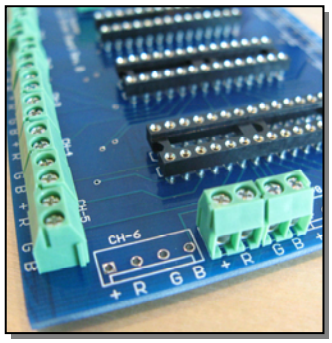

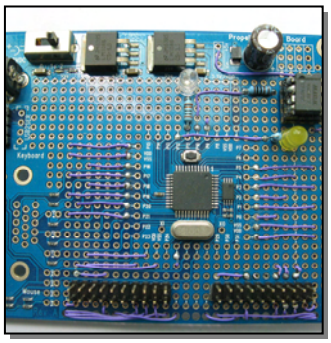

LIVING ROOM LED DISPLAY

OVERVIEW

The 16 Channel RGB TLC5940 Driver PCB by Brilldea is used to create dynamic LED lighting displays. This product is well suited for high channel counts of red, green, blue LED control because the PCB is designed for three TLC5940 ICs. This application note details the design and creation of a living room LED display using the 16 Ch. RGB TLC5940. This living room LED display was posted on the Make Magazine Blog in December 2007 and featured as a customer application on Parallax's website. See the video of this living room display in action on YouTube.

THE PROJECT

This project took shape in my living room. The living room has three bookcases arranged along a wall, evenly spaced by about 10 inches. Each bookcase required assembly and the kit contained white corrugated plastic sheets to be mounted as a backing to the bookcases. While assembling and arranging the bookcases I decided not to attach the plastic sheets but to mount them in between the bookcases to fill the gap.

Custom LED lighting was placed behind the white panels to create a color wash and programmable light show. The lighting display is programmed to influence the mood and energy of the room. The lights softly swirl as colors blend together to create a relaxing atmosphere. The lights dance and chase each other to create an energetic, fun environment. A color changing LED display was just the right project to brighten my living space.

Brilldea

Application Note

Living Room LED Display

Rev 01.0

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THE DESIGN

The Living Room Display needed to achieve the following design goals:

- The system had to be low cost; US$275 was my project budget. This project can now be built for less using the equipment sold by Brilldea.
- The system had to be non-intrusive, that is to say the system had to hide behind the white corrugated plastic.
- The system had to have a standalone operation mode where the colors slowly cycle and a DMX-512A mode where each channel could be controlled by an external controller.
- The system had to have red, green, and blue LEDs with color mixing ability.
- The system had to have as many channels of control as was reasonable for creating unique effects. In other words, each column and each color and each row should be controlled independently.

The final design of the Living Room Display included the following equipment:

- **Master Controller:** Built from a Parallax Propeller Proto Board. The Proto Board contains one Propeller microcontroller that was used to control the display. (one piece, ~US$19.95)
- **LED Driver Board:** A specially designed 16 channel RGB TLC5940 board was created for this project and is now sold by Brilldea. (two pieces, ~ US$100.00, this includes tooling cost for the PCB.)
- **96 SMD RGB LED:** The RGB LEDs were purchased mounted to a flexible printed circuit board. The LEDs and FPC are designed for 12 VDC operation. The FPC can be cut every 10 centimeters. (3.3 meters, ~US$90)
- **12 VDC Power Supply:** A Meanwell AC to DC regulated power supply capable of 5 Amps DC output. (one piece, ~ US$20.00)
- **Misc. Equipment:** This included ribbon cable, power cables, etc (~US$30.00)
- **DMX Equipment (optional):** The master controller was designed to control the two columns with DMX-512A. Equipment to generate DMX was needed. (Pricing varies based on hardware/software chosen.)

The following is a diagram of the components in the system and how they are connected.

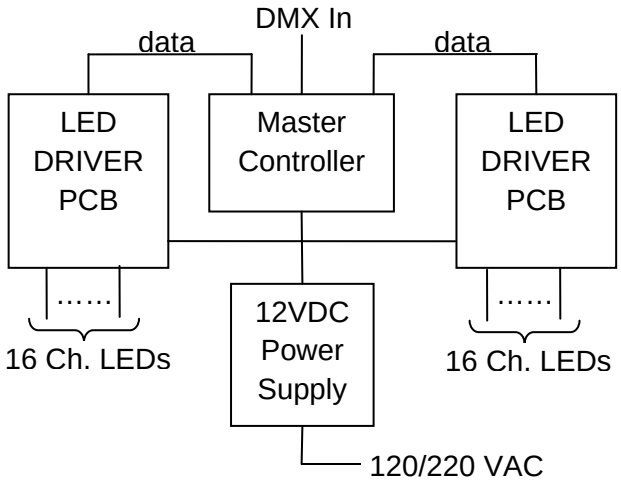

Figure 1 LED Living Room LED Display System Design

MASTER CONTROLLER

The master controller was assembled from a Parallax Propeller Proto Board. One of the unique characteristics of the Propeller is that it is 8 microcontrollers in one! The

 © Brilldea

Propeller has amazing processing power and yet is easy for a beginner to learn.

The Proto Board offered a great starting point. Because of the limited project budget, a PCB was not designed specifically for this project. Instead the Proto Board was used so components could easily be assembled and soldered directly to the PCB.

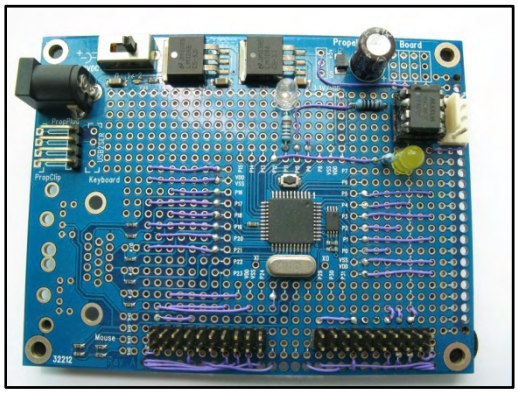

Figure 2 Front side of Master Controller

The Proto Board comes preassembled with a Propeller MCU, EEPROM, 5 VDC regulator, 3.3VDC regulator, power switch and a Prop Plug connector (for programming).

