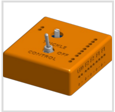

Feb 18, 2020

3D Printing Case for LED Controller

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ABSTRACT

The electronics control circuit for the illuminated orbital shaker should be housed in a case to protect it from damage by short-circuit, but also to minimize injury by electrical current and fire hazard.

This document is part of the Illuminated Orbital Shaker for Microalgae Culture project:

- Procuring Parts for Algal Shaker


Assembling LED Controller Electronics
by Jakub Nedbal,
King's College London
PREVIEW RUN

- 3D Printing Case for LED Controller *(this document)*
- Assembling Cooled LED Illuminator
- Cutting and Drilling Clear Acrylic Sheet
- Assembling Algal Shaker

EXTERNAL LINK

https://app.labstep.com/sharelink/b5760252-f0e4-42a3-ae65-595c75d5a999

GUIDELINES

The electronics control circuit for the illuminated orbital shaker should be housed in a case to protect it from damage by short-circuit, but also to minimize injury by electrical current and fire hazard. Any sufficiently large plastic box can be used for this purpose with holes drilled in the appropriate places for switches and connectors. With the wide availability of 3D printers these days, printing the case is a time- and cost-efficient way to obtain a snugly fitting customized case.
This document introduces the CAD files modelling the case, the printing, and the final finishing of the case.

In-house or Out-Sourced Printing

Fused deposition modeling, which is available in many research labs and workshops, offers sufficient quality print to produce a functioning case for the electronics. Commercial 3D printing, based on laser sintering of polyamide, would produce a superior finish and look, but may come with higher cost and longer lead time. It is up to everyone to judge their situation and priorities. We have used an in-house Stratasys uPrint SE Plus fused deposition modelling printer with printed support to produce the case.

MATERIALS TEXT

Materials

- 3D printer with material and accessories.
- M3 thread tapping set *(#4-40 UNC thread tapping set, where imperial threads are used).*
- Four M3×10 mm counter sunk screws *(four #4-40 UNC 3/8"-long counter sunk screws, where imperial threads are preferred).*
- Screwdriver or Allen key for the above screws.

SAFETY WARNINGS

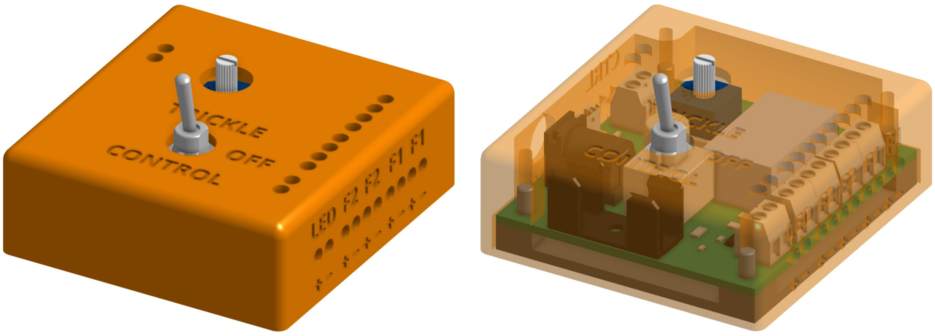
3D printing involves melting plastics. It can release fumes and the nozzle is hot. Operate the 3D printer safely according to instructions and local regulations. Use personal protective equipment if prescribed.

Some 3D printers use support material, which is later removed by soaking the printed object in warm hydrogen peroxide. This is a strong oxidizing agent, use personal protective equipment and follow instructions and local regulations to protect skin, eyes, and clothes from damage.

Cutting threads involves using thread taps. Thread taps and screwdrivers are sharp. The acts of cutting threads and screwing screws requires repetitive hand motion. The risk of injury is small. However, observe safe working practices to minimize the risk.

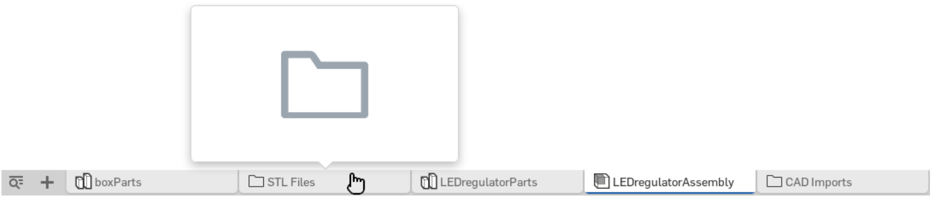
1 Obtain Source Files

The electronics circuit has been designed in KiCAD. KiCAD PCB files can be opened in FreeCAD. This in turn allows exporting the 3D render of the PCB into an industry-standard STEP file format. The STEP file can then be imported into Onshape, which is a 3D CAD tool. Onshape was then used to create a 3D model of a case to hold the electronics printed circuit boards with all its components. The case consists of two parts, the Top and the Bottom, which are fixed together by screws during the final assembly. The model of the case with the embedded electronics circuit is openly available on the LED regulator case project page.



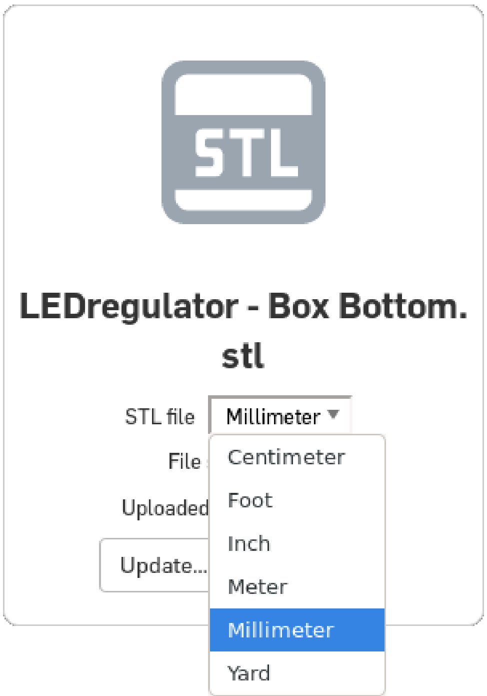
Assembled case for the LED controller circuit. (Left) the outside view of the case, (right) a transparent rendering of the case to show the electronics within.

3D printing, whether done in-house or outsourced, requires STL files to work from. The STL files can be found on the LED regulator case project page in a subfolder named **STL Files**, as shown in the screenshot below:



Click the STL Files tab on the LED regulator case project to access the STL files for 3D printing.

There are two files in this folder, named **LEDregulator - Box Top.stl** and **LEDregulator - BoxBottom.stl**. Download these files. During the download phase, ensure you select the desired units, matched to those specified for the 3D printing. In my case, that would be **Millimeter**, as in the image below:



Download the files scaled to the units used by your 3D printer.

