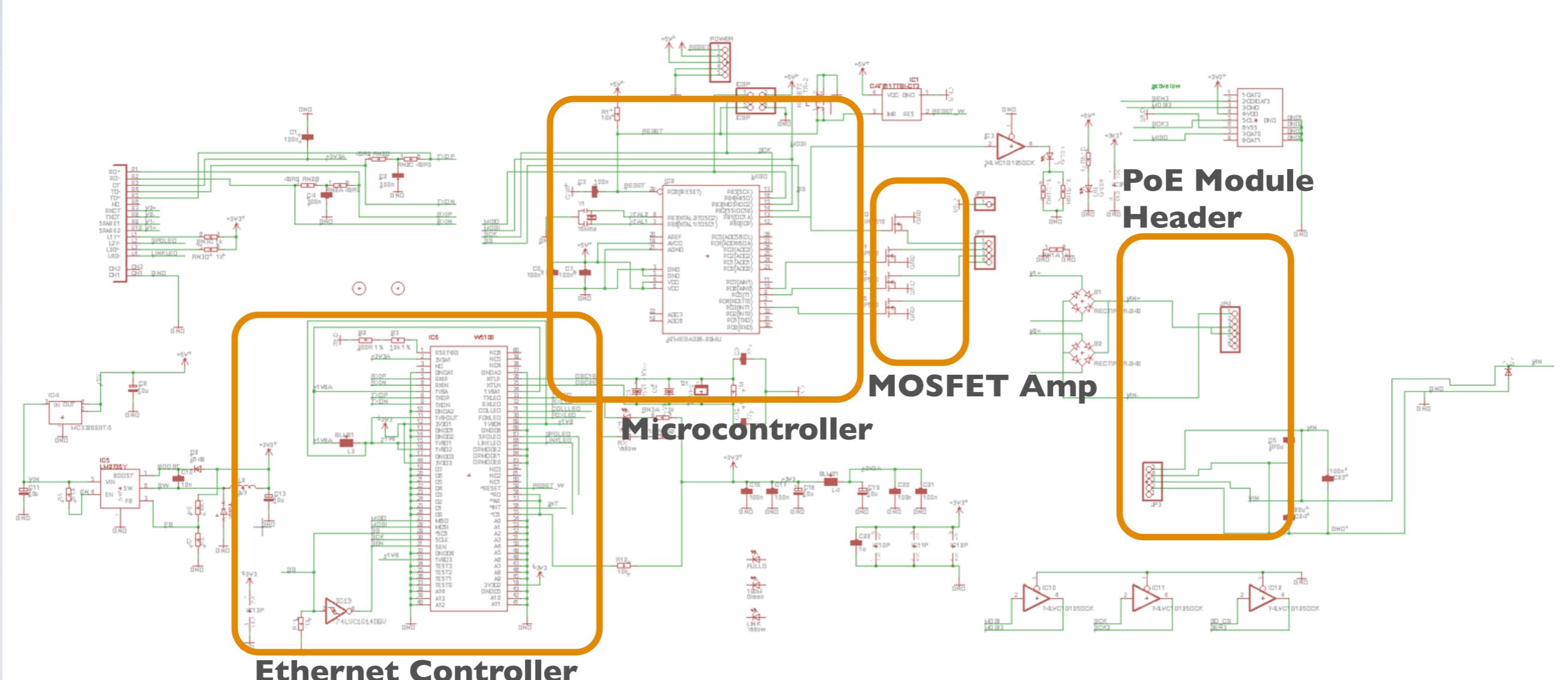
EMBER SHIELD



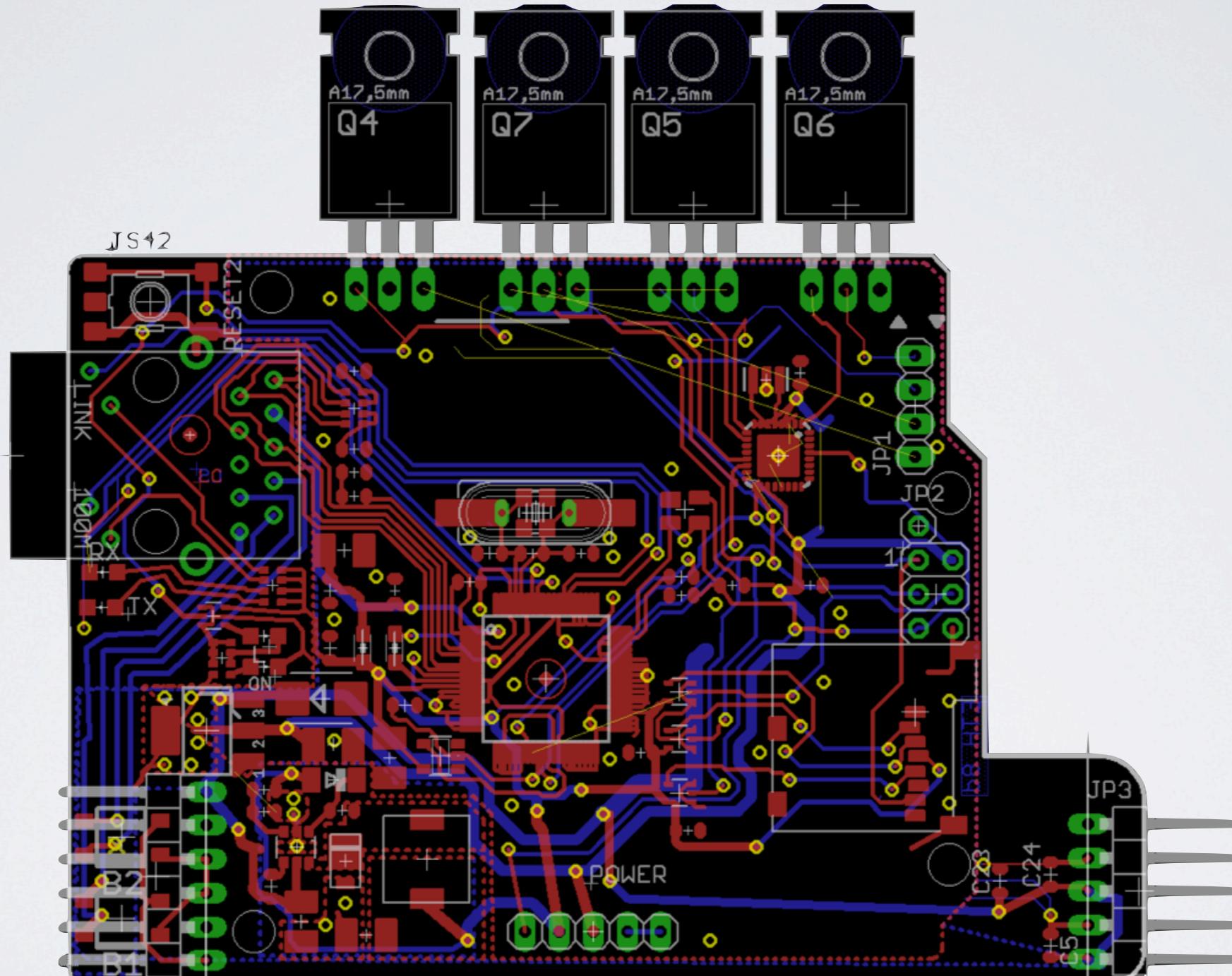
SCHEMATIC



SCHEMATIC



LAYOUT



IMPLEMENTATION

Software:

- C Code for Arduino
- Ethernet Library
- mDNS Library
- Ember Library



LIBRARIES

- Arduino Ethernet Library:
 - Provides TCP Server for receiving commands
- mDNS Library:
 - Allows auto-discovery before assigning an IP address
- Ember Library:
 - Processes network API commands into PWM output



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HARDWARE TESTING

- Compliance with IEEE PoE+ standard
- LED amplifier circuit



SOFTWARE TESTING

- Direct socket communication
- TCP mock client
- Node.JS client / web interface
- iPad client



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CHALLENGES

- Selecting appropriate project scope
- Selecting technologies
- Inexperience with board design



FUTURE OF THE PROJECT

- Deliver design to client
- Shield fabrication
- Board fabrication
- Support more types of LED



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QUESTIONS