To create the Master Controller I soldered the following elements to the Proto Board:

DMX Receive Circuit: A circuit for receiving DMX-512A was added. This required one input pin (P10) on the Propeller to receive the serial signal. A four pin connector was provided to attach a “pigtail” that has a 5-pin male XLR. A Maxim MAX487E IC was used to translate the 12VDC signal levels of DMX-512A (similar to RS-485) to 5VDC levels. A resistor was used in series with the Propeller input pin to drop the 5VDC voltage to a safe level for the Propeller I/O.

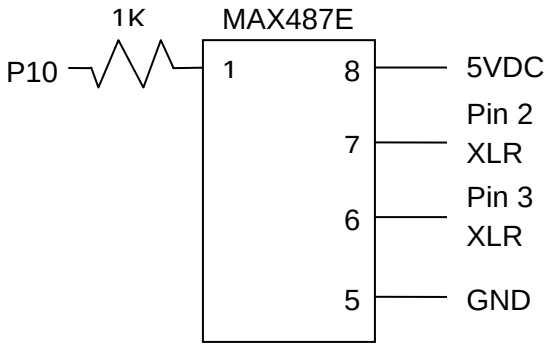

Figure 3 DMX Receive Circuit

DMX Indicator Circuit: A yellow 5 mm LED was used as an indicator to signal activity on the DMX-512A network. When the software in the Propeller is properly receiving data, the LED blinks. The LED is attached to one output (P12) of the Propeller microcontroller.

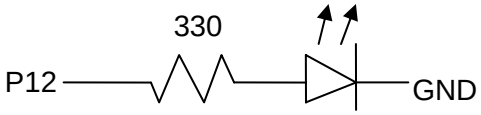

Figure 4 DMX Indicator Circuit

Misc Indicator Circuit: A blue 5mm LED was added to an output (P11) of the Propeller to indicate status while debugging and programming.

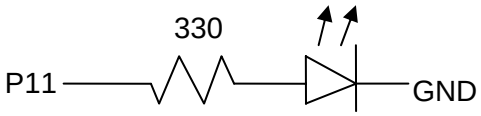

Figure 5 Misc. Indicator Circuit

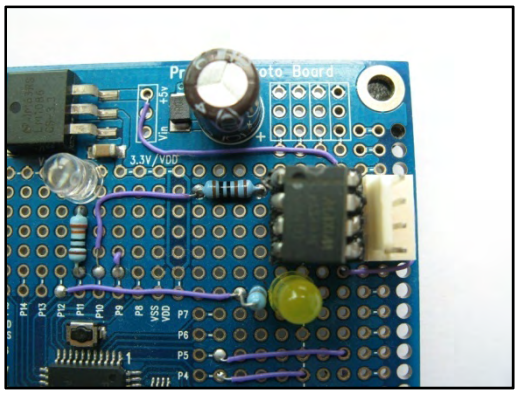

Figure 6 DMX Receive Circuit and LEDs

Connection to/from LED Driver PCB:
The Propeller communicates with an LED Driver PCB for each column (two columns in the design). A 2x10, 0.1" header was employed to make the connections easy for each column. The various I/O, 3.3VDC and GND connections were wired to these headers.

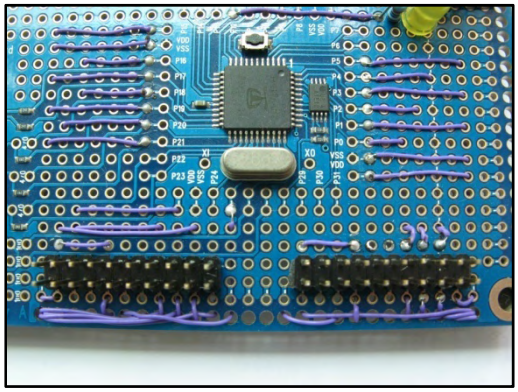

Figure 7 Connections to LED Driver PCB

The components were soldered to the Proto Board and the connections were made with small diameter wire wrap wire.

Further on in this application note the software running in the Propeller will be described.

LED DRIVER PCB

I discovered the Texas Instrument TLC5940 integrated circuit during the planning of this project. This IC is a 16 channel LED driver with DOT correction and grayscale PWM control. The chip is available in various IC packages which makes it good for both hobbyists and engineers to experiment.

The TLC5940 was used to gain control of many LEDs with minimal hardware design. Multiple TLC5940 ICs were chained together so that the software from the Master Controller talks to each chip. The basic concept of the TLC5940 is that it is a FIFO serial shift register. That is to say that data can be clocked out of the Master Controller and sent to each chip in the chain by going through the chips before it.

In order to use the TLC5940 a printed circuit board had to be designed. Since the project was going to use red, green, blue (RGB) LEDs, the PCB was designed with 3 pieces of the TLC5940 so that each board is a 16 channel RGB controller.

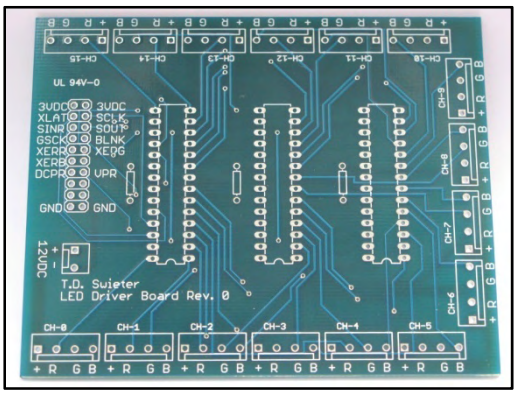

Figure 8 LED Driver PCB

The PCB was designed with components that could easily be soldered to the board. A 2x10, 0.1" spaced header was chosen as well as a DIP package for the IC. Screw terminal blocks were used to connect the

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LEDs to the PCB. To keep costs down, the PCB is 2 layers.

The PCB design required a logic power supply for the IC (3.3VDC) and an LED power supply (12 VDC). The PCB is attached to the Master Controller with a colorful 20 conductor ribbon cable with 2x10, 0.1" Insulation Displacement Connector (IDC) on each end.