Use the two downloaded files **LEDregulator - Box Top.stl** and **LEDregulator - BoxBottom.stl** to 3D print the two case parts.

2 3D Printing

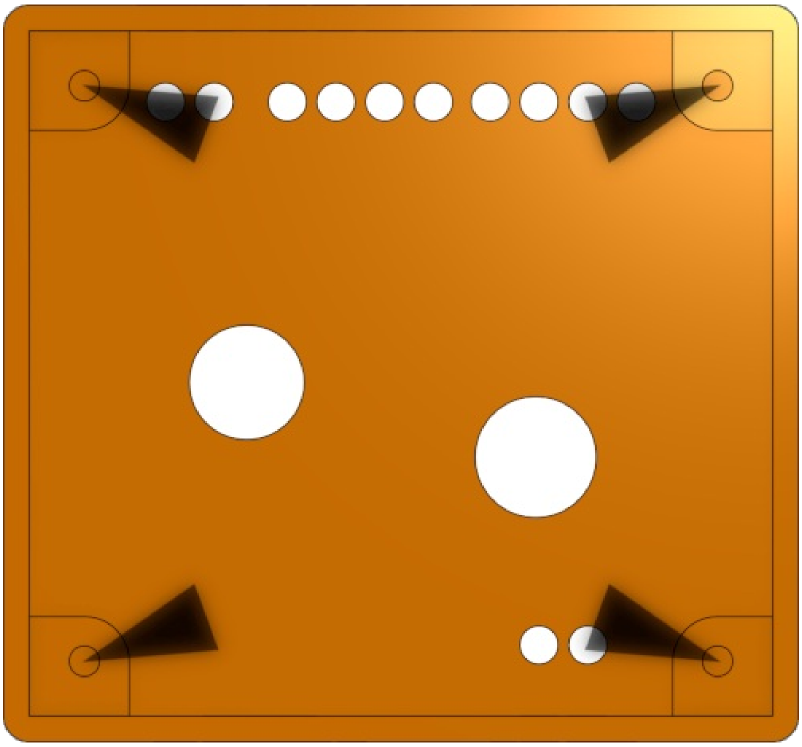
There is no general instruction on how to run a 3D printer. We used an in-house [Stratasys uPrint SE Plus] fused deposition modelling printer with printed support according to manufacturers instructions. The support material was subsequently dissolved by immersing the 3D printed parts in a warm hydrogen peroxide bath.

This step is potentially hazardous. All local regulations and procedures were observed and personal protection equipment was used.

Finally, the two parts were thoroughly washed with copious amounts of water and dried prior to further processing.

3 Tapping Threaded Holes in the 3D Printed Case

The Top part of the case is printed with four blind holes in each corner, highlighted by the black arrows in the image below:



Four holes to be tapped with M3 (or#4-40 UNC) threads for screws holding the case closed.

Use an M3 thread tap to create M3 threaded holes in each corner. In areas, where Imperial thread sizes are in use, swap the M3 threads for locally common #4-40 UNC threads instead. They have similar diameter and due to their courser thread spacing, they are better suited for soft materials like plastic.
The thread is typically created in three steps using three thread taps with progressively deeper cutting threads. Start with the shallowest thread tap and finish with the deepest thread tap. Some tap manufacturers help identifying the order of taps by the number of engraved lines (see image below). First comes a tap with one line, followed by a tap with two lines, and finished with a tap with no lines. Use a tap wrench to do the thread tapping. An illustrative image of an M3 thread tap set and a tap wrench are in the image below:

Image of a set of M3 thread taps and a tap wrench.

4 **Assembling the Case**

The document

Assembling LED Controller Electronics
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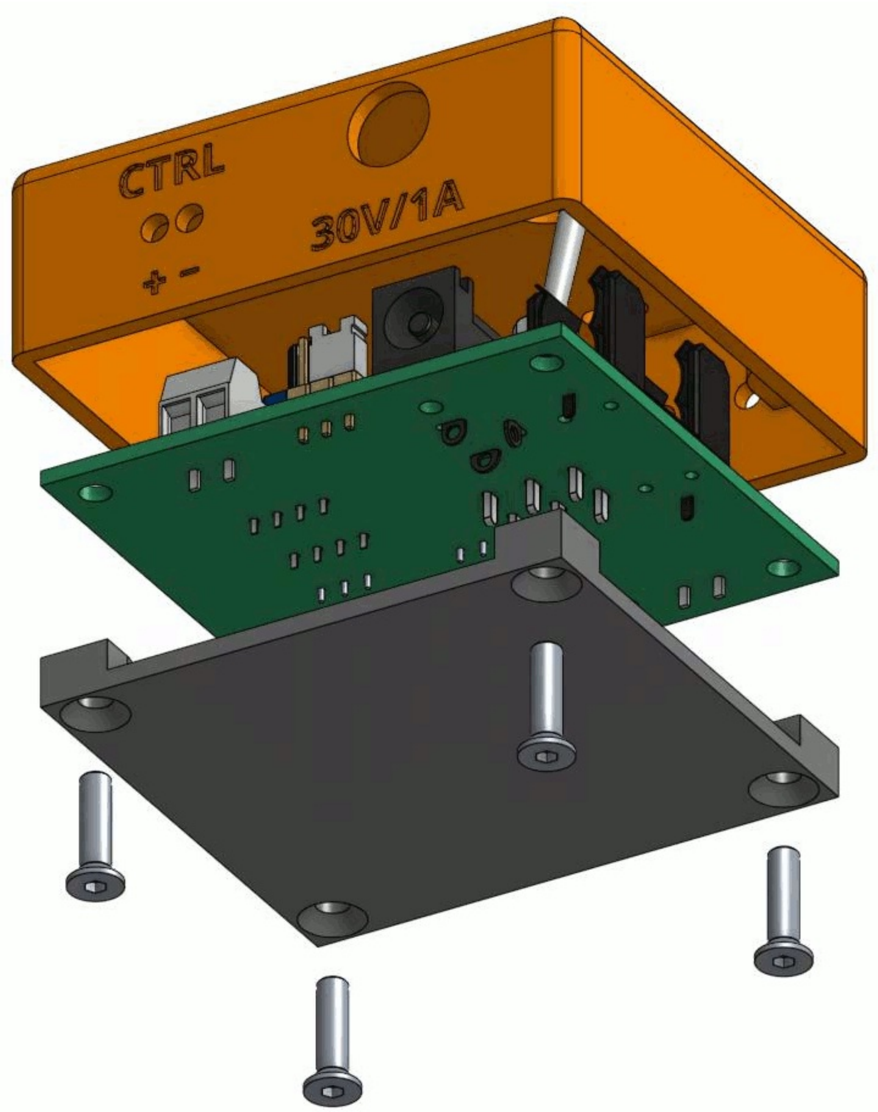
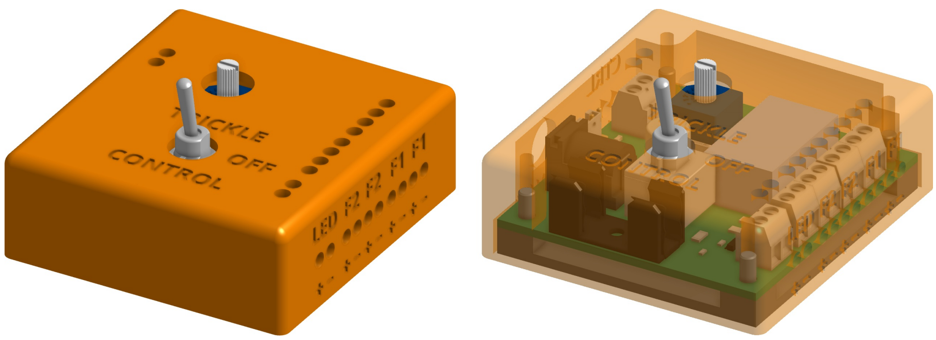
explains how the electronics is assembled onto a printed circuit board (PCB). The PCB fits into the printed 3D case. The case is held together by four M3×10 mm counter sunk screws. Where imperial threads are common, four #4-40 UNC 3/8"-long countersunk screws should be used instead. The assembly is really trivial and only takes a screwdriver or an Allen key, depending on which screw head type is available. The image below should be sufficient to explain the assembly procedure:



