S2011

California Polytechnic State University- San Luis Obispo
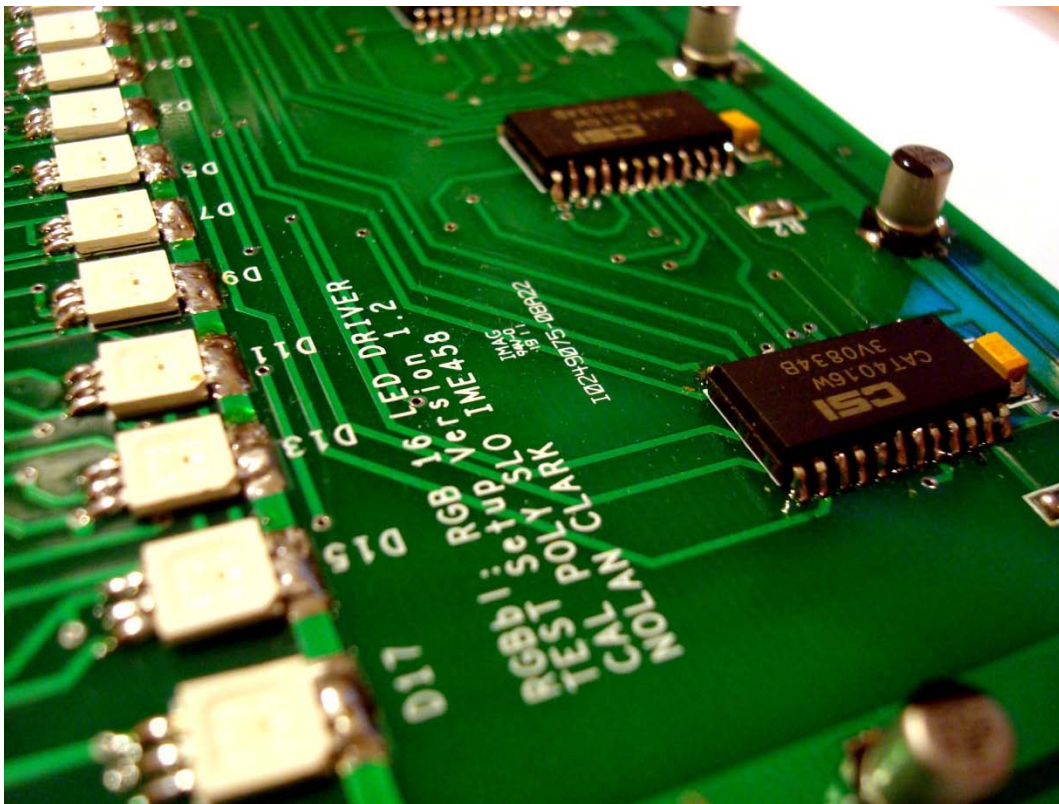
IME 458 Microelectronic and Electronic Packaging

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[16 CHANNEL RGB LED CONTROLLER]

FINAL PROJECT

June 01, 2011

Abstract:

Design a 16 channel red, green, and blue (RGB) light emitting diode (LED) controller capable of sourcing up to 100mA per channel by the most cost effective means possible. The design contains a microcontroller for uploading programs an allowing the PCB to function independently from an external source. Each color of all 16 LEDs should be individually controllable via an SPI connection traversing across each IC. The overall goal is to use a CAT4016 16-channel constant current LED driver for the design to demonstrate its functionality and possibility for use in other LED related projects.