The I/O and power connections were labeled in the silkscreen of the PCB so that the signals from the Master Controller or other devices could easily be attached during design testing.

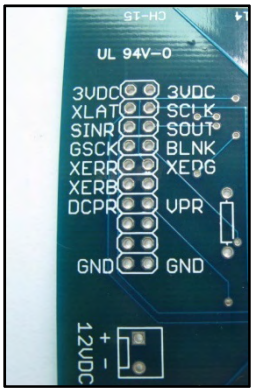

Figure 9 Labels on the PCB Silkscreen

See the end of this document or the separate PDF file for the schematic of the 16 Ch. RGB TLC5940 Driver PCB.

The PCB design contains three TLC5940 ICs wired in series. The serial data from the Master Controller is clocked into the first chip (SIN). When the register of the first TLC5940 is full, the data appears at the output of the chip (SOUT) and then the second TLC5940 register begins receiving data.

There is a current setting resistor for each TLC5940 so that the LED max current (brightness) can be set. All of the TLC5940 I/O features are brought to the header so that more advanced controllers can be attached to all the functions of the IC. For the Living Room LED Display the following I/O was used:

- SCLK
- SIN
- XLAT
- GSCLK
- BLANK
- VPROG

Again, note that an LED power supply must be provided in addition to the logic power supply. Each power supply must stay within the ratings stated in the TLC5940 datasheet.

Accidentally, the 0.1uF decoupling capacitor for each IC was left out of the PCB design. This problem was discovered while soldering the manufactured PCBs. A decoupling capacitor is recommended and was added between the VCC and GND pins on the bottom of the PCB.

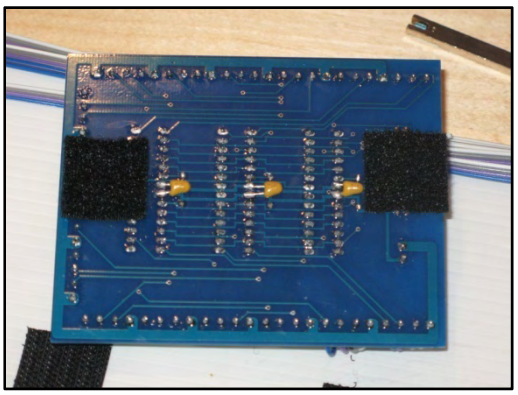

Figure 10 Capacitors added between VCC and GND Pins

To further understand the TI TLC5940, please see the datasheet on the Texas Instruments' website.

RGB SMD LEDS

Several different LEDs and LED clusters were experimented with to give the wash look on the white corrugated plastic. The testing revealed that the best look was created with a high quantity of LEDs spaced throughout the back of the plastic surface. The LEDs were also set back from the "projection surface" in order to give a smooth wash instead of point lights.

Remember a requirement of the project was to have red, green, and blue LEDs. As the channels, LED count, and ideas were adding up it looked like a lot of soldering was going to be happening. That is when a supplier in China was found that offered the perfect solution on a flexible printed circuit board (FPC) with mounted LEDs designed for 12VDC! Perfect!

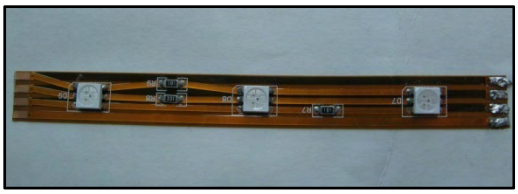

Figure 11 SMD LEDS stripe

3.3 meters of the FPC was purchased for this project. The FPC can be cut every 10cm so that each unit includes 3 RGB SMD LEDs. 16 10cm pieces were used for each column. The pieces were mounted on a piece of white corrugated plastic that was placed behind the front surface.

So, each column contains 16 rows of LEDs and each row contains 3 LEDs for a total of 48 LEDs per column. Each row is individually controlled. Further, each color (red, green, blue) is individually controlled within each row. In other words you can control the red, the green, and the blue intensity of each row in your display.

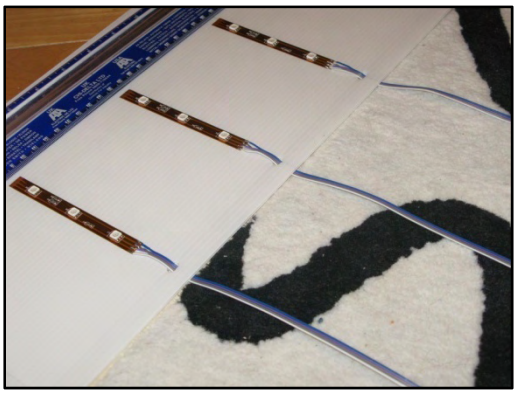

Figure 12 LED stripes being laid out

Figure 13 LED final assembly

LED POWER SUPPLY

To power the LEDs (and the rest of the system) a 12VDC power supply was required. The power supply was plugged into a 120/220VAC outlet and produces 12VDC. The size of the power supply for your system may vary, but the one used in this system allows for 8.3 amps DC. This is overkill for this system and a 4 amp power supply would have sufficed. Double check your power calculations.

The power supply is a regulated power supply. Be careful using unregulated power

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supplies as their voltage may sag if all the LEDs in the system are turned on at once.

The 12VDC power supply also powers the Master Controller. Even though the Proto Board may be able to handle a 12VDC input, it is recommended not to attach 12 VDC to it. Instead a small circuit was created on perf board to regulate the 12 VDC to 7 VDC for input into the Master Controller.

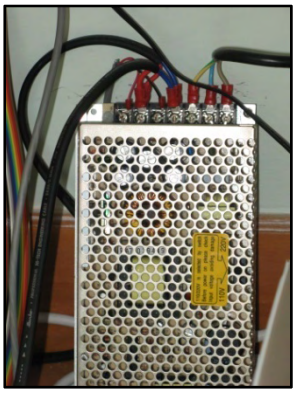

Figure 14 12 VDC Power Supply

Note that the connections to the power supply are terminated with ferrules and ring terminals. Using ferrules and ring terminals not only makes your project look professional, but it also helps to eliminate any small strands of wires from accidentally shorting the positive and common voltage. Yikes!