Assembly steps for the LEC controller case. The PCB slides into the case. The bottom of the case goes over the PCB and is fastened with four M3×10 mm (#4-40 UNC × 3/8") screws.

The assembled LED Controller is shown as 3D render in the image below:

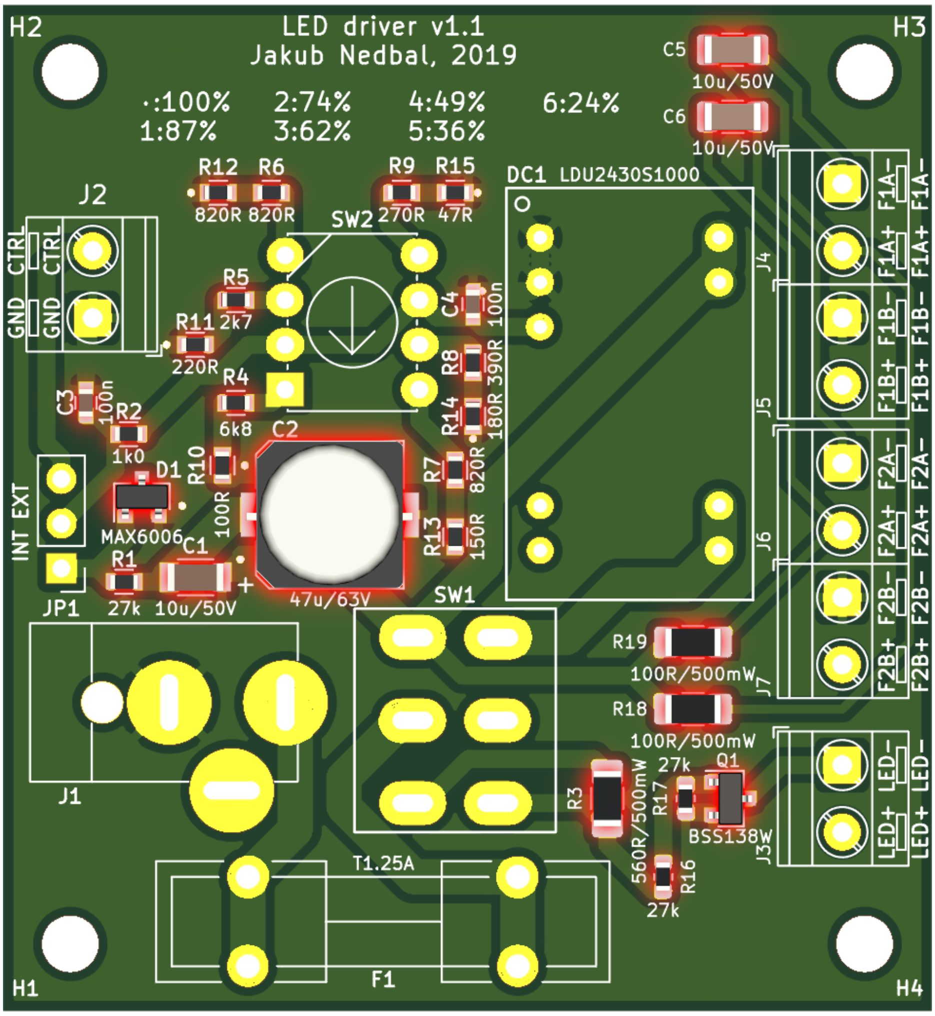


Assembled case for the LED controller circuit. (Left) the outside view of the case, (right) a transparent rendering of the case to show the electronics within.

4.1 Assembly of SMD Components

Start the assembly with all the SMD components first.

Use a thin solder wire, solder flux, and watchmaker's tweezers to help with the soldering. The SMD components that need to be soldered are highlighted in the image below:

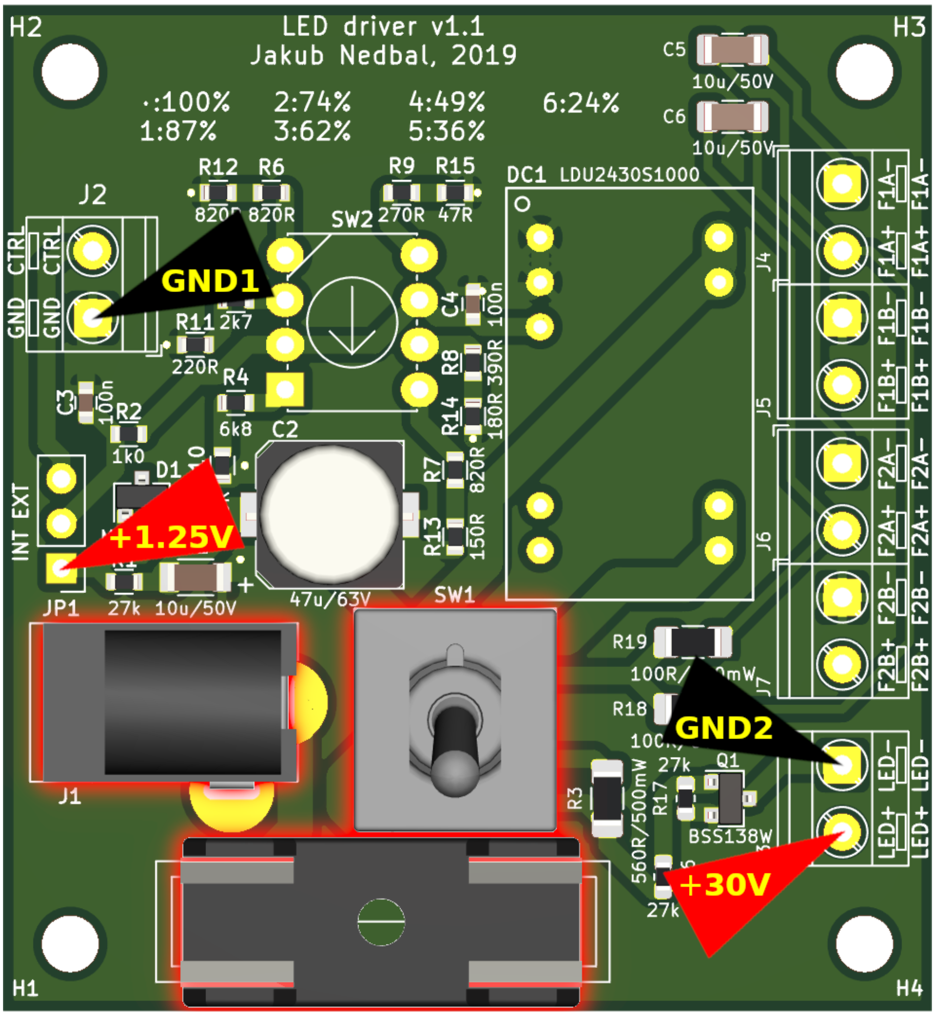


SMD components, highlighted in red, are assembled first. This way the larger through-hole components do not restrict the access to the soldering pads.

4.2 Adding the Power Supply Connection

In this step, the power supply connection is added and the first test of the circuit is performed.

Solder the power supply connector (J1), toggle switch (SW1), the fuse holder (F1), and insert T1.25A fuse into the fuse holder according to the image below:



The DC power supply connector, fuse in a fuseholder, and toggle switch are soldered next. The partial circuit functionality is tested by connecting the power supply to the DC power supply connector and ensuring the expected voltages are measured at the test points highlighted by the black and red arrows in the diagram.

With the components soldered in place, connect the +30V power supply to DC power jack (J1). Make sure the T1.25A fuse is in the fuse holder (F1). Use a digital multimeter in the DC Voltage mode to probe the Voltages on test points of the board.

Make sure the toggle switch (SW1) is in the position as shown in the image above. Connect the multimeter ground lead (black) to the test point labelled **GND1** in the image above. Connect the positive lead (red) to the test point labelled **+1.25V** in the image above. The multimeter should show a value close to 1.25 V on the display. If it does not, check the soldering. On an occasion, we found the shunt reference D1 (MAX6006) failed after assembly and had to replace it. It may be that this component is quite sensitive to mishandling and so you may need to replace it if it does not work before proceeding to the next steps.

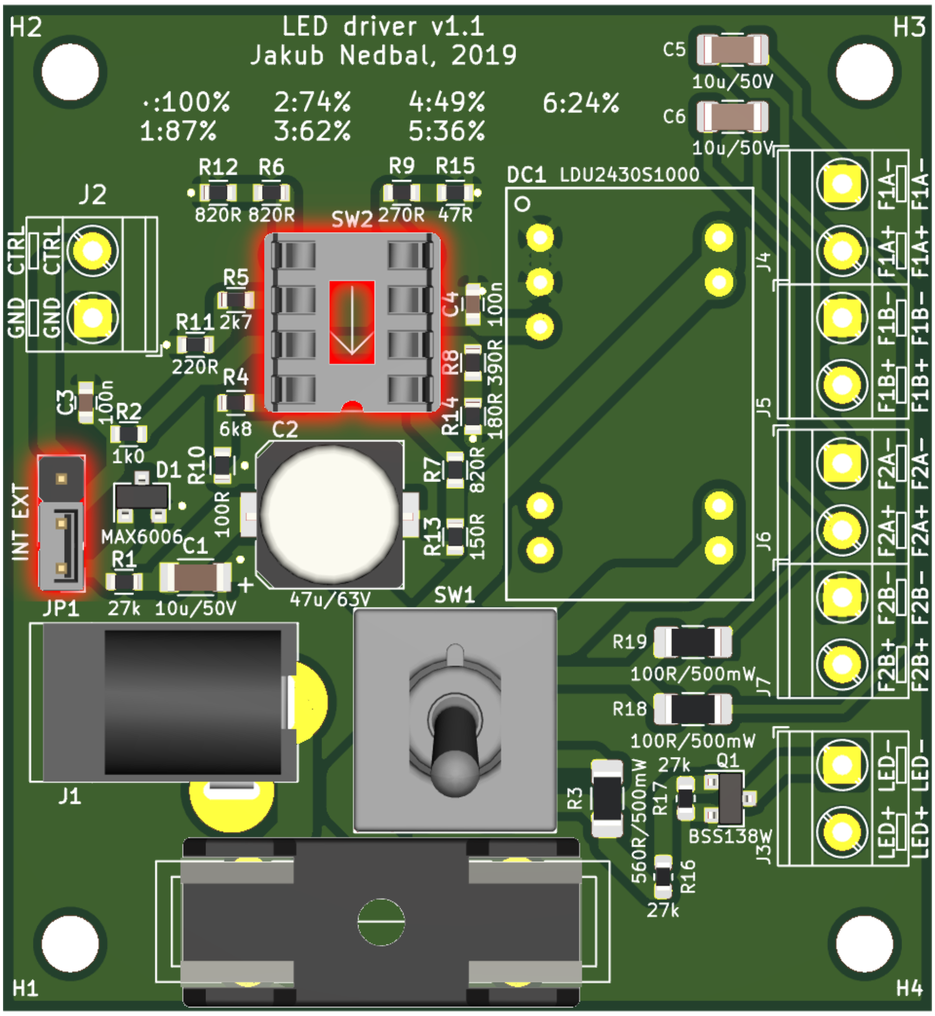
Switch the toggle switch (SW1) to the opposite position to the one shown in the image above. With the multimeter ground lead connected to the **GND2** test point, probe the Voltage at the testpoint labelled **+30V**. Make sure the measured Voltage is close to +30 V. If not, check the soldering. The only component that may be susceptible to failing due to mishandling is Q1. Check if it works and replace it if required.