The primary design component consists of designing the PCB, using Cadence Allegro, to comply with all the manufacture parameters.
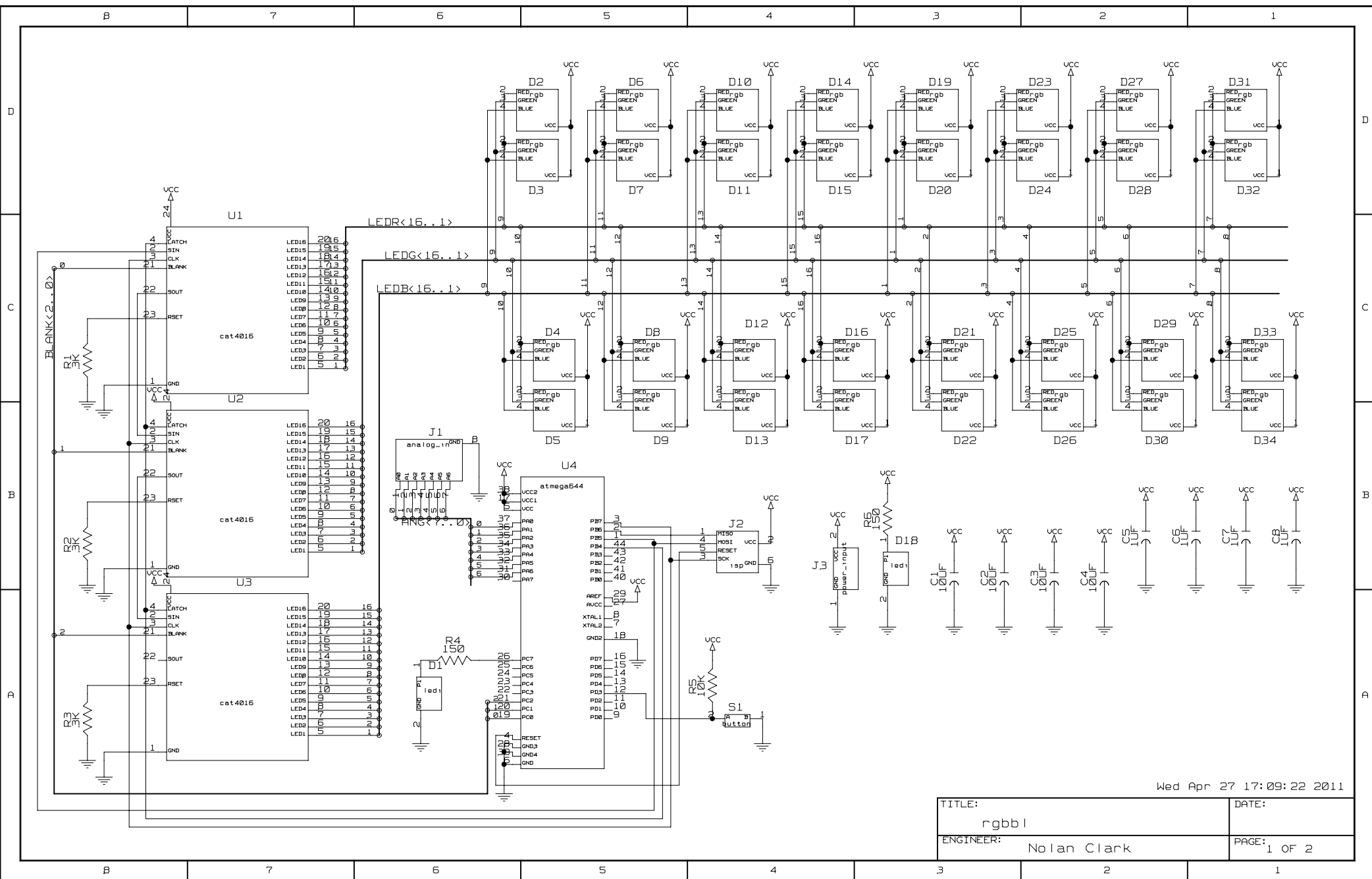
Project Description:

The design uses a 16-channel constant current LED controller (CAT4016) for each LED color allowing for individual color control. The LED driver integrated circuit communicates with a 44-pin ATMEL ATMEGA644A microcontroller by serial communication. The CAT4016 LED controllers are daisy chained together minimizing the number of IO port necessary to set the colors. The program sends each color out in a set of 16 data bits, totaling 48 bits of data transfer for each set-up cycle. The data is latched in the shift registers of the ICs and then output based on the enable pin on the IC. Each enable pin is controlled by the microcontroller allowing a single color output if desired. If all 16 RGB LEDs are turn on at once, producing the color white, the system draws a total of 1 Ampere. The input voltage can range from 3.3V to 5V depending on the power supply. The design includes several capacitors to reduce input noise and improve the reliability of all the ICs and LEDs. The LED current is set to 20mA using an external resistors on the RSET pin of the CAT4016. The blue and green portions of the LEDs have a turn on voltage 3.2-3.3V and red of 2.2V.