MISC. EQUIPMENT

The cables, connectors and wiring are the final components required to piece everything together. It is important to lay out the components in an orderly manner so that it can be easily serviced in the future if needed. Be sure to route the cable cleanly and use ferrules and crimp terminals as needed. I also recommend tinning any bare wires before attaching them into screw terminals. This will help keep all the wire strands together.

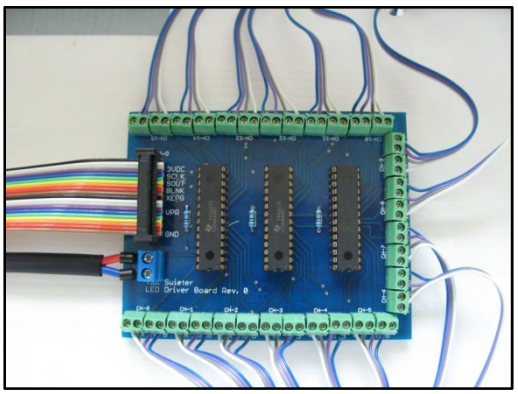

Figure 15 Clean connections to the PCB

DMX EQUIPMENT

One of the project's design criteria was to be able to control the LED columns with DMX-512A. DMX is an industry standard protocol for controlling lighting equipment, fog machines and other theatrical devices. DMX can be found in theaters, night clubs, churches and touring events – pretty much anywhere you have professional lighting equipment. For further information, check out the Wikipedia article for DMX-512A.

The Master Controller was configured with a DMX input. To complete the system, hardware and software for generating DMX was purchased. An Enttec OPEN DMX USB device was chosen for generating DMX.

Figure 16 Enttec OPEN DMX USB device

Vixen Lights was chosen as the software to create the Living Room LED Display as shown in the YouTube video. Vixen Lights is free software and is easy to use with plenty of help from a forum. Check it out!

SOFTWARE

Two pieces of software were created for the Living Room LED Display. The first piece of software is the program that runs in the Propeller microcontroller. The second piece of software is the Vixen Lights show file that runs on a PC and sends DMX packets synchronized with music.

The program files for the Propeller can be downloaded from Brilldea's website on the Resources page.

The software implements two modes of operation. One mode is standalone in which the LED columns slowly cycle through different colors. In the second mode DMX controls the LEDs. The modes automatically change if a DMX signal is detected.

The Propeller software is constructed from several software objects. The objects are documented in the software and their use should be evident from the code comments.

Basically intensity levels are set for each channel of RGB LEDs. The LED display is broken into the left column and the right column. The software is mostly written in SPIN and should be easy to follow.

CONCLUSION

The Living Room LED Display was a success! Every evening the RGB LED can be found dancing away in my living room. This project is only the tip of an iceberg of what could really be done. The software has room to expand so that other types of fades, washes and wipes can be implemented when not receiving DMX.

Another idea is that the controller could play back routines stored in its EEPROM or played off an SD card slot.

The possibilities are endless and only your creativity is your limit.

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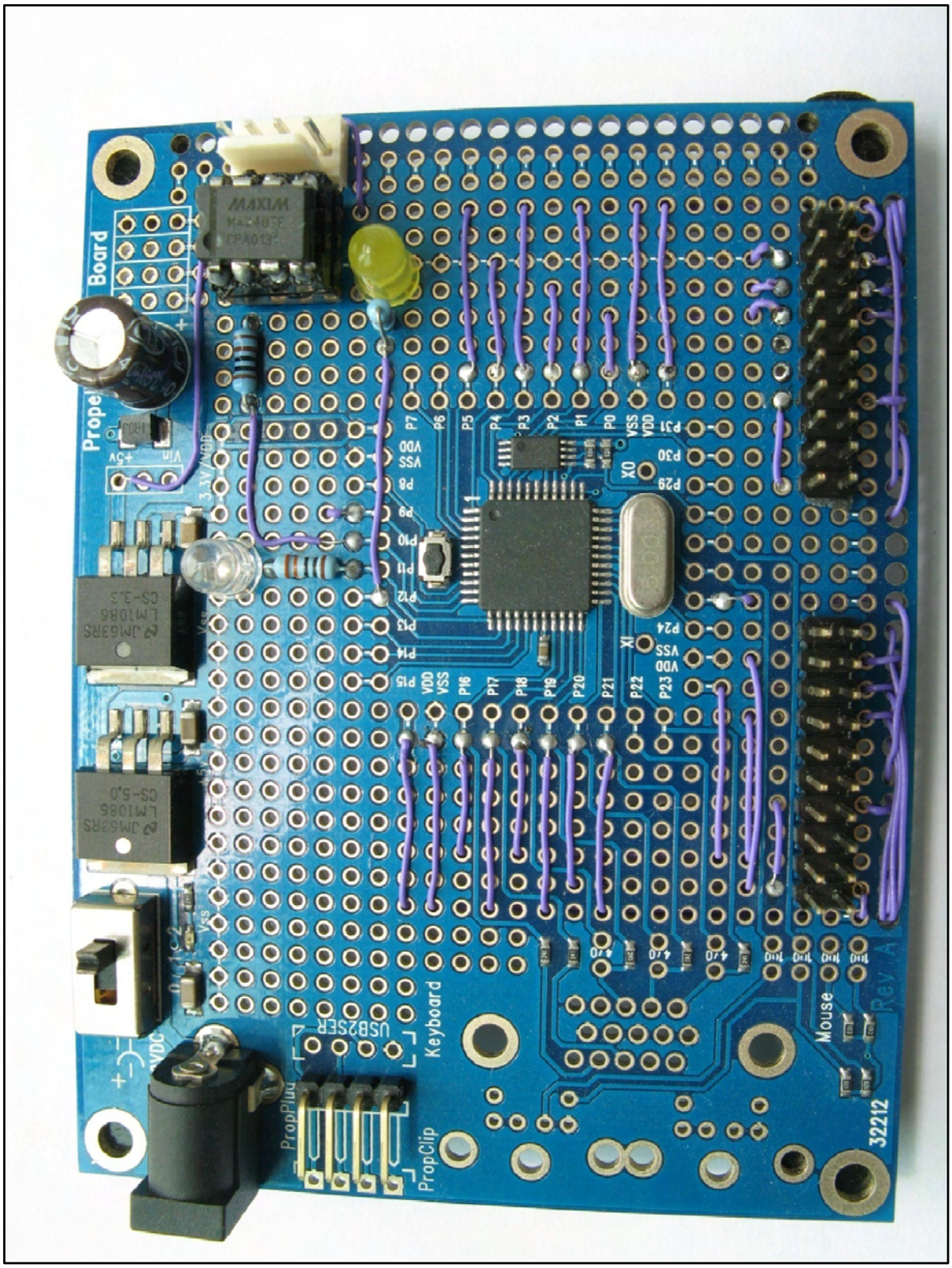
HIGH RESOLUTION IMAGES