Do not proceed to the next steps, until you verified the circuit works as described above. Replacing components will become hard or impossible once the remaining large through-hole components are soldered to the PCB.

4.3 Adding the LED Current Regulation

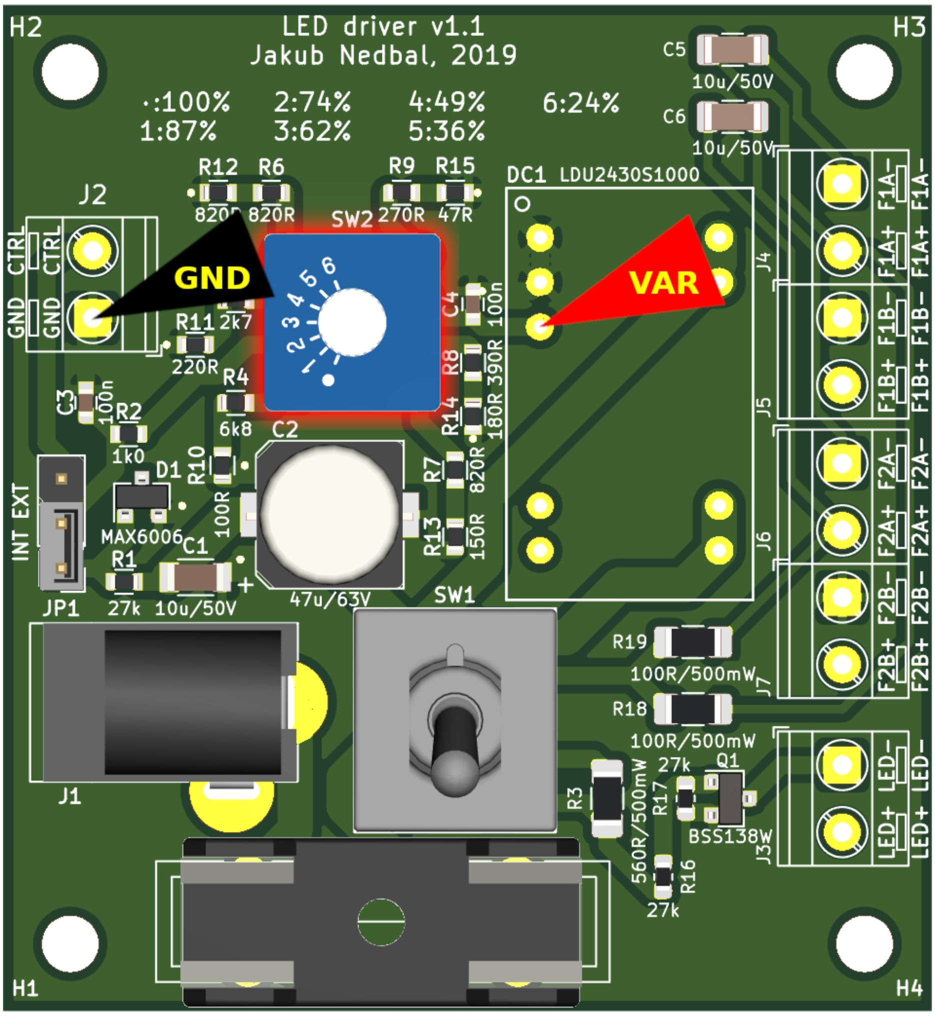
In the next steps, the rotary switch and the input control jumper will be installed and tested.

Solder in the 3-way header (JP1). Insert a jumper shunt across onto the two lower pins of the three way header (JP1) labelled **INT**. Solder a DIP-8 socket into the place for the rotary switch SW2, according to the image below (**do not** solder the rotary switch directly into the PCB):



Solder a DIP-8 socket and a 3-pin header with to the PCB. Connect a jumper shut to the lower two pins of the 3-pin header.

Now, insert the rotary switch into the DIP-8 socket that has just been soldered to the PCB, according to the figure below:



Plug a 6-position rotary switch into the DIP-8 socket. Connect the power supply into the DC power supply connector. Check the voltage between the test points highlighted by the black and red arrows. The voltage should change with the rotary switch position.

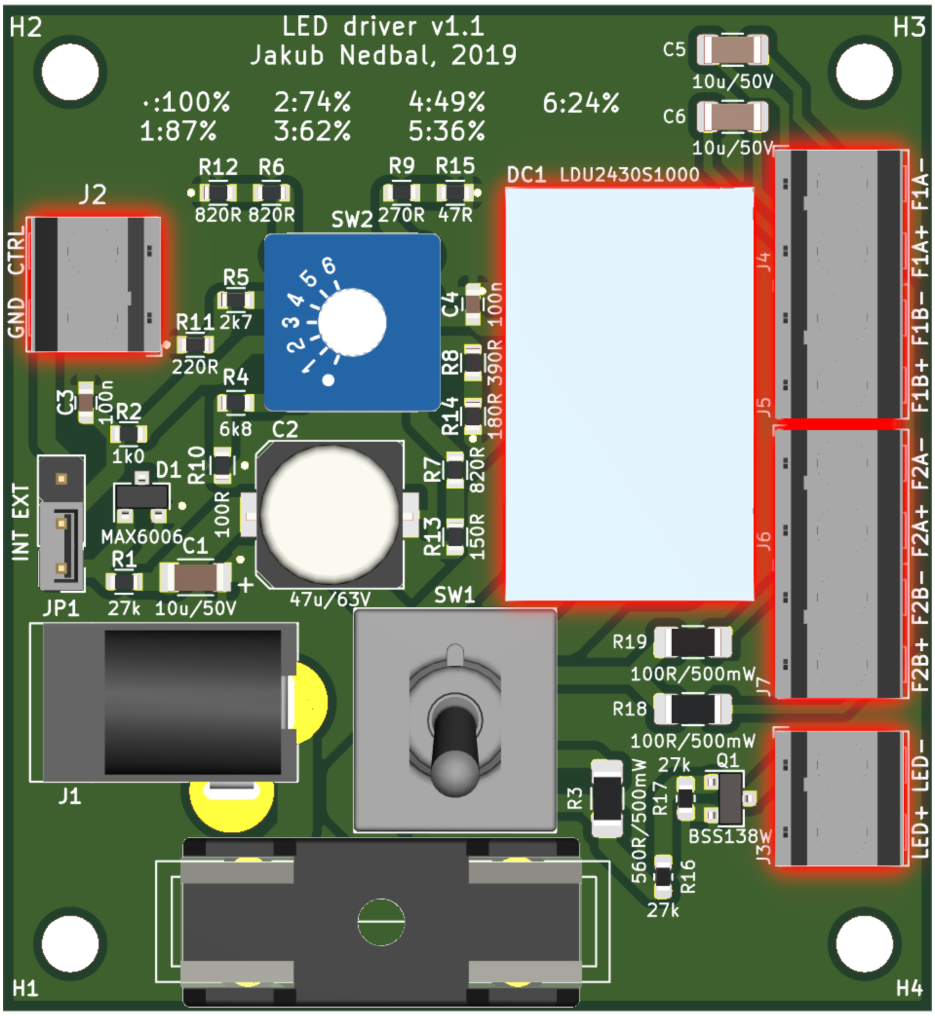
With the switch in place and the +30V power supply connected to DC jack (J1), use a multimeter to test the Voltage between test points labelled **GND** and **VAR**. The Voltage measured should vary in steps of 1.25 V, 1.09 V, 0.93 V, 0.78 V, 0.62 V, 0.46 V, and 0.30 V, which are respective to rotary switch positions of •, 1, 2, 3, 4, 5, and 6. Check these Voltages for every rotary switch position. If any vary significantly, check the soldering and measure the resistances of the SMD resistors. Fix any loose soldering joints or erroneous component placement. If no Voltage can be measured at any position, make sure there is a jumper shunt in the correct position on the 3-way jumper (JP1), as described above.