The overall goal of the project is to demonstrate the functionality of the CAT4016 constant current drivers for RGB LED control. The design incorporates analog inputs, allowing the board to be used as an analog voltage level indicator by changing the program on the microcontroller.
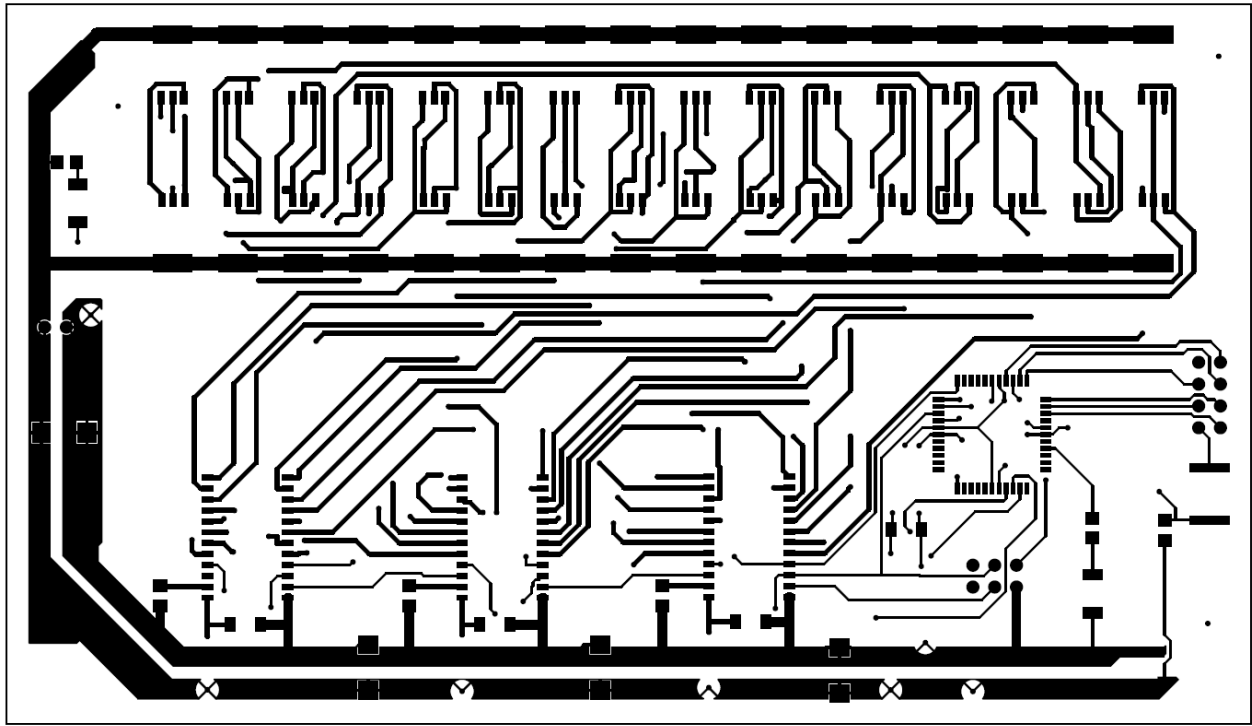
Design Parameters:
- Maximum board size 4x6
- Minimum 10mil trace width
- Minimum 10mil spacing
- Minimum 15mil vias
- Minimum 20mil traces for LED connections to reduce resistance (voltage drop)
- Polarity Capacitors to clean incoming DC noise
- Provide ISP programming connection for ATMEGA644A microcontroller
- LED for power indicator
- LED for programming indicator
- Button for mode switching
- Extra set of LED connections for all 16 channels
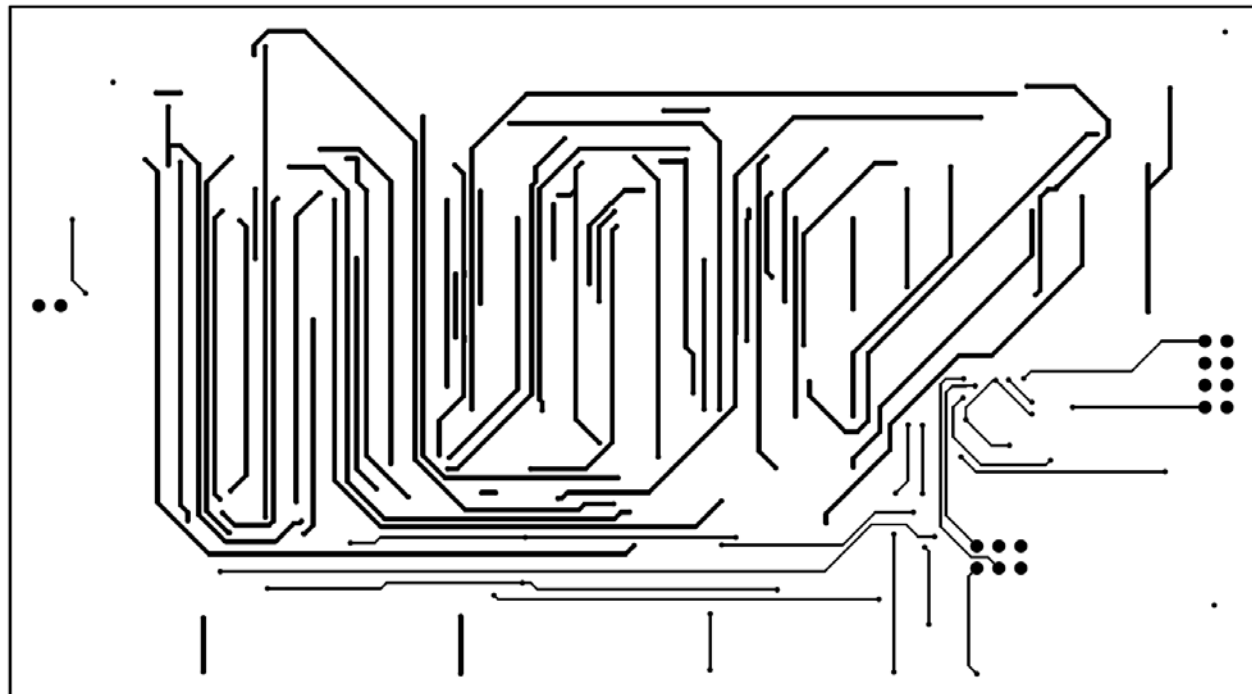- CAT4016 sourcing 20mA/ channel