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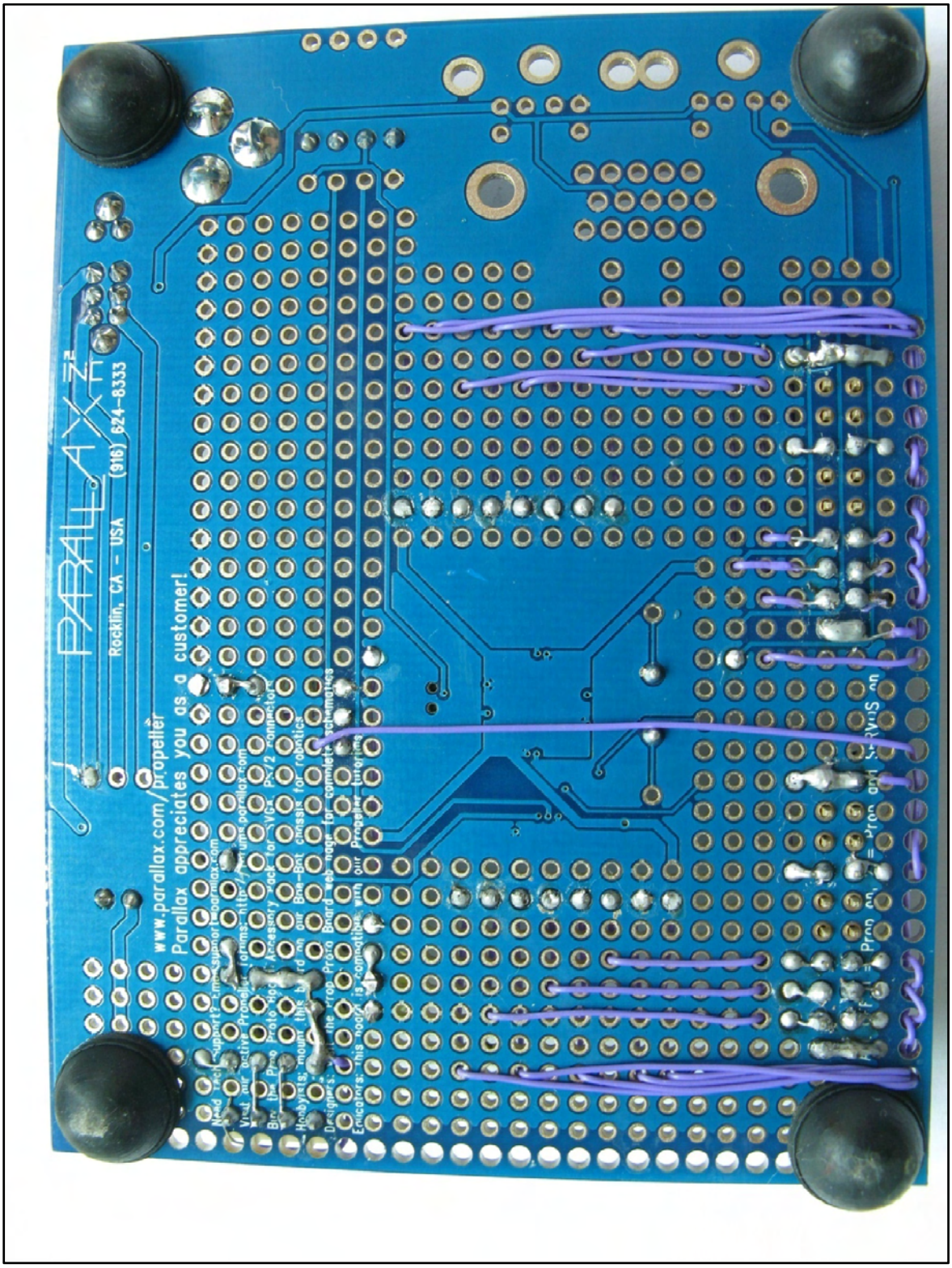
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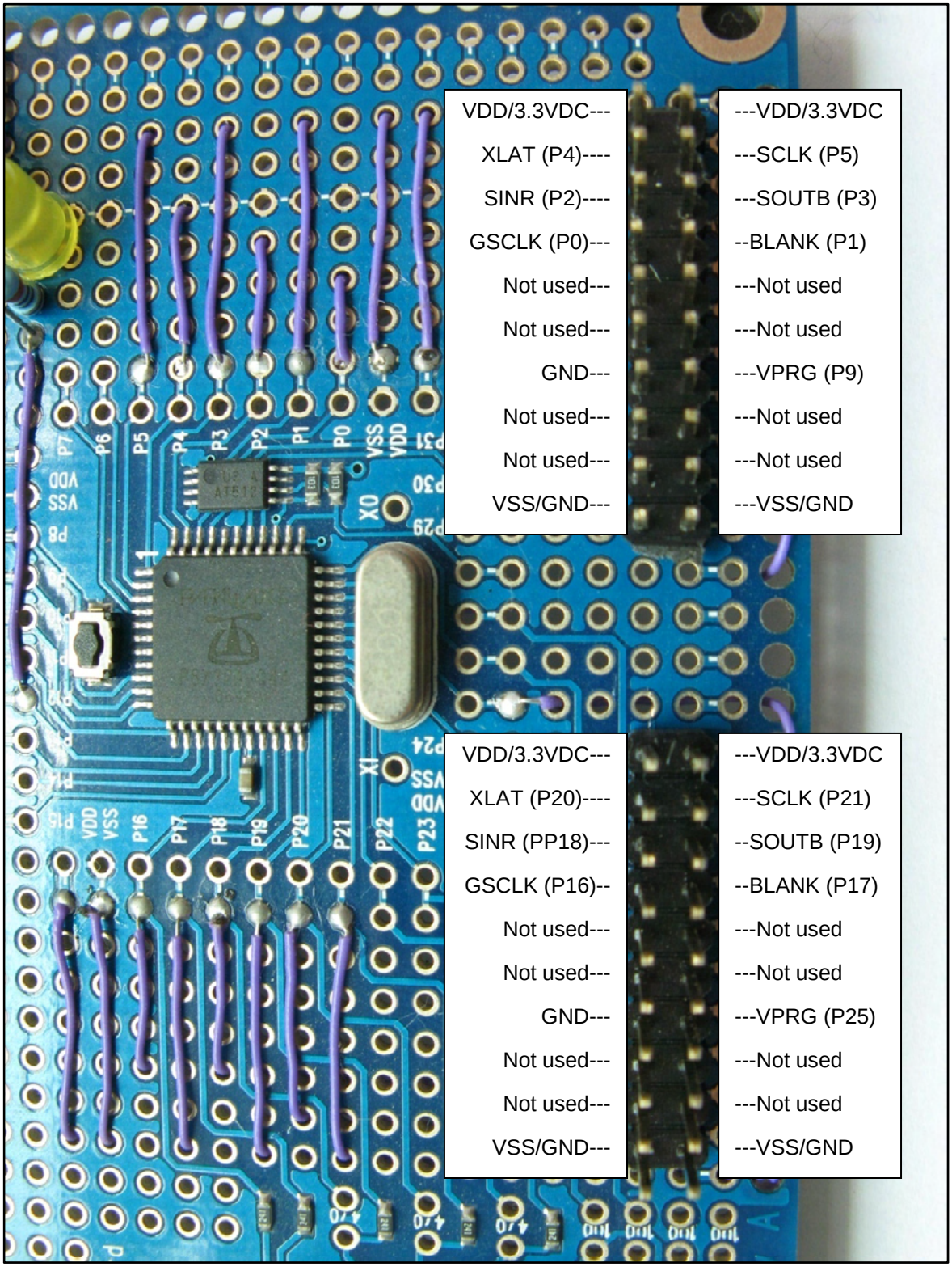