<u>Do not proceed to the next steps, until you verified the circuit works as described above.</u>

4.4 Adding the LED Controller

In the final assembly step, the adjustable LED driver (DC1) is added together with the screw terminal connectors (J2–J7).

Solder in all these components according to the image below:



Solder the last through hole components to the PCB. These include the screw terminal connectors and the adjustable LED driver.

This completes the circuit assembly. Do not test the function of the circuit with the LEDs just yet. The LED strip needs to be mounted onto the heatsink first, to avoid overheating of the LEDs at full power.

4.5 Cleaning the PCB

Cleaning the PCB from residual flux is important to avoid long-term corrosion and possible future reliability issues. There are professional PCB cleaners in spray, which dissolve the flux that can be wiped off together with the solvent.
Instead, I use a widely available solvent **isopropanol** (isopropyl alcohol, IPA, propan-2-ol) for cleaning. Get a small tub just about fitting the PCB with a lid (an old margarine tub works fine).

- Place the PCB into the tub and cover it completely with the solvent (the parts do not need to be completely submerged).
- Close the lid and let it soak for at least 10 minutes (or even overnight). This should soften the flux.
- Use a toothbrush and a toothpick to rub and scrape off any flux deposits from the PCB.
- Empty the tub with the solvent according to local waste disposal regulations.
- Place the PCB back into the tub, cover it with fresh isopropanol, close the tub lid and let the board soak for additional 10 minutes.
- Brush and pick any residual flux.
- Flick any residual solvent from the board and let it dry.

The above steps explained how to clean the flux from the printed circuit board for long-term reliability of the LED regulator circuit.

4.6 Summary

This document described the assembly process for the LED controller electronic circuit. The assembly took place in steps, each followed by test instructions to verify the function of the circuit before embarking on the next assembly steps. By the end, the circuit board is ready to be installed into a custom case, which is described in the 3D printing LED controller case document.

4.7 References

- LEDregulator Circuit: KiCAD files with the circuit diagram and PCB design files.
- OrbitalShaker_ElectronicsPartsList.xlsx: Excel document listing all electronics and electrical parts, and fixing required in the assembly of the illuminated Orbital Shaker.
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- Procuring Parts for Algal Shaker
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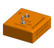

3D Printing Case for LED Controller
by Jakub Nedbal,
King's College London

PREVIEW RUN

- Assembling Cooled LED Illuminator
- Cutting and Drilling Clear Acrylic Sheet
- Assembling Algal Shaker

5 Summary

This document described how to obtain STL files to print a case for the LED regulator electronics circuit. It explained the assembly steps. Once the electronics is inside the case, it is ready for use with the Cooled LED Illuminator.

6 References

- LED regulator case: Onshape project with STL files available for download for 3D printing the case for the LED regulator electronics.

7 **This document is part of the [Illuminated Orbital Shaker for Microalgae Culture](#) project:**

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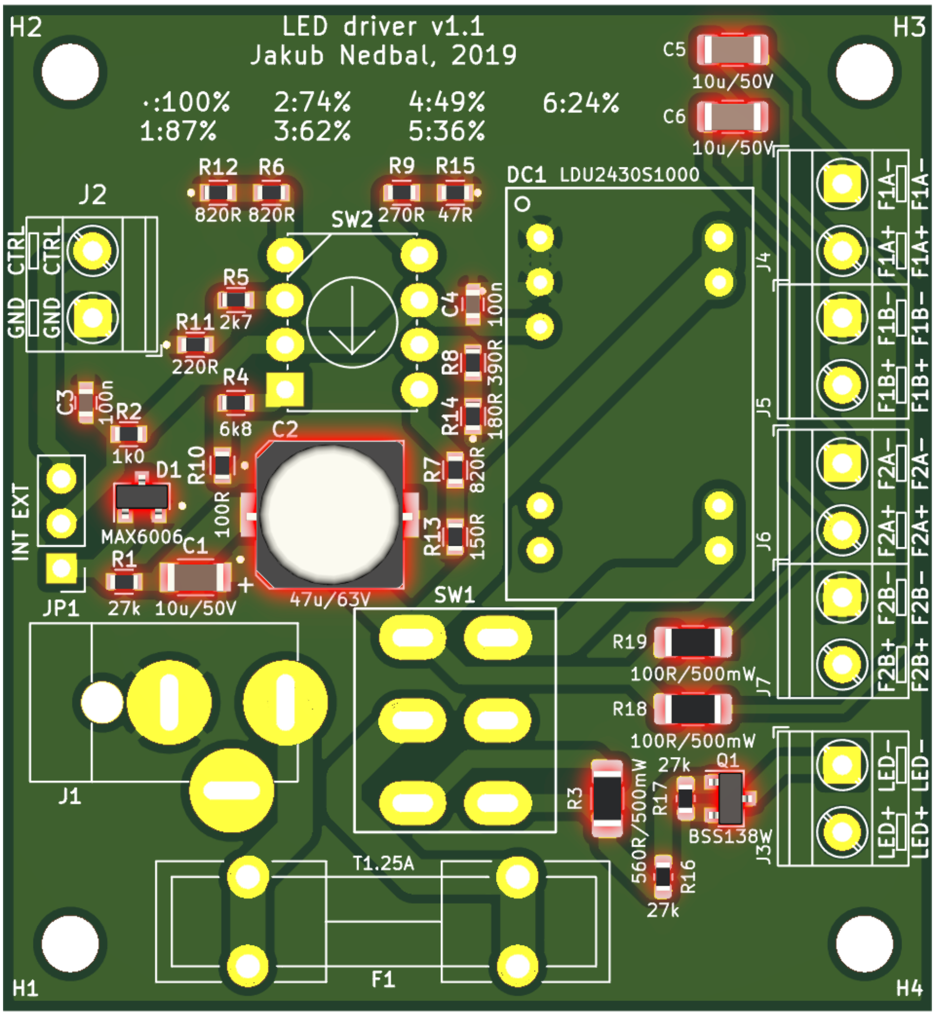