TITLE:
rgbbl
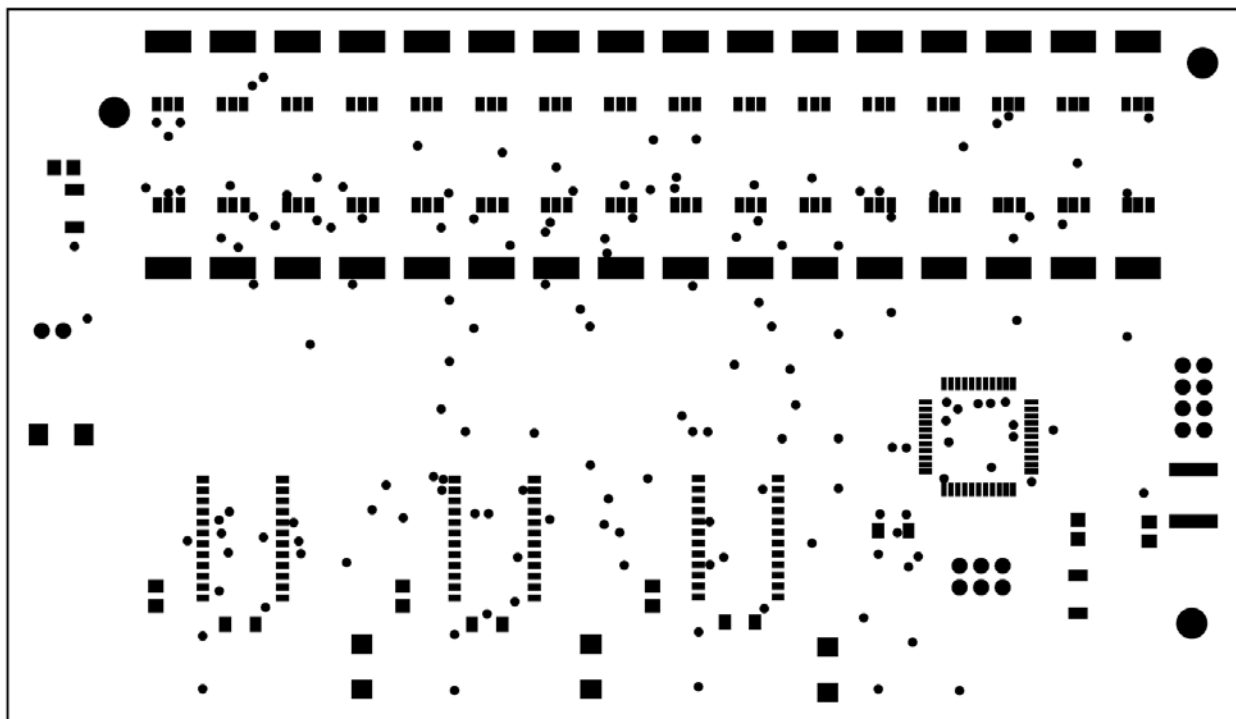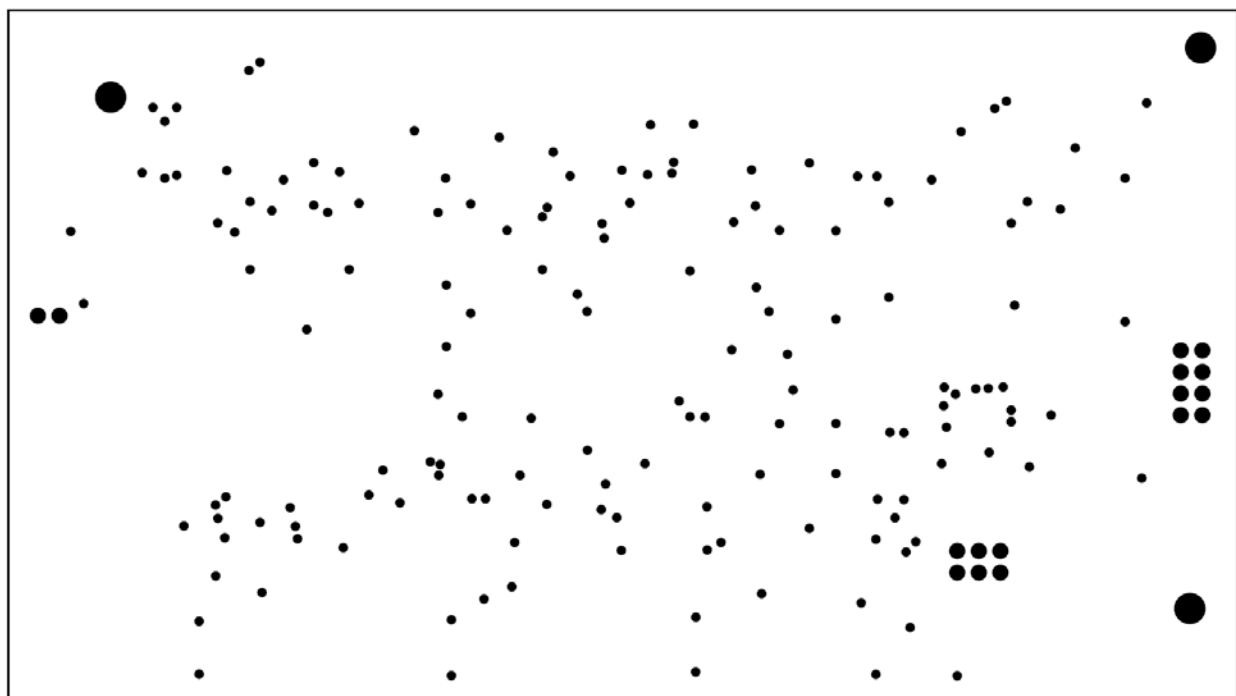
DATE:

ENGINEER:
Nolan Clark

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Wed Apr 27 17:09:22 2011

PWB Design:

Top Layer

Bottom Layer

Solder Mask Top

Solder Mask Bottom

Silk Screen

The silkscreen shows a PCB layout with the following labeled components:

Top row of diodes (left to right): D16, D14, D12, D10, D8, D6, D4, D2, D33, D31, D29, D27, D25, D23, D21, D19

Second row of diodes (left to right): D17, D15, D13, D11, D9, D7, D5, D3, D34, D32, D30, D28, D26, D24, D22, D20

Other labeled components: C6, C2, C3, C5, U3, R3, R2, C6, U2, R1, C7, U1, C4, C1, U4, C8, J2, R4, R5, J1, S1

Silkscreen text:
RGBbl: RGB 16 LED DRIVER
TEST Setup Version 1.2
CAL POLY SLO IME458
NOLAN CLARK

Notes:

The original design called for 4 layers, but due to pricing, the board is modified to accommodate a 2 layer design. The turnaround time for the 2-layer design was less than 5 hours in Cadence Allegro, but because of the time constrain many of the traces are placed using AutoRoute. The silkscreen is not as clean as originally designed because the design did not transfer over well from the original 4-layer board.

Component placement changed slightly to accommodate the 2-layer design because of spacing restrictions for the traces. The 2-layer design required more trace space to accommodate the power and ground traces leaving less room for the component interconnections. Component placement changed to help relieve some of these issues.