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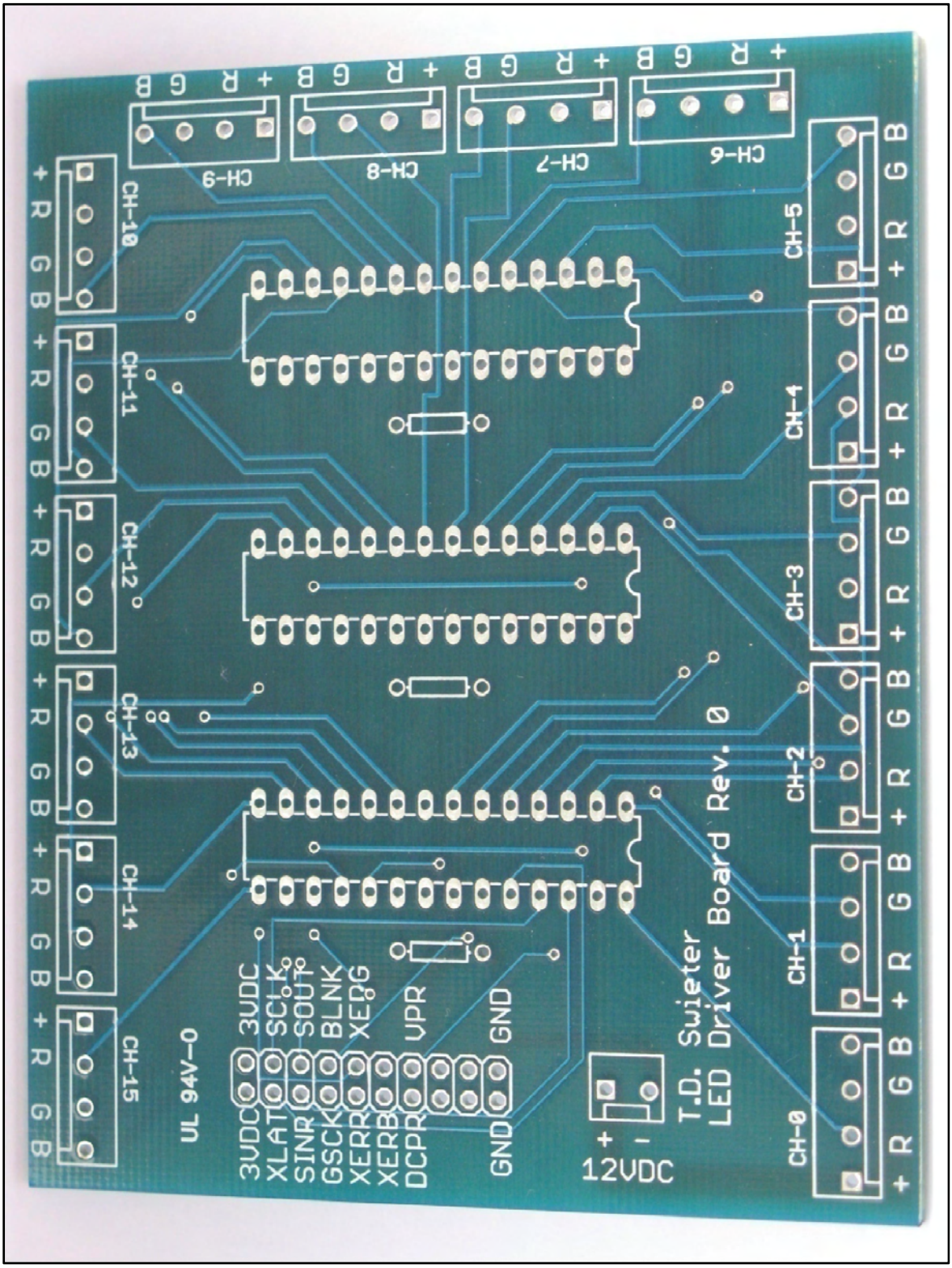
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LED Driver Board Rev. 0