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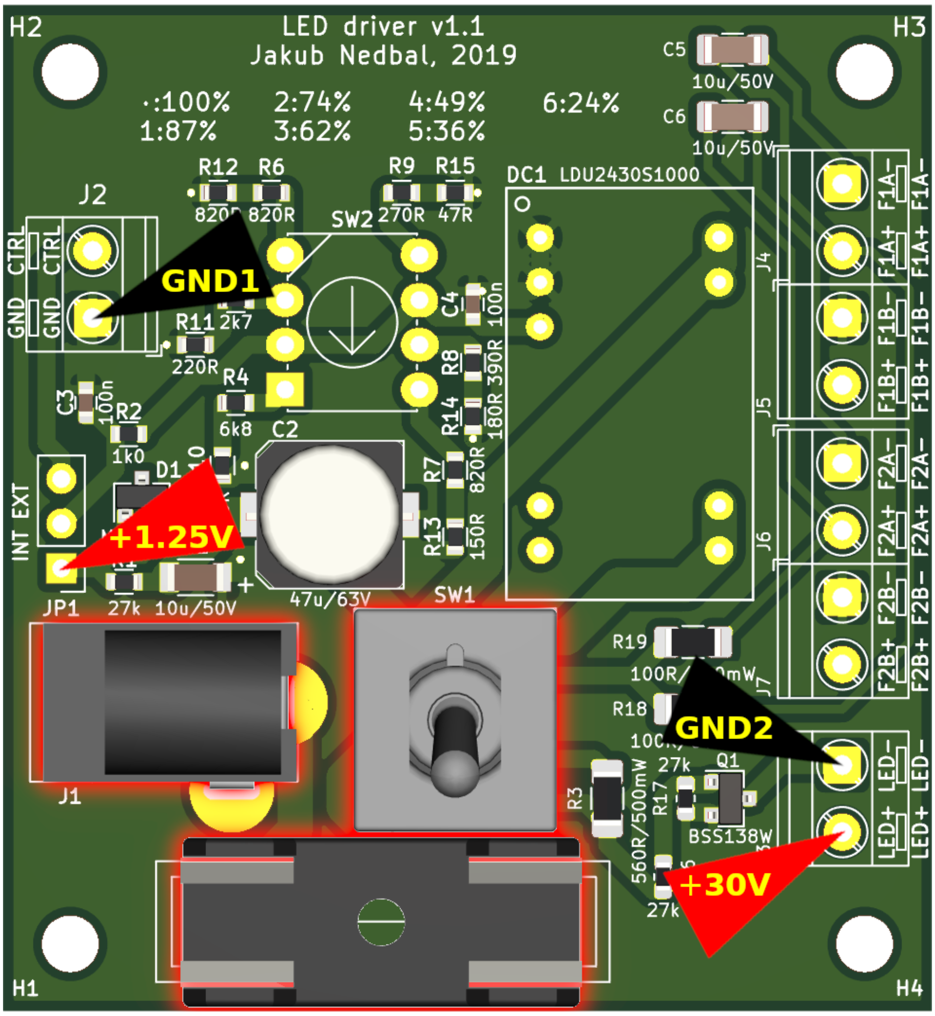

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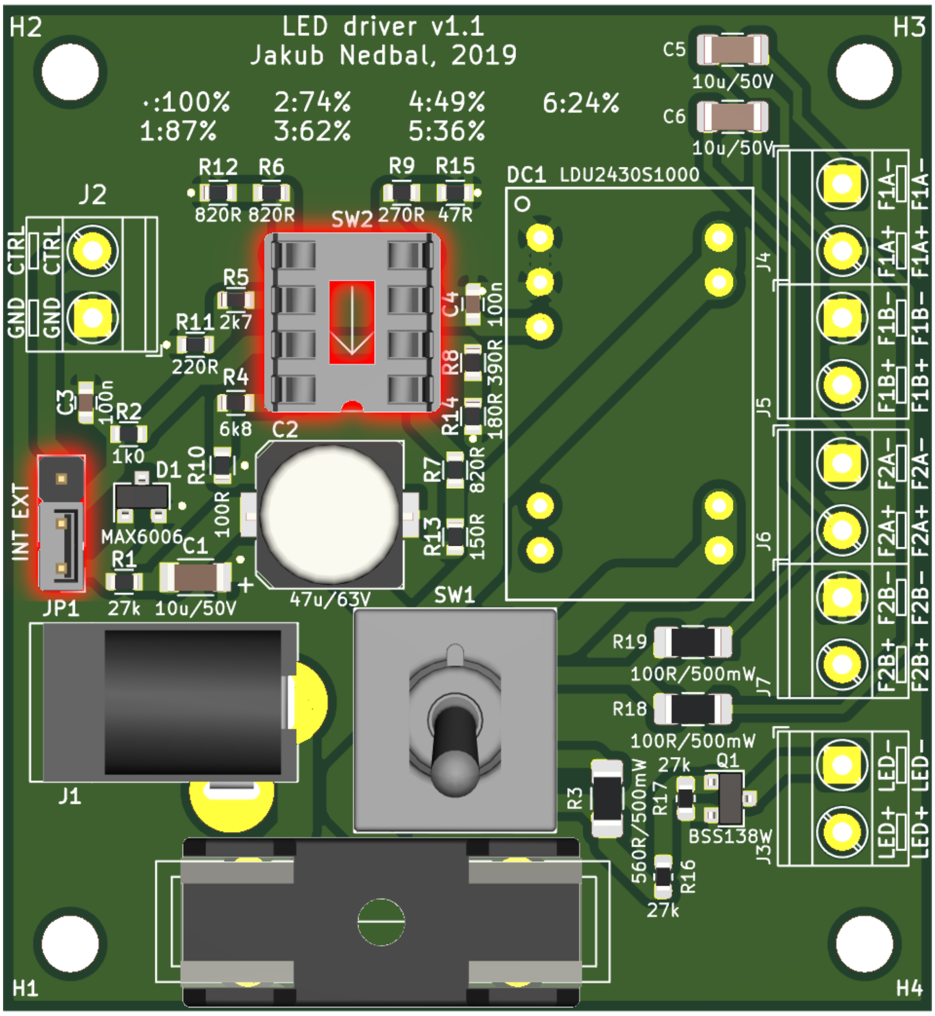