Completed PCB:

Unpopulated:

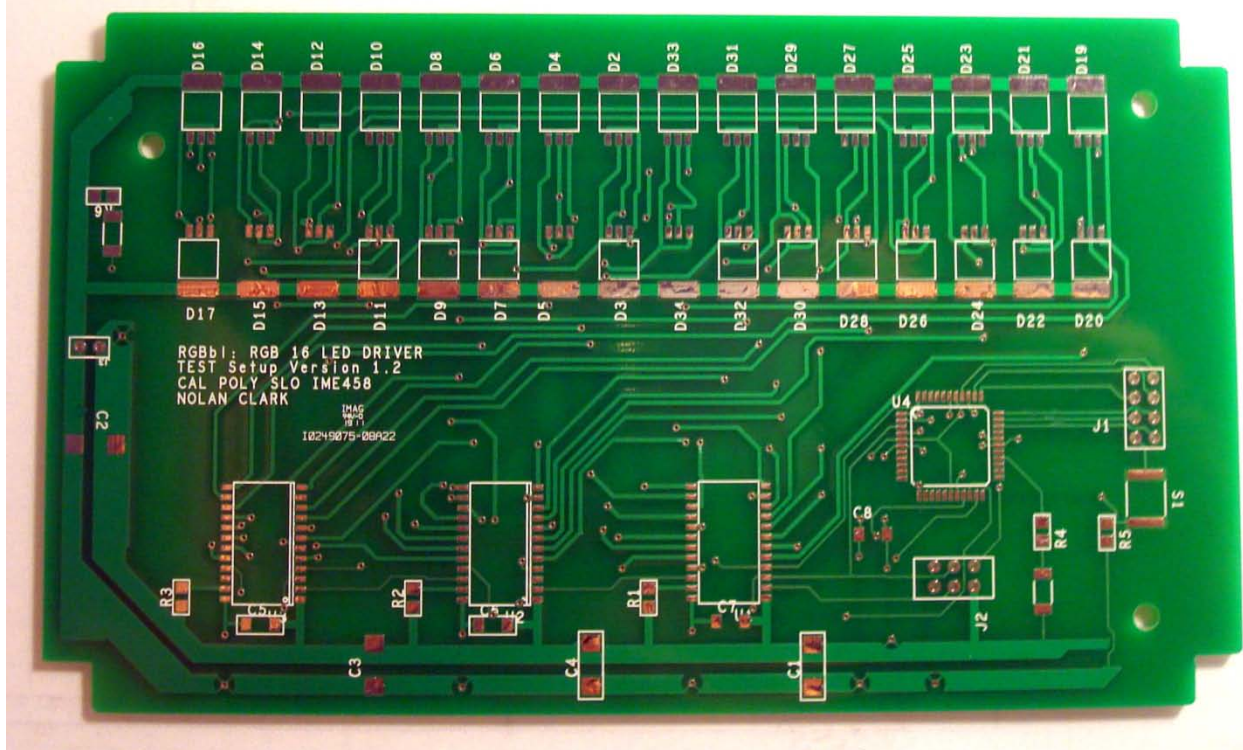PWB without components straight from the manufacturer
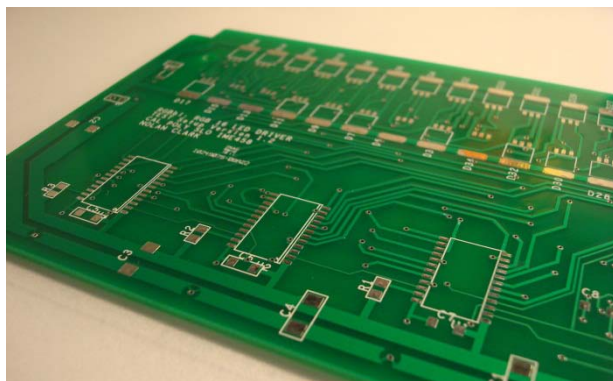

Figure 1: PWB image of entire board

Figure 3: Image of 3 16-Channel Constant Current Control IC Location and positive and ground voltage rails (thick traces on lower edge of PWB)
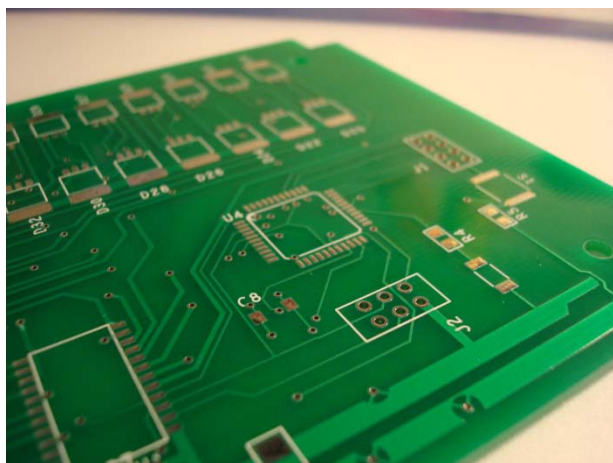