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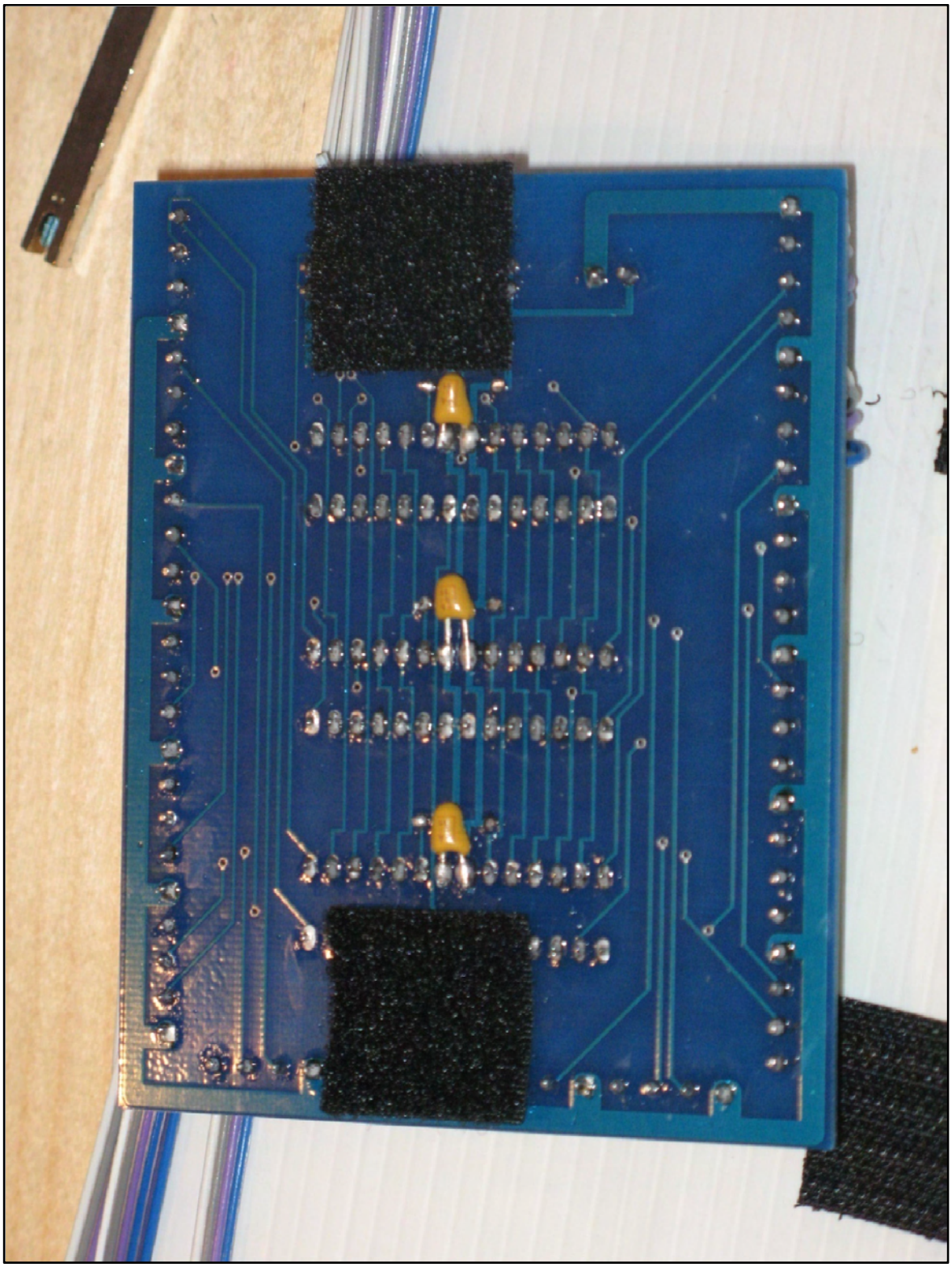