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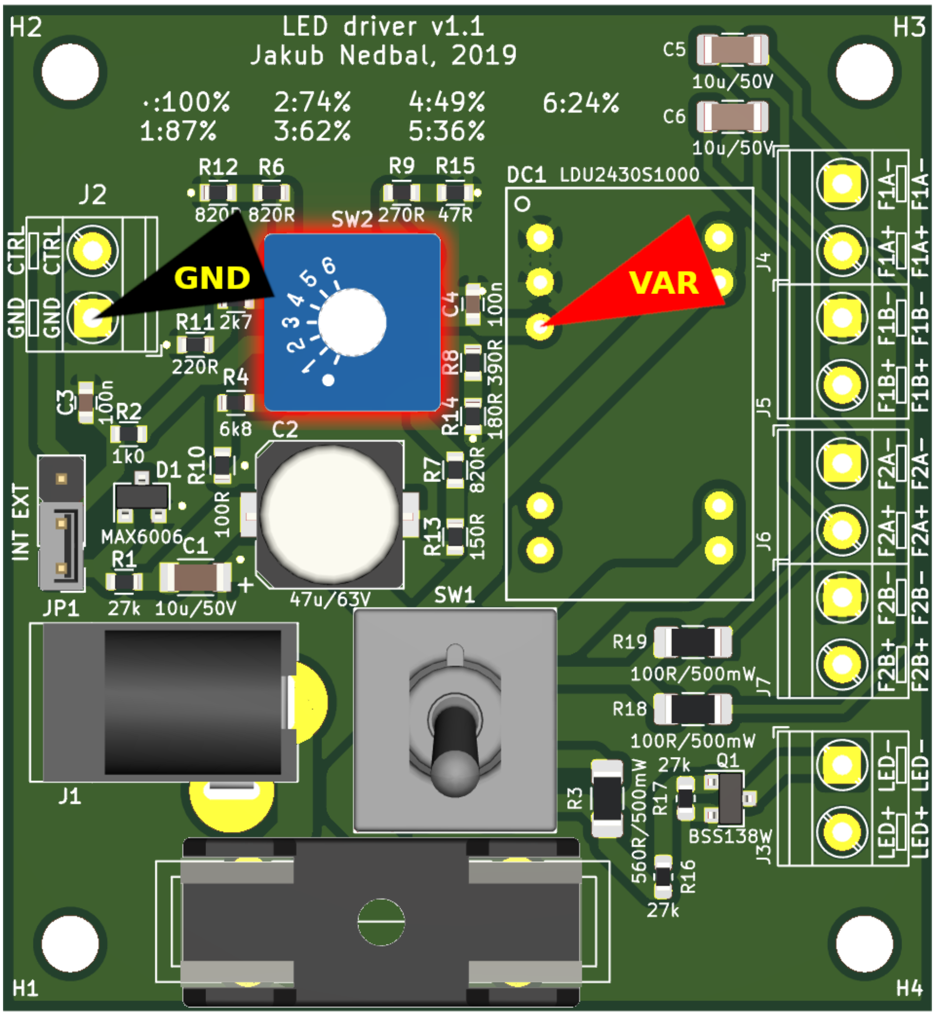

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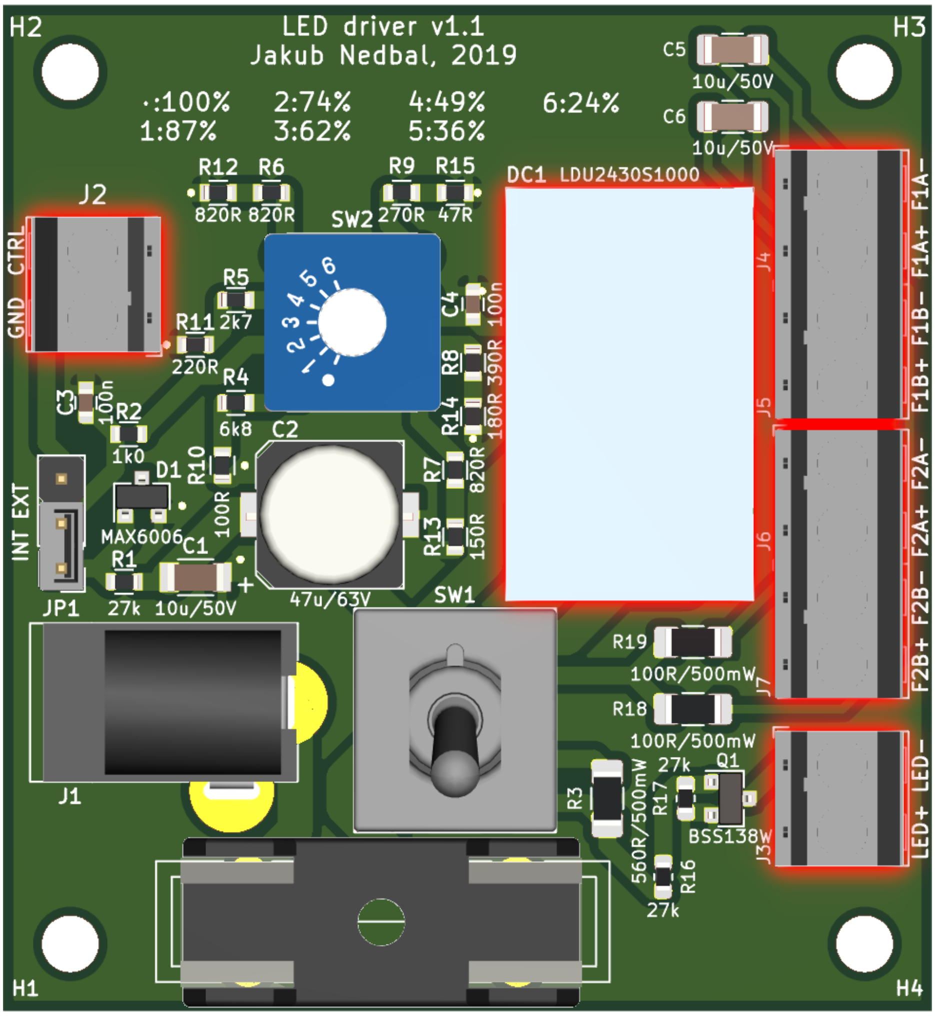

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