Figure 2: Image of Microcontroller location as well as ISP programming pins

Populated:

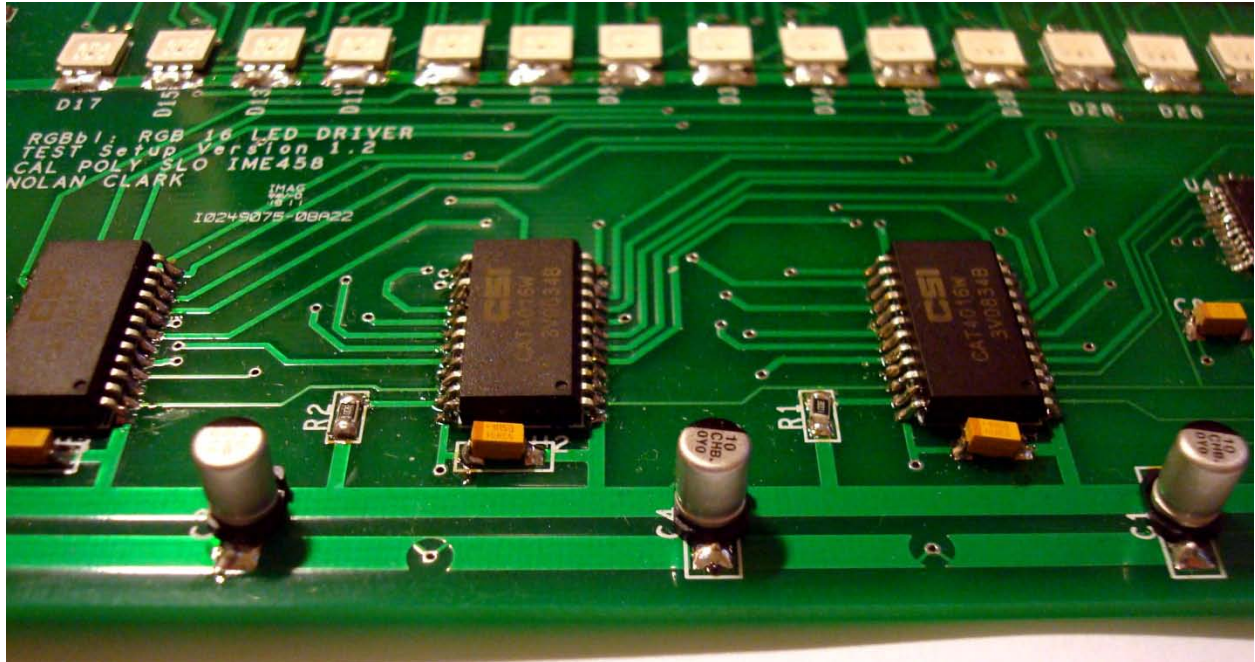PCB with all SMD components solder to board using SAC 305 Solder

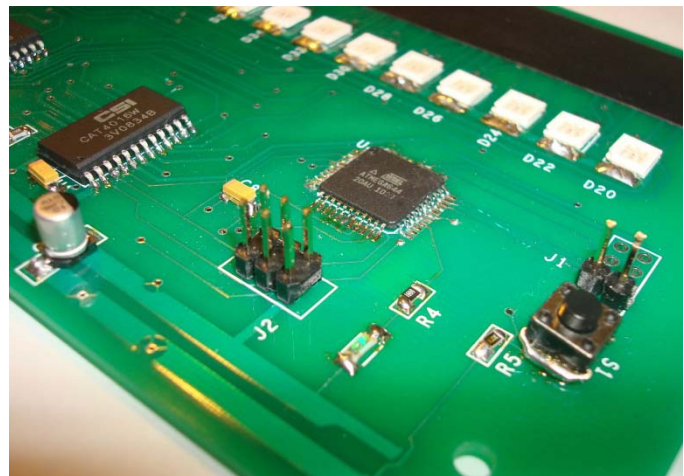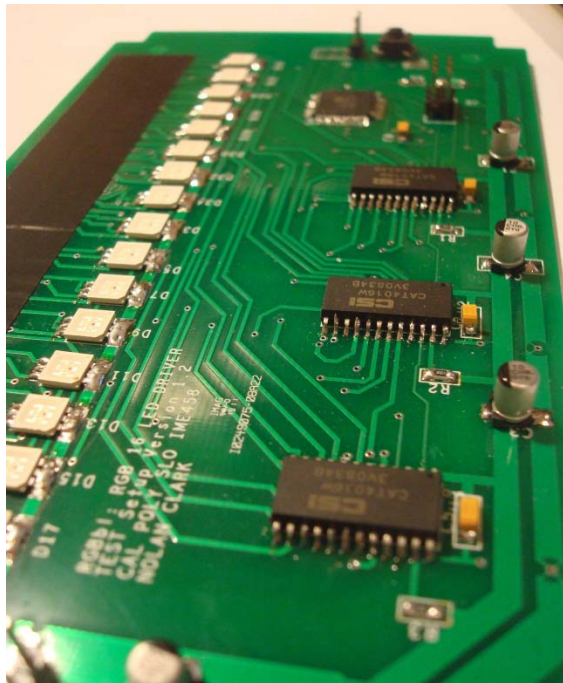**Figure 4: 3 16-Channel Constant Current LED drivers soldered to board**