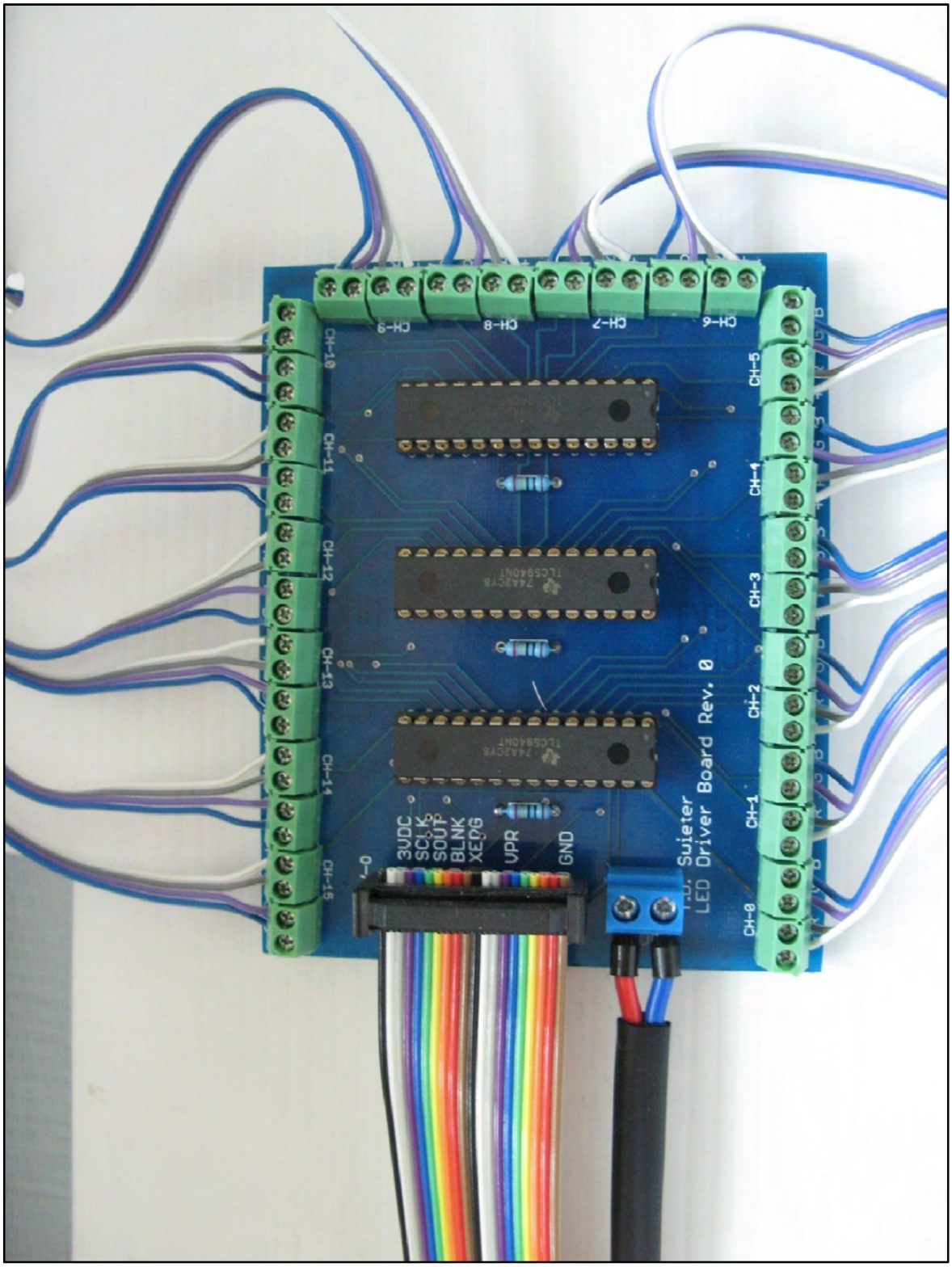
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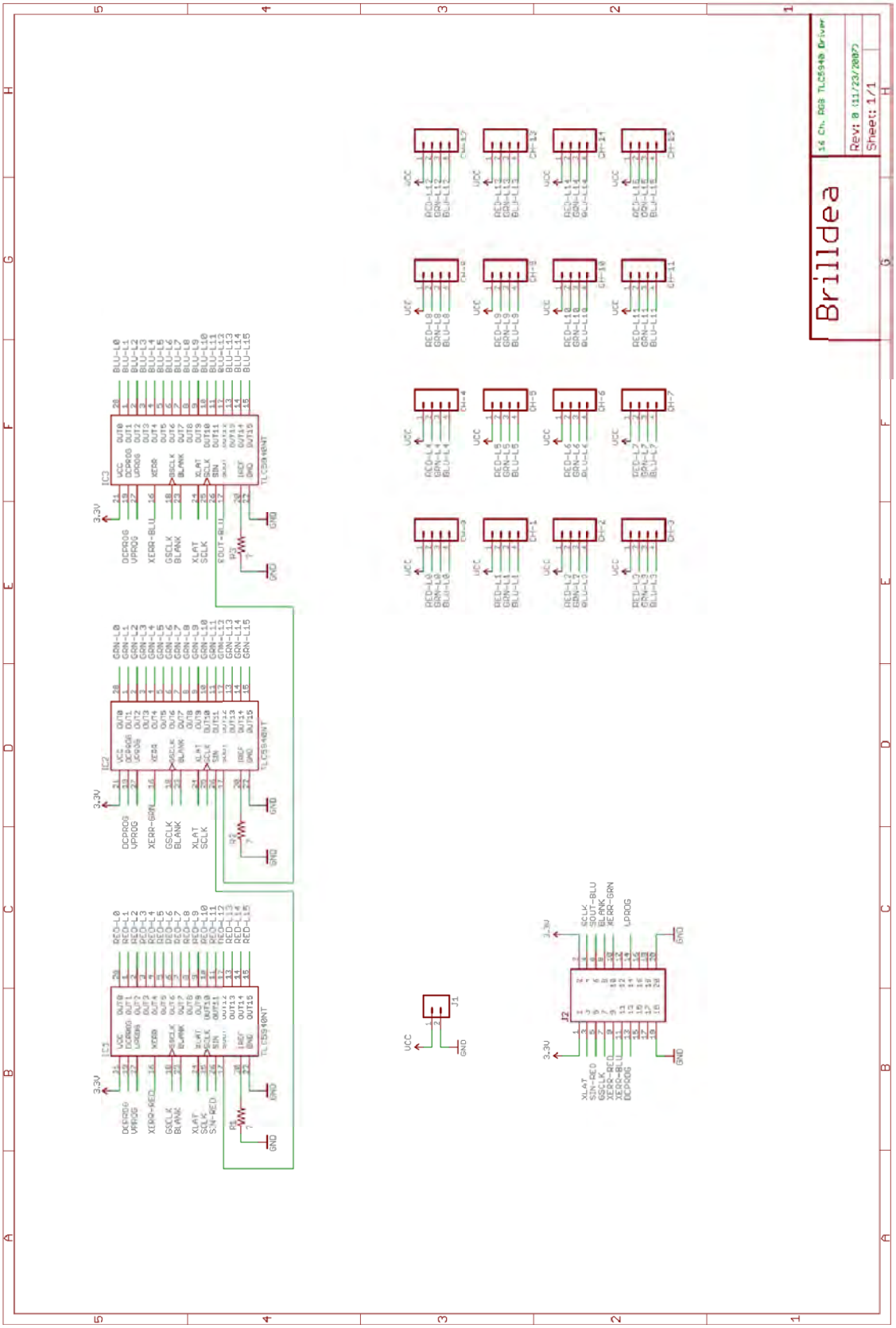
SCHEMATIC


Brilldea
16 Ch. RGB TLC5940 Driver
Rev: 0 (11/23/2007)
Sheet: 1/1
TLC5940NT
3.3V
GND
VCC

REVISION HISTORY

Release Date	Document Revision	Change Description
2008-04-07	01.0	Initial Release

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