Figure 5: Image of 44-pin Microcontroller, ISP programming pins, programming LED, and Button

Figure 6: Entire Board soldered and ready for programming (Black electrical tape (left side of image) used to cover unused LED connection pads to prevent undesired electrical contact).

Bill of Material

Bill of Material Report - 16 RGB LED DRIVER

Design Name C:/Users/Owner/Documents/Cad_data/RGBv1/worklib/rgbbl/physical/RGB_lightv2_final_drill.brd

Date Wed May 04 12:53:12 2011

Nolan Clark

IME 458

COUNT	REFDES	DESCRIPTION	VALUE/PART#	PACKAGE	MANUFACTURE	MANUFACTURE PART #
4	C1, C2, C3, C4	Electrolytic Capacitor 16V	10uf +/-20%	SM_6032	std	std
4	C5, C6,C6,C8	Tantalum Capacitor	1uf +/-20%	SM_1206	std	std
2	D1, D18	Green LED	LED 3.2V	SM_1206	std	std
32	D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, D14, D15, D16, D17, D19, D20, D21, D22, D23, D24, D25, D26, D27, D28, D29, D30, D31, D32, D33, D34	High Brightness RGB LED 20mA 5x5mm package	SMLW56	RGB*	ROHM Seimconductor	SRGB-SMLW56
1	J1	8 PIN Jumper Connection	8 PIN	Through-hole	std	std
1	J2	6 PIN Jumper Connection	6 PIN	Through-hole	std	std
1	J3	2 PIN Jumper Connection	2 PIN	Through-hole	std	std
3	R1	Resistor	3k 5%	SM_0805	std	std
2	R4	Resistor	150 5%	SM_0805	std	std
1	R5	Resistor	10k 5%	SM_0805	std	std
1	S1	SWITCH TACT 4MM SQ	SWITCH	CUSTOM	std	7914G-000ECT-ND
3	U1, U2, U3	LED Current Driver	CAT4016	SOIC24W	ON Semiconductor	CAT4016W-T1CT-ND
1	U4	Microcontroller	ATMEGA644A	PQFP44	Atmel	ATMEGA644-20AU
NOTES:	* RGB: Custom Footprint for component					
	** Resistor values subject to change depending on input voltage					

Conclusion

Designing the schematic and PCB using Cadence Allegro proved to be rather challenging especially without any prior knowledge of how the program operated prior to this experience. Allegro provides a versatile platform allowing the user to full customize the design based on the desired specifications. Designing the schematic image and footprint and associated the pins between the two took several trial and error runs. Once the entire library was developed, along with the footprint, placing the components in the schematic moved very smoothly with the provided tutorials. Creating the 4-layer board moved relatively smoothly, aside from issues getting vias to fall within parameters. The real issues came when attempting to transfer everything over to a 2-layer board. The major problem was removing the extra layers and deleting the AutoRoute traces. The next major issue development from adjusting the via sizes to meet the 15 mil compliance. The final major issue involved using AutoRoute while still keeping the desired power traces intact. Once all the issues were worked out the PCB passed the manufactures DRC and moved on to production.

With the passage of one week the PCB return complete, and the major traces were tested to ensure proper connectivity. All the components were soldered to the board and the solder joints were inspected for good contact. Any connections that appeared to have issue were re-soldered. The completed board was plugged in to a 3.3V power source and tested at specific contact points and solder connections. The entire design appears to operate correctly and only requires programming. Overall the PCB design is a